

# Top Ten Energy Efficiency

## Best Available Technologies (BATs) and Best Practices (BPs)



### Professional Guidance from (Alphabetically ordered)

Ji Xie, Jiarong Zhao, Jinjiang Liu, Ping He, Qing Fang, Qing Wang, Rongchun Bai,



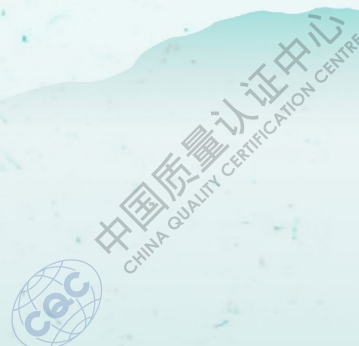
Shuben Ren, Xudong Zhao, Yande Dai, Yi Jiang, Yong Wu

### Planner

Shaoshan Xu

### Editorial Associates

Nan Hu Yingjin Jiang Ying Zhang



P4	Preface	
P6	Chronicle of Events	Edited by Nan Hu
P8	Background of TOP TENs	Shaoshan Xu
P10	TOP TENs Evaluation Methodologies and Indicators	Nan Hu, Yingjin Jiang, Ying Zhang
P33	First Batch of Domestic TOP TENs List	
P33	China	Edited by Nan Hu
P52	Japan	Edited by Quan Bai
P129	The United States	Edited by Sheng Xin
P140	Australia	Edited by Baorong Yuan
P155	Second Batch of Domestic TOP TENs List	
P155	China	Edited by Yingjin Jiang
P227	Japan	Edited by Jianfu Wang
P316	The United States	Edited by Jing Sang
P322	France	Edited by Jing Sang
P366	First Batch of International TOP TENs List	
P366	Energy Efficiency Best Available Technologies (BATs)	Edited by Yunpeng Zhang, Kan Wang
P368	Energy Efficiency Best Practices (BPs)	Edited by Xiaoliang Sun
P369	Second Batch of International TOP TENs List	
P369	Energy Efficiency Best Available Technologies (BATs) of Industry Sector	Edited by Ying Zhang
P370	Energy Efficiency Best Practices (BPs) of Industry Sector	Edited by Wei Han
P371	Energy Efficiency Best Available Technologies (BATs) of Building Sector	Edited by Bin Hao
P372	Energy Efficiency Best Practices (BPs) of Building Sector	Edited by Qingpeng Wei, Lanqin Zhang

## P373 Enterprise Interviews

Reprinted from China Economic Herald

P373 Transform Corporate Social Responsibility into the Driving Force for Energy Conservation:

Pacific Textiles Strives to be an Industrial Pioneer

P378 S Zorb Low-temperature Waste Heat Power Generation: 'New Pacemaker' of Energy Conservation Technologies of Chemical Industry

P382 Energy Passed in the Air-Permanent Magnetic Transmission Energy Saving Device of Xinyu Iron & Steel: The Energy Saving Practice with the Maximum Power in the World

P386 Energy Consumption Waste of Compressed Air? Leave It to Smart Collocation Air Compression Station

P391 Yungang Thermal Power's Way to Achieve Energy Conservation Serves Three Purposes

P395 Beautiful but Not 'Wasteful': White Swan Hotel's Development Fueled by Energy Saving Measures

P399 CECEP Green Building Museum: Building A Glamorous Energy Conservation Visiting Card for Hangzhou

P404 Sino-German Ecopark 'Passive House' Project: Goes in the Forefront of Sustainable Energy Conservation

P407 'Green Joy City' Implemented Objectives Oriented "Whole Process Energy Efficiency Management"

P411 Green Parks Can Realize the Energy Saving Effect by Following Certain Mode

## P415 Expert Perspectives

P415 Scale up Energy Efficiency Investments: U.S. Top Tens Energy Efficient Technologies

Shaoshan Xu

P417 Application of Energy Efficient Technologies and Practices is the Vital Measure to Realize Energy Efficiency Improvement

Jointly written by METI/ANRE and ECCJ

P421 Vigorously Deepen Multilateral Cooperation to Jointly Promote Energy Efficiency Improvement

Andrea Mott, Meredydd Evans, Sha Yu, Aaron Staniszewski,  
Artur Denysenko, Lindsay Parker

## P424 Promotion Events of TOP TENS

CQC, ECCJ, PNNL

## P428 Appendix: G20 Energy Efficiency Leading Programme (G20 EELP)

Edited by Nan Hu, Ying Zhang, Yingjin Jiang



## Preface

As one of the key drivers of economic growth, energy efficiency improvement is an important basis for enhancing energy security, optimizing energy structure, and improving environmental quality; it also plays an important role in promoting ecological civilization and sustainable development. According to the International Energy Agency (IEA), the global energy demand increased by 0.9% and the global energy intensity by 1.6% in 2019. Energy efficiency improvement is the cornerstone to promote energy transformation and high-quality development. The continuous breakthroughs in energy efficient technologies and management models is the core power to drive a new round of technological revolution and industrial revolution. Further international cooperation in energy saving and energy efficiency improvement on a global scale will help countries actively tackle with climate change and transition towards low-carbon development.

Industry, buildings, and transportation are key energy-consuming sectors. To identify and promote energy efficient technologies and management practices in these sectors, in 2013 China and Australia jointly led the establishment of an international cooperation mechanism under the framework of the International Partnership for Energy Efficiency Cooperation (IPEEC) – "Top Ten Energy Efficiency Best Available Technologies and Best Practices (TOP TENs)". China Quality Certification Centre (CQC), a professional third-party certification body, has decades of experience in energy efficiency, environmental protection, and low-carbon development. CQC has been promoting economic, environmental, and social development in several business areas, including energy conservation certification, new energy certification, energy efficient technology assessment, energy audit, greenhouse gas audit, carbon footprint accreditation, and became one of the key technical institutions supporting the Chinese government. Since 2013, designated by the National Development and Reform Commission (NDRC), CQC has been serving as the implementing agency of TOP TENs to promote international cooperation on energy efficiency. CQC has been collaborating with the Pacific Northwest National Laboratory (PNNL), the Lawrence Berkeley National Laboratory



(LBNL), the Energy Conservation Center of Japan (ECCJ), the French Environment and Energy Management Agency (ADEME) and other technical institutions to assess energy efficient technologies and best practices across countries and develop international TOP TENS lists. In 2016, G20 leaders launched an Energy Efficiency Leading Programme (EELP) and TOP TENS was highlighted as one of the G20's key areas of collaboration on energy efficiency under the framework of EELP. By now, two batches of international TOP TENS lists have been released, and vigorous promotion activities have been conducted on the occasion of G20 side events, China-U.S. Energy Efficiency Forum, China-Japan Comprehensive Forum on Energy Saving and Environment Protection, and other bilateral and multilateral cooperation activities, which have gained widespread attention and positive responses in the international community, facilitated the TOP TENS brand building, and laid a good foundation for further cooperation.

To further enhance the influence of TOP TENS, advance energy efficiency, and facilitate energy transformation, CQC publishes the "TOP TENS Special Issue" in the journal of "China Quality Certification", highlighting the best energy efficient technologies and practices widely used and vigorously promoted in China, Australia, France and Japan. It is expected that TOP TENS could provide technical and management solutions and important support to key energy-consuming sectors to conserve energy, improve energy efficiency, and realize high quality development.

At present, countries have made commitments of peaking carbon dioxide emissions and reaching carbon neutrality, energy efficiency, as the "first fuel", will play an important role in fulfilling these international commitments. As the implementing agency of TOP TENS, CQC will strengthen TOP TENS cooperation with member countries, build a platform to promote the "going out" and "bringing in" of energy efficient technologies and practices, foster new prospects for win-win international cooperation, and promote low carbon and sustainable development.

# Chronicle of Events

Edited by Nan Hu

TOP TENs was positioned as one of the G20's key areas of collaboration on energy efficiency under the framework of Energy Efficiency Leading Programme (EELP).

The TOP TENs task group was set and the Term of Reference was released.

The 1st batch of domestic TOP TENs list was released.

The 1st batch of international TOP TENs list was released.

**Oct. 2013**

**Jun. 2015**

**Dec. 2015**

**Sep. 2016**





## Background of TOP TENs

### Background of "Top Ten Energy Efficiency Best Available Technologies (BATs) and Best Practices (BPs)"

Shaoshan Xu

To promote energy efficiency, China and Australia jointly led the establishment of the international cooperation mechanism of "Top Ten Energy Efficiency Best Available Technologies (BATs) and Best Practices (BPs)" (TOP TENs) under the framework of the International Partnership for Energy Efficiency Cooperation (IPEEC) in 2013. TOP TENs is the first inter-governmental international energy efficiency cooperation project initiated by China. With member countries including China, Australia, Canada, France, Japan, South Korea and the United States, TOP TENs aims to select and promote the best energy efficient technologies and practices, improve energy efficiency and energy conservation management in key sectors, promote industrial upgrading, and realize resource conservation and environmental protection.

In order to ensure the selection of the best energy efficient technologies and practices, the National Development and Reform Commission (NDRC) of China coordinated the governments of the member states, as well as the China Quality Certification Center (CQC), the Pacific Northwest National Laboratory (PNNL), the Lawrence Berkeley National Laboratory (LBNL), the Energy Conservation Center of Japan (ECCJ), the French Environment and Energy Management Agency (ADEME), and other technical supporting institutions to establish an international expert panel in 2014. Building on international methodologies of evaluating technologies and considering the key factors such as energy-saving potential, economic and social characteristics, environment, health and safety, the expert panel developed a fair, scientific, and rigorous

evaluation method, which adopted a three-level index system and included both qualitative and quantitative indicators, serving as an important technical foundation for the TOP TENs evaluation. By applying this method, each member state carries out a selection process consisting of initial screening, preliminary evaluation, technical review, re-evaluation, and on-site verification to ensure that the energy efficient technologies and practices in each country's domestic TOP TENs list are the most advanced, innovative, and replicable ones. Following this method and process, each member state first formulates its own domestic TOP TENs list per end-use sector, and then the international expert panel evaluates the energy efficient technologies and practices in all the member countries' domestic lists and finally select 10 best energy efficient technologies and 10 best energy efficient practices to form an international TOP TENs list per sector.

Since the launch of the TOP TENs, the National Development and Reform Commission (NDRC) of China, the Department of the Environment and Energy (DEE) of Australia, the Department of Energy (DOE) of the United States, the Ministry of Economy, Trade and Industry (METI) of Japan, the Ministry of Ecological and Solidarity Transition (MTES) of France, and other governmental departments have paid high attention to TOP TENs and played active roles in developing and promoting TOP TENs. In 2013, the 1st round of TOP TENs evaluation was launched, with a focus on the industrial sector. In 2015, the 1st batch of international TOP TENs list was released, covering best technologies and practices in the metallurgical, steel, cement, chemical, and other sectors. In 2016, TOP TENs was highlighted as one of the G20's key areas of

collaboration on energy efficiency under the framework of the Energy Efficiency Leading Programme (EELP). In 2017, the 2nd round of TOP TENs evaluation was launched, focusing on both industrial and buildings sectors. In 2019, the 2nd batch of international TOP TENs list was released; the steel, textile, coal, electric power, petroleum and petrochemical, and other industrial technologies and practices, as well as heating, cooling, lighting, wall thermal, door, window, and other building technologies and practices, were included. Compared with the 1st round of TOP TENs selection, the areas involved in the 2nd round of selection were more extensive, and fully demonstrated the advanced energy efficient technologies and practices adopted and applied by member states.

The formulation and release of the international TOP TENs lists have gained widespread attention and positive responses in the international community, highlighted the great importance attached by member states to energy conservation and energy efficiency improvement, deepened the multilateral and bilateral technical exchanges and international cooperation on energy efficiency, and demonstrated the significant role of TOP TENs in improving energy efficiency and promoting energy transition in G20 economies.

# TOP TENS Evaluation Methodologies and Indicators

Nan Hu Yingjin Jiang Ying Zhang

## I. Introduction of TOP TENS

### i. Background

The IPEEC TOP TENS Task Group was established to enhance multilateral cooperation for sharing and identifying energy efficient best practices (BPs) and best available technologies (BATs), improve how energy end-users apply them, and develop a consistent criteria and methodology to compile, evaluate and disseminate such findings.

Through TOP TENS, members will share the available information on best practices and technologies and create a refined list from this information, which will have broad

international relevance and will be applicable to end-users in developed and emerging economies.

The goal of this work is to:

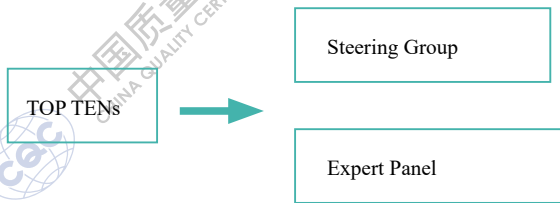
- develop methodologies and approaches for the evaluation, dissemination and promotion of practices and technologies, and
- develop and maintain the TOP TENS' lists on BPs and BATs.

### ii. Organizational structure and management procedures

The following provides a clear understanding of the organizational structure of TOP TENS (up to Sep. 2014) and information on how the TOP TENS program is managed.



## Organizational structure



## Membership

- Co-Leaders: China, Australia
- Members: U.S., Japan, France, Canada, South Korea

## Operating Agency

- CQC (China Quality Certification Centre)

## Technical Support Agency

- China: CQC, NECC (National Energy Conservation Centre), CECEP (China Energy Conservation and Environmental Protection Group) and related bodies
- Australia: IIP (Institute for Industrial Productivity)
- U.S.: LBL (Lawrence Berkeley National Laboratory)
- Japan: ECCJ (Energy Conservation Centre, Japan)
- France: ADEME (Agency for Ecological Transition)

All IPEEC members are invited to join the Task Group. Non-member nations, international organizations and private sector entities are encouraged to participate in the Task Group initiatives upon approval of the participating economies.

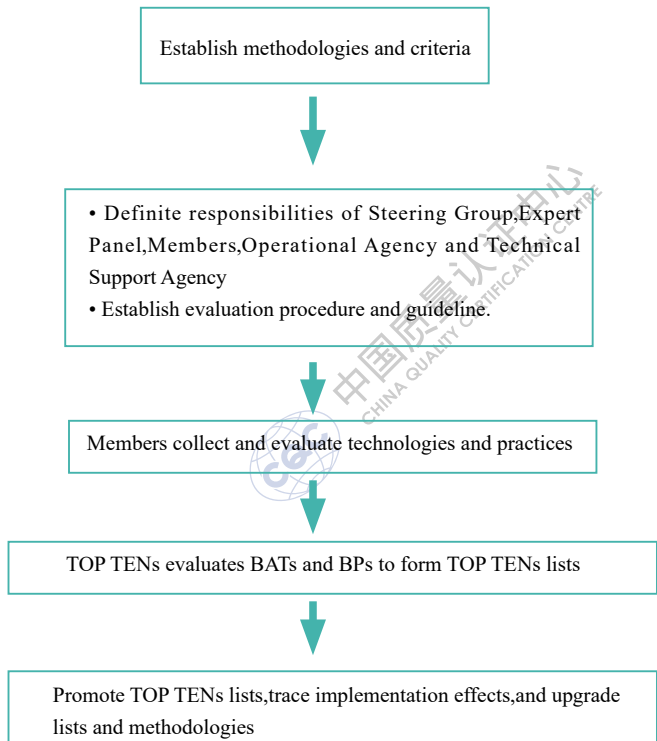
## iii. Management procedures

Refer to the figure on the right.

## II. Introduction of Evaluation procedure and methodologies

### i. What is the purpose of this document?

The purpose of this document is to provide a standard method for assessing and subsequently ranking (energy management) practices and (energy saving) technologies, according to



specific and internationally-agreed sets of criteria.

All Task Group members are invited to assess any and all practices and technologies being used by business within their economy, and submit a list of the top ten best (energy management) practices and the top ten best (energy saving) technologies as determined by the standard methodologies set out in this document.

All submitted lists will then be aggregated and rigorously assessed by an international panel of industry experts, using the methodologies set out in this document, to form the 'TOP TENS' lists. The 'TOP TENS' lists will then be disseminated and promoted internationally.

### ii. What is contained within this document?

This document provides the following documents:

- Introduction of TOP TENS, including background, organizational structure and management procedure.

- Evaluation procedure for compiling,analyzing and ranking a country-specific list of (energy management) practices and (energy saving) technologies.

- Evaluation methodologies for TOP TENs BATs and BPs,including the indicators with weightings,guidelines and actual evaluation examples of how practices and technologies could be evaluated,application templates and requirements.

### iii.What is defined as a 'practice'?

Fundamentally,a 'practice' is a way of doing things. In the context of the TOP TENs,a practice is the particular way an organization unit undertakes that results in energy savings. TOP TENs best practices cover all sectors except agriculture,multiple lists of practices will be developed in the next steps. Examples include: running an energy management workshop each quarter. a business-wide 'energy management awards' program. or setting energy management KPIs for operations personnel that are reported on weekly. to name a few.

Practices will either be particular to a certain project stage,or cover a business' entire operations. For example,a mining company may have a particular practice which is adhered to in the design stage of a new mine,but is not relevant once the mine is built. On the other hand,a manufacturer may have a business-wide energy efficiency policy that all staff must adhere to.

Any country's government policy and/or regulation regarding energy efficiency is not intended to be assessed,addressed or ranked by the methodologies detailed in this document. Any country's government policy and/or regulation regarding energy efficiency is not included in this document. However,if there are such

demands raised by member countries,it's possible to publish a list of best political practices.

### iv.What is defined as a 'technology'?

Best available technologies refer to the technologies themselves,and do not include specific products and equipment (which are the carriers of the technologies) or system optimization and management systems. There is no limit on the sectors that energy-saving technologies can be collected from. Both generic and sector-specific technologies (including cross-sector technologies) can apply for evaluation,all of which will be evaluated using BAT evaluation method in this document.

Each member country shall select and recommend energy-saving technologies in key development areas according to their own resource endowment and energy structure. Each member should select at least eight energy-saving technologies to form a national BATs list,then submit at least five,and no more than ten,energy-saving technologies as candidates to the TOP TENs Task Group. The TOP TENs BAT list will take into account the development of industry,transportation,and buildings in each country,and also the different needs of developing versus developed countries.

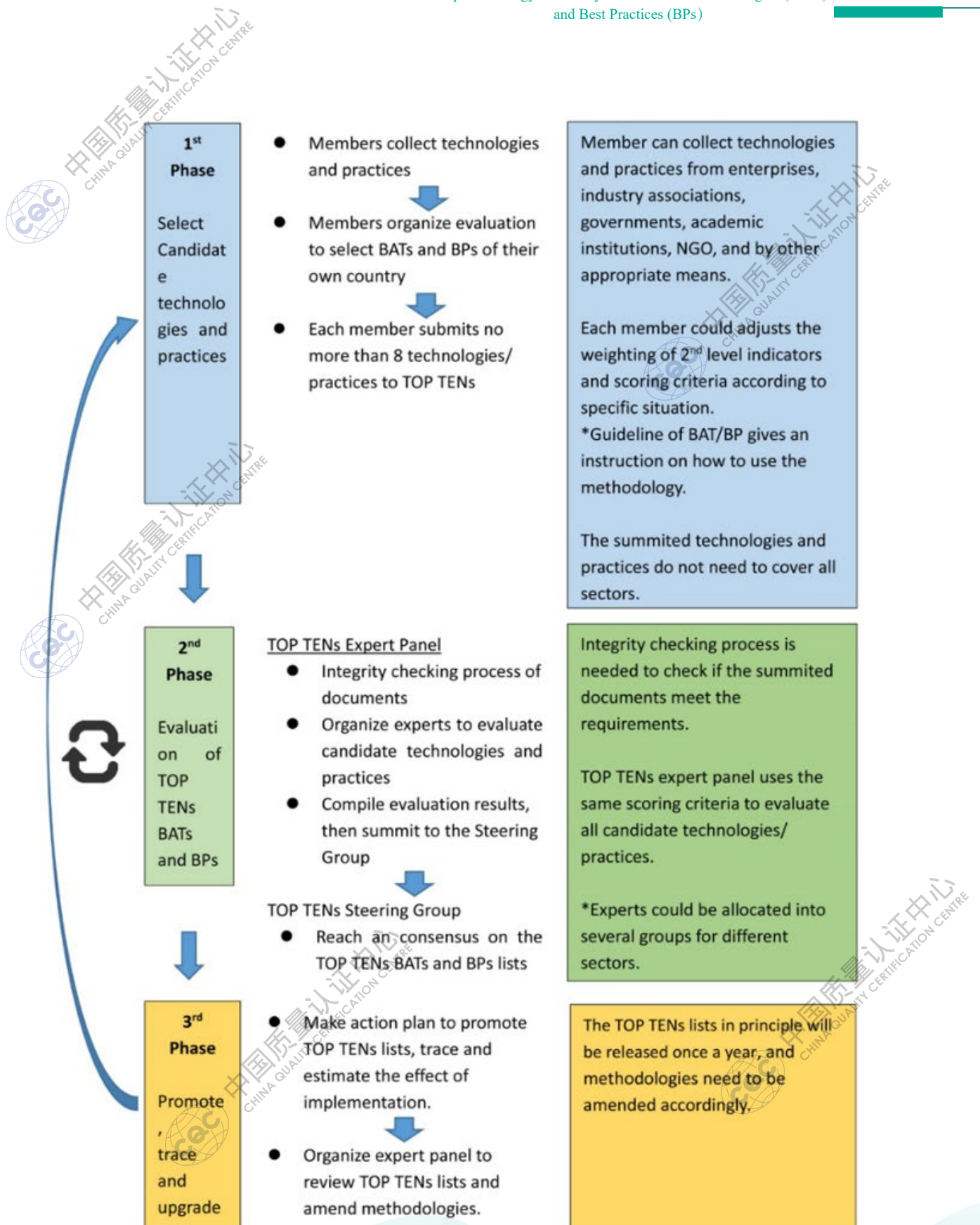
### v.Evaluation Procedure for TOP TENs BATs and BPs

Refer to the figure on the next page.

### vi.Promotion of the TOP TENs lists

The TOP TENs lists can be promoted by means such as,but not limited to,expositions,energy saving and energy efficiency forums,capacity-building workshops,multimedia platforms,and policy instruments (e.g. tax incentives,demonstration projects).

Each member country shall determine the strategy for





promoting the country-specific list of best practices and best available technologies and the TOP TENs lists.

#### vii. Maintenance of the TOP TENs lists

The TOP TENs lists in principle will be released once a year. In order to ensure the lists are up-to-date, they will be updated dynamically when:

- (i) the evaluation methodologies are modified, or
- (ii) practices and technologies are updated, or
- (iii) a practice/technology has become ubiquitous or business as usual (BAU) for most businesses.

### III. Indicators for Evaluating Best Available Technologies

The Evaluation Indicator System is divided into two parts: 'Decisive Threshold Indicators' and 'Qualitative & Quantitative Indicators'. The energy-saving technology must first meet the requirements of the Decisive Threshold Indicators.

The full score of the Evaluation Indicator System is 100 points, which is the highest sum of the secondary indicators. The total evaluation score of the energy-saving technology can be calculated by multiplying its score from the 2nd level indicators by the weights corresponding to those indicators.

The indicator explanation is only for providing the basis for the evaluation, while each member country shall determine its own evaluation criteria and the weight of the 2nd level indicators. Member countries should submit their adjusted Evaluation Indicators System, Energy-Saving Technology Application Form, and Scoring Tables together to the TOP TENs Task Group.

Technologies will be evaluated against the following criteria: Environment, Health, and Safety (EHS), Maturity, Energy-

Saving Potential, Technology Characteristics and Practicality, Economic Characteristics, and Social Characteristics.

#### i Decisive Threshold Indicators

##### (i) Environment, Health, and Safety (EHS)

The energy-saving technology shall have little or no impact on the environment, health, safety, and other areas of public concern, e.g. pollution to air, water, or soil, occupational injury rate and accident rate, toxicity, teratogenicity due to long-term exposure.

##### (ii) Maturity

The energy-saving technology should meet at least one of the following requirements:

- Mass production/ large-scale production.
- Commercialization.
- Promoted at national level.

#### ii Qualitative & Quantitative Indicators

##### (i) Energy-Saving Potential

###### • Level of energy efficiency

To compare the energy efficiency of different technologies, the baseline for calculating energy-savings could refer to the historical energy consumption of each technology. If available, it is recommended that international baseline data receive preferential consideration.

###### • Market prospect

This is judged from the application proportion of the energy-saving technology in 2014, and the expected promotion proportion of the technology in 2017.

###### • Energy-saving potential

Forecast the potential annual energy-savings in each member country by 2017.

#### (ii) Technology Characteristics and Practicality

##### • Advanced nature and innovative nature

Judge whether the technology is advanced at the international level by comparing its parameters with international baselines, which are provided by experts in the relevant field.

Judge whether the technology is innovative, the judgment is based upon innovative application of the conventional technology.

##### • Reliability

The reliability of the technology should be scored according to its MTBF (mean time between failures).

#### (iii) Economic Characteristics

##### • Investment per unit saved energy

Investment includes the infrastructure investment, equipment investment, and maintenance & operation costs. The investment shall be specified in heat or power units.

##### • Payback period

The payback period is the time needed to recover all investment or reach the break-even point. Investment refers to the expense of new technology and its operation & maintenance.

#### (iv) Social Characteristics

##### • Social impact

Judge by comprehensive impacts to sustainable development, climate change, energy supply and employment.

#### (v) Weighting of indicators

Each indicator is weighted such that when summed scores will add to a value between 20 and 100. The

following process should be used to reach a final score:

- 1) Score each 2<sup>nd</sup> Level Indicator out of 100.
- 2) Multiply that score by the sub-weighting listed for that 2<sup>nd</sup> Level Indicator.
- 3) Sum all sub-weighted scores to form the final score out of 100.

1 <sup>st</sup> Level Indicator	Weight	2 <sup>nd</sup> Level Indicator
Energy Saving Potential	35%	Level of energy efficiency
		Market prospect
Technical Characteristics and Practicality	20%	Advanced nature and innovative nature
		Reliability
Economic Characteristics	35%	Investment per unit saved energy
		Payback period
Social Characteristics	10%	Social impact

## IV. Guideline for TOP TENs Best Available Technologies

### i. Introduction

This Guideline discusses the following aspects of the evaluation system in the order it was organized, and these are: Guide for Documentation. Declaration Form Template. Example of technology (filled in declaration form). Evaluation criteria for indicators. Example of complete methodology for TOP TENs BATs. Example of Actual Technology Evaluation.

It is the intention of this Guideline to be used as the official reference document by the IPEEC TOP TENs Member Country applicants when joining the work. Moreover, to increase more applicants by keeping them fully aware on the requirements and other procedural matters prescribed by the Steering Group.



## ii Guide for Documentation

Procedural guidelines and applicable formation preparing the national entry documents as shown and discussed below.

### • Best Available Technologies Declaration Form

The declaration Form submitted by applicants should at least include the following information,

- Overview of technology (including Background, Technical Characteristic, Scope of use etc.).
- Related information and data required by evaluation criteria.
- Certification and endorsement.
- Brief Introduction of the applicant entity.

## iii Evaluation Criteria for Indicators

### (i) Decisive Threshold Indicators

#### Environment, Health, and Safety (EHS)

• Evaluation criteria is as follows.

- ① Excellent
  - ② Fairly Excellent
  - ③ Unaccepted
- ①, ② ⇒ proceed to Quantitative & Qualitative Indicators

### • Maturity

Evaluation criteria is as follows.

- ① Excellent
  - ② Fairly Excellent
  - ③ Unaccepted
- ①, ② ⇒ proceed to Quantitative & Qualitative Indicators

### (ii) Qualitative & Quantitative Indicators

#### 1. Energy-Saving Potential (35%)

##### 1.1 Level of energy efficiency (15%)

1.1 includes 3 indicators for evaluation: Energy Saving Rate, Energy Consumption by Physical Units (Energy Intensity), and Continuity of energy saving for recent 3 years.

#### Evaluation Criteria for 1.1 Level of energy efficiency

① Energy Saving Rate		② Energy Consumption by Physical Units (Energy Intensity)	
mark	criteria (%)	mark	criteria (ranking in the total entry)
100	≥ 40%	100	top 20% group of total entry
80	≥ 30%	80	top 20-40% group of total entry
60	≥ 20%	60	top 40-60% group of total entry
40	≥ 10%	40	top 60-80% group of total entry
20	< 10%	20	top 80-100% group of total entry
$\text{Energy Saving Rate} = (E_b - E_a) / E_b \times 100\%$ Ea: energy consumption per unit of the evaluated product Eb: average energy consumption per unit product in member country (base scenario)		1. If the energy saving activity is continuously done for more than 3 years, then the mark can be one grade higher.  1. Eb could be obtained from government statistic data, average data of submitted technologies which are in the same category etc.	

#### 1.2 Market prospect (10%)

1.2 includes 2 indicators for evaluation: Proportion Applied in 2014, Increased Promotion from 2014-2017.

#### Evaluation Criteria for 1.2 Level of Market prospect

① Proportion Applied in 2014		② Increased Promotion from 2014-2017 within member country or world-wide (estimated number)	
mark	criteria (%)	mark	criteria (%)
100	> 80%	100	> 50%
80	≤ 80%	80	≤ 40%
60	≤ 50%	60	≤ 30%
40	≤ 20%	40	≤ 20%
20	≤ 10%	20	≤ 10%
		1. For those widely applied technologies (application proportion > 90% in the country), ② should use estimated proportion in the world-wide.  Formula is TBD.	



### 1.3 Energy-saving potential (10%)

1.3 includes 3 indicators for evaluation: Energy Saving Amount, Perspective Application Cases by 2017, and Market Capacity by 2017.

#### Evaluation Criteria for 1.3 Energy-saving potential

① Contribution rate of energy savings to the sector	
mark	criteria (%)
100	> 80%
80	≤ 80%
60	≤ 60%
40	≤ 40%
20	≤ 20%
Formula is TBD.	

## 2. Technical Characteristics and Practicality (20%)

### 2.1 Advanced nature and innovative nature (10%)

2.1 includes 2 indicators for evaluation: Advanced nature, Innovative nature.

#### Evaluation Criteria for 2.1 Level of energy efficiency

① Advanced nature		② Innovative nature	
mark	criteria	mark	criteria
100	advanced at the international level	100	a very innovative technology compared with the conventional ones
80	(not apply)	80	(not apply)
60	average at the international level	60	some improvements to the conventional technology
40	(not apply)	40	(not apply)
20	below average at the international level, but advanced at the country level	20	no improvement to the conventional practice
1. Parameters of international baseline could be obtained from database of international institutes, expert comments etc.			

### 2.2 Reliability (10%)

2.2 includes 1 indicator for evaluation: MTBF (mean time between failures).

## 3. Economic Characteristics (25%)

### 3.1 Investment per unit saved energy (15%)

#### Evaluation Criteria for 2.2 Level of Reliability

##### ① MTBF (mean time between failures)

mark	criteria (ranking in the total entry)
100	40% higher than average of total entry/ sector standard
80	20% higher than average of total entry/ sector standard
60	10% higher than average of total entry/ sector standard
40	5% higher than average of total entry/ sector standard
20	lower than average of total entry/ sector standard

3.1 includes 1 indicator for evaluation: Investment Per Unit Saved energy.

#### Evaluation Criteria for 3.1 Investment Per Unit Saved energy

##### ① Investment Per Unit Saved energy

mark	criteria
100	> 30% lower than the base scenario
80	30% lower than the base scenario
60	10% lower than the base scenario
40	almost the same as the base scenario
20	more than the base scenario

### 3.2 Payback period (10%)

3.2 includes 1 indicator for evaluation: Payback Period.

#### Evaluation Criteria for 3.2 Payback Period

① Payback Period	
mark	criteria
100	≤ 3 years
80	≤ 5 years
60	≤ 10 years
40	≤ 15 years
20	> 15 years

## 4. Social Characteristics (10%)

### 4.1 Social impact (10%)

4.1 includes 4 indicators for evaluation: sustainable

#### Evaluation Criteria for 4.1 Social impact

##### ① in accordance with the general evaluation criteria (see below)

mark	criteria
100	Excellent (4 yes)
80	Good (3 yes)
60	Fair (2 yes)
40	Below Average (1 yes)
20	Poor (0 yes)
1. If the technology has positive impact on one aspect of social impact (4.1.1~4.1.4), it counts for 1 yes.	

development, climate change, energy supply, and employment.

## V. Indicators for Evaluating Best Practices

Practices will be evaluated against the following criteria: Energy Saving and Cost, Sustainability, Originality and Innovation, Transferability, Co-benefits.

### i. Overall Impact Indicator

#### • Impact on Environment, Health, Safety

The energy-saving technology shall have little or no impact on the environment, health, safety, and other areas of public concern.

#### • Overall impact of originality and innovativeness on the successful EE/C activities.

### ii. Qualitative & Quantitative Indicators

#### (i) Energy Saving and Cost

##### • Energy Saving Value

-Energy saving in terms of energy intensity (energy unit consumption) by implementation of the subject BP.

-Percentage of energy reduction from "the baseline" (as described in 2.2) <N.B.>.

-Units to be Wh/year, kL/y, ktce/y, etc.

-Energy conversion factors to be specified (probably the one used in the country or IEA method).

##### • Cost Effectiveness

-Investment cost which realized the subject BP.

-Payback period <N.B.>

-Monetary unit to be the hard currencies such as USD.

-Basic data used in calculation to be clearly shown.

##### • Prospect

-Future prospect of the subject practice to be proposed in terms of future possible amount of energy reduced.

-The scope of the energy-saving policy should be considered.

#### (ii) Sustainability

##### • PDCA (Plan, Do, Check, Act)

Plan and Do:

-Along "The baseline", the energy consumption data to be collected.

-Historical data as well, preferably a few years at least are needed.

-Action Plan to be compiled after the prioritization of possible EC projects.

-Such plan, often multi-year basis to be consistent with the entity's mid- or long-term management plan.

-The plan to be put into implementation after the approval within the entity.

Check and Act:

-Progress to be continuously monitored in comparison with the plan.

-Proper remedial actions to be made if something wrong is found.

-After the completion of the plan, results to be assessed from various viewpoints, and feedback to be made for the future stages.

#### (iii) Originality and Innovation

##### • Originality of Practice

-Introduction of advanced technologies

-Excellency in issue-finding and problem-solving procedure.

##### • Innovative application of conventional Practice

-Measures based upon innovative application of the conventional technology.

#### (iv) Transferability

##### • Generality

- Because of general versatility, replicable in other areas of the same factory/other factories.
- Because of general versatility, replicable in other sectors/areas.

##### • Ease of Implementation

- Ease of equipment procurement.
- Ease of maintenance including parts procurement.
- Introduction of the technology and equipment eligible for government subsidy.

##### • Ability to integrate External resources

- The ability to obtain political support.
- The ability of commercialization.
- The ability to leverage private sector expertise to facilitate execution and promotion of the practice (e.g. build on ESCO and other financing program options, consider outsourcing the practice to NGO that specialize in program design and implementation, leverage PDCA activities).

#### (v) Co-benefits

##### • Environmental Benefits

- Amount and percentage of CO<sub>2</sub> reduction to be described. <N.B.>.
- Conversion factors (nationally defined coefficients or an international norms such as IEA's to be clarified.
- If any type of reductions in waste and or pollution occurs, specify the items and changes.

##### • Social Awareness Benefits

- Improve energy-saving awareness of the staff and /or general public, effect on sectors media attention to the practice.

- Influences on health condition and safety of the staff and /or general public.

#### (vi) Weighting of indicators

Each indicator is weighted such that when summed scores will add to a value between 20 and 100. The following process should be used to reach a final score:

- Score each 2<sup>nd</sup> Level Indicator out of 100.
- Multiply that score by the sub-weighting listed for that 2<sup>nd</sup> Level Indicator.
- Sum all sub-weighted scores to form the final score out of 100.

1 <sup>st</sup> Level Indicator	Weight	2 <sup>nd</sup> Level Indicator
Energy Saving and Cost	35%	Energy Saving Value
		Cost Effectiveness
		Prospect
Sustainability	20%	Management Factor
		PDCA (Plan, Do, Check and Act)
Originality and Innovation	20%	Originality of Practice
		Innovative application of conventional Practice
Transferability	15%	Generality
		Ease of Implementation
		Ability to integrate External resources
Co-benefits	10%	Environmental Benefits
		Social Awareness Benefits

## VI. Guideline for TOP TENs Best Practices

### i. Introduction

- To promote and disseminate Best Practices (hereinafter called BP) in energy management demonstrated or applied in all the sectors in the TOP TENs member countries.
- To encourage all sector participation in adopting and implementing innovative and creative energy management approaches towards energy conservation to enhance business growth.
- To promote energy management as a tool to save



energy, as another form of energy resource, and, to improve environmental quality in the TOP TENs member countries and other countries in the future.

## ii. Criteria and Distribution of Scores

The Board of Judges shall give evaluation scores in view of the substance of the contents and information presented therein in the submitted entry documents in reference to sets of established criteria.

The maximum total point score number is 100 marks based on the major criteria distribution.

They are: Energy Saving and Cost, Sustainability, Originality and Innovation, Transferability and Co-benefits.

Table on page 21 shows the main criteria and its sub-criteria group with corresponding maximum percentage point allocation.

## iii Guide for Documentation

Procedural guidelines and applicable formation preparing the national entry documents as shown and discussed below.

### (i) Application Form

Applicants should follow documentation format in the organized item order presentation as shown on page 22.

Remark:

- All entries must be typewritten in single paragraph, Times New Roman 12 pt font, 1 inch margin from all sides. A4 size paper.
- There is no definite number of pages allocated for each submission heading or discussion items. However, the

total number of pages must not exceed 17 pages.

### (ii) Project/Activity Overview

Summarize the following in brief within 1 page.

1. Status of the project in EE&C policy / commitment
2. Purposes and targets of the project including reasons to select the theme.

This may include the current energy status such as annual energy consumption.

3. Outline of the project specifics with the following points.

(1) Organization of energy management implementation and dissemination of measure.

(2) Duration of project.

(3) Process flow and specific area(s) for improvement

(4) Key measures for improvement including changes in process flow.

(Operating / maintenance conditions and modification / installation of equipment and process)

(5) Impact by comparing the following between the baseline and after implementing the project:

-Energy consumption (Annual total and unit energy consumptions)

-Economical merits

-Other tangible / intangible merits to be emphasized

(6) Measures to sustain improvement such as standardization and training.

4. Future plan .

### (iii) Guidelines for Overall Impact Indicators

#### • Impact on Environment, Health, and Safety

-The energy-saving technology shall have little or no impact on the environment, health, safety, and other areas of public concern.

### Criteria and Mark Structures

No	Criteria Group	Maximum Marks Allocation
1	Energy Saving and Cost(Achieved)	35%
	1.1 Energy Saving Value	15%
	1.1.1 Energy Saving Amount (kWh/year, kL/year, ktoe)	
	1.1.2 Energy Saving Ratio (%)	
	1.1.3 Continuity of Energy Saving for these 3 years	
	1.2 Cost Effectiveness	10%
	1.1.1 Investment	
	1.1.2 Payback Period	
	1.3 Prospect	10%
	1.3.1 Promotion Potential within the country	
2	Sustainability (How achieved)	20%
	2.1 Management Factor	10%
	2.1.1 Leadership and people	
	2.1.2 Capacity Building	
	2.2 PDCA	10%
	2.2.1 Data analysis and target setting(Plan)	
	2.2.2 Developing Action Plan and Implementation	
	2.2.3 Monitoring Process	
	2.2.4 Feedback Process	
3	Originality and Innovation(How Achieved)	20%
	3.1 Originality of Practice	10%
	3.2 Innovative application of conventional Practice	10%
4	Transferability (Replicability)	15%
	4.1 Generality	5%
	4.1.1 General Applicability	
	4.2 =4.2.1 Ease of Implementation	5%
	4.3 =4.3.1 Ability to Integrate External resources	5%
5	Co-Benefits	10%
	5.1 Environmental Benefits	7%
	5.1.1 Reduction in CO <sub>2</sub>	
	5.1.2 Reduction in waste and/or pollution(air/water/noise/odor etc)	
	5.2 Social Awareness benefits	3%
6	Total	100%

Evaluation criteria is as follows:

- ① Excellent } ①, ② ⇒ proceed to Quantitative  
② Fairly Excellent } & Qualitative Indicators  
③ Unaccepted }

Overall impact of originality and innovativeness on the

successful EE/C activities

Evaluation system is as follows:

- ① Excellent } ①, ② ⇒ proceed to  
② Fairly Excellent } Quantitative & Qualitative  
③ Unaccepted }

Item No.	Submission Heading/Discussion Items	Maximum Number of Page Allocation*
1	Application Cover	1
2	Certification and endorsement	1
3	Project/Activity Overview	1
	1.1 Description	No requirement
	1.2 Rationale	
	1.3 Target	
4	Indicators for Evaluating TOP TENs BPs	
4-(1)	Overall Impact Indicators	
	1.Impact on Environment,Health,and Safety	
	2.Overall Impact of originality and innovativeness on the successful EE/C activities	
4-(2)	Quantitative and Qualitative Indicators	
	1.Energy Saving and Cost	
	1.1 Energy Saving Value (kWh/year,kL/year,ktoe)	
	1.1.1 Energy Saving amount	
	1.1.2 Energy Saving ratio	
	1.1.3 Continuity of Energy Saving for 3 years	
	1.2 Cost Effectiveness	
	1.2.1 Investment	
	1.2.2 Payback Period	
	1.3 Prospect	
	1.3.1 Promotion Potential within the country	
	2.Sustainability	
	2.1 Management factor	
	2.1.1 Leadership and people	
	2.1.2 Capacity building	
	2.2 PDCA	
	2.2.1 Data analysis and Target setting(Plan)	
	2.2.2 Developing action Plan and Implementation(Do)	
	2.2.3 Monitoring Process(Check)	
	2.2.4 Feedback Process(Act)	
	3.Originality and Innovation	
	3.1 Originality of Practice	
	3.1.1 Originality of Practice	
	3.2 Innovative application of conventional Practice	
	3.2.1 Innovative application of conventional Practice	
	4. Transferability	
	4.1 Generality	
	4.1.1 General Applicability	
	4.2 Ease of Implementation	
	4.2.1 Ease of Implementation	
	4.3 Ability to integrate External resources	
	4.3.1 Ability to integrate External resources	
	5. Co-Benefits	
	5.1 Environmental Benefits	
	5.1.1 Reduction in CO <sub>2</sub>	
	5.1.2 Reduction in waste and/or pollution	
	5.2 Social Awareness Benefits	
	5.2.1 Awareness Improvement on Energy Saving,Environmental protection,Health and Safety.	



#### (iv) Guidelines for Quantitative and Qualitative Indicators

##### 1. Energy Saving and Cost (35%)

##### 1.1 Energy Saving Value (kWh/year, KL/year, ktce/year) (15%)

###### 1.1.1 Energy saving amount

###### 1.1.2 Energy saving ratio

1.1.3 Continuity of energy saving for these three years  
Evaluated from two sets of numbers i.e. energy intensity and energy reduction percentage versus subject process total energy consumption

(1) Energy Intensity (energy unit consumption, specific energy consumption)

On the premise that the data has a normal distribution, we divide all the entry data into 5 portions by every 20% from the top.

Evaluation system is as follows.

Mark	Criteria
100	top 20% group of total entry
80	top 20% -40% group of total entry
60	top 40%-60% group of total entry
40	top 60% -80% group of total entry
20	top 80%-100% group of total entry

(2) Energy reduction percentage versus total energy consumption of the entity

Evaluation system is as follows:

Mark	Criteria
100	≥ 30% of total energy consumption of the entity
80	≥20% of total energy consumption of the entity
60	≥10% of total energy consumption of the entity
40	≥5% of total energy consumption of the entity
20	<5% of total energy consumption of the entity

(3) If the energy saving activity is continuously done

for more than 3 years, then the mark can be one grade higher.

In case of more than 1 year, the subject number (energy intensity) to be converted to the same production basis.

(4) Energy reduction percentage of the whole production process as well to be described for the reference.

(5) In case 'the base line' is too low, due consideration to be taken when deciding final mark.

(6) In regard to item 1.1 (Energy Saving Value), average mark of the each items to be calculated. (ex. ①=100 ②=80 average=90)

##### 1.2 Cost Effectiveness (10%)

###### 1.2.1 Investment

Evaluated from the percentage of the energy conservation investment out of total investment of the entity

Evaluation system is as follows:

Mark	Criteria
100	≥ 3% of annual total investment of the entity
80	≥ 2% of annual total investment of the entity
60	≥ 1% of annual total investment of the entity
40	≥ 0.5% of annual total investment of the entity
20	<0.5% of annual total investment of the entity

###### 1.2.2 Payback Period

Payback Period is calculated by the following formula however, applicant to clarify the actual calculation method in detail.

Payback period = Cost of Project / Annual Cash Inflows (energy saving merit - running cost of the

related facility-maintenance cost of the related facility).

<N.B.>

- Monetary unit to be the hard currencies such as USD.
- Basic data used in calculation to be clearly shown .

Evaluation system is as follows:

Mark	Criteria
100	~2 years
80	2~3 years
60	3~5 years
40	5~ 10 years
20	10~ years

If actual number of the investment and payback-period is not available,there is no need to evaluate cost effectiveness,then the comment to be made what is the cost-effectiveness in detail

\* In regard to item 1.2 (Cost Effectiveness),average mark of the each items to be calculated.(ex. ①=100,②=80 average=90)

### 1.3 Prospect

#### 1.3.1 Promotion Potential within the country

Future prospect of the subject practice to be proposed in terms of possible amount of energy reduced in the future.

Evaluation system is as follows:

Mark	Criteria	Judgment standard
100	Excellent	more than 30 cases can occur in the future
80	Good	more than 20 cases can occur in the future
60	Fair	more than 10 cases can occur in the future
40	Below Average	more than 5 cases can occur in the future
20	Poor	more than 3 cases can occur in the future

## 2. Sustainability (20%)

### 2.1 Management Factor (10%)

#### 2.1.1 Leadership and people

Whether or not clear commitment of the top management

to promote EC in the following area exists

permanent EC manager,specific EC organization,energy policy,energy target etc.

#### 2.1.2 Capacity Building

Whether or not necessary capacity building is being carried out to level up the capacity of the people involved and ,awareness-raising and motivation are being given during the course of capacity building?

Evaluation system is as follows:

Mark	Criteria (yes/no answer to the questions regarding existence of permanent EC manager,specific EC organization,and the capacity building program )
100	three yes's plus two other aspects of the management factor
80	three yes's plus one other aspects of the management factor
60	three yes's
40	two yes's
20	one yes

### 2.2 PDCA (10%)

#### 2.2.1 Data analysis and Target setting (Plan)

#### 2.2.2 Developing Action Plan and

#### Implementation (Do)

} 5%

•Along "The baseline",the energy consumption data to be collected.

•Historical data as well,preferably a few years at least are needed.

•Action Plant to be compiled after the prioritization of possible EC projects.

•Such plan,often multi-year basis to be consistent with the entity's mid- or long-term management plan.

•The plan to be put into implementation after the approval within the entity.

Evaluation system is as follows:

Yes/no answer to the questions regarding existence of  
①the data along with the baseline ②historical data of these a few years ③action plan after the prioritization of possible EC project ④multi-year plan consistent with the entity's mid or long term management plan ⑤implementation after the approval within the entity.

Mark	Criteria
100	5 yes's
80	4 yes's
60	3 yes's
40	2 yes's
20	1 yes's

#### 2.2.3. Monitoring Process (Check)

#### 2.2.4. Feedback Process (Act)

} 5%

- Progress to be continuously monitored in comparison with the plan.
- Proper remedial actions to be made if something wrong is found.
- After the completion of the plan,results to be assessed from various viewpoints,and feedback to be made for the future stages.

Evaluation system is as follows:

Yes/no answer to the questions regarding ① progress to be continuously monitored in comparison with the plan ②proper remedial actions to be made if something wrong is found ③ results to be assessed from various viewpoints ④feedback to be made for the future stages.

Mark	Criteria
100	4yes's plus any other aspects of the PDCA related action
80	4 yes's
60	3 yes's
40	2 yes's
20	1 yes's

### 3. Originality and Innovation

#### 3.1. Originality of Practice

##### 3.1.1 Originality of Practice

- Introduction of advanced technologies
- Excellency in issue-finding and problem-solving procedure.

Evaluation system is as follows:

Mark	Criteria
100	introduction of such a very advanced technology
80	(not apply)
60	introduction of ordinary but new technology
40	(not apply)
20	no introduction of such a new technology

#### 3.2 Innovative application of conventional Practice.

##### 3.2.1 Innovative application of conventional Practice.

- Measures based upon innovative application of the conventional technology.

Evaluation system is as follows:

Mark	Criteria
100	a very innovative application compared with the conventional practices
80	(not apply)
60	some improvements to the conventional practice
40	(not apply)
20	no improvement to the conventional practice

### 4. Transferability (Replicability)(15%)

#### 4.1 Generality

##### 4.1.1 General Applicability

- Because of general versatility,replicable in other areas of the same factory/other factories.
- Because of general versatility,replicable in other sectors/areas.

Evaluation system is as follows:

Mark	Criteria
100	prevalent without any limit in terms of the area
80	(not apply)
60	prevalent in all over the entity
40	(not apply)
20	no prevalence except for the subject project area



## 4.2 Ease of Implementation

### 4.2.1 Ease of Implementation

- Ease of equipment procurement.
- Ease of maintenance including parts procurement.
- Introduction of the technology and equipment eligible for government subsidy.

Evaluation system is as follows:

Yes/no answer to the questions regarding existence of

①ease of equipment procurement ②ease of maintenance including parts procurement ③introduction of the technology and equipment eligible for government subsidy.

Mark	Criteria
100	three yes's of all but not limited to the above items plus something else
80	three yes's from within the above three items
60	two yes's from within the above three items
40	one yes's from within the above three items
20	no yes

## 4.3 Ability to integrate External resources

### 4.3.1 Ability to integrate External resources

- The ability to obtain political support other than subsidy
- The ability of commercialization
- The ability to leverage private sector expertise to facilitate execution and promotion of the practice(e.g. Build on ESCO and other financing program options,consider outsourcing the practice to NGO that specialize in program design and implementation,leverage PDCA activities).

Evaluation system is as follows:

②Yes/no answer to the questions regarding existence of  
①the ability to obtain political support ②the ability of commercialization ③the ability to leverage private sector

expertise to facilitate execution and promotion of the practices.

Mark	Criteria
100	three yes's of all but not limited to the above items plus something else
80	three yes's
60	two yes's from within the above three items
40	one yes's ditto
20	no yes

## 5. Co-benefits (10%)

### 5.1 Environmental Benefit (5%)

#### 5.1.1 Reduction in CO<sub>2</sub>

#### 5.1.2 Reduction in waste and/or pollution (air/water/noise/odor etc)

- Amount and percentage of CO<sub>2</sub> reduction to be described.

<N.B.>

- Conversion factors (nationally defined coefficients or an international norms such as IEA's to be clarified.
- If any type of reductions in waste and or pollution occurs,specify the items and changes.

Evaluation system is as follows:

Refer to the table on the next page.

### 5.2 Social Awareness Benefits (5%)

- Improve energy-saving awareness of the staff and /or general public,effect on sectors media attention to the practice.
- Influences on health condition and safety of the staff and /or general public.

Evaluation system is as follows:

Mark	Criteria
100	active in inside and outside of the entity
80	(not apply)
60	active in inside or outside of the entity
40	(not apply)
20	not active

Mark	Criteria (ranking in the total entry)	Mark	Criteria (CO <sub>2</sub> reduction %)
100	top 20% group of total entry	100	≥ 30%
80	top 20-40% group of total entry	80	≥ 20%
60	top 40-60% group of total entry	60	≥ 10%
40	top 60-80% group of total entry	40	≥ 5%
20	top 80-100% group of total entry	20	< 5%

\* If there are reductions in any other items than CO<sub>2</sub> i.e. air,water,noise,odor etc. to a certain degree,then the mark can be one grade higher.

\* In regard to item 5.1 (Environmental Benefits),average mark of the each items to be calculated.(ex. ①=100,②=80 average=90) ■

## TOP TENs Indicators for Evaluating Best Available Technologies

### <Decisive Threshold Indicators>

Indicator	Description	Evaluation Criteria ①,②→proceed to Quantitative & Qualitative Indicators
Environment, Health, and Safety (EHS)	The energy-saving technology shall have little or no impact on the environment, health, safety, and other areas of public concern, e.g. pollution to air, water, or soil, occupational injury rate and accident rate, toxicity, teratogenicity due to long-term exposure.	① Excellent ② Fairly Excellent ③ Unaccepted
Maturity	The energy-saving technology should meet at least one of the following requirements: • Mass production/ large-scale production; • Commercialization; • Promoted at national level.	① Excellent ② Fairly Excellent ③ Unaccepted

### <Qualitative and quantitative Indicators>

Indicators			Evaluation Criteria		
1 <sup>st</sup> Level Indicator	Indicators for Evaluation	A. max marks	B. weight	C= A×B	
Energy Saving Potentials	1.1 Level of Energy Efficiency	100	15%	15	
					1.1.1 Energy Saving Rate
	1.2 Market Prospect	1.2.1 Application Proportion in 2014	100	10%	10
		1.2.2 Increases in Application Proportion from 2014 to 2020	100	10%	10
Increases in Energy Intensity(Energy consumption ratio)					
mark criteria (%) 100 > 50% 80 ≤ 40% 60 ≤ 30% 40 ≤ 20% 20 ≤ 10% It is calculated by the following formula: -(Eb-Ea)/Eb*100% Ea: energy consumption ratio after applying the energy saving technology Eb: energy consumption ratio before applying the energy saving technology(ie conventional technology)					
① Application Proportion in 2014 within member country (actual number) mark criteria (%) 100 > 80% 80 ≤ 80% 60 ≤ 50% 40 ≤ 20% 20 ≤ 10% Increases in Application Proportion to 2020 within member country Bothway is available. Selection to be subject to each country's preference. -quantitative way-> mark criteria (%) 100 > 50% 80 ≤ 40% 60 ≤ 30% 40 ≤ 20% 20 ≤ 10% *For those widely applied technologies( application proportion >90% in the country) should use estimated proportion in the world-wide.					



2	Technical Characteristics and Practicality	2.1 Advanced nature and innovative nature	2.1.1 Advanced nature	100	5%	5	1. Judge whether the technology is advanced at the international level or not by Judge's expertise	① Advanced nature mark 100 advanced at the international level (not apply) 80 average at the international level (not apply) 40 below average at the international level but advanced at the country level 20
			2.1.2 Innovative nature	100	5%	5	2. Judge whether the technology is innovative or not, in another words the case is based upon innovative application of the conventional technology or not.	② Existence of Innovative application of conventional Technologies mark 100 a very innovative application of the conventional technology (not apply) 80 ordinary application of the conventional technology (not apply) 40 no introduction of such a conventional technology 20
		2.2 Reliability	2.2.1 Reliability of technology	100	10%	10	The reliability of the technology should be scored according to easiness of the operation, easiness of maintenance, etc.	Reliability mark 100 better than average (not apply) 80 average (not apply) 40 not better than average 20
3	Economic Characteristics				20%	20		
		3.1 Investment Per Unit Saved energy	3.1.1 Investment Per Unit Saved energy	100	25%	25	Investment includes the infrastructure investment, equipment investment, and maintenance & operation costs. The investment shall be specified in heat or power units.	① Investment Per Unit Saved energy mark 100 more than 30% lower than the conventional technology 80 30% lower than the conventional technology 60 10% lower than the conventional technology 40 almost the same as the conventional technology 20 more than the conventional technology
		3.2 Payback Period	3.2.1 Payback Period	100	10%	10	The payback period is the time needed to recover all investment cost or reach the break-even point. Investment refers to the expense of new technology and its operation & maintenance.	① Payback Period mark 100 ~2 years 80 2~3 years 60 3~5 years 40 5~10 years 20 10~ years
4	Social Characteristics (co-benefits)				35%	35		
		4.1 Social Impact	4.1.1 sustainable development 4.1.2 climate change 4.1.3 energy security 4.1.4 employment 4.1.5 Pollution Reduction	100	10%	10	Judge by comprehensive impacts to sustainable development, climate change, energy supply and employment, etc.	① in accordance with the general evaluation criteria(see below) mark 100 Excellent (4 and more yes) 80 Good (3 yes) 60 Fair (2 yes) 40 Below Average (1 yes) 20 Poor (0 yes)
					100%	100		*If the technology has positive impact on one aspect of social impact, it counts for 1 yes.

## TOP TENS Indicators for Evaluating Best Practices of EE/C

### < Overall Impact Indicator >

Description		①,②⇒proceed to Quantitative & Qualitative Indicators	Actual Marks	Remarks
The energy-saving technology shall have little or no impact on the environment, health, safety, and other areas of public concern		①Excellent ②Fairly Excellent ③Unaccepted	①or②or③	
overall impact of originality and innovativeness on the successful EE/C activities		①Excellent ②Fairly Excellent ③Unaccepted	①or②or③	

### < Quantitative and Qualitative Indicators >

Indicators					Description	Evaluation Criteria	Rating Criteria for Qualitative indicators
1st Level Indicator	2nd Level Indicator	Indicators for Judgment	A. max mark	B. weight			
Energy Saving and cost (Achievement)	1.1 Energy Saving Value	1.1.1 Energy saving amount	100	15%	15	•energy saving in terms of energy intensity (energy unit consumption) by implementation of the subject BP •percentage of energy reduction from “the baseline” (as described in 2.2) <N.B> •units to be Wh/year, kJ/y, kcal/y, etc. •energy conversion factors to be specified (probably the one used in the country or IEA method) <div><input type="checkbox"/></div>	①energy intensity(energy unit consumption) mark criteria (ranking in the total entry) top 20% group of total entry $\geq 30\%$ top 20-40% group of total entry $\geq 20\%$ top 40-60% group of total entry $\geq 10\%$ top 60-80% group of total entry $\geq 5\%$ top 80-100% group of total entry $< 5\%$  ②energy reduction % of the process total consumption criteria (%) 100 $\geq 30\%$ 80 $\geq 20\%$ 60 $\geq 10\%$ 40 $\geq 5\%$ 20 $< 5\%$  *1.If the energy saving activity is continuously done for more than 3years, then the mark can be one grade higher. However, in case of more than 1 year, the subject number(energy intensity) to be converted to the same production basis. *2.Energy reduction % of the whole production process as well to be described for the reference. *3.In case “the base line” is too high, due consideration to be taken when deciding final mark.
		1.1.2 Energy saving ratio (%)	100	15%	15		
		1.1.3 Continuity of energy saving for these 3 years					
	1.2 Cost Effectiveness	1.2.1 Investment	100	10%	10	• investment cost which realized the subject BP. • payback period <N.B> •monetary unit to be the hard currencies such as USD. • basic data used in calculation to be clearly shown .	①investment amount mark criteria(percentage in the total investment) mark criteria(years) 100 $\geq 3\%$ of annual total investment 80 $\geq 2\%$ of annual total investment 60 $\geq 1\%$ of annual total investment 40 $\geq 0.5\%$ of annual total investment 20 $< 0.5\%$ of annual total investment ②payback period mark 100 $\sim 2$ years 80 2-3 years 60 3-5 years 40 5-10 years 20 10- years 1. Payback period=investment cost/annual energy saving merit 2. If actual number of the investment and payback-period is not available, there is no need to evaluate cost effectiveness, then the comment to be made what is the cost-effectiveness in detail.
		1.2.2 Payback Period					
1.3 Prospect	1.3.1 Promotion Potential within the country	100	10%	10	• future prospect of the subject practice to be proposed in terms of future possible amount of energy reduced • the scope of the energy-saving policy should be considered	in accordance with the general evaluation criteria(see below) 100 Excellent 80 Good 60 Fair 40 Below Average 20 Poor	future prospect of the practice criteria mark 100 more than 30 cases can occur 80 more than 20 cases can occur 60 more than 10 cases can occur 40 more than 5 cases can occur 20 more than 3 cases can occur
			35%	35			

Sustainability (How achieved)	2.1 Management Factor	2.1.1 Leadership and people				<ul style="list-style-type: none"> <li>• Clear commitment of the top management to promote EC in the following areas: permanent EC manager, specific EC organization, energy efficiency, energy management building to be carried out level up the capacity of the people involved</li> <li>• Awareness-raising and motivation to be given during the course of capacity building.</li> </ul>	In accordance with the general evaluation criteria (see below) 100 Excellent 80 Good 60 Fair 40 Below Average 20 Poor	mark 100 80 60 40 20	criteria (yes/no answer to the questions regarding existence of permanent EC manager, specific EC organization, and the capacity building program) three yes's plus two other aspects of the management factor three yes's two yes's one yes
		2.1.2 Capacity Building	100	10%	10				
	2.2 PDCA	2.2.1 Data analysis and Target setting (Plan)				<ul style="list-style-type: none"> <li>• Along "The baseline", the energy consumption data to be collected</li> <li>• Historical data as well, preferably a few years at least are needed.</li> <li>• Action Plan be compiled after the prioritization of possible EC projects</li> </ul>	In accordance with the general evaluation criteria (see below) 100 Excellent 80 Good 60 Fair 40 Below Average 20 Poor	yes/no answer to the questions regarding existence of ① the data along with the baseline ② historical data of these a few years ③ action plan after the prioritization of possible EC project ④ multi-year plan consistent with the entity's mid or long term management plan ⑤ implementation after the approval within the entity mark 100 80 60 40 20	② historical data of these a few years ③ action plan after the prioritization of possible EC project ④ multi-year plan consistent with the entity's mid or long term management plan ⑤ implementation after the approval within the entity mark 100 80 60 40 20
		2.2.2 Developing Action Plan and Implementation (Do)	100	5%	5	<ul style="list-style-type: none"> <li>• Such plan and multi-year plans to be consistent with the entity's mid or long-term management plan.</li> <li>• The plan to be put into implementation after the approval within the entity</li> </ul>			
Originality and Innovation (How achieved)	3.1 Originality of Practice	2.2.3 Monitoring Process (Check)				<ul style="list-style-type: none"> <li>• Progress to be continuously monitored in comparison with the plan</li> <li>• Proper remedial actions to be made if something wrong is found.</li> <li>• After the completion of the plan, results to be assessed from various viewpoints, and feedback to be made for the future stages.</li> </ul>	In accordance with the general evaluation criteria (see below) 100 Excellent 80 Good 60 Fair 40 Below Average 20 Poor	yes/no answer to the questions regarding ① progress to be continuously monitored in comparison with the plan ② proper remedial actions to be made if something wrong is found ③ results to be assessed from various viewpoints ④ feedback to be made for the future stages. mark 100 80 60 40 20	criteria 4 yes's plus any other aspects of the PDCA related action 4 yes's 3 yes's 2 yes's 1 yes's
		2.2.3 Feedback Process (Act)	100	5%	5				
	3.2 Innovative application of conventional Practice	3.1.1 Originality of Practice		20%	20	<ul style="list-style-type: none"> <li>• Introduction of advanced technologies</li> <li>• Excellence in issue-finding and problem-solving procedure</li> </ul>	In accordance with the general evaluation criteria (see below) 100 Excellent 80 Good 60 Fair 40 Below Average 20 Poor	introduction of advanced technology mark 100 80 60 40 20	criteria introduction of such a very advanced technology (not apply) introduction of ordinary but new technology (not apply) no introduction of such a new nor advanced technology
		3.2.1 Innovative application of conventional Practice	100	10%	10	<ul style="list-style-type: none"> <li>• Measures based upon innovative application of the conventional technology</li> </ul>	In accordance with the general evaluation criteria (see below) 100 Excellent 80 Good 60 Fair 40 Below Average 20 Poor	introduction of Innovative application of conventional Practice mark 100 80 60 40 20	criteria introduction of such a very innovative application of the conventional practice (not apply) introduction of ordinary application of the conventional practice (not apply) no introduction of such a conventional practice
Transferability (Replicability)	4.1 Generality	4.1.1 General Applicability		20%	20	<ul style="list-style-type: none"> <li>• Because of general versatility, replicable in other areas of the same factory/other factories</li> <li>• Because of general versatility, replicable in other sectors/areas</li> </ul>	In accordance with the general evaluation criteria (see below) 100 Excellent 80 Good 60 Fair 40 Below Average 20 Poor	To be prevalent in various areas mark 100 80 60 40 20	criteria prevalent without any limit in terms of the area (not apply) prevalent in all over the entity (not apply) no prevalence except for the subject project area
		4.2.1 Ease of Implementation	100	5%	5	<ul style="list-style-type: none"> <li>• Ease of equipment procurement</li> <li>• Ease of maintenance including parts procurement</li> <li>• Introduction of the technology and equipment eligible for government subsidy</li> </ul>	In accordance with the general evaluation criteria (see below) 100 Excellent 80 Good 60 Fair 40 Below Average 20 Poor	yes/no answer to the questions regarding existence of ① ease of equipment procurement ② ease of maintenance including parts procurement ③ introduction of the technology and equipment eligible for government subsidy mark 100 80 60 40 20	criteria three yes's of all but not limited to the above items plus something else three yes's two yes's from within the above three items one yes's ditto no yes



4.3 Ability to integrate External resources		4.3.1 Ability to integrate External resources	100	5%	5	<ul style="list-style-type: none"> <li>the ability to obtain political support</li> <li>the ability of commercialization</li> <li>the ability to leverage private sector expertise to facilitate execution and promotion of the practices (e.g. build on ISO and other financing and management standards, the design and implementation, leverage PDCA activities)</li> </ul>	100 80 60 40 20	Excellent Good Fair Below Average Poor	In accordance with the general evaluation criteria (see below)	100 80 60 40 20	①reduction amount mark reduction % criteria (ranking in the total entry) top 20% group of total entry top 40-60% group of total entry top 60-80% group of total entry top 80-100% group of total entry * If there are reductions in any other items than CO <sub>2</sub> i.e. air, water, noise, odor etc. to a certain degree, then the mark can be one grade higher.	②reduction % mark criteria(CO <sub>2</sub> ) ≥ 30% ≥ 20% ≥ 10% ≥ 5% ≤ 5%	yes/no answer to the questions regarding existence of support②the ability of commercialization③the ability to leverage private sector expertise to facilitate execution and promotion of the practices mark criteria three yes's, of all but not limited to the above items plus something else three yes's, from within the above three items two yes's, ditto one yes's, ditto no yes
Co-benefits (Side-effect of the Achievement)	5.1 Environmental Benefits	5.1.1 Reduction in CO <sub>2</sub>	100	7%	7	<ul style="list-style-type: none"> <li>amount and percentage of CO<sub>2</sub> reduction to be described.</li> <li>&lt;N.I&gt;</li> <li>conversion factors (nationally defined)</li> <li>efficiency or international norms such as IEA's</li> <li>If any type of reductions in waste and/or pollution occurs, specify the items and changes.</li> </ul>	15%						
		5.1.2 Reduction in waste and/or pollution (air/water/noise/odor etc)											
	5.2 Social Awareness Benefits	5.2.1 Awareness Improvement on Energy Saving, Environmental Protection, Health and Safety	100	3%	3	<ul style="list-style-type: none"> <li>Improve energy-saving awareness of the staff and/or general public, effect on sectors media attention to the practice</li> <li>Influences on health condition and safety of the staff and/or general public</li> </ul>							public relationship mark criteria active in inside and outside of the entity (not apply) active in inside or outside of the entity (not apply) not active
	Total		100%	10%	10								

# First Batch of Domestic TOP TENS List

## China BAT List

Edited by Nan Hu

### BAT1: Foundry metal stress relief technology

#### 1. Technical principle

Spectrum harmonic based stress processing technique is to perform Fourier analysis on metal workpieces, to detect harmonic frequencies within 100Hz, applies adequate energy at multiple detected harmonic frequencies to vibrate, generates multi-directional dynamic stress, superimposed with multi-dimensional distributed residual stress. It creates a plastic yielding effect, thereby reducing the peak residual stress and homogenizing the residual stress distribution as well. By applying this technology, it no longer needs heat treatment of the metal workpiece, and the residual stress

can be eliminated, thereby saving energy.

#### 2. Main technical specifications

The Fourier spectrum analysis of the metal workpiece can detect 5 resonant frequencies and 2 spare resonant frequencies. The other vibration parameters are adjusted automatically by the vibration equipment except that the excitation force is adjusted to ensure two maximum vibration acceleration values of  $30\sim70\text{m/s}^2$ . The vibration frequency is below 6000rpm, with low noise. The maximum exciting force can reach 80kN.

#### 3. Energy saving effects

Compared with traditional TSR (Thermal Stress Relief), this technology has energy saving more than 95% on average. Compared with sub-resonant VSR (Vibration

Stress Relief) technology, the application area of spectrum harmonics-based stress relief technology reaches more than 90%, while the application area of the former is only 23%.

#### 4. Application areas

This technology can be widely used to eliminate the residual stress of metal workpieces after casting, forging, welding, cutting, etc.. It is mainly used for stress relief of small, light and thin-walled metal workpieces, and can also be used for stress relief of some large structural parts.

### BAT2: Waste energy recovery technology in the metallurgical industry using a coaxial drive turbine unit

#### 1. Technical principle

Blast furnace Power Recovery Turbine unit (BPRT) and Sintering blower residual Heat Recovery Turbine (SHRT) refers to the combination of blast furnace blower and gas turbine into one unit, and the energy recovered by the gas turbine directly drive the blast furnace blower. At the same time, the original motor-driven sintering blower and sintering residual heat power generation system are modified, and the main blower is jointly driven by the steam turbine and the electric motor. Both BPRT and SHRT eliminate power generators, power generation and distribution systems, and merge auto control, lubricating oil, and power oil systems, avoids energy losses caused by energy conversion, improves energy efficiency, reduces environmental pollution, and reduces product costs.

#### 2. Main technical specifications

BPRT main Specifications: Blast furnace gas flow:

500,000 Nm<sup>3</sup>/h. Inlet pressure: 150kPa. Gas turbine speed: 3000rpm ~ 3600rpm. Output power: 100MW. SHRT main Specifications: sintering circular cooling system: 220m<sup>2</sup>. Configures 5000kW residual heat recovery steam turbine. sintering main blower flow rate 22000m<sup>3</sup>/min. motor: 8000kW, residual energy utilization efficiency increased by 5%.

#### 3. Energy saving effects

Compared with blower unit, the average energy saving efficiency of BPRT technique is more than 50%. compared with the original sintering main blower, the average energy saving efficiency of SHRT unit is more than 60%.

#### 4. Application areas

This technology can be widely used in the field of joint applications of waste heat & waste pressure power recovery and mechanical driving system, which is applicable for metallurgy, coal chemical industry and other industries.

### BAT3-1: Industrial Low Grade Waste Heat Recovery: Slag water waste heat recovery blast furnace

#### 1. Technical principle

The direct heat exchange waste heat recovery technology of blast furnace slag water adopts a special slag water heat exchanger to realize the 60°C~90°C blast furnace slag water directly enters the heat exchanger, heats the heating water without filtering, which is used for heat supply, thereby reducing coal consumption and pollutant



emissions, to achieve the purpose of energy conservation and emission reduction. After cooling, the slag water continues to circulate slag flushing. For the slag flushing processes such as INBA, Jiaheng, and Minte with cooling towers, the cooling tower can be closed to further save power and water consumption. and for the slag flushing processes without cooling towers, after the slag water being cooled, the evaporation of the slag water is reduced, which can reduce the water consumption.

## 2. Main technical specifications

Per ton of iron output, can be equipped with a heating area of 0.4~0.6m<sup>2</sup>, energy saving 5~7.5 kg of standard coal, water saving 40.0~57.6 kg, power saving 0.3~0.4 kWh. the slag water no need to be filtered.

## 3. Energy saving effects

At present, the iron output is about 710 million tons in China, the slag iron ratio is 350kg, and the waste heat resources from slag flushing are equivalent to about 15.3 million tons of standard coal. In which, iron output in the north accounts for 63.5% of the total output, and 36.5% in the south. With the increasing demand for central cooling and heating in China, there is a broad market prospect for the direct heat exchange waste heat recovery technology of blast furnace slag water. Estimated by the promotion of this technology in 50% of the applicable production capacity, it'll achieve an annual energy saving of 2.22 million tons of standard coal and 4.9 million tons of carbon dioxide emissions reduction.

## 4. Application areas

This technology is suitable for the recovery and utilization

of waste heat from blast furnace slag water during production processes such as ironmaking and copper smelting. it is more meaningful to be promoted especially in north China where has demands of central heating.

## BAT3-2: Industrial Low Grade Waste Heat Recovery: Thermoelectric coordinated central heating technology

### 1. Technical principle

The thermoelectric coordinated central heating technology is to improve heating capacity, reduce heating energy consumption, realize energy conservation by recovering waste heats, including specially developed absorption heat exchange units and waste heat recovery dedicated heat pump units. In the thermal station of the cogeneration central heating system, the heat pump heat exchange unit replaces the conventional water-to-water heat exchanger, which greatly reduces the return water temperature of the primary network to about 20°C. the heating water is heated to 130°C by waste heat recovery dedicated heat pump unit of the thermal power plant (recovering waste heat from steam turbine condenser exhaust steam in power plant) and peak heaters by cascade style, and then supplied. During the operation, a heat storage device is installed in thermal station, so that the heat pump can fully utilize the valley power to maintain the required return water temperature in primary network. a heat storage tank is installed in thermal power plant to maintain heating supply capacity and stable waste heat recovery, and the on-grid power of generator units can be adjusted within the range of 60%-100%

of the rated value,alleviating the problem of peak load regulation difficulties of the power grid in winter. The key technologies mainly include heat pump heat exchange units and heat pump waste heat recovery units of power plant as the core.

## 2.Main technical specifications

Compared with the conventional cogeneration system,the heating capacity is increased by 30%-50%,and the heating network transmission capacity is increased by 60%-80%,which can realize long-distance heating supply. For the new built large-scale heating network,the construction investment can be reduced by more than 30%.

## 3.Energy saving effects

Compared with conventional thermal power plants,the energy consumption of heating supply is greatly reduced,the energy-saving effect is nearly 50%. If this technology is promoted in central heating area of 300 million m<sup>2</sup>,it will have energy saving 1.2 million tons of standard coal annually.

## 4.Application areas

This technology is applicable for central heating area,to replace small and medium-sized coal boilers,is an effective way to solve the shortage of heating sources in northern cities in winter.

## BAT4: Cement suspension preheating and calcining technology with high solid-gas ratio

### 1.Technical principle

The cement suspension preheating and calcining technology with high solid-gas ratio is to improve the internal solid material and airflow mass ratio of the system to achieve the effects of improving the thermal efficiency of the system and enhancing the thermal stability of the system,which is an original processing technique,has comprehensive benefits of energy conservation,production increasing,quality improvement,and emissions reduction,consists of suspension preheaters with high solid-gas ratio and external circulation reactor with high solid-gas ratio. The high solid-gas ratio suspension preheater adopts parallel double series airflow and cross one-way material flow to complete gas-solid heat exchange,improves the contact area between solid material and hot gas and the times of gas-solid heat exchange,which greatly improves the heat transfer efficiency and significantly reduces the gas temperature of preheater exit. The external circulation reactor with high solid-gas ratio makes unburnt or incompletely reacted coarse particulate return to the reactor many times,which greatly improves solid-gas ratio and the residence time of the material in calciner,makes the raw material reaction rate close to 100 %. This technology is jointly configured with grate coolers and process control technology,achieves a better integration effect.

### 2.Main technical specifications

Compared with the ordinary five-stage preheating and pre-calcining technology,the exhaust gas temperature is reduced by 20%,the exhaust gas volume is reduced by 20%,and the emissions of SO<sub>2</sub> and NO<sub>x</sub> are reduced by more than 50%.

### 3.Energy saving effects

Compared with the ordinary five-stage heat exchange technology, the production capacity is increased by 40%, the coal consumption per ton of cement clinker is reduced by 16kg, the power consumption is reduced by 13%, and the energy saving rate is above 10%.

#### 4. Application areas

This technology is applicable for the calcination of cement clinker and applied to heat exchange and reaction engineering of powder.

### BAT5-1: Data Center Energy conservation: Data Room Smart Direct-Cooling Technology

#### 1. Technical principle

The Data Room Smart Direct-Cooling Technology innovated applies the natural phase change circulating technology of the refrigerant to the cabinet-level cooling of the data center, which generates a pressure difference in the form of temperature difference, drives the natural phase change circulate flow of the refrigerant, realizes no power heat exchange between indoor and outdoor of data room. At the same time, according to variances of refrigerant evaporation capacity, carries out real-time monitoring through self-developed energy efficiency management software and environmental maintenance system monitoring software to control the cooling capacity of the circulated refrigerant, realizes adaptive cooling capacity adjustment and cabinet-level temperature distribution control, significantly reduces power consumption of the air-conditioning in data room.

The technology also switches between air-cooling chiller units (mechanical refrigeration) and closed cooling towers (natural cooling sources) according to the outdoor temperature, to improve the utilization efficiency of natural cooling sources and reduce the mechanical power consumption of the air-cooling system, thereby greatly reduces data center's PUE value.

#### 2. Main technical specifications

This technology can achieve a single cabinet cooling capacity of 20 kilowatts. The power saving rate of air conditioning of data centers using this technology reaches 50%-80%, can reduce the PUE value of data centers to 1.2-1.4.

#### 3. Energy saving effects

Use a data center as an example, with an installed capacity of 1,000 kilowatts, annual operating time of 8,760 hours, compared with conventional precision air conditioners, this technology saves power of 3.504 million kWh each year, the power saving rate is 64.5%, which is equivalent to 2,628 tons of CO<sub>2</sub> emissions reduction.

#### 4. Application areas

The technology is not limited by conditions such as climate, atmospheric environment, water resources, etc., and can replace the existing traditional cooling methods of data centers. It is applicable for the energy-saving transformation of the data room that is using traditional air conditioning in data centers.

### BAT5-2: Data Center Energy Conservation: high temperature resistant valve-regulated sealed battery



technology for communication

### 1. Technical principle

High temperature resistant valve-regulated sealed battery for communication adopts lead-tin-based multiple alloy technology with independent intellectual property rights, positive 4BS seeding technology, unique carbon material additives and other technologies, achieves a breakthrough in the applicable temperature of battery products, which makes the battery normal use temperature increased to 35°C, and can be used at the extreme temperature of 75°C. Thereby, the air conditioning temperature setting of the base station for communication is increased by 10°C compared with that of the conventional base station, and the air conditioner operating time is reduced, the power consumption and investment cost of air conditioning can be reduced.

### 2. Main technical specifications

The product meets the technical requirements of IEC60896-2004 and YD/T799-2010 "Valve-regulated sealed lead-acid battery for communication" and YD/T 2657-2013 "High-temperature valve-regulated sealed lead-acid battery for communication". Under the working condition of environment temperature of 35°C, the designed floating charge life is  $\geq 10$  years, the battery can withstand the maximum working condition of environment temperature of 75°C. Under the working condition of environment temperature of 55°C, the life cycle of 80% DOD is greater than 12 big cycles, and each big cycle contains eleven 80% DOD

discharge cycles.

### 3. Energy saving effects

Compared with conventional base stations, for the base stations equipped with high-temperature resistant valve-regulated sealed lead-acid batteries, the annual comprehensive energy saving rate is above 26%.

### 4. Application areas

This technology can be widely applied in the transformation of base station batteries for communications, and also can be used in fields such as solar energy storage and wind energy storage.

## BAT6: Infrared Radiant Porous Ceramics Energy Saving Combustion Technology

### 1. Technical principle

Infrared Radiant Porous Ceramics Energy Saving Combustion Technology adopts full pre-mixed no-flame catalytic combustion technology, precisely controls the air-fuel ratio, achieves complete combustion and improves combustion efficiency. Heat is transferred by infrared radiation, it has a high temperature of the combustion front, and short transfer distance, greatly reduces the physical heat loss during the heat transfer process. The surface of the cooker adopts a high emissivity infrared coating, so that the infrared emission wavelength band of the coating and the infrared absorption wavelength band of the heated materials are matched as much as possible, which heat absorption efficiency is further improved. This technology uses ceramics to replace traditional high-energy-consuming

metal materials such as copper, Fe-Cr-Al alloy and nickel-chromium alloy to produce cookers, which can reduce manufacturing energy consumption and save a lot of metal materials.

## 2. Main technical specifications

The thermal efficiency is above 70%, the average emissivity of the infrared coating reaches 0.9, and the emission level of CO and NO<sub>x</sub> is reduced by more than 30%.

## 3. Energy saving effects

Compared with the atmospheric type cooker, the average energy saving is more than 20%, each household can save 48 m<sup>3</sup> of natural gas (equivalent to 64 kg of standard coal) per year. Due to infrared energy-saving cookers replacing traditional metal materials with high infrared emissivity porous ceramics, the manufacturing energy consumption of each cooker is reduced by 0.8 kg of standard coal.

## 4. Application areas

This technology can be fully promoted in the field of gas cooker production, which not only helps to reduce the energy consumption in the manufacturing process of cookers, but also greatly improves the energy utilization efficiency of gas cookers.

## BAT7: Efficient New-type Membrane gap Ion Membrane Electrolysis Technology

### 1. Technical principle

Efficient New-type Membrane gap Ion Membrane

Electrolysis Technology designs the cathode assembly of the ion membrane electrolyzer as a flexible structure, so that the ion membrane is stably attached to the anode during the operation of the electrolyzer to form a membrane gap distance, reduces the ohmic drop of the solution (IR solution), realizes energy saving and consumption reduction. In the ion-exchange membrane electrolysis process, the cell voltage is an important technical indicator that affects the power consumption of electrolyzer, includes six parts:  $V_{\text{cell}} = V_0 + V_M + V_{\text{Anode}} + V_{\text{Cathode}} + IR_{\text{solution}} + IR_{\text{Metal}}$  (IR solution is ohmic drop in the solution). Among them,  $V_{\text{Anode}}$ ,  $V_{\text{Cathode}}$  and  $IR_{\text{solution}}$  have greater influences on the  $V_{\text{cell}}$  voltage.

### 2. Main technical specifications

Take NBZ-2.7 cell type of China national Bluestar (Group) Co., Ltd. as an example. The design current density is 6.0 kA/m<sup>2</sup>, operating current density is 5.5 kA/m<sup>2</sup>, unit cell voltage is 2.98 V, and DC power consumption is 2035 kWh per ton of caustic soda, concentration of caustic soda is 32% (mass fraction).

### 3. Energy saving effects

The cell voltage decreases by about 100 mV, the power consumption per ton of caustic soda decreases by about 70 kWh, for every 1 mm reduction of electrode gap. Compared with the traditional ion-exchange membrane electrolyzers, the distance between the anode and cathode of each pair of unit cells is 2 to 3 mm, adopts the membrane gap technology can reduce the DC power consumption per ton of caustic soda by 100-170



kWh. At present, the total production capacity of this technology is 12.15 million tons per year, which saves power by 1.58 billion kWh, reduces CO<sub>2</sub> emissions by 1.188 million tons per year.

#### 4. Application areas

This technology can be used to renovate existing equipment, or increase new production capacity as well.

### BAT8: Energy-saving technology of two stage screw air compressor

#### 1. Technical principle

The two-stage ultra-high-efficiency screw air compressor is an integrated technical system that has a main engine of two-stage high-efficiency compression screw as the core, consisting of the air end, driving motor, driving system, air intake system, cooling system, oil filtering system, oil and gas separation system, and auto-control system, etc. components. The two-stage compression high-efficiency screw air end adopts the Y-type screw rotor profile technology and uses the two-stage compression principle, reduces the compression ratio of each stage. Through the unique inter-stage cooling design, makes the compression process approaching to the isothermal compression process with the most energy-saving level. It carries out comprehensive innovations to the spray cooling method, the compression ratio distribution at all levels, and the oil - gas separation technology, combined with the integrated structure design of the upper and

lower parts' overlap, cooperated with the whole process auto-control technology, to achieve the ultra-high-efficiency of air compressor.

#### 2. Main technical specifications

The product reaches the level I energy efficiency of GB19153-2009 standard. has 15% of power saving than level II energy efficiency air compressor. 30% of power saving than level III energy efficiency air compressor.

#### 3. Energy saving effects

Compared with conventional air screw compressors, the average energy saving is more than 20%.

#### 4. Application areas

This technology can be widely applied in industries that use compressed air, such as machinery, steel, metallurgy, mining, electronics & electricity, and chemical etc., also can be used in pneumatic conveying fields in cement and textiles etc. industries.

### BAT9: High-efficiency industrial pulverized coal Boiler

#### 1. Technical principle

High-efficiency industrial pulverized coal Boiler system technology adopts multiple techniques such as precision pulverized powder supply, air staged combustion, and full-process auto-control etc., realizes efficient operation and clean emissions of coal boilers. Through the precision powder supply system, real-time adjustment of powder feeding, to ensure that



the pulverized coal fed into the furnace is stable and matches the oxygen supplying volume. adopts low-nitrogen combustion technologies such as air stages combustion, reduces the amount of nitrogen oxides in the furnace while ensuring pulverized coal burn-out rate. through the combustion control system, realizes automatic and stable load variation, optimizes excess air coefficient, improves combustion efficiency, saves energy. By using assistant methods such as instant power on or off and system frequency variable control to improve the overall energy efficiency of the system.

## 2. Main technical specifications

The combustion efficiency reaches more than 98%, boiler operating thermal efficiency reaches 88% - 92%. Comprehensive multi-stage combination of pollution removal technology, achieves exhaust smoke consists of dust  $\leq 30\text{mg/Nm}^3$ ,  $\text{SO}_2 \leq 100\text{mg/Nm}^3$ , and  $\text{NOX} \leq 200\text{mg/Nm}^3$ .

## 3. Energy saving effects

Compared with conventional chain boilers, the energy saving rates of 40t/h (steam boiler) and 58MW (hot water boiler) pulverized coal boilers are 18.7% and 19.8%, respectively.

## 4. Application areas

This technology has low requirements for coal types, can use class III bituminous coal with a particle size of 200 mesh or less ( $R_{75} \leq 15\%$ ). It is applicable for the replacement of traditional chain furnace, grate furnace and new buildings' heating supply, industrial heating and steam supply systems.

# BAT10: Heat Pump Energy conservation: Two-stage heat pump technology

## 1. Technical principle

The air source heat pump technology based on the two-stage Vapor Enhancement frequency variable compressor is a technology that greatly improves the heat pump capacity through the operation of a single-compressor two-stage compression with Enhanced Vapor Injection and variable displacement ratio. The basic principles are: (1) The compression process is changed from one-stage compression to two-stage compression, which reduces the pressure difference of each stage, reduces the internal leakage of the compression chamber, improves the volume efficiency. (2) The exhaust temperature is reduced by the intermediate flashing replenishes vapor, the isentropic efficiency is improved, and the flow rate of the high-pressure refrigerant is increased, both of the heating capacity in the low temperature environment and the cooling capacity in the high temperature environment are improved. (3) Adopts displacement variable technology, realizes Two two-stage compression operation modes with variable displacement and variable displacement ratio, so as to achieve a greatly increase of cooling capacity/heating capacity and energy efficiency improvement under severe working conditions and high load, and energy efficiency enhancement under light working conditions and low load.

This technology broadens the application scope of heat pump air conditioners and air source heat pump water

heaters, greatly improves the heating/cooling capacity and energy efficiency level in the environment of -25°C to 54°C. It can be widely used in high temperature and low temperature districts for cooling and heating demands.

## 2. Main technical specifications

Compared with conventional air source heat pump technology, this technology increases the energy efficiency by 5%-10% under the rated heating (outdoor 7°C) condition. increases the heating capacity by 50%-100% and improves energy efficiency by 5%-20% in the environment of outdoor -20°C.

## 3. Energy saving effects

Compared with conventional air conditioners, this

technology saves power 16.3% annually. Compared with conventional heat pump water heaters, the air-source heat pump water heaters using this technology can save power 24% annually.

## 4. Application areas

This technology is highly adaptable to outdoor environment temperature and can be promoted and applied in most of districts. Mainly applied for heat pump air conditioners, multi-connected air conditioners, heat pump water heaters (machines), household floor heaters and other equipment in residences, offices, hotels etc. places. ■

# First Batch of Domestic TOP TENS List

## China BP List

Edited by Nan Hu

### BP1: Using low-temperature industrial waste heat for district heating

Utilizing low-grade industrial waste heat from steel plants to provide heating service for civil buildings in urban area, replacing the original coal boilers, greatly reducing coal consumption, significantly improving the energy efficiency of industrial enterprises, and achieving good environmental and economic benefits, having innovated a new business model. Chifeng HERAN Energy Efficiency Technical Service Co., Ltd. utilizes low-grade waste heat from a steel plant 10 kilometers away from the Qianxi, Chifeng, provides heating service for 3.6 million m<sup>2</sup> of civil buildings in the town, has replaced seven pcs of 40-ton coal boilers. In order to realize the stable and efficient operation of the system, the project has developed

a special new vertical absorption heat exchanger to reduce the return water temperature of the primary network, realizes large temperature difference heating supply, improves the waste heat recovery rate and the transmission capacity of the pipe network. Establishing project companies in terms of the heating network and heat sources respectively, combines the business modes of Energy Performance Contracting (EPC) and Public-Private Partnership (PPP), has explored an operation model named "Integration of network and source", which is suitable for China's national conditions in the field of low-grade waste heat recovery, realizes the transformation of operation model and technology for heating supply, provides a practical mode that promotes utilizing industrial low-grade waste heat to urban central heating



projects.

According to the project operation status of the first phase, the total amount of industrial waste heat is recovered 64,000 tons of standard coal annually, reduces CO<sub>2</sub> emissions by 168,000 tons, reduces SO<sub>2</sub> emissions by 543 tons, reduces NO<sub>x</sub> emissions by 473 tons, saves water by 380,000 tons. The energy saving rate is > 85%.

Chifeng HERAN Energy Efficiency Technical Service Co., Ltd. has changed the traditional business model of heating supply, uses long-distance industrial low-grade waste heat for urban heating service, operates the business model successfully. Its practice has actively explored in the field of industrial low-temperature waste heat utilization, has innovated a business model for centralized heating in "The Three Norths" of China where have increasingly tight heat sources, high energy consumption, and abundant low-grade waste heat resources from surrounding industrial enterprises.

## BP2: Zero-energy office building practices

The public housing exhibition center of China-Singapore Tianjin Eco-City integrates clean energy utilization and integrated building design, combines the energy demands of buildings with the city energy system, maximizes the use of clean energy, achieves "zero energy consumption".

Based on the design concept of green building, there are multiple schemes of building benchmark model established in the design stage, comprehensively considering the possible happened complex energy uses of the building, performing the simulations such as sunlight, shading, natural lighting, natural ventilation, and underground heat storage, providing the basis for

passive energy-saving design in the architectural plan. At the same time, based on the design idea of the photovoltaic micro-grid system, in-grid operating of the city power grid, realizes power generation of the photovoltaic system is consistent with the building energy consumption, achieves the design goal of zero energy consumption. Maximizes the use of clean energies, integrates the design with the building, such as roof design and installation of solar photovoltaic power generation systems, ground-source heat pump air-conditioning systems coupled with solar hot water systems, to realize that the utilization of renewable energy accounts for 100% of the total building energy consumption.

The technology of the renewable energies, such as Air Through Tunnel technology, liquid desiccant fresh air unit, and capillary mat air-conditioning terminal radiation system etc., which is used in the project are all leading technologies in China.

The building area of the public housing exhibition center project is 3467m<sup>2</sup>. Compared with the reference building in the same area and the same model that doesn't adopt various green building energy-saving technology, the energy saving rate is 52.6%. The operation saves 257,000 kWh (equivalent to 31.7 Tons of standard coal), reduces CO<sub>2</sub> emissions by 257.9 tons, SO<sub>2</sub> emissions by 0.7 tons, and NO<sub>x</sub> emissions by 0.3 tons annually.

The public housing exhibition center project embodies the concept of green building from design, construction, operation, management and other stages, integrates the applications of green building technology. The practice has provided a path mode to promote "zero energy consumption" for new

buildings in the Northern China.

### BP3: Energy conservation in the refining and chemical industries

Jiangsu Huachang Chemical Co.,Ltd. uses the excellent performance management model to establish overall strategic objectives and specific methods for energy efficiency management,clarify the organization structure and responsibilities - authorities,formulate short-term and mid-term energy conservation plans and performance evaluation targets. It combines the concepts of benchmarking and process management and excellent performance management model as an organic integration,continuously improves the company's energy performance through the four steps of Plan,Do Check,Analysis and improvement.

The management process of Jiangsu Huachang Chemical is: Establishing energy-saving working mode → Improving organization structure of energy-saving management → Making short-term and Mid-term energy-saving plans → Analyzing and determining key indicators → Setting benchmarks → Strengthening and improving information measurement management system → Carrying out expertise cooperation → Organizing energy-saving analysis of production facilities → Continuous improvement and promotion. The main methods include the establishment of a Three-Level energy management system in the company,workshops,and lines. setting annual and monthly energy-saving targets,and adjusting them according to the completion status to continuously improve performances. daily monitoring and analyzing to the targets and energy-saving KPI (key performance

indicators),identifying energy-saving improvement opportunities,and implementing them after review. using advanced process simulation software to carry out the whole process simulation calculation,analyzing the existing production process problems,and formulating process optimization and technical transformation schemes. sending employees to participate energy-saving professional training regularly.

From 2011 to 2014,the company has a total investment of 54.2 million RMB in energy conservation and environmental protection,with the profit rate of 22%,return period of 4.5 years. has been awarded with the honor of 'Leader' in energy efficiency in China's petroleum and chemical industry 4 times,achieves the accumulated energy-saving amount of 82,000 tons of standard coal,CO<sub>2</sub> emissions reduction by 204,000 tons. Annually reduces SO<sub>2</sub> emissions by 121 tons and NO<sub>x</sub> emissions by 190 tons.

Jiangsu Huachang Chemical has combined years of experiences in energy management with "GB/T23331 Energy Management System Requirements",realizes systematic and standardized energy management. This model has a good demonstration and reference effect for various energy-consuming units and has the practical value.

### BP4:'Gradual catch-up' Energy Manafement Model in Qingdao

SINOPEC Qingdao Refining and Chemical Co.,Ltd. 'gradual catch-up' energy management model takes the indicators of leading enterprises as the 'gradual catch-up' goals,continuous improves the energy-saving targets



through data collection, analysis and comparison, Cascaded tracking learning mechanism by learning the advanced experiences and practices to continuously improve energy performance, to catch up and step over the competitors.

The "gradual catch-up" energy management model can be summarized as: learning best practices and continuously improving metrics. The best practices refer to the most effective measures and methods adopted by leading companies in energy conservation and consumption reduction in the same industry. Continuously improving metrics refer to a set of indicator systems that can really and objectively present energy performances at different stages and the corresponding benchmark data for 'gradual catch-up'.

Use the "gradual catch-up" energy management model, learn from the advanced experiences of domestic and foreign refining and chemical companies, realize flat structure of energy management, systematic management systems, standardized process control, informatic monitoring and analysis, and continuous optimization and improvement. The first is to establish an energy-saving and emission-reduction management system in accordance with the requirements of 'gradual catch-up'. Refers to the experiences and practices of first-class domestic and international enterprises in the same industry, carries out systematic learning and continuous improvement. The second is to develop more professional and lean energy management and control. The lean management concept is implemented through the entire process of energy utilization, deploy repeated calculations, elaborate demonstrations, formulating schemes, strengthening implementation for the operation

and control at each step of energy utilization. Promote the maximization of energy-saving benefits by lean energy management. The third is to institutionalize the improvement of energy-saving technologies. Through benchmarking analysis, continually collect and search advanced domestic and international energy-saving technologies in the same industry, continuously carry out energy-saving technological transformations base on sufficient demonstration and evaluation.

Qingdao Refining and Chemical Co., by using the "gradual catch-up" energy management model, reduces the comprehensive energy consumption of refining from the design level of 74 kg standard oil/ton to 57.2 kg standard oil/ton in 2014, achieves drop of 23%. Its Energy Density Index (EII) that reflects the energy utilization level of the refinery plants takes the leading position in the Sinopec group, is also at the world's leading level in the performance evaluation system of Solomon's global refining industry.

The "gradual catch-up" energy management model is continuously learning the effective energy management measures and methods of leading companies in the same industry, as well as the continuously improving measurement standards, which has a general reference effect for energy conservation and emission reduction.

#### **BP5: Water Cube LED lighting power-saving demonstration project**

The National Aquatics Center ('Water Cube' for short) proceeds technological innovation and management model innovation in parallel, directly applies scientific research results to engineering practice, comprehensively



implements complex curved surface structure optical modeling technology, Efficient energy-saving LED lamps and advanced information network technology, realizes large-scale, full-color, variable-scene LED landscape lighting in large public building firstly.

Aims to the layout of the architectural membrane structure, Water Cube adopts the lighting method of "light transmission in cavity", which breaks through the technical problem of the surface brightness uniformity under the curved surface of the special ETFE air pillow. Uses computer simulation to construct the optical model of complex curved surface structure, establish a functional relationship between the surface illuminance and brightness of the membrane structure air pillow, maximize the optimization of the lighting layout under the ETFE irregular air pillow, provides a new application method to illuminate the transparent material with the complex curved surface structure. application methods. has researched and developed lens materials and lamp structures suitable for the characteristics of the building structure, realizes the high-efficiency secondary optical design of the LED and has solved the heat dissipation problem, formed the high-efficiency LED lighting technology with independent intellectual property rights. adopts information network technology to control the LED lighting, realizes remote high-speed synchronous control of Large-scale LED lighting, achieves more controllable energy-saving effects. The above-mentioned research and innovation are directly

applied to engineering practice, realizes large-scale full-color variable-scene LED landscape lighting on nearly 50,000 m<sup>2</sup> of ETFE membrane structure and its maintenance system.

The Water Cube LED lighting power-saving demonstration project uses 36,170 sets of LED lamps with a total power of 489 kW. Configures with information network control technology, the actual load power is 180 kW. Compared with using T5 fluorescent lamps, the power saving rate is 14.7%, achieves annual power saving 1.06 million kWh, reduces CO<sub>2</sub> emissions by 795 tons.

The Water Cube LED lighting power-saving demonstration project uses simulation technology to optimize the design for the special building structures, overcomes the problems of membrane structure air pillow lighting and corresponding heat dissipation, comprehensively uses multiple energy-saving technologies. This project plays an important demonstration role for high-efficiency application of LEDs used in large-scale public building landscape lighting.

#### BP6: Shendu Building Implements Passive Building Transformation in Shanghai

The transformation project of Shanghai Xian Dai Shendu Building is a transformation on an existing building, which overall plan is based on the characteristics of the original building, realizes the adaptation of building functions and operation modes, and establishes a comprehensive building operation energy-saving management system.

The transformation project is implemented in the whole process of planning, design, construction, operation and maintenance with green concept. According to the functional characteristics and operation modes of the building space, it integrates multiple passive energy-saving technologies for the envelope structure, applies efficient air-conditioning, lighting and intelligent control technologies. In the actual operation process, a set of analysis, adjustment and control measures have been established to control the standby energy consumption of air conditioners, the islanding effect of solar photovoltaic system, the supplementary water level control of the rainwater system, the overheating prediction control of the solar hot water system and the operation adjustment system of public lighting. The building information modeling (BIM) technology is applied to the Facility Management (FM) of the e-estate management, develops an operation and maintenance management portal platform combined with localized operation and maintenance requirements. Integrates the sub-metering system and the building auto-control system, proceeds optimization management.

The building area of this project is 7,301 m<sup>2</sup>. It realizes annual power saving 434,000 kWh, equivalent to 130.1 tons of standard coal, which is less than 50% of the standard level of energy consumption of the same type building. This project reduces CO<sub>2</sub> emissions by 281 tons per year.

Shanghai Xian Dai Shendu Building transformation project fully considers the characteristics of building functions and operation modes through the whole project process, continuously optimizes the management

model during the operation process, which experiences can be promoted to the transformation of multi-story public buildings that have clear usage patterns and centralized management system of building air conditioning, ventilation and lighting.

#### BP7: Promoting "Educational energy conservation" and "Energy conservation education" in Beijing Jiaotong University

Beijing Jiaotong University implements energy conservation in its education system, uses modern communication and control technology to build a campus intelligent energy management system, realizes the organic integration of "educational energy conservation" and "energy conservation education".

Beijing Jiaotong University has listed energy conservation education in its teaching plan, strengthens energy conservation education and publicity for students through classroom education, campus education, demonstration education, and practical education. Over the past three years, there are more than 30 energy-saving renovation projects have been implemented, including building envelope renovations, classroom lighting system, air-conditioning intelligent power-saving system, elevator energy feedback system, and boiler flue gas waste heat recovery. Energy-saving products and new energy products have been widely used to improve energy efficiency level of buildings and operating equipment. It has built an intelligent energy management system covers all energy consumption factors of the campus, carries out system integration of energy-saving monitoring platform, heating

auto-control, 3D underground pipe network, classroom intelligent monitoring, library intelligent power-saving control, non-negative pressure water supply intelligent control, intelligent security system, and automatic repair claim platform, etc. systems, realizes online monitoring and real-time analysis of energy use, forecasting of energy consumption trends, optimizing scheduling and management, realizes intelligent energy-saving management in the university. In 2015, in accordance with the requirements of GB/T 23331, the university has accomplished an energy management system certification.

Since 2011, Beijing Jiaotong University has reduced its total energy consumption by 1407 tons of standard coal annually, water saving 43,000 tons, with an average energy-saving rate of 8.7% and a water-saving rate of 3.6% under the condition of continuous increasing of building area and energy-using equipment. Indirectly reduces SO<sub>2</sub> emissions of 23.2 tons, NO<sub>x</sub> emissions of 22.0 tons, and smoke and dust of 13.5 tons annually.

Beijing Jiaotong University fully plays the role of educational institutions with its advantages and characteristics, integrates energy conservation into education process, realizes the visualization and systematic management and control of energy consumption. Its energy conservation practice has reference significance for comprehensive and systematic improvement of energy conservation work in universities.

#### BP8: Dynamic closed-loop energy management and control system in CIMC

Shenzhen Southern CIMC Equipment Manufacture

Co., Ltd. (hereinafter referred to as CIMC) combines HAIYIDA full-time dynamic energy efficiency management and control technology with production processes, establishes a dynamic closed-loop energy management and control system to realize fine management of energy-saving and consumption reduction, significantly improves energy efficiency.

CIMC combines the production process and equipment characteristics, has established a dynamic closed-loop energy management and control system of "monitoring → efficiency analysis and modeling → model simulation → efficiency management and control", provides an effective and fine management tool for enterprises continuous energy-saving and consumption reduction. The system adopts full-time dynamic energy efficiency management and control technology to realize real-time collection and storage of all energy parameters and operating parameters of energy-using facilities in the plant. A real-time online analysis model of energy efficiency is established based on process data, to realize real-time management and control of energy efficiency level and energy consumption process of energy-using facilities. A simulation model covering the whole process of 'monitoring → analysis-management and control' is established in further, continuously optimizes energy efficiency model through simulation verification, assisting enterprises to continuously optimize the energy management system, formulating energy management plan, providing supporting data for energy-saving transformation, and verifying the effectiveness of energy-saving transformation. Besides of direct energy saving, the system also has functions such as



safety management of energy supply and use, equipment management, malfunction alert and processing, remote control etc., realizes indirect energy saving and efficiency improvement by preventive maintenance of equipment

Since CIMC adopted full-time dynamic energy efficiency management and control technology to establish a dynamic closed-loop energy management and control system, the single-phase manufacturing has achieved a power saving rate of 35.4%. It saves power 19.85 million kWh and reduces CO<sub>2</sub> emissions by approximately 14,900 tons annually.

CIMC has established a dynamic closed-loop energy management and control system to provide decision-making support for company's energy-saving transformation and energy management. Its concept, design and management model provide a demonstration case for improving energy consumption in industries, public buildings, rail transit, petroleum and petrochemical, coal and other fields.

#### BP9: Energy saving in a gigawatt-scale coal-fired generation unit

Shenhua Guohua Power comprehensively utilizes internal and external research capabilities to formulate and implement a clean energy development strategic action plan based on specific turbine flow passage modification and "near-zero emission" technical routes, has established a long-term mechanism for energy-saving technological progressing.

Shenhua Guohua Power implements the "Guohua Power Strategic Action Plan to Promote Clean Energy Development", carries out comprehensive green

upgrading and transformation of existing coal-fired generator units in terms of energy-saving, environment protection, efficiency improvement, capacity increase and heating supply. During the period, the enterprise has played the technical leading role of the post-doctoral mobile station at Guohua Electric Power Research Institute-level, and brought together the strengths of the three power groups of Harbin, DEC Boiler and SAIC group to carry out technical research, forms a unique turbine flow passage modification and "Near zero emission" technical route, including high-medium pressure cylinder flow enhancement + low pressure cylinder Last Stage Blade optimization + nozzle group, regulating stage, high-medium-low pressure rotor, high-medium-low pressure inner cylinder, diaphragm and diaphragm sleeve upgrade and transformation + steam Sealing transformation + cold end optimization transformation + generator and auxiliary equipment efficiency improvement transformation + heating supply transformation, etc., and systematically establish and implement Energy-saving technological progressing mechanism, which core contents consisting of technical implementation routes, management organization, project implementation progress, investment planning arrangement, and operational risk control etc.

Suizhong Power Plant, Shenhua Guohua Power has No. 2 Russian-made unit, before and after the transformation of 800 MW at the same valve level, the coal consumption of power supply decreased by nearly 40 g/kWh, which saves 328,000 tons of standard coal

per year and reduces power consumption rate by more than 2%. All indicators are better than the requirements of "Coal Power Energy Conservation and Emission Reduction Upgrade and Transformation Action Plan" that issued by the three ministries and commissions.

The practice of Shenhua Guohua Power provides a practical reference for coal power companies to establish a long-term mechanism for energy-saving technological progressing, continuously promote energy-saving technology progress, and promote energy-conservation and emission-reduction of coal generator unit by gathering ideas from internal and external Think Tank.

#### BP10: IBR Green Building Demonstration Project

Shenzhen Institute of Build Research Co.,Ltd. (IBR) Green Building demonstration project is based on the local climate and resource conditions, fully integrated with the natural environment, passive technology priority, green building with a character of "growth".

The IBR Green Building is designed, constructed and operated based on the green design concept of "sharing and balance", under the premise of fully understanding the climate characteristics, resources - environment, social culture, and the principle of integration of "Nature-Building-People". First of all, according to the distribution of building functions, dominant wind direction and physical environment of the site, through digital analysis, adopts the shape of Chinese character "凹

" to design the building shape and layout, creates good conditions for the building's natural ventilation and natural lighting. Secondly, integrates the high-performance outer envelope structure, external shading facilities, 3D greening system, solar shading system, etc. to construct a comprehensive building insulation system. Thirdly, adopts efficient conditioning system, LED lighting system, energy-saving elevators, ecological reclaimed water system, solar photovoltaic system, seat air supply system, energy-saving power distribution system, and optimized operation control system to efficiently utilize active technologies. Through the integrated application of green technology system, IBR Building provides a comfortable and healthy office environment for users while efficiently using commercial energy.

Compared with the standard of "Shenzhen Office Building Energy Consumption limits", the IBR Building saves power about 1.04 million kWh (equivalent to 347 tons of standard coal), reduces CO<sub>2</sub> emissions by 923 tons. The total investment of the project is 70.55 million RMB, of which the incremental cost of Green Building is 10.34 million RMB. The ROI (return on investment) is 10.3% and the return period is 9.7 years.

The IBR Building combines the concept of "sharing and balance" with architectural design and operation, which experience is suitable for projects in hot summer and warm winter districts. ■

# First Batch of Domestic TOP TENs List

## Japan BAT List

Edited by Quan Bai

### BAT1: High-efficiency Heat Pump

#### 1.Introduction

A heat pump is a system that can transfer heat from a low-temperature zone to a high-temperature zone, consuming only a small amount of motive power by means of a change in state such as the pressure and temperature of a heating medium (refrigerant).

A high-efficiency heat pump features a high coefficient of performance\* (COP). Heating can be performed at higher efficiency than that achieved by conventional combustion of fossil fuels. this technology thereby contributes to reducing CO<sub>2</sub> emissions and limiting global warming. In its Renewable Energy Directive that came into effect in 2009, the European Union recognized heat energy

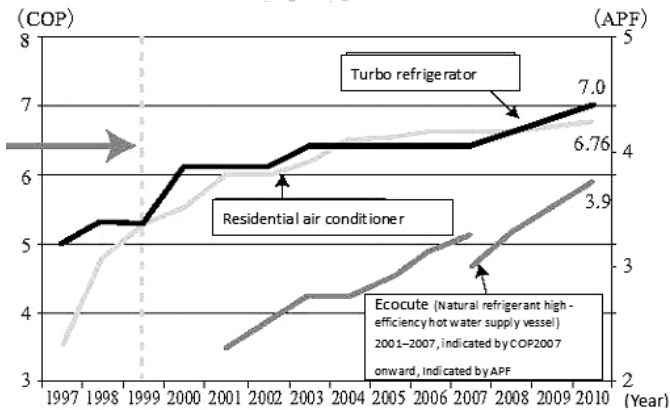
generated by heat pumps as a form of renewable energy (RE).

As illustrated in Fig. 1, the COP achieved by heat pumps has shown rapid advancements in the past ten years through the enforcement of a top-runner system and other measures. This has been achieved by: (1) Use of an inverter, (2) High efficiency of compressor and heat exchanger, and recently (3) Use of a new refrigerant (R32), among various factors.

#### 2.Technological Trends of Industrial Heat Pumps

(1) Higher Temperature Generated by Industrial Heat Pump





\* Values are those of top-runner equipment.

Residential air conditioners are 2.2 kW in capacity.

Dimensions are not specified.

Fig.1 Year-on-year changes in COP of turbo refrigerator, residential air conditioner and Ecocute\*1

At present, several manufacturers produce equipment for hot water supply and heating that can generate temperatures of 90°C. Painting and printing businesses use drying equipment that can generate hot air of 120°C. As of 2013, the highest temperature achieved by a heat-generating pump on the market was 165°C (7 MPa).

### (2) Increase in Equipment and Cases for Simultaneous Use of Cooling and Heating

By utilizing both cold energy and hot energy that are generated simultaneously, a heat pump can double the level of efficiency achievable when they are used separately.

Cold water, chilled water, cold wind and other fluids are generated on the cold heat side, while hot wind and steam can also be generated on the hot heat side in addition to hot water and hot wind. The breadth of their possible combinations has expanded, and simultaneous use of cold

heat and hot heat is increasing in production processes, air conditioning, hot water supply, and other applications.

### (3) Miniaturization of Heat Pump Equipment (Cooling Capacity approximately 10 USRt. 30 kW)

Rather than installing equipment with a large capacity, several compact standard units are installed in order to minimize the capacity of standby equipment, thereby achieving high efficiency when the load is low.

## 3. Industrial Applications of Heat Pumps

(1) A large number of industrial heat pumps are installed in the foodstuff industry, and usage is expected to increase. The utilization temperature of the foodstuff industry is about -60°C to 120°C, and this temperature range can be supplied by current heat pump technology. Additionally, foodstuff manufacturing lines typically have mixed demands for cold heat and hot heat, allowing easy utilization of both forms of heat available from heat pumps.

(2) The use of heat pumps is expanding in various drying processes. In processes such as painting, printing, and fluidized-bed drying, heat pumps are installed before existing equipment for heating and drying, using waste heat as an energy conservation measure for existing drying equipment.

(3) In the past, only boilers could supply high-temperature steam at temperatures of 120°C or more, for applications such as sterilization, concentration, drying, and distillation. However, high-temperature steam in excess of 120°C can now be supplied by a heat pump.

#### 4.Introduction of Heat Pump Technology and Energy Conservation Cases in Industrial Applications

The following cases describe the items to which the heat pump technology and industrial applications apply.

(1)Development and introduction of simultaneous cooling and heating heat-pump system for production process: Aisin AW Co.,Ltd.

1) Heat pump technology 2-(2)

2) Industrial applications of heat pump 3-(1)

(2)Steam-condensation-type vacuum degreasing cleaner:

IHI Machinery and Furnace Co.,Ltd.

1)Heat pump technology 2-(2)

2) Industrial applications of heat pump 3-(2)

(3)Heat pump system for high-efficiency steam supply:

Machinery division of Kobe Steel,Ltd.

1) Heat pump technology 2-(1)

2) Industrial applications of heat pump 3-(3) ■

## BAT1–1: The Simultaneous Heating and Cooling Heat Pump System

### 1. Business Categories Adopting This Technology

Automotive parts manufacturing

### 2. Classification of Technology

Recovery of low-temperature waste heat (used in high-efficiency heat pumps)

### 3. Energy Source

Waste heat

### 4. Year of Commercialization

2012

### 5. Overview

In automotive parts manufacturing process machining line involves cutting and cleaning metals. Cutting machines use a cooler for the cutting fluid while cleaning machines use steam from a boiler to heat the cleaning fluid. A new heat-pump system has been developed to eliminate the use of steam. The heat pump uses the heat generated by cutting machines to heat the cleaning fluid. This new system has been installed on all the lines in the plant.

### 6. Principles and Operation

The heat pump is a system that can transfer heat from a low-temperature zone to a high-temperature zone consuming only a small amount of power. It accomplishes this by a change in state (i.e., pressure and temperature) of a heating medium (refrigerant).

#### (1) Development of the Heat Pump System for the Production Process

The required heating temperature of the cleaning machine is high (50°C–70°C). The cutting machine requires machining accuracy to micrometers and each cutting machine has a cooler to avoid the effects on quality caused by expansion or contraction of the work pieces due to temperature fluctuations. To meet these temperature requirements and ensure product quality, a new system capable of simultaneous cooling and heating (heat pump) was developed for the production process. With this heat pump, it is now possible to heat the cleaning machine using only heat generated by the cutting machines.

#### (2) One Heat Pump Can Cool Multiple Machines

• Cooling water is circulated in a closed circuit through a



heat pump and heat exchanger.

- Cooling of several machines is simultaneously controlled using valves operated by electric motors.
- A heat-pump compressor inverter controls the cooling power.

## 7.Improvement Made

See Figure 1&2.

## 8.Effects of Improvement – Improvement in Energy Consumption Rate (Option for Improvement of Energy Conservation Rate)

See Table1.

## 9.Economic Efficiency and Changes

(1) Initial equipment investment cost

91,000,000 JPY

(2) Remodeling cost

(3 )Running costs

32,920,000 JPY/year → 6,890,000 JPY/year →

26,030,000 JPY/year

(4) Years Needed for Recovery of Investment 3.5 years

See Table 2.

## 10.Market Situations and Conditions

(1) Penetration Rate at Present Not available

(2) Forecast of Penetration in 2017 (or 2020)

Not known

## 11.Additional Information for Reference

(1) Reduction of CO<sub>2</sub> Emission

1,094 tons/year

(2) Social Impacts and Other Factors

1) Patents and utility models

•Production line system (Patent application No. 2010-039003, patent application date February 24 2010), Two patents pending (Patent No. 2011-213211, Patent No. 2011-213206), Application date: 12 September 2011)

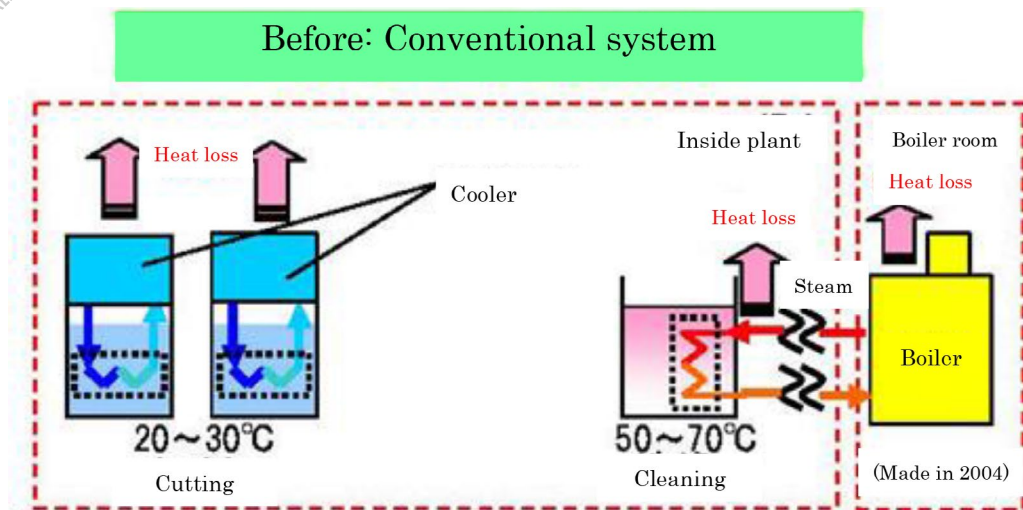


Figure 1

### After: Newly developed system

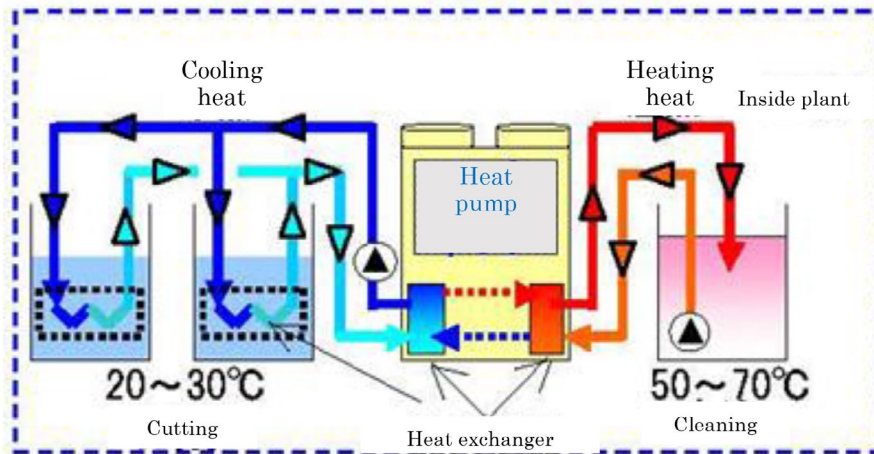


Figure 2

Table 1 Effect of Newly Developed Energy System

	Before		Newly Developed System		Reduction Achieved
Power Consumption (MWh/yr)	193 (100%)	• Boiler auxiliary equipment • Cooler	570 (295%)	• Heat pump	+377 (+195%)
Fuel Oil Consumption (KL/yr)	470 (100%)	• Boiler fuel oil	0 (0%)	• Heat pump	-470 (-100%)
Water Consumption (KL/year)	6,953 (100%)	• Steam raw material	0 (0%)	• Heat pump	-6,953 (-100%)
Heat Loss (MWh/yr)	-15,497 (100%)	• Boiler • Steam • Cooler	0 (0%)	• Heat pump	-15,497 (-100%)
Fuel Oil Equivalent (KL/yr)	522 (100%)	• Boiler • Cooler	85 (16%)	• Heat pump	-437 (-84%)
CO2 Emissions (tons of CO2)	1,364 (100%)	• Boiler • Cooler	270 (20%)	• Heat pump	-1,094 (-80%)

Table 2 Effect of Technology Introduction Cost

	Before (Conventional System)		After (Newly Developed System)	
Investment Amount	• Boiler (including piping) JPY 75,300,000 • Steam heater JPY 10,500,000 • Cooler JPY 50,400,000 <u>Total JPY 136,200,000 (100%)</u>		• Simultaneous cooling and heating heat pump system (6-hp units x 6, 12-hp units x 8) <u>Total JPY 91,000,000 (66.8%)</u> (Reduction of JPY 45,200,000 or 33.2%)	
Annual Running Cost	• Electricity 193 MWh JPY 2,340,000 • Fuel oil 470 KL JPY 28,130,000 • Water treatment 6,953 KL JPY 2,450,000 <u>Total JPY 32,920,000 (100%)</u>		• Electricity 570 MWh JPY 6,890,000 • Fuel oil 0 JPY 0 • Water treatment 0 JPY 0 <u>Total JPY 6,890,000 (20.9%)</u> (Reduction of JPY 26,030,000 or 79.1%)	

## 2) History of Awards Received

- Recipient of special letter of appreciation from the Heat Pump & Thermal Storage Technology Center of Japan on

occasion of 'The 14th Heat Storage Conference'

## 3) Literature and Other Information

- Monthly 'Energy Conservation' magazine (June



2014,pages 31 to 35),special edition on heat pumps.  
'Technology Development News' published by Chubu  
Electric Power Co.,Inc. (No. 139,July 2010,pages 7 and 8).

## 12.Bibliography and Reference Information

'Development and Introduction of Simultaneous Cooling  
and Heating Heat Pump System for Production Process,'  
recipient of 2011 Energy Conservation Grand Prize

(Energy Conservation Sector),Collection of Applications  
Containing Technological Accomplishments,The Energy  
Conservation Center,Japan

## 13.For More Information,Please Contact

Aisin AW Co.,Ltd.  
General Heat Pump Industry Co.,Ltd.  
Chubu Electric Power Co.,Inc. ■



## BAT1-2: Steam-condensation Type Vacuum Degreaser

### 1. Business Categories Adopting This Technology

Manufacturer of machined metallic parts

### 2. Classification of Technology

High-efficiency heat pumps

### 3. Energy Source

Waste heat

### 4. Year of Commercialization

2013

### 5. Overview

Degreasing to remove lubricating oil, quenching oil, and other oil and grease, is necessary for mechanical assembly of machined-metal parts. Vacuum degreasers using vacuum-steam condensation with petroleum solvent have widely replaced fluorocarbons and trichloroethane. The use of these two solvents has been prohibited because these substances deplete the ozone layer. However, two problems related to replacement of these degreasers have been the need for a large amount of solvent (more than 2500 liters), and the demand for substantial power to obtain equivalent cleaning performance. The new degreaser reduces the drying time by 90%, and increases

the heat-recovery rate four-fold compared with before.

The new degreaser also drastically reduces the running cost, by several million yen (JPY) per year. This is achieved by incorporating the following two new technologies: (1) a heat-pump heat-recovery system (energy conservation), and (2) a cryogenic drying system.

### 6. Principles and Operation

#### (1) The heat-pump heat-recovery system

This is a heat-energy-reutilization system that incorporates a heat pump using an alternative fluorocarbon refrigerant. The system recovers nearly 100% of the energy needed to regenerate the shower liquid. The shower liquid of the vacuum degreasers is regenerated by vacuum distillation of the shower liquid mixed with oil. Conventional models discharge about 27 kW to the outside. This is energy used to regenerate shower liquids outside of the plant building, using cooling water of a shower-liquid-condensation heat exchanger. Similarly, about 9 kW of the energy needed for a waste-liquid-concentration unit (vacuum-distillation type), and other equipment, is typically discharged to the outside of the plant building

in cooling water. The new system recovers about 27 kW of shower-liquid-regeneration energy using an alternative fluorocarbon refrigerant in place of cooling water. This refrigerant is used for heating and evaporation of the cleaning liquid in the heat-pump system of a 9 kW compressor. Heating output equal to 36 kW by a conventional system can be obtained with only the 9 kW needed to run a compressor.

## (2) Cryogenic drying system

The system dries treated materials on the high-temperature side by vaporizing on that side any cleaning solvents remaining from the cleaning process. This system also instantaneously transfers the vapors to the low-temperature condenser.

Drying is adequately feasible if there is a temperature difference of 20°C between the high and low-temperature sides, thereby allowing drying of thin aluminum and stainless steel sheets. In the past, these have been difficult to dry due to rapid lowering of their temperature.

## 7.Improvement Made

See Figure 1&2.

## 8.Effects of Improvement - Improvement in Energy Consumption Rate (Option for Improvement of Energy Conservation Rate)

'Conditions for Comparison'

- (1) Treated material: Weight of treated material per charge is 800 kg.
- (2) Hours of operation: Annual operation is set at 7,200 hr.
- (3) Annual amount of treatment: Amount of treatment is 3,000 Charges/year.
- (4) CO<sub>2</sub> emissions: Conversion value to power consumption is set to 0.555 kg/kWh.
- (5) Electricity charge: JPY15/kWh.
- (6) Cost of petroleum solvent: JPY250/L.

Power consumption/Charge: 31.1 → 19.7 kWh  
-11.4 kWh

## After Improvement

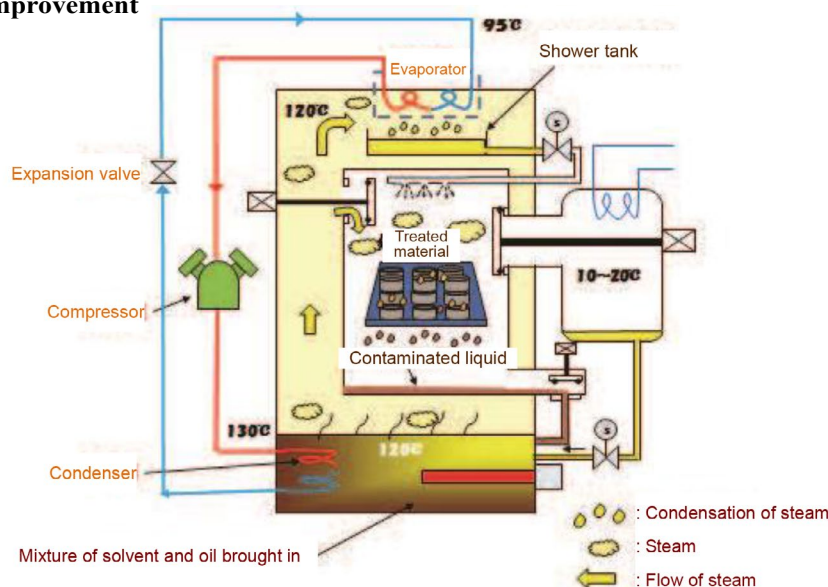


Fig. 1 The heat-pump heat-recovery system

## After Improvement

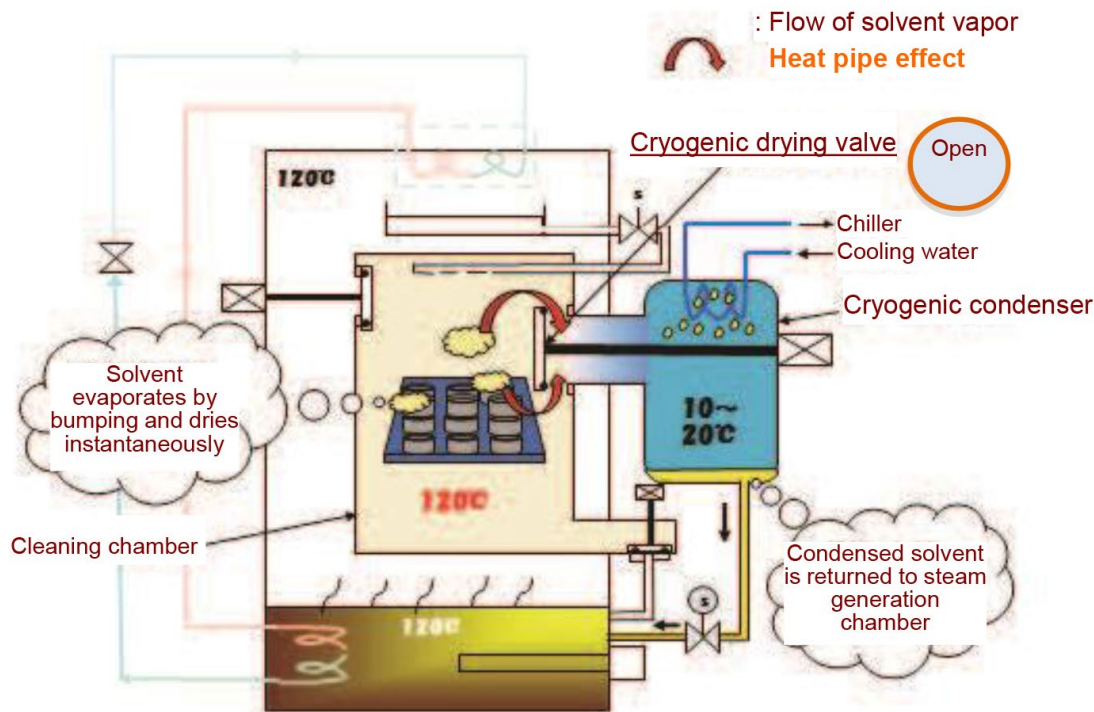


Fig. 2 Cryogenic drying system

Energy conservation rate: 44.4%

See Table 1.

## 9. Economic Efficiency and Changes

Energy Conservation (Cost of solvent is not included)

- (1) Initial equipment investment cost: Not available.
- (2) Remodeling cost.
- (3) Operation cost: 3,990,000 JPY/year → 2,218,000 JPY/year, Around -1,772,000 JPY/year.
- (4) Years Needed for Recovery of Investment: Not available see Table 2.

## 10. Market Situations and Conditions

In the future, IHI Machinery and Furnace Co. plans

to build a network of operations in China and Europe, and to undertake sales activities aimed at increasing sales of EvaCryo degreasers inside and outside of Japan, to a target of JPY 2,000 million in 2015.

## 11. Additional Information for Reference

- (1) CO<sub>2</sub> emission reduction 168 tons/yr reduced.
- (2) Social impacts and other factors.

1) History of Awards Received.

• Recipient of 2013 Excellent Energy Conservation Equipment Award presented in the name of the Minister of Economy, Trade and Industry sponsored by the Japan Machinery Federation.



Table 1 Comparison of energy conservation performance

	Conventional HWV degreaser	EvaCryo	Difference	Reduction Rate
Power consumption for shower liquid regeneration/Charge	16.8 kWh	4.3 kWh	12.5 kWh	75%
Power consumption /Charge	31.1 kWh	19.7 kWh	11.4 kWh	36.7%
Annual power consumption	265,986 kWh	147,849 kWh	118,137 kWh	44.4%
Annual CO <sub>2</sub> emissions	148 tons of CO <sub>2</sub> /yr	82 tons of CO <sub>2</sub> /yr	66 tons of CO <sub>2</sub> /yr	44.4%
Annual electricity charge	JPY 3,990,000/yr	JPY 2,218,000/yr	JPY 1,772,000/yr	44.4%

Table 2 Comparison of economic efficiency

	Conventional HWV degreaser	EvaCryo	Difference	Reduction Rate
Solvent consumption /Charge	0.9 L	0.4 L	0.5 L	55%
Annual consumption of solvent	13,500 L	6,000 L	7,500 L	55%
Annual cost of solvent	JPY 3,380,000	JPY 1,500,000	JPY 1,880,000	55%

## 12. Bibliography and Reference Information

Japan Machinery Federation

2013 Excellent Energy Conservation Equipment  
Award

[Award in the name of the Minister of Economy, Trade  
and Industry]

## 13. For More Information, Please Contact:

IHI Machinery and Furnace Co., Ltd. ■

## BAT1-3: Heat Pump System for High-efficiency Steam Supply

### 1. Business Categories Adopting This Technology

Biofuel manufacturers

### 2. Classification of Technology

Recovery of low-temperature waste heat (uses a high-efficiency heat pump)

### 3. Energy Source

Waste heat

### 4. Year of Commercialization

February 2013

### 5. Overview

Spurred by the requirements of energy conservation in face of global warming, there has been a demand for a highly efficient technology that produces high-temperature steam in excess of 120°C by way of a heat pump. Until now, high-temperature steam in excess of 120°C could only be supplied by boilers that use steam in processes such as sterilization, condensation, drying, and distillation. However, a heat pump system (Steam Grow Heat Pump) for providing steam supply with high efficiency at temperatures in excess of 120°C has now been developed. In this respect, Model SGH120 has a

mounted heat pump and is capable of supplying steam of 120°C, and Model SGH165 has an additionally mounted steam compressor onto the heat pump and can supply steam at a maximum temperature of 175°C.

### 6. Principles and Operation

Up until the present day, heat pumps could provide high temperatures of more than 100°C but could supply either high-temperature water and steam simultaneously or only hot air. Kobe Steel has now developed the following technologies to supply only saturated steam at a temperature in excess of 120°C.

For developing this technology, the design of gaps and openings in various parts of the compressor were first reexamined, taking thermal deformation at a high temperature into consideration. A method used to directly atomize a refrigerant liquid into the motor (to cool the motor) was also adopted to prevent the motor overheating even when the compressor is operating under a high suction temperature. This achieved both compressor reliability, and the maintenance of compressor performance.

A high-efficiency operation was then achieved by using a different screw compressor in accordance with the

compression ratio. For instance, a dual-stage compressor is used in Model SGH120 and a single-stage compressor is used in Model SGH165.

Third, R245fa, which is a type of hydrofluorocarbon (HFC), was used as a refrigerant for the heat pump unit. It is also a low-pressure refrigerant with a high critical temperature ( $154.0^{\circ}\text{C}$ ), and can be used as a base refrigerant. The selection of an optimal refrigerant component ratio using R134a (critical temperature  $101.1^{\circ}\text{C}$ ) was then achieved at a high efficiency.

Through the development of the foregoing technologies, the rated performance of SGH120 has been enhanced to a supply an amount of steam equivalent to 0.51 t/h and COP3.5, and SGH165 to deliver an amount of 0.84 t/h and COP2.5. By recovering heat from the following areas: the cooling water of the water-cooled chiller, the high-temperature waste water from the production process, and the unutilized heat-source water inside the plant, steam can therefore now be supplied at a high efficiency.

## 7.Improvements Made

See Figure 1&2.

## 8.Effects of Improvement - Improvement in Energy Consumption Rate (Option for Improvement of Energy Conservation Rate)

See Figure 3&4.

## 9.Economic Efficiency and Associated Changes

(1)Initial equipment investment cost:

Data currently unavailable

(2)Remodeling cost:

(3)Running costs: 95,000,000 JPY/year  $\rightarrow$  42,000,000

JPY/year, Approximately 50,000,000 JPY/year.

(4)Number of years required to recover investment:

Data currently unavailable.

## 10.Market Condition

(1)Penetration rate at present: Data not currently available.

(2)Forecast of penetration in 2017 (and 2020):

### Before Improvement

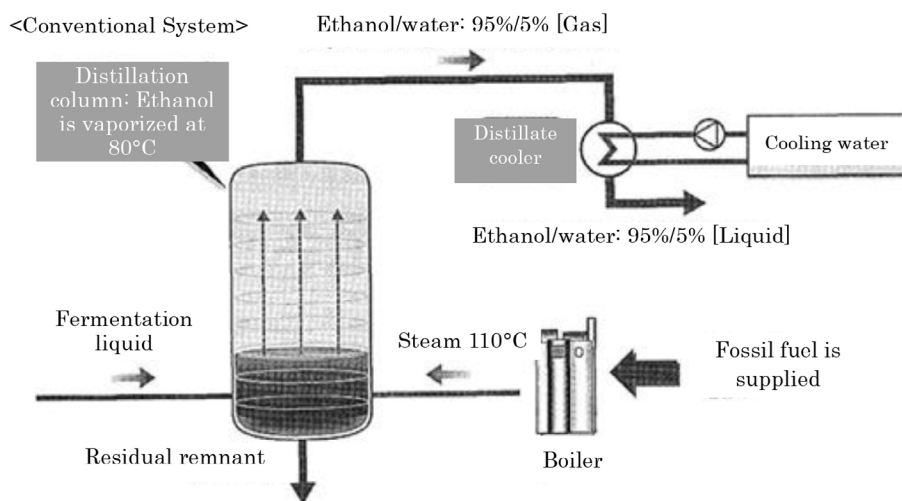


Figure 1



## After Improvement

<System incorporating Steam  
Grow Heat Pump>

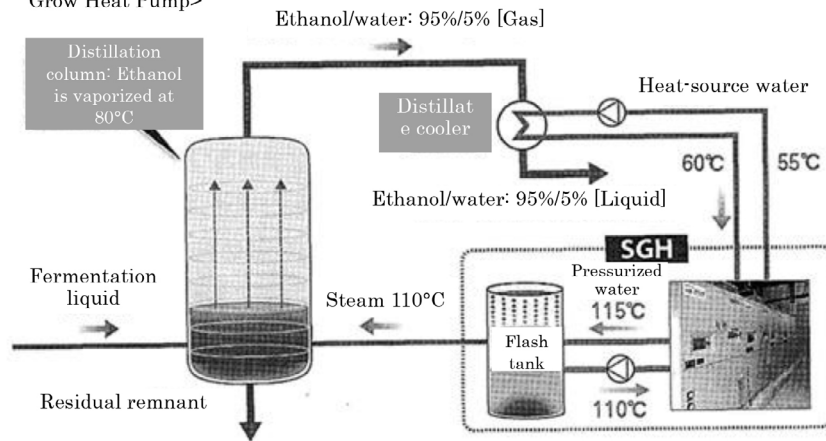


Figure 2 Image of system incorporating Steam Grow Heat Pump

Data currently unavailable.

## 11. Additional Relevant Information

- (1) CO<sub>2</sub> emission reduction: 1,290 tons/year.
- (2) Social impacts and other factors.

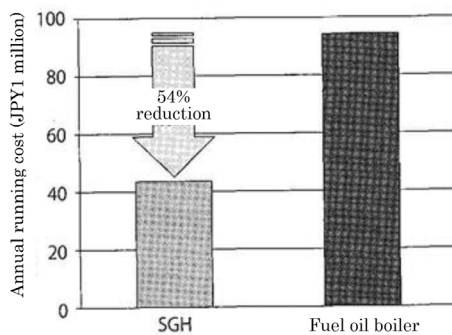


Fig. 3 Comparison of annual running costs

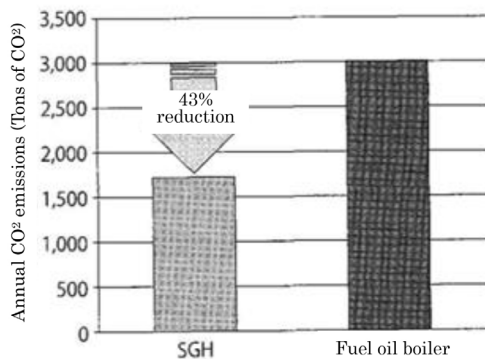


Fig. 4 Comparison of CO<sub>2</sub> emissions

1) Literature:

- Monthly publication of Energy Conservation (June 2014), pp 42–45, (special edition for heat pumps).

## 12. Bibliography and Reference Information

'Heat Pump System for Supply of Steam at High Efficiency and Examples of System Installations,' Monthly publication Energy Conservation, Vol. 66, No. 6, June 2014, pp 42–45, The Energy Conservation Center, Japan.

## 13. For More Information, Please Contact:

The Machinery Division of Kobe Steel, Ltd. ■

## BAT2: High Efficiency Boilers

### 1. Introduction

Industrial steam boilers can be categorized as: (a) those that directly supply heat to users, and (b) those that generate power by rotating a turbine, from which the exhaust gas is used as a heat source for factories. This article describes boilers that do not generate power.

See table 1.

#### (1) Boiler Classification

In general accordance with the Industrial Safety and Health Law of Japan, boilers are classified as: simplified boilers, small boilers, and boilers.

**Boiler Schematic (water tube type)**

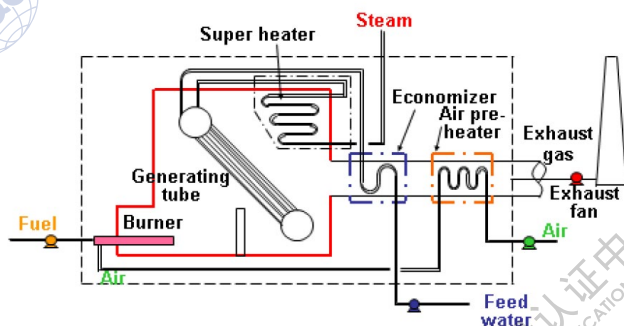


Fig. 1

#### (2) Energy Conservation Measures of Boilers

The general energy conservation options for boilers are

as follows:

- Optimizing air ratio.
- Reducing heat lost via exhaust gas.
- Reinforcing heat insulation (adiabatic insulation).
- Preventing heat loss caused by intermittent boiler operation.
- Recovery of steam drain.
- Improving FDF/IDF (forced draft fan/induced draft fan) efficiency under partial load.
- Preventing losses from steam trap and blow water.

### 2. Technical Trends of Once-through Boilers

Among steam boilers operating in Japan for general industrial purposes excluding power.

generation, it is estimated that about 65% of the steam requirement is supplied by once-through boilers, while about 20% and 15% are supplied by flue and smoke tube boilers and water tube boilers respectively. In recent years, newly manufactured boilers are predominantly of the once-through type. The features and technical trends of once-through boilers are summarized in the following.

See Figure 2.

Table 1

Boiler Classification		Steam Boiler* <sup>1</sup>	Hot Water Boiler	Once-through Boiler* <sup>4</sup>
Simplified Boiler		Boiler pressure $\leq 0.1$ MPa, with heat transfer area $\leq 0.5$ m <sup>2</sup>	Boiler pressure $\leq 0.1$ MPa, with heat transfer area $\leq 4$ m <sup>2</sup>	Boiler pressure $\leq 1$ MPa, with heat transfer area $\leq 5$ m <sup>2</sup> * <sup>2</sup> , * <sup>3</sup>
Small Boiler		Boiler pressure $\leq 0.1$ MPa, with heat transfer area $\leq 1$ m <sup>2</sup>	Boiler pressure $\leq 0.1$ MPa, with heat transfer area $\leq 8$ m <sup>2</sup>	Boiler pressure $\leq 1$ MPa, with heat transfer area $\leq 10$ m <sup>2</sup> * <sup>2</sup> , * <sup>3</sup>
			Boiler pressure $\leq 0.2$ MPa, with heat transfer area $\leq 2$ m <sup>2</sup>	
Boiler	Small in scale	Heat transfer area $\leq 3$ m <sup>2</sup> , regardless of pressure	Heat transfer area $\leq 14$ m <sup>2</sup> , regardless of pressure	Heat transfer area $\leq 30$ m <sup>2</sup> , regardless of pressure* <sup>3</sup>
		Boilers that do not comply with the above definitions	Boilers that do not comply with the above definitions	Boilers that do not comply with the above definitions

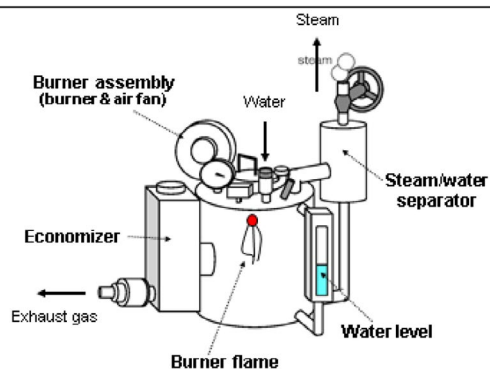
\*1) Some steam boilers are classified by drum dimensions.

\*2) Once-through boilers classified as simplified boilers and small boilers have internal header diameter  $\leq 150$  mm.

\*3) A dimensional limit is placed on the steam separator of once-through boilers of small-scale boilers or smaller

\*4) The Industrial Safety and Health Law of Japan classifies water-tube boilers that have a steam separator and that subsequently return hot water to a heating tube as once-through boilers in cases where the total amount of water at the inlet of the heating tube is not greater than twice the maximum volume of feed water.

### Small Once-through Boiler



Low boiler space, High fuel efficiency, Quick start-up

Fig. 2

#### (1) Increased Evaporation

The evaporation achieved by small once-through boilers was initially around 350 kg/h, but some models presently manufactured in Japan can achieve evaporation of 2 t/h to 2.5 t/h.

#### (2) Higher Boiler Efficiency

The use of an economizer (waste heat recovery equipment) has increased boiler efficiency from approximately 70% to as much as 95%–96%. Boilers with efficiency greater than 100% (on the basis of lower heating value) are also available, by installing economizers to recover latent heat from water vapor in exhaust gas.

#### (3) Improved Combustion Burner

Burners have been developed that respond better to fluctuations in load, such as a low-NO<sub>x</sub> burner.

burners with a high turn-down ratio. those designed for combustion at a low air ratio. and those with a turn-down ratio of 6:10 from low and high combustion loads.

#### (4) Improved Control of Boiler Operation and Optimal Number of Boilers

Remote monitoring and control (control of the number of boilers for efficient operation in low-load zone) has



improved operational efficiency.

(5) Energy Conservation through use of Inverter with Exhaust Fan

### 3. Introduction of Energy Conservation Cases with High-efficiency Once-through Boiler

The following cases show the application of energy conservation technologies previously listed in section 2.

(1) Once-through boiler featuring wide combustion zone with burner for fully-premixed surface-stabilized combustion and condensing (Hirakawa Corporation)

Energy conservation technology 1-(2)-a,b,c

(2) System comprising multiple compact once-through boilers, combined with optimal-efficiency monitoring (Miura Co.,Ltd.)

Energy conservation technology 1-(2)-a,b,c,d,e

(3) Compact, gas-fired once-through boiler with jet-film combustion, featuring low air ratio (Nippon Thermoener Co.,Ltd. and Takuma Co.,Ltd.)

Energy conservation technology 1-(2)-a,b,c ■

## BAT2-1: Once-through Boiler Featuring Wide Combustion Range with Burner for Fully-premixed Surface-stabilized Combustion and Condensing

### 1. Business Categories Adopting this Technology

General

### 2. Classification of Technology

High-efficiency boiler

### 3. Energy Source

City gas

### 4. Year of Commercialization

2011

### 5. Overview

This is a once-through boiler featuring low NO<sub>x</sub> emissions and high efficiency, incorporating the FPSCC technology (fully-premixed surface-stabilized combustion and condensing). Fuel gas and combustion air are fully premixed before feeding to the burner, achieving surface-stabilized combustion and condensing, which forms short, stabilized flames uniformly across a relatively large flame-forming surface of the burner, and for 'recovery of latent heat.'

Using this type of burner enables stable combustion across the entire burner surface, via which the once-through boiler can modulate burner output and control combustion over a wide range up to a low firing area (turn-down ratio 10:1).

### 6. Principles and Operation

#### (1) Wide Combustion Range

Conventional once-through systems meet the heat demand by operating multiple boilers that use three-stage control after ignition, namely: high firing, low firing, and stop. The combustion control widths (turn-down ratios) of conventional boilers are about 3:1, in some cases requiring frequent starts and stops when the heat demand is low. Post-purging and pre-purging are performed to release both unburned gases and high-temperature air from within the boilers, resulting in start- and stop-losses due to cooling of the boiler and lowering of the efficiency.

In order to optimize the burner devices and peripheral equipment, the boiler features modulating combustion control at a wide turn-down ratio of 10:1, allowing continuous combustion down to 10% of the rated capacity. Compared

with conventional once-through boilers,the newly-developed boiler reduces start-stop heat losses,resulting in improved boiler efficiency.

## (2) High Efficiency

The boiler structure features an enlarged heating surface that maximizes absorption of heat input,and its waste-heat recovery unit is equipped with a feed-water preheater (economizer) that can recover even latent heat. Additionally,a good match is attained between the boiler itself and the burners,to maintain stable efficiency across the entire combustion range described in (1),thereby achieving a high boiler efficiency of more than 102% (on the basis of lower heating value) over the entire combustion range.

## (3) Low NOx Emissions

Featuring metal fibers that have a sufficiently large surface area,the fully-premixed surface-stabilized combustion and condensing burner achieves uniform lean combustion of premixed air and fuel gas with short flames so as to control the locally generated high-temperature parts that create thermal NOx in the flames,thereby reducing NOx emissions ( $O_2 = 0\%$  conversion) to

less than 25 ppm across the entire combustion range.

## 7.Improvements to Boiler Structure

See Figure 1.

## 8.Effects of Improvement on Energy Consumption Rate (Option for improvement in energy conservation Rate)

See Table 1.

## 9.Economic Efficiency and Changes

(1) Initial investment cost	Not available
(2) Remodeling cost	Not available
(3) Operational costs	-9,088,000 JPY/year → 24,744,000 JPY/year -4,344,000 JPY/year
(4) Investment recovery (years)	Not available

## 10.Market Conditions and Conditions

(1) Present market penetration rate	Not available
-------------------------------------	---------------

### After Improvement

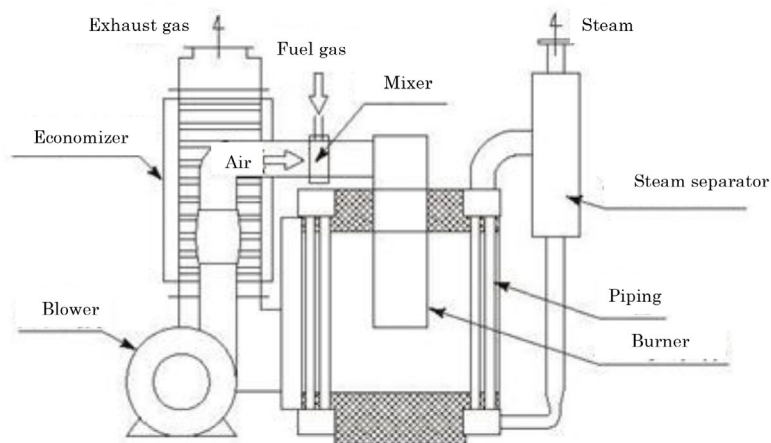


Figure 1 Boiler Structure



(2) Forecast market penetration in 2017 (or 2020)

Not available

## 11. Additional Information for Reference

(1) CO<sub>2</sub> emission reduction 130 t/year

(2) Social impacts and other factors

1) History of awards received

•2011 Excellent Energy Conservation Equipment Award, on behalf of the president of the Japan Machinery Federation

2) Literature

•Monthly publication: 'Energy Conservation,' May 2012, page 60.

## 12. Bibliography and Reference Information

(1)'2011 Excellent Energy Conservation Equipment,' Monthly publication: 'Energy Conservation,' Vol. 64, No. 5, May 2012, page 60, The Energy Conservation Center, Japan

(2) Information from Hirakawa Corporation

## 13. For More Information, Please Contact:

Mr. Hiroshi Matsumoto, Director, Planning Office, Management Division, Hirakawa Corporation

Telephone: +81-6-6458-8687

email: h\_matumoto@hirakawag.co.jp ■

Table 1. Comparative Economic Efficiencies of Conventional and Newly Developed Boilers

		Conventional Boiler	Newly Developed Boiler	Difference
Equivalent evaporation	Kg/h	2,500	2,500	-
Boiler efficiency (LHV)	%	96	102	+6
Feed water temperature	°C	15	15	-
Operational efficiency	%	86.9	100.6	+13.7
Fuel (City gas 13A)				
Fuel consumption	m <sup>3</sup> N/h	144.7	136.0	-8.7
Unit price of fuel	JPY/m <sup>3</sup> N	70	70	-
Annual fuel charge	JPY/Year	28,198,017	24,324,262	-3,873,755
Electricity				
Power consumption	kWh	5.3	2.5	-2.8
Unit price of electricity	JPY/kWh	20	20	-
Annual electricity cost	JPY/Year	894,000	420,000	-470,400
Total fuel and electricity costs	JPY/Year	29,088,117	24,744,202	-4,344,155
CO <sub>2</sub> emissions	t-CO <sub>2</sub> /Year	910	780	-130

\* The operating conditions are based on a 30% load factor and boiler operating 24 hours per day, 350 days per year.

## BAT2-2: Multiple Installation (MI) System of Small Once-through Boilers with Optimal-efficiency Operation Function

### 1. Business Categories Adopting This Technology

General

### 2. Classification of Technology

High-efficiency boiler

### 3. Energy Source

City gas, LPG

### 4. Year of Commercialization

2010

### 5. Overview

According to the result of a load analysis made by Miura Co.,Ltd,the average load factor of steam systems is about 20% to 50%. However,the new SQ boiler series drastically improves the system efficiency in this load region. The efficiencies of boilers vary with operating conditions,and boilers have a combustion point known as the 'Eco-Operation Point,' at which the efficiency shows the highest values in accordance with the operating conditions. In relation to this,boiler system efficiency significantly improves when

boilers preferentially perform combustion at the 'Eco-Operation point.'A system efficiency of 100% has been achieved in the case where even latent heat in exhaust gases has been recovered.

### 6. Principles and Operation

(1) Development of New Combustion Control System 'High Speed Multi-Position Step Control'

The efficiency of a boiler varies with its operating conditions (boiler load factor,feed-water temperature,and steam pressure),and boilers have a combustion point at which the efficiency shows the highest values in accordance with the operating conditions. Miura Co.,Ltd. named the combustion point at which the efficiency becomes the highest,the 'Eco-Operation point,' and have developed 'High-speed multi-position control' technology that features a combustion output tailored to the eco-operation point.

Expanding the turn-down ratio to 1:5,combustion outputs of 0%–20%–45%–100% have been achieved. The rated efficiency (boiler load factor 100%,steam pressure 0.49 MPa,feed water temperature 15°C,and an air supply temperature of 35°C) has attained an efficiency of

98%,thereby delivering an improvement of 2% compared with conventional models manufactured by Miura Co.,Ltd.

## (2) Development of New MI Control System

Miura Co.,Ltd. has developed a new system to control the number of boilers (patented),known as the 'MI control system,'which maximizes the eco-operation point effect.

The new system controls the number of boilers in order to maximize how many boilers are operating at the eco-operation point,resulting in the drastic increase of system efficiency. An increase in the number of boilers combusting at the eco-operation point reduces power consumption through the inverters (which are installed as a standard specification).

## (3) Development of New Economizer

A new economizer (of the down-flow type) that enhances the latent-heat recovery effect has been developed.

## 7. Improvements Made

### Before Improvement

(1) Development of New Combustion Control System

(2) Development of New Economizer

See Figure 1.

### After Improvements

(1) New combustion control system

(2) Development of new MI control system

(3) Economizer of new type

See Figure 2&3.

## 8. Effects of Improvement - Improvement in Energy Consumption Rate (Option for Improvement in Energy Conservation Rate)

See Table 1.

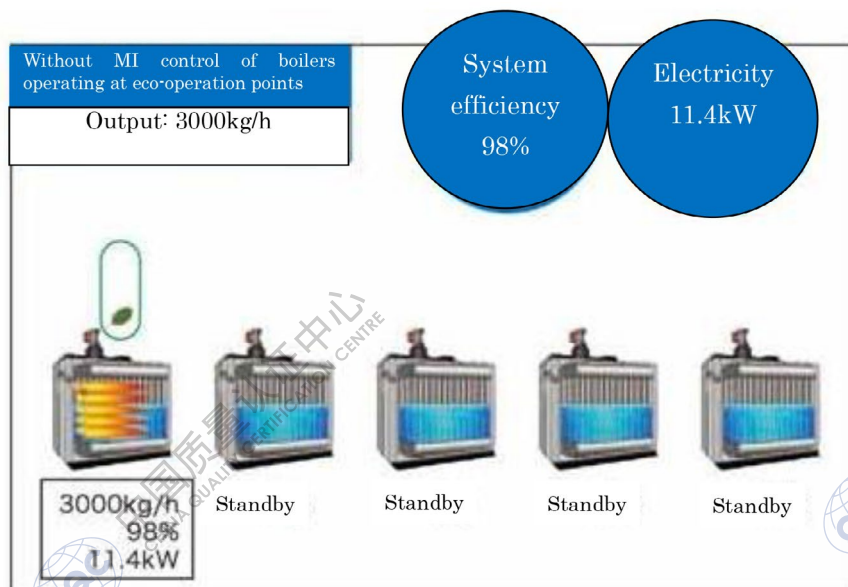


Figure 1



## 9. Economic Efficiency and Changes

(1) Initial investment cost: 40 million to 50 million JPY

(2) Remodeling cost:

(3) Running costs: (5 units)

Fuel: -8,254,000 JPY/year

Electricity: -579,000 JPY/year

Total for 5 units: -8,833,000 JPY/year

(4) Number of Years Required to Recover Investment:  
Approximately 5 years

## 10. Market Situations and Conditions

(1) Penetration rate at present:

46% (actual rate achieved in 2013)

(2) Forecast of penetration in 2017 (or 2020):

Data not currently available

## 11. Additional Information for Reference

(1) CO<sub>2</sub> emission reduction: 304 tons/yr (for 5 units)

(2) Social impacts and other factors

1) History of Awards Received

• Recipient of the 2010 Excellent Energy Conservation Equipment Award

( Japan Machinery Federation):awarded by the president of the Japan Machinery Federation.

2) Literature

• Monthly publication of 'Energy Conservation,' (April 2011),pp. 70-71.

## 12. Sites Adopting This Technology

Nara Plant of Taihei Food Co.,Ltd.

Change from a flue and smoke tube boiler to 7 units of SQ-3000AS + BP-201ST

(1) Higher boiler efficiency: 84.8% → 96.5%

(2) CO<sub>2</sub> reduction: 37% reduction

(3) Labor-saving: Daily management is outsourced to maintenance servicing of Miura Co.,Ltd. (program ZMP-SL)

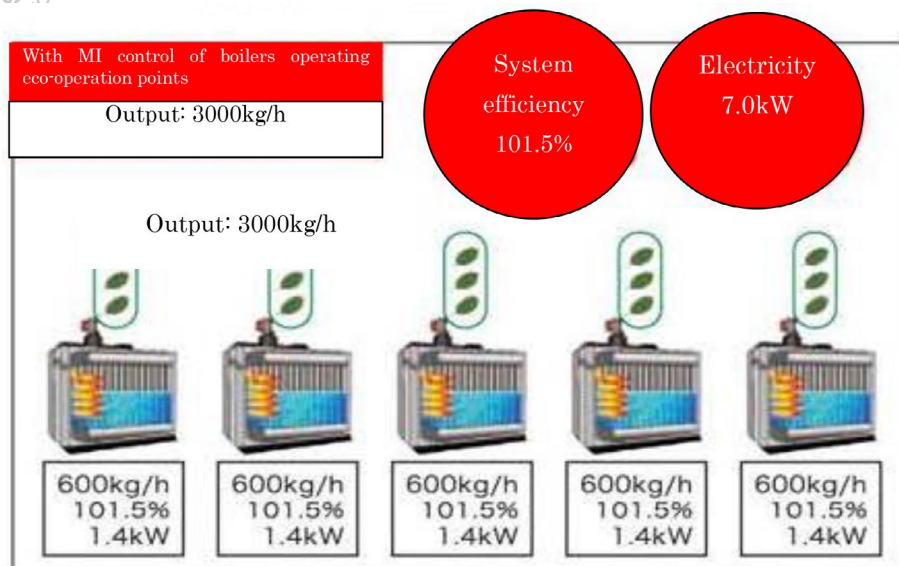


Figure 2

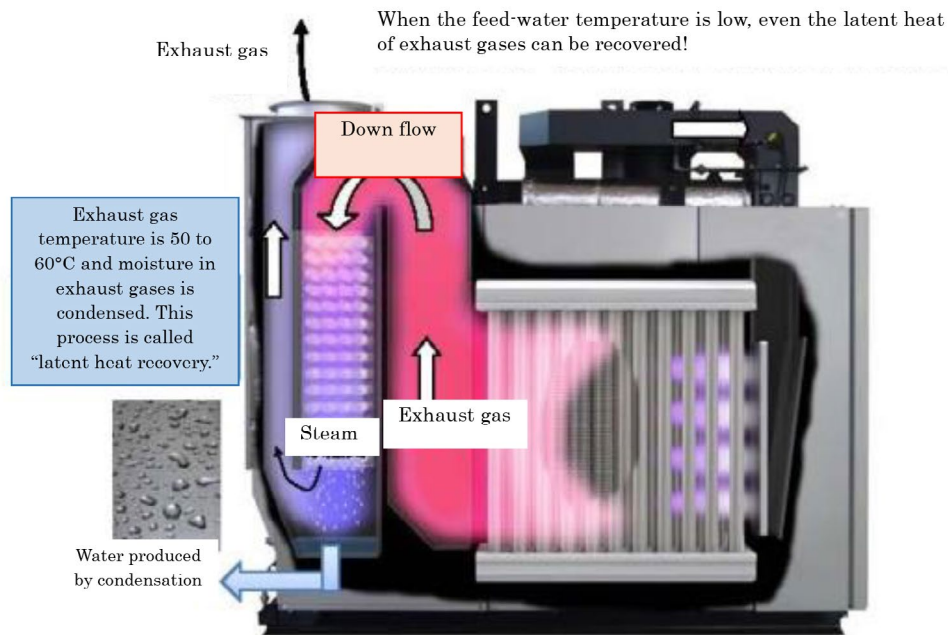


Figure 3

Table 1 Calculation of an Example of Fuel Costs and CO<sub>2</sub> Emissions for a Steam System with a  
Total Capacity of 15 t/h

System	Conventional System	New SQ-3000 model x 5 Units	Difference
Amount of Steam [t/Year]	26,280	26,280	—
System Efficiency [%]	92 (Estimated)	100	+8 points
Fuel Consumption [m <sup>3</sup> N]	1,587,000	1,460,000	-127,000 m <sup>3</sup> N
Fuel Cost [Thousand JPY/Year]	103,173	94,919	-8,254,000 JPY
Electricity Consumption [kWh]	99,864 kWh	61,320 kWh	-38544 kWh
Electricity Charge [Thousand JPY/Year]	1,498	919	-579,000 JPY
CO <sub>2</sub> Emissions [t-CO <sub>2</sub> /Year]	3,668	3,364	-304 t-CO <sub>2</sub> /Year

Calculation Conditions: System load factor 20%, fuel city gas 13A (JPY65/m<sup>3</sup>N, 2.29kg-CO<sub>2</sub>/m<sup>3</sup>N) Electricity Charge: JPY 15/kWh, 0.339kg-CO<sub>2</sub>/kWh



(4) Saving of floor space: Approximately 50% space saved by changing the flue and smoke tube boiler to a small once-through boiler.

### 13. Bibliography and Reference Information

'2010 Excellent Energy Conservation Equipment,' Monthly publication 'Energy Conservation', Vol. 63 No. 4, April 2011, pp 70-71, The Energy Conservation Center, Japan.

### 14. For More Information, Please Contact:

The Maintenance Service Sales Promotion Department Miura Co., Ltd.

7 Horiecho, Matsuyama, Ehime Prefecture 790-2696 Japan

Telephone +81-89-979-7000.

Fax +81-89-978-2321

<http://www.miura.co.jp> ■



## BAT2-3: Small Gas Fired Once-through Boiler

### 1. Business Categories Adopting This Technology

General

### 2. Classification of Technology

High-efficiency boiler

### 3. Energy Source

City gas

### 4. Year of Commercialization

January 2009

### 5. Overview

Using conventional technology simultaneous control of CO and NO<sub>x</sub> at a low air ratio has been difficult in compact once-through boilers with a large thermal load to the combustion chamber. Air ratios of about 1.3 (exhaust gas O<sub>2</sub>: 4.9%) have been the limit. In general, the heat transfer area of the economizer has been increased to achieve a high efficiency. Aiming to achieve both high efficiency and low power consumption through combustion at a low air ratio, the new type of small, gas-fired boiler uses a once-through design with a unique, independently developed jet-film burner

to simultaneously control CO and NO<sub>x</sub>. The new boiler redefines performance expectations for both high-efficiency combustion and low environmental load at an ultra-low air ratio of 1.17 (O<sub>2</sub> concentration in exhaust gas = 3%), which could not be achieved by the conventional technology.

### 6. Principles and Operation

A unique jet-film combustion technology has been developed to simultaneously control CO (complete combustion) and NO<sub>x</sub> (control of high-temperature combustion) while the burner and combustion chamber have been optimized to simultaneously accomplish low CO and NO<sub>x</sub> emissions.

Figs. 1 and 2 illustrate the cross-sections of the burner and combustion chamber, respectively.

### 7. Improvement Made

Sweep filter dust and to form a flow at high speed and the upstream side of the burner into the combustion chamber, to form a self-recirculating gas flow. This is mixed with thin-film flames thereby controlling the flame temperature and thermal NO<sub>x</sub> emission.

High-speed jetting accelerates the mixing of fuel gas and

air,allowing control of CO even at low air ratio.

## 8.Effects of Energy Consumption Rate (Option for Improvement of Energy Conservation Rate)

By changing the air ratio (which was previously limited to 1.3) for combustion to an ultra-low ratio of 1.17 ( $O_2$  concentration in exhaust gas = 3.0%),the rated boiler efficiency has been improved from 96% in the past to 98%. Additionally,by

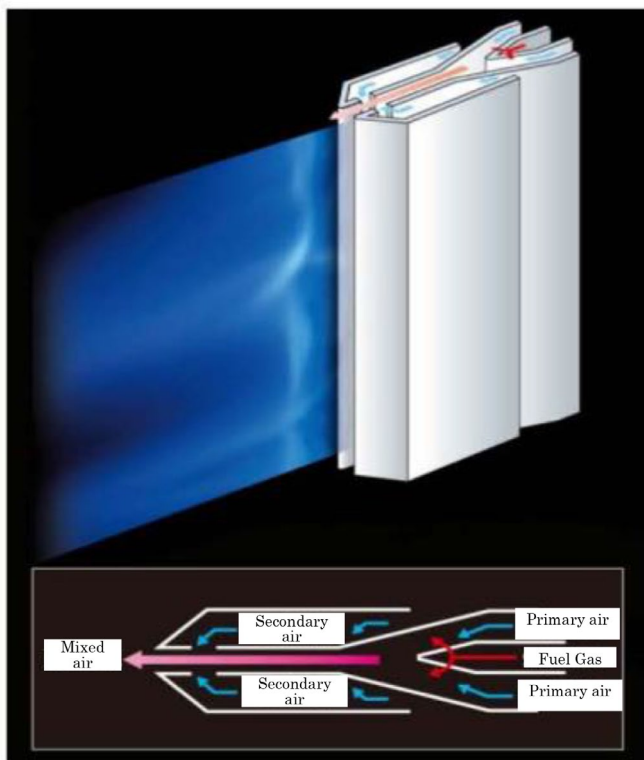


Fig. 1 Cross section of burner

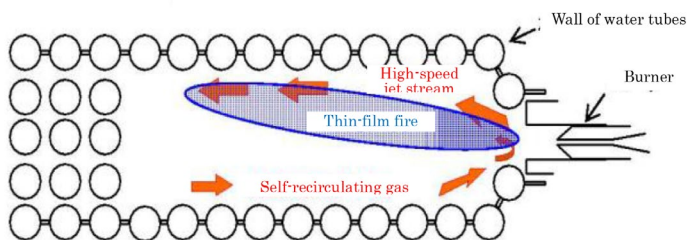


Fig. 2 Cross section of combustion chamber

improving the turn-down ratio,the efficiency at low load and significantly improved by 20% at a 20% load.

The power consumption of the blower has been reduced by between 22% and 45% by operating at low air ratio and installing an inverter with the blower.

Refer to Figure 3,4 & table 1.

High-efficiency operation is feasible with this boiler through four-stage control of combustion under the following conditions: stop (0% load),low combustion (20% load),medium combustion (50% load),and high combustion (100% load). Compared with boilers of the conventional type (three-position control at 0,50,and 100% loads),operational efficiency is dramatically increased,especially within the low load region of 20%–50%.

By installing multiple units of this boiler,and by controlling the number of boilers in combustion,large capacities can be

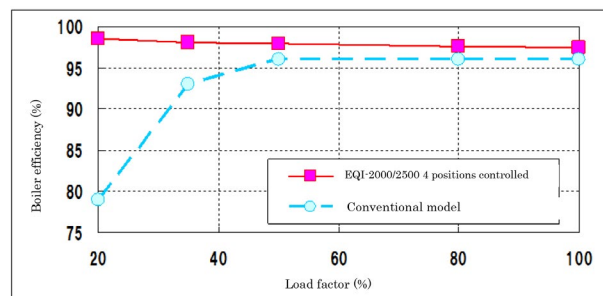


Fig. 3

Table 1 Comparison of efficiency between conventional and new boilers

Load factor	Boiler Efficiency (%)		Efficiency Improvement Ratio
	EQI	Conventional model	
20%	98.0	79.0	20%
35%	98.0	93.0	5%
50%	98.0	96.0	2%
80%	98.0	96.0	2%
100%	98.0	96.0	2%

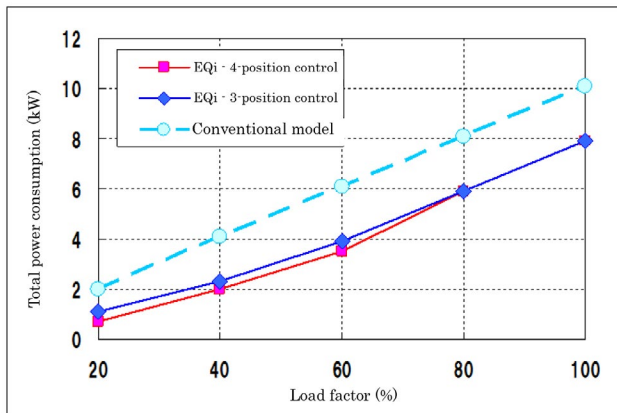


Fig. 4 Comparison of power consumption between conventional and new boilers

achieved. In this operational mode, settings are established to increase the number of boilers operating at low-to-medium load, because operation within this load range gives high boiler efficiency and low power consumption.

See Figure 5.

## 9. Economic Efficiency and Changes

(1) Initial investment cost: Not available (Cost is lower than conventional boilers)

(2) Remodeling cost: Not available

(3) Operating costs

Fuel	-420,000 JPY/year
Electricity	-110,000 JPY/year
Total	-530,000 JPY/year

(4) Repayment period 0 year

See Table 2.

## 10. Market Situations and Conditions

(1) Current market penetration rate for new boiler type:

Total number of boilers shipped (from 2009 to first half of 2014) = 350 units.

A: Annual shipment of new boiler type = 85 boilers/year (2011 to 2013 average).

B: Annual shipments of small, once-through boilers = 4,000 boilers/year (2011 to 2013 average).

C: Market penetration ratio of new boiler type =  $A/B = 2\%$

(2) Forecast total shipments of new boiler type to 2017 = 800 units.

Forecast annual shipments of new boiler type = 135 units/year

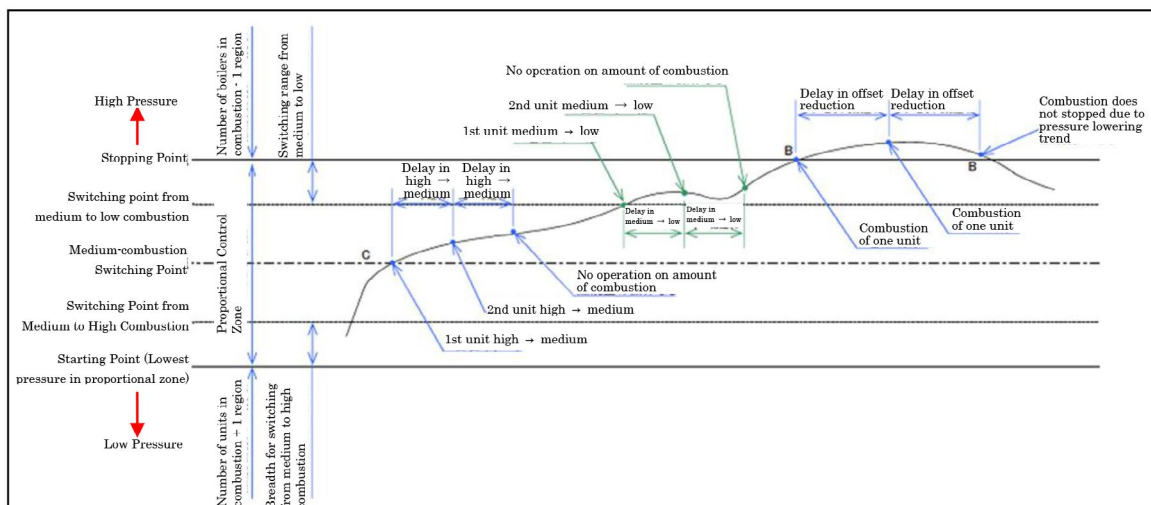


Fig.5 Example of number of units in combustion in 4-position multi-stage operation in pressure control consumption.



Table 2 Comparative operating costs of conventional and new models

Parameter	Conventional Model	New boiler
Heat output	1,250 kW	
Annual load factor	50%	
Boiler efficiency	96%	97.5%
Annual fuel saving	7,000 m <sup>3</sup> (N)/year	
Annual fuel cost advantage	Approximately 420,000 JPY/year	
Rated power consumption	5.1 kW	2.8 kW
Annual electricity saving	10,000 kWh	
Annual electricity cost advantage	Approximately 110,000 JPY/year	
Annual reduction of CO <sub>2</sub> emissions	Approximately 20 t-CO <sub>2</sub> /year	

(penetration rate 3%).

Forecast total shipments of new boiler type to 2020 = 1,300 units.

Forecast of annual quantity of this boiler shipped = 180 units/year (penetration rate 5%).

## 11. Additional Information for Reference

(1) CO<sub>2</sub> emission reduction

20 t/year (heat output = 1,250 kW)

(2) Social impacts and other factors.

1) History of Awards Received

- Recipient of 2010 Excellent Energy Conservation Equipment Award (on behalf of the president of the Japan Machinery Federation).

- 2011 Excellent Technology Award (Combustion Society of Japan).

- 2011 Excellent Environmental System Award (on behalf of the president of the Japan Society of Industrial Machinery Manufacturers).

2) Literature

- 'Industrial Machinery,' No. 698 (Nov. 2008, page 15)

- 'Environment and Energy,' (April–May 2010, page 47)

- 'Boiler Research,' No. 361 (June 2010, page 16)

- Monthly publication 'Energy Conservation,' N (April 2011, page 74)

- 'Industrial Machinery,' No. 733 (Oct. 2011, page 19)

- Journal of Combustion Society of Japan, Vol. 54, No. 167 (Feb. 2012, page 6)

- 'Industrial Machinery,' No. 746 (Nov. 2012, page 44)

## 12. Sites Adopting This Technology

Sales networks deployed in Thailand and Japan

## 13. Bibliography and Reference Information

'2010 Excellent Energy Conservation Equipment,' Monthly publication 'Energy Conservation,' Vol. 63, No. 4, April 2011, pages 74 and 75, The Energy Conservation Center, Japan

## 14. For More Information, Please Contact:

Nippon Thermoener Co., Ltd. and Takuma Co., Ltd. ■

## BAT3: Cogeneration System



### 1. Business Categories Adopting This Technology

N/A

### 2. Classification of Technology

N/A

### 3. Energy Source

Natural gas

### 4. Year of Commercialization

December 2007

### 5. Overview

- The power generation efficiency of standard type engines (KG series) is 48.5%. The power generation efficiency of the high-efficiency type (KG-V series) is 49.0% (LHV-base).
- NO<sub>x</sub> emissions are low at 200 ppm or less (converted at O<sub>2</sub> = 0%) and environmental performance is high.
- The continuous operation range is wide, ranging from 30% to 100% load. The engine uses the spark ignition method and does not require a liquid pilot fuel. The output range is 5 to 7.8 MW<sup>2</sup> and covers varied output requirements.
- Power generation can be started within three minutes after starting the engine. The rated output can be reached within ten minutes.

- The engine is completely developed by in-house technology and manufactured in the mother factory in Japan. Therefore, the engine can flexibly meet various customer requirements. The engine has better power-to-weight ratio and excels in transportability and installability. Refer to table 1.

### 6. Principles and Operation

- The engine is ignited by the spark ignition method using a spark plug. The pre- and main-combustion chambers are independent in supplying gas, and optimum gas injection is achieved by a high-speed solenoid valve.
- The structure of the combustion chamber is designed with high anti-knocking performance. Ignition timing and gas amounts for each cylinder are individually controlled by the Knocking Analyzer and the Main Control Unit in order to maintain the performance of the engine at a maximum.
- In the KG-V series, suction pressure is controlled by a variable nozzle system, instead of the conventional bypass system, in order to achieve high efficiency through effective utilization of exhaust energy.
- Cogeneration system is applied using waste heat energy, making energy conservation feasible.

See Figure 1&2

Table 1

Type		KG-12	KG-18	KG-12-V	KG-18-V
No. of Cylinders		12	18	12	12
Power Generation Output kW	50Hz/750rpm	5,200	7,800	5,200	7,800
	60Hz/720rpm	5,000	7,500	5,000	7,500
NOx		200 ppm (O <sub>2</sub> = 0% equivalent) or less			
Power Generation Efficiency		48.5%		49.0%	

(On ISO 3046, 13A Gas Basis)

## 7.Improvements Made

See Figure 3&4

## 8.Effects of Improvement —Improvement in Energy Consumption Rate (Option for Improvement of Energy Conservation Rate)

See Figure 5&6.

## 9.Economic Efficiency and Changes

Assuming a gas charge of 50JPY/Nm<sup>3</sup> to 70 JPY/Nm<sup>3</sup> for projects in Japan (cogeneration system,power generation + steam supply)

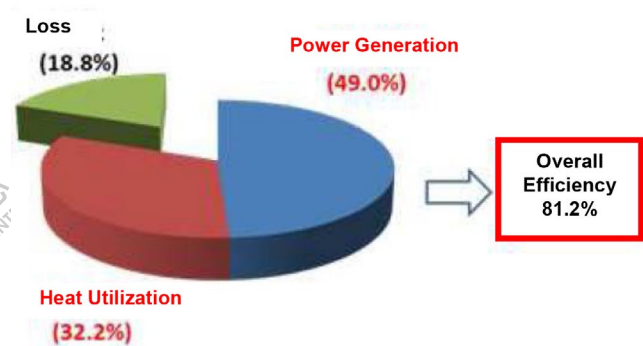
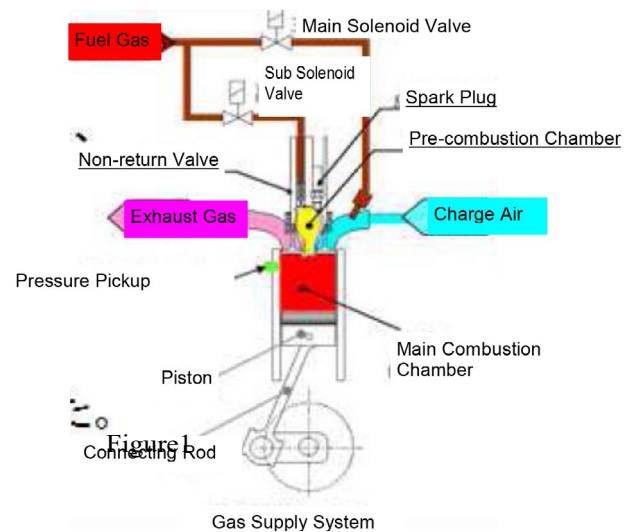
- Economical merit in installing cogeneration system: 3.8JPY/kWh to 6.9 JPY/kWh
- Payback period: 3 to 6 y.

## 10.Market Situations and Conditions

(1)Penetration rate at present: Record of engines delivered as of September 30,2014:

- Japan: The market share of Green Gas Engines in the large gas engine market of Japan is nearly 100%.
- Outside Japan: Green Gas Engines have been delivered to Singapore,India,and the United States

(2) Forecast of penetration in 2020: 300 engines as a cumulative total.





## Before Improvement

### Conventional System (KG Series)

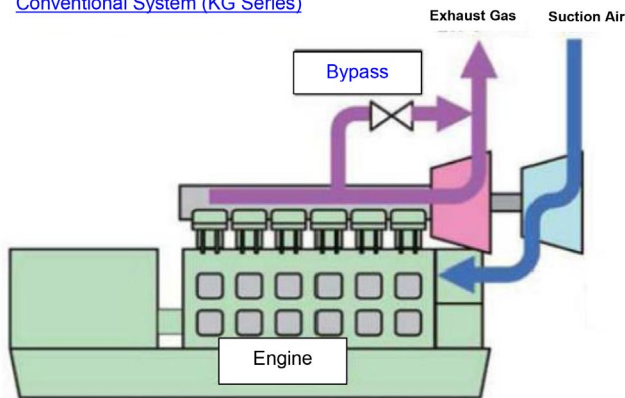


Figure3

## After Improvement

### Variable Nozzle System (KG-V Series)

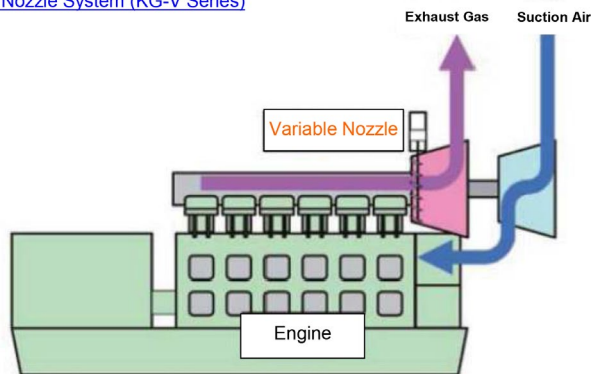


Figure4

## 11.Additional Information for Reference

### (1)CO<sub>2</sub> Emission Reduction

The overall efficiency varies in accordance with the waste-heat recovery applications. The specifics of the efficiency are as follows:

Power generation + Steam + Hot water: 77.1%

Power generation + Hot water: 81.2%

Power generation + Cold water: 74.7%

### (2)Social Impacts

Green Gas Engines have been put into operation at the Kobe Works of the Kawasaki Heavy Industries since January 2010. The engines were initially used for research,development,and demonstration purposes. The engines contributed to cutting the peaks in power demand loads as on-site power generation equipment. Thus,they contributed to the prevention of rotating blackouts within the service areas of the Kansai Electric Power Co.

## 12.Sites Adopting This Technology

A power plant has been installed on the premises of the Kobe Works of the Kawasaki Heavy Industries.

## 13.Bibliography and Reference Information

JASE-World,Collection of Technologies Used at International Sites (F-22)



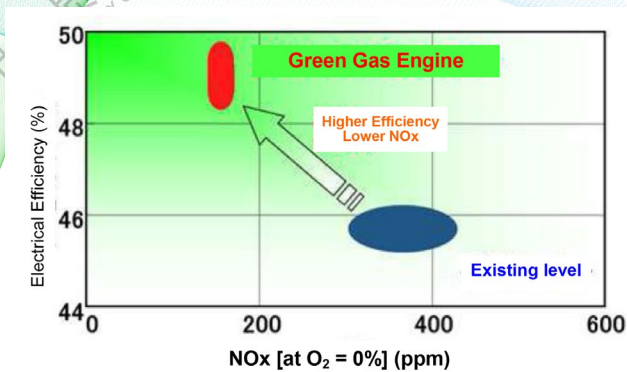


Figure 5

14. For More Information, Please Contact

Energy Solution Division, Gas Turbine & Machinery  
Company, Kawasaki Heavy Industries, Ltd.

Telephone: +81-3-3435-2211, Fax: +81-3-3435-2022

<http://www.khi.co.jp/> ■

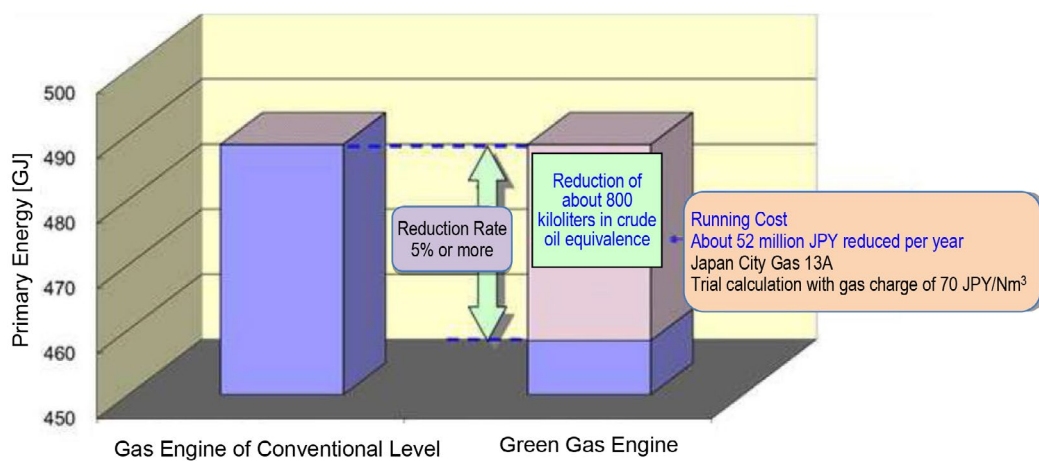


Figure 6

## BAT4: High-performance Industrial Furnace (Regenerative Burner)

### 1. Business Categories Adopting This Technology

Iron and steel, nonferrous metals

### 2. Classification of Technology

Waste heat recovery (medium to high temperature)

### 3. Energy Source

Fuel gas

### 4. Year of Commercialization

1992

### 5. Overview

The technology is applied to industrial furnaces and other heating facilities. The system consists of a pair of regenerative burners. Each regenerative burner unit comprises a burner portion and a regenerator made of heat-resistant ceramic. The two burners are fired alternately. As one burner is fired, the other idling unit recovers sensible heat from the firing regenerator's high-temperature exhaust gas, which preheats the combustion air in the idling unit to a high temperature, thereby achieving a significant reduction in fuel gas consumption when the idling unit is switched to the combustion mode.

In addition, the high-temperature combustion technology

based on this technology also realizes a drastic reduction in thermal NO<sub>x</sub> generation.

### 6. Principles and Operation

(1) The high-temperature exhaust gas generated by combustion in one unit of a pair of regenerative burners is passed into the regenerator of the other idling regenerative burner, heating the latter regenerator. After transferring heat to the regenerator, the lower-temperature exhaust gas is discharged to the flue. (See Fig. 1)

(2) Next, the burner of the idling unit begins combustion with high-temperature combustion air that was highly preheated by passing through the heated regenerator. At the same time, the other regenerative burner stops burning fuel and is switched to idling mode to heat its own regenerator by recovering sensible heat from the firing unit's exhaust gas passing through its regenerator. (See Fig. 2)

Thus, as described above, combustion with high-temperature preheated air and the recovery of sensible heat from exhaust gas to preheat the combustion air are performed alternately by each unit.

(3) Preheating the combustion air drastically reduces fuel consumption. Moreover, this high-temperature combustion with an improved burner design creates burning conditions that mitigate a thermally intensified combustion spot, which



results in lowering the maximum flame temperature and hence reducing thermal NOx generation.

## 7.Improvement Made

### Before Improvement

In the case of a conventional steel reheating furnace for steel slabs etc.,the combustion exhaust gas is discharged from the charging side of the furnace and passes through a metal recuperator. After preheating the combustion air in the recuperator,the exhaust gas is discharged through a stack. Due to the conditions of the metallic recuperator,including the thermal constraints of its materials,the temperature of the preheated air is limited to several hundred °C (See Fig. 3).

### After Improvement

The ceramic regenerator of the regenerative burner drastically increases the upper temperature limit of the preheating air relative to a metal recuperator,allowing combustion air to be preheated to over 1,000°C in the high-temperature heating zone

(soaking zone).

Heat is recovered by each unit of a pair of burners so that heat can be recovered by selecting a desired heating zone. (See Fig. 4)

## 8.Effects of Improvement - Improvement in Energy Consumption Rate (Option for Improvement of Energy Conservation Rate)

The improvement effect varies greatly depending on the type and size of the furnace. According to data collected at the integrated steelworks of JFE Steel Corporation,after installing the regenerative burners on steel reheating furnaces,fuel consumption was reduced by 9 to 56% and the annual total amount of energy saved was 29 to 294 TJ.

See table1.

## 9.Economic Efficiency and Changes

Published data or information on monetary amounts is not available.

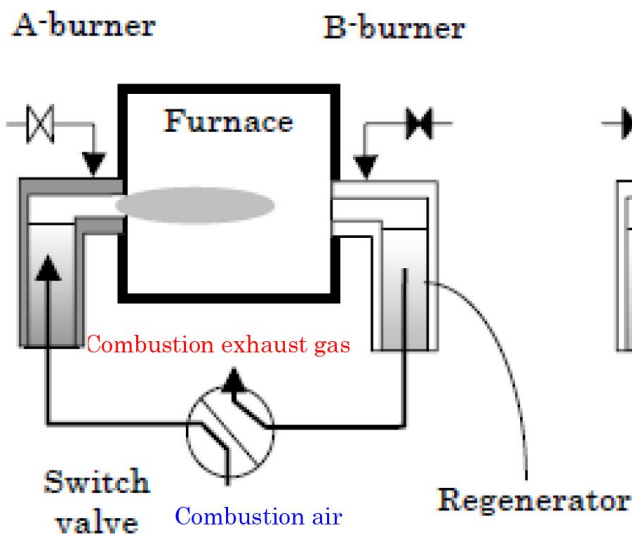


Figure 1

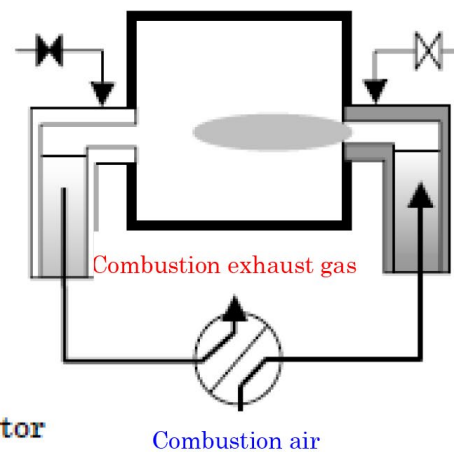


Figure 2

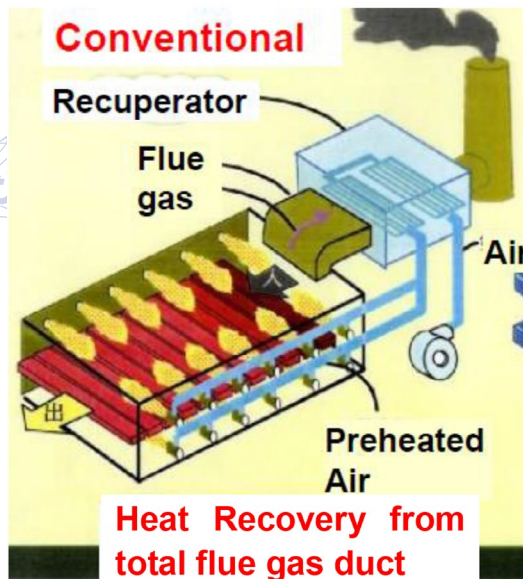


Figure 3

(1)+(2) Equipment investment cost and modification cost:

Published information is not available. However, these costs vary greatly depending on the equipment type and the size and scope of modification. They are estimated to typically range from approximately 10 million JPY to several hundred million JPY. In the case of Item No. 1 shown in Table 1 (Reheating

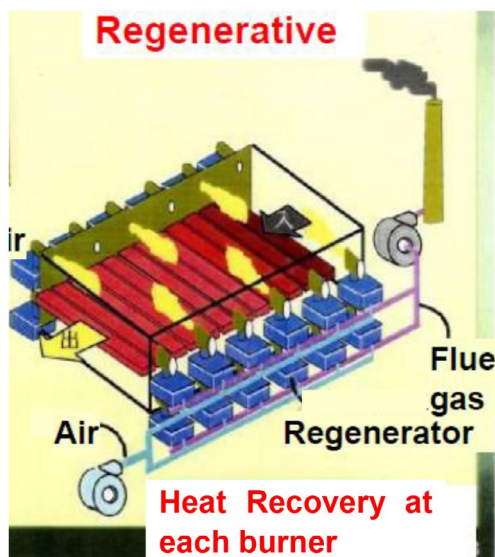


Figure 4

Furnace #3 of Hot Strip Mill #1, Fukuyama Steel Works), the initial investment level is estimated to be approx. 600 million JPY, whereas the annual energy conservation advantage is estimated to be approx. 150 million JPY based on the typical energy price level at the time when the regenerative burners were installed.

(3) Running costs:

As shown in Table 1, specific reductions in fuel amounts or operating costs achieved through the installation of regenerative burners vary greatly in accordance with the type and size of the facilities. The running costs include the cost of electric power to drive switch-over valves and other devices.

(4) Maintenance costs:

The increased maintenance costs compared with conventional burners include the repair costs of switch-over valves and the regenerators. However, the total maintenance cost is normally less than 3% of an investment amount.

(5) Payback years:

Available information indicates that compared to conventional burners, the cost difference of constructing a new reheating furnace equipped with regenerative burners can normally be recovered within approx. three years.

Energy prices such as the price of natural gas are increasing, and the potential for introducing/disseminating regenerative burners is high in India and other developing countries where steel mills are expected to be newly constructed or expanded.

## 10. Market Situations and Conditions

(1) Current dissemination rate

- In Japan, the new regenerative burners are installed in almost all reheating furnaces that are in continuous operation.
- In countries outside of Japan, Europe, and the USA, regenerative burners are not installed in most heating facilities for iron- and



Table 1 Summary of Effects

NO	Furnace	Burners	Reduction in Fuel		NO <sub>x</sub>
			▼%	▼TJ/Y	
1	Reheating Furnace #3, Hot Strip Mill #1, Fukuyama Steel Works	76	25	294	80
2	Ladle Heater for Electric Arc Furnace, Keihin Steel Works	2	56	29	
3	Batch-type Reheating Furnace #1, Steel Plate Mill, Fukuyama Steel Works	12	40	111	60
4	Reheating Furnace #1, Steel Plate Mill, Keihin Steel Works	16	13	212	31
5	Reheating Furnace #2, Hot Strip Mill #1, Fukuyama Steel Works	76	25	294	80
6	Batch-type Reheating Furnace #3, Steel Plate Mill, Fukuyama Steel Works	6	37	51	53
7	Reheating Furnace #1, Steel Plate Mill, Fukuyama Steel Works	30	9	65	44
8	Reheating Furnace #2, Steel Plate Mill, Fukuyama Steel Works	30	9	65	44

steel-making and nonferrous industries.

(2) Forecast of dissemination after 2017:

- It is expected that this technology will be well-disseminated because more manufacturers in the ferrous and non-ferrous industries could utilize regenerative burners if information on best practices could be collected and disseminated through this program. In particular, the potential to disseminate the ladle heater will be high because the investment required is relatively small and the modification is easy.

- The strong ability of this technology to drastically reduce thermal NO<sub>x</sub> makes the potential for dissemination higher, especially in developing countries where regulations on pollution control are expected to become stricter in the future.

- Introduction and dissemination of the regenerative burners is also possible in nonferrous industries such as processing and manufacturing plants that feature an ingot melting

process, including the process to re-melt aluminum ingots and recycled scrap.

## 11. Additional Information for Reference

### (1) Reduction of CO<sub>2</sub> Emissions

Depending on the energy balance and operation (energy mixture) of steel mills, the reduction of CO<sub>2</sub> emissions will be 55 tons/TJ in case of a reduction in consumption of purchased fuel (natural gas) through a reduction in fuel consumption through energy conservation.

### (2) Social Impact

This technology reduces the consumption of fossil fuels through higher efficiency alone and is extremely effective both in stable energy supply and in reducing the emission of greenhouse gases. Additionally, the technology is also effective in improving atmospheric environmental quality through reducing the generation of thermal NO<sub>x</sub> in exhaust gases.



## 12. Sites Adopting This Technology

Integrated steel works and the other steel mills in Japan including the Fukuyama and Keihin Steel Works of JFE Steel Corporation

## 13. Bibliography and Reference Information

(1) NKK Technical Journal No. 178 (August 2002) 'Eco-friendly Regenerative Burner Heating System Technology Application and Its Future View' ([http://www.jfe-steel.co.jp/archives/nkk\\_](http://www.jfe-steel.co.jp/archives/nkk_)

[giho/178/06.html](http://www.jfe-steel.co.jp/archives/nkk_giho/178/06.html))

(2) 'Regenerative Burner,' Nippon Furnace Co., Ltd.

## 14. For More Information, Please Contact

JFE Steel Corporation

Nippon Furnace Co., Ltd.

Chugai Ro Co., Ltd.

Japan Industrial Furnace Manufacturers Association ■

## BAT5: High Efficiency Inverters

### 1. Progress of inverter energy savings

In recent years, measures have been introduced for the prevention of global warming and depletion of energy resources, such as the Energy Conservation Law. As a result, energy use is under careful consideration in various fields. With the development of global environmental preservation and the growing interest in cost reduction through energy savings, the demand for saving energy through the use of inverter drives is increasing. Consequently, the technology associated with energy saving inverters has also progressed every year.

### 2. Energy savings from inverters

Power supplied from energy providers generally has an alternating current (AC) with fixed frequency and voltage. Therefore, when motors are driven by a commercial power supply, the rotational speed is fixed. However, the use of an

inverter will allow the rotational speed of the motor to vary.

The inverter converts the commercial power supply to a direct current (DC) (converter), followed by a return to an AC of variable frequency (inverter). The frequency and the voltage can be changed arbitrarily (Figure 1).

The rotational speed of the motor is proportional to the frequency. By varying the frequency and voltage applied to the motor by the inverter, the motor can be operated at variable speeds.

The load torque of fans and pumps is proportional to the square of their speed (air flow), and the output is proportional to the cube of their rotational speed (air volume). Therefore, if a machine with a variable load torque is controlled with an inverter, significant energy savings can be expected in comparison with the commercial operation (damper control\*2) (Figure 2).

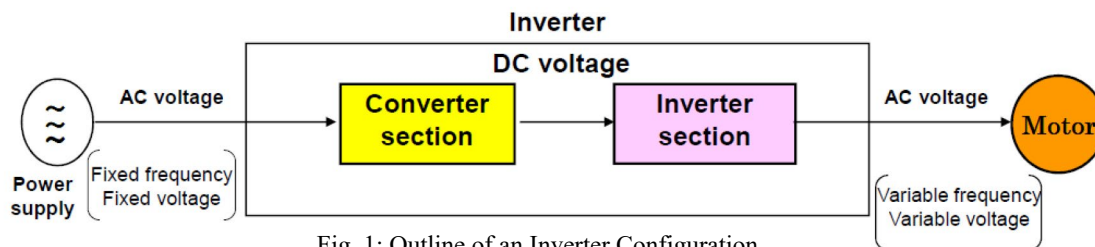


Fig. 1: Outline of an Inverter Configuration

[Example of blower operation characteristic]

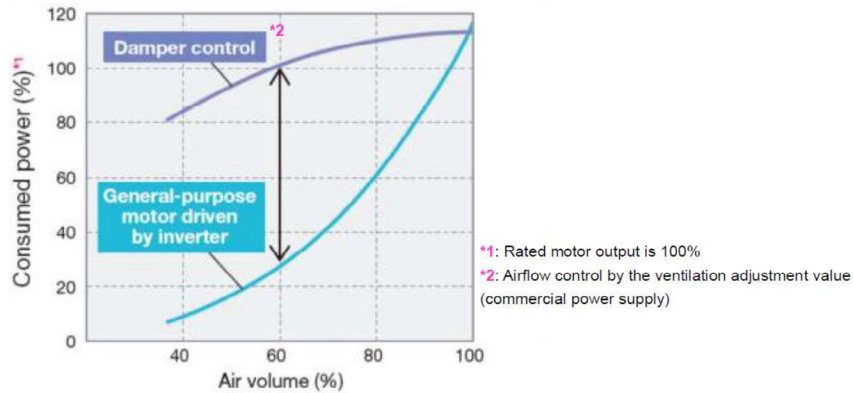


Fig. 2: Outputs with variable torque

### 3. Energy-saving technology of inverters

Modern inverters are equipped with energy saving technologies.

#### (1) Driving high-efficiency motors

As a recent highly effective method of energy saving, the Interior Permanent Magnet (IPM) motor has deterred attention away from induction motors. The IPM motor is a synchronous motor with embedded permanent magnets in the rotor. Induction motors apply a current to the rotor conductor in order to obtain a rotational force (torque). This generates a magnetic flux, which leads to a loss in the rotor (secondary copper loss). Because the IPM motors contain magnets, loss current does not flow in the rotor and secondary copper loss does not occur. The efficiency is improved compared with the induction motor.

IPM motors that are driven by a general-purpose inverter simplify inventory management through product integration. It is possible to change only the motor to an IPM motor at the time of motor renewal, and consequently, achieve further energy saving benefits.

#### (2) High-efficiency control of induction motors

A suitable efficiency control scheme has also been devised for the induction motor. Typically, V/F control is a constant ratio of the output frequency and the output voltage to the motor. By utilizing high-efficiency control to improve motor efficiency, it can be increased by more than 10%.

#### (3) Standby power reduction

By using DC24V externally, it is possible to only operate the

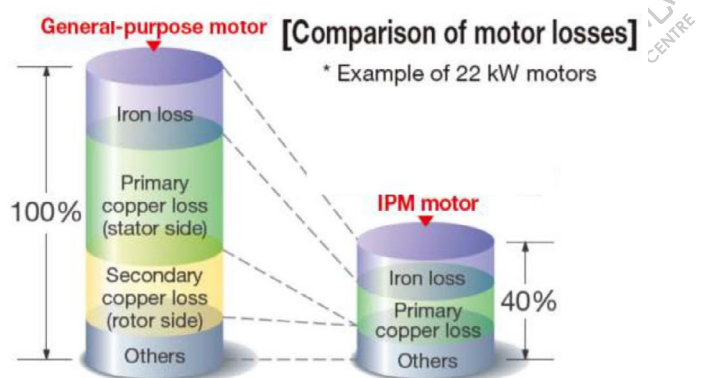


Fig. 3: Efficiency comparison



control circuit. While maintaining the parameter settings or communication, it is possible to turn off the main power supply to the circuit. This makes it possible to reduce standby power. Additionally, the operation of the cooling fan is controlled according to the temperature of the cooling fin of the inverter. This allows a reduction in the standby power by decreasing unnecessary fan operation.

#### 4. Application examples

In the following examples, the energy-saving effects of the inverter are shown:

- (1) Cooling water pump
- (2) Air conditioning for buildings ■

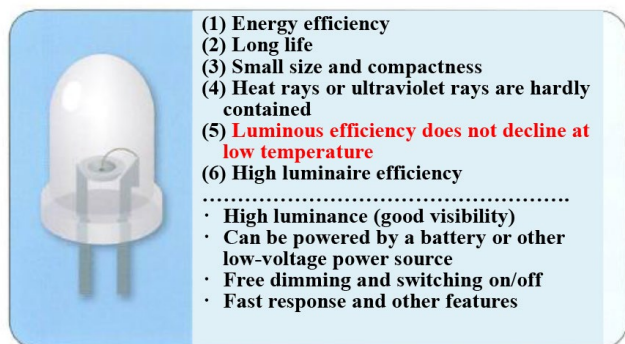
## BAT6: Application Expansion of High Efficiency Lighting

### 1. Evolution of LED Lighting Technology

The emergence of LEDs has extended the interest in lighting to a wide range of fields including design engineers involved in architectural facility design, architectural designers, lighting consultants, organizations promoting energy conservation, and general consumers. The trend even involves engineers in industries not directly related to lighting, and people across a wide range of business sectors, including light-applied sectors.

#### 1.1 LED Features with regard to Lighting Application

Features that cannot be found with other light sources, such as energy efficiency, long life, small size, and compactness.



#### 1.2 Evolution of Technology

An LED chip is a directional point light source, and was originally suitable for use in spot-lighting and down-lighting. LED lamp manufacturers have repeatedly launched products with unique light dispersion characteristics, in order to provide luminosity with similar intensity of distribution to that of

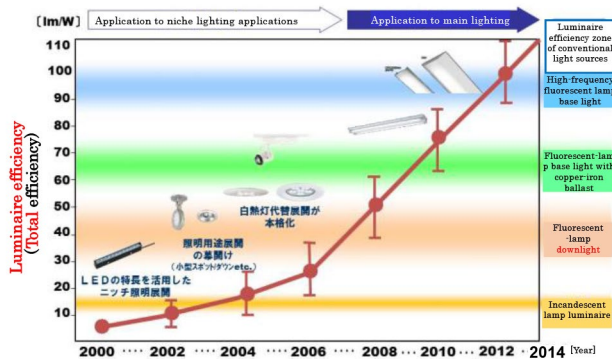
fluorescent lamps so that they can be used as general purpose lighting and base lighting, such as fluorescent lamps. Thus, the debut of LEDs has further spurred the development of new lighting design techniques such as variance in color of light and enhancement of color rendering properties. Overlooking the changes of LED products in lighting in architectural facilities, the luminaire efficiency has already reached the level of high-frequency fluorescent lamps.

Incandescent lamps cannot exceed approximately 15 lm/W and are being replaced by fluorescent and LED lighting. The luminous efficiency of general fluorescent lamps had been leveling-off until high-frequency inverter fluorescent lamps were introduced, after which efficiency started to increase again. The efficiency of high-pressure sodium vapor lamps has saturated at a high level. When white LED lamps were developed in the second half of the 1990s, their efficiency was less than that of incandescent lamps. However, efficiency has increased significantly each year since the technology was commercialized.

Refer to the figure on the next page.

#### 1.3 Toward Market Penetration of LED Lighting

High expectations are placed on the future of LED lighting. Technological development of LED lighting is advancing toward market penetration and expansion by incrementally resolving the following challenges.



• Comparison of service lives of conventional light sources and LED lamps

LED lamps have long service life of up to 40,000 hours, compared with 12,000 hours for high-frequency fluorescent lamps and high-intensity discharge lamps.

• Enhanced luminosity efficiency of various light sources

- (1) Higher energy efficiency
- (2) Better quality of light
- (3) Higher color-rendering properties
- (4) Control of dispersion characteristics
- (5) Cost reduction per luminous flux
- (6) Quality

## 2.LED Lighting and Energy Conservation

The crucial matter for energy conservation in lighting is a reduction in power consumption during lighting. Delamping and lowering of illuminance levels are hardly primary methods of energy conservation. The energy consumption of a lighting system is obtained by multiplying the power of the luminaire by the number of luminaires by the lighting duration. Therefore, the points for energy conservation are as

follows:

- Power consumption: low loss of ballast (inverter ballast)
- Lighting duration: sensor control and timer control
- Area: optimal control of lighting for each area
- Lamp luminous flux: use of high-efficiency lamps
- Utilization factor: luminaire of high efficiency and high interior reflectance

• Maintenance factor: lamps with high luminous flux retention rate. cleaning and maintenance of luminaires and lamps

Additionally, wide-ranging technologies are currently being developed, including: higher efficiency, larger luminous flux, more products for each color temperature, higher color rendering index, better luminous intensity distribution characteristics, development of light-color control and dimming functions, and improved light-color and color-rendering properties for each application.

The following two examples are taken from the aforementioned examples, to demonstrate recent developments in energy conservation.

(1) Hitachi Appliances, Ltd.

Promotion of improvement of LED lamps and ceiling lighting, aimed at achieving both larger luminous flux and higher efficiency by improvement of heat radiation performance.

(2) Toshiba Lighting & Technology Corp.

Development of technologies for LED lamps compatible with incandescent bulb dimmers to achieve smooth and stable control for full-range dimming. ■



## BAT6-1: High-efficiency LED Lighting

### 1. Business Categories Adopting This Technology

Lighting equipment

### 2. Classification of Technology

High-efficiency lighting

### 3. Energy Source

Electricity

### 4. Year of Commercialization

2014

### 5. Overview

The proportion of energy consumed for lighting purposes is high, comprising approximately 13% in ordinary households, and approximately 21% in office buildings.

There is an increasing demand for LED lighting with a high output of light and high efficiency, as an alternative source of light. As the LED temperature and heat emission increases, its luminous efficacy decreases. One of the major challenges associated with LED lighting is to achieve both a high output of light and high efficiency at the same time. In recognition of its efforts to address this challenge, Hitachi Appliances Ltd. was

awarded the 2013 Energy Conservation Grand Prize for its creation of residential LED ceiling lights and LED light bulbs. These ceiling lights and light bulbs have a high output of light and high efficiency, through a structural design featuring compactness and high-heat radiation efficiency, and an optical design to improve the luminous intensity distribution with minimal loss.

Additionally, the performance of LED ceiling lights and light bulbs are significantly enhanced through the continuous development of core technologies, and Hitachi Appliances has expanded the application of its high-efficiency LED lighting technology to LED lamps (E39 cap) for commercial facilities.

Hitachi Appliances is accelerating the commercialization of high-efficiency LED lighting products as its contribution to energy conservation in a variety of locations, without sacrificing brightness.

### 6. Principles and Operation

With LED lighting, Hitachi Appliances is continually developing a common core technology that disperses and efficiently radiates heat emitted by LED modules to achieve both a high output of light and high efficiency at

the same time. By fully employing structural design expertise and material utilization technology to enhance heat transfer performance, optical design technology to minimize optical losses while ensuring a luminous intensity distribution, and a design process using high-accuracy thermal analysis and optical simulation, the design of high-efficiency LED lighting products can be optimized within a short time period. The developmental power of these technologies allows the creation of products with excellent performance in the wide-ranging field of LED lighting. Specific examples of these technologies are described below:

#### (1) Technology for High Output of Light and High Efficiency for LED Ceiling Lights

1) Dispersed arrangement of LED modules to lower temperature increases Many high-efficiency LED modules are mounted almost uniformly on a large circuit board to disperse the heat generated by the emission of a large quantity of light.

2) Optics technology to distribute lighting with minimal losses Each LED module has a specially designed dome-shaped lens that efficiently distributes the light emitted by the LED module with minimal reflection loss. Therefore, the entire surface of the LED Ceiling Light can emit light uniformly and clearly. This results in excellent light distribution and contributes to an increase in brightness throughout the room.

3) Automatic dimming control with illuminance sensors for additional energy conservation

The Eco-illuminance Sensor detects room brightness, and automatically adjusts the brightness of the room to a preset level. The sensor automatically reduces light output to minimize surplus power consumption when the room brightness is high due to natural light, or other light sources.

#### (2) Technology for High Output of Light and High Efficiency of LED Light Bulbs.

The size of the circuit board for the light source, on which LED

modules are mounted, is increased in order to enhance the heat radiation performance of the board, and to disperse the heat of the LED modules. By increasing the contact area with the aluminum heat sink, heat is effectively transmitted to a heat sink of a new design featuring a large surface area, thereby providing high heat radiation performance.

#### (3) Technology for High Output of Light and High Efficiency for LED Lamps in Commercial Facilities (E39 cap)

An optimal shape for the heat radiation fin has been developed through repeated simulations using an original heat-conduction analysis method to radiate heat. This heat is generated by emitting a large quantity of light, in excess of 20,000 lumens, using a compact heat sink that can be mounted on existing luminaires. High efficiency is achieved through a unique concept involving the arrangement of LED modules aligned to individual radiation fins.

## 7. Improvement Made

### Before Improvement

LED ceiling lights for 13 m<sup>2</sup> (LEC-AHS810B) to 30 m<sup>2</sup> (LEC-AHS1810BC) LED light bulbs of compact bulb type (LDA6L-H-E17/S) to general bulb type (LDA17L-G)

### After Improvement

Hitachi Appliances has developed the following technologies for high-efficiency LED lighting aimed at achieving both a high output of light and high efficiency.

The LED ceiling lights optimize the number of LED modules for each room area class, and feature a dispersed placement of the LED modules. The lights incorporate a dome-shaped lens that effectively distributes light with minimal optical loss. See Figure 1.

The LED light bulbs have LED modules mounted

dispersively on a large circuit board to disperse heat generation. The bulbs also have a newly developed compact and fin-shaped body with a large surface area to effectively radiate heat.

LED lamps used for commercial facilities have a large aluminum circuit board,featuring a structure that directly transmits heat to a body with a large surface area,achieving a high-efficiency performance paired with a high light output of 21,500 lm.

### 8.Effects of Improvement - Improvement in the Energy Consumption Rate (Option for the Improvement of the Energy Conservation Rate)

#### (1) LED Ceiling Lights

A comparison of the total luminous flux (lm) and luminaire efficiency (lm/W) of products from major manufacturers for each room area class is shown in the following table. The LED ceiling lights of Hitachi Appliances feature the highest illuminance and the highest energy conservation performance.

See Table 2.

#### (2) LED Light Bulbs

A comparison of the luminaire efficiency (lm/W) of products from major manufacturers for each brightness level is shown in the following table. The LED light bulbs by Hitachi Appliances,including those under development,show the

highest efficiency the highest compared to all other products in this class.

See Table 3.

#### (3)LED Lamps for Commercial Facilities (E39 Base)

A comparison of the luminaire efficiency (lm/W) of products from major manufacturers in each class is shown in the following table. The efficiency of LED lamps from Hitachi Appliances is the highest out of all three classes.

See Table 4.

### 9.Economic Efficiency and Changes

#### (1) Market Potential

According to statistical data compiled by the Japan Lighting Manufacturers Association,the number of LED ceiling lights shipped to the Japanese market amounts to about 17 million as of April 2014. As LED ceiling lights could be installed in multiple rooms in 50 million households in Japan,the market is anticipated to expand further in the future. Based on statistics of light bulb shipments compiled by the Japan Lighting Manufacturers Association,Hitachi Appliances estimates that the present penetration rate of LED light bulbs is about 28%,and that this percentage will increase further. The debut of LED lamps with the E39 cap will accelerate the replacement of

Table 1

Objective	Technology Developed	Residential LED Ceiling Light	LED Light Bulb E26 and E17 Bases	LED Lamp for Commercial Facilities E39 Base
Control of Generated Heat	Use of high-efficiency LED modules	◎	◎	◎
Heat Dispersion	Large circuit board	○	◎	◎
	Dispersed placement of LED modules	◎	◎	◎
High Heat Radiation Performance	Direct heat radiation	○	○	◎
	Radiator body with a large surface area	○	○	◎
Minimum Loss	High-efficiency drive circuit	○	○	○
	Reduction of optical losses	◎Dome-shaped LED unit	◎Light-diffusion cover	◎Reflector

◎ denotes technology developed in 2014 FY



Table 2

Room Floor Area	Eco-illuminance Sensor Western type							Western type				
	Up to 30 m <sup>2</sup> Color LED ring	Up to 30 m <sup>2</sup>	Up to 23 m <sup>2</sup>	Up to 20 m <sup>2</sup>	Up to 17 m <sup>2</sup>	Up to 13 m <sup>2</sup>	Up to 10 m <sup>2</sup>	Up to 30 m <sup>2</sup>	Up to 23 m <sup>2</sup>	Up to 20 m <sup>2</sup>	Up to 17 m <sup>2</sup>	Up to 13 m <sup>2</sup>
Model (beginning with a prefix LEC)	AHS1810CC	AHS1810C	AHS1410C	AHS1210C	AHS1010C	AHS810C	AHS610C	AH1800C	AH1400C	AH1200C	AH1000C	AH800C
		AHS1816C	AHS1416C	AHS1216C		AHS816C		AH1811C	AH1411C	AH1211C	AH1011C	AH811C
								AH1815C	AH1415C	AH1215C	AH1015C	AH815C
								AH1850C	AH1450C	AH1250C		AH850C
Rate Luminous Flux (lm)	8,000	8,000	6,099	5,499	4,899	4,299	3,699	8,000	6,099	5,499	4,899	4,299
Rated power consumption (W)	63.6	63.6	49.5	44.6	39.8	34.8	30.0	63.3	49.2	44.3	39.5	34.5
Luminaire Efficiency (lm/W)	125.8	125.8	123.2	123.3	123.1	123.5	123.3	126.4	124.0	124.1	124.0	124.6
Luminaire Efficiency of the conventional model of Hitachi Appliances (lm/W)	84.8 AHS1810BC	-	104.8 AHS1410B	103.0 AHS1210B	103.1 AHS1010B	102.4 AHS810B	-	-	104.8 AH1400B	103.0 AH1200B	103.1 AH1000B	102.4 AH800B

fluorescent and incandescent lamps in the LED lamp market for commercial facilities. The LED product lineups featuring a high, top-class output and a high efficiency in various product groups are considered to be predominant in the market.

#### (2) Economic Efficiency


Calculations of the annual reduction in electricity charges in the case of replacement of conventional light sources with LED lighting are shown below. The table does not include luminaire purchasing and installation costs. The calculations are based on a standard household with a living room, dining

room, kitchen, and three rooms, while assuming that four ceiling lights and five light bulbs are lit 2,000 hours per year. The trial calculations for factory lighting are based on 30 metal halide lamps of 400-W class, lit 3,000 hours per year while assuming a medium-sized area of 640 m<sup>2</sup> as an example. The calculations show that approximately 19,000 JPY (69%) is saved per year for a residential house, and approximately 480,000 JPY (61%) for a factory, indicating that LED lighting can offer high economic efficiency in various facilities and living spaces.

Table 3

Type	General Bulb Type (E26 Base) Wide Light Distribution Type								General Bulb Type (E26 Base) For dimmer control device		Compact Bulb Type (E17 Base) Wide Light Distribution Type		Compact Bulb Type (E17 Base) Lower Part Light Distribution Type				Beam Lamp Type (E26 Base)		
Date Launched	Sep. 10 2014		Sep. 10 2014		July 10 2014		Feb. 10 2014		Sep. 10 2014		Sep. 10 2014		Sep. 10 2014		Sep. 10 2014		Oct. 10 2014 (scheduled)		
Product Full View																			
Model	LDA13L-G/100C	LDA11D-G/100C	LDA10L-G/80C	LDA10D-G/80C	LDA9L-G/60HC	LDA9D-G/60HC	LDA8L-G/60A	LDA7D-G/60A	LDA9L-G/7D/60C	LDA7D-G/7D/60C	LDA5L-G-E17/S/40C	LDA5D-G-E17/S/50C	LDA7L-H-E17/S/60C	LDA6D-H-E17/S/60C	LDA4L-H-E17/S/40C	LDA4D-H-E17/S/40C	LDR14L-W/150C	LDA11L-W/100C	LDA7L-W/75C
Light Color	Electric Lamp Color	Daylight Color	Electric Lamp Color	Daylight Color	Electric Lamp Color	Daylight Color	Electric Lamp Color	Daylight Color	Electric Lamp Color	Daylight Color	Electric Lamp Color	Daylight Color	Electric Lamp Color	Daylight Color	Electric Lamp Color	Daylight Color	Electric Lamp Color	Electric Lamp Color	Electric Lamp Color
Total Light Flux (lm)	1,520		1,160		1,000		810		810		500	600	760		440		1,550	1,100	800
Approx. Brightness	Equivalent to 100 W Class		Equivalent to 80 W Class		Equivalent to 60 W Class		Equivalent to 60 W Class		Equivalent to 60 W Class		Equivalent to 40 W Class	Equivalent to 50 W Class	Equivalent to 60 W Class		Equivalent to 40 W Class		Equivalent to 150 W Class	Equivalent to 100 W Class	Equivalent to 75 W Class
Rated power consumption (W)	13.3	11.4	10.3	9.5	9.3	8.7	8.1	7.3	9.0	7.3	5.0	5.2	6.9	5.8	4.4	4.0	14.4	11.0	7.3
Luminaire Efficiency (lm/W)	114.2	133.3	112.6	122.1	109.0	114.9	100.0	111.0	90.0	110.9	100.0	115.3	110.1	131.0	100.0	110.0	107.6	100.0	109.5
(Top Runner Standard FY2017 Achievement Percentage)	(115%)	(121%)	(114%)	(111%)	(109%)	(104%)	(101%)	(100%)	Not Covered Under Top Runner Program		(101%)	(104%)	(111%)	(119%)	(101%)	(100%)	Not Covered Under the Top Runner Program		
Luminaire Efficiency of the Conventional Model of Hitachi Appliances (lm/W)	91.0 LDA17L-G	101.3 LDA15D-G	77.3 LDA15L-G	101.8 LDA11D-G-A	-	-	71.1 LDA11L-G-A	92.0 LDA9D-G	-	-	72.9 LDA7L-G-E17/S	88.6 LDA7D-G-E17/S	-	108.6 LDA7D-H-E17/S	81.5 LDA5L-H-E17/S	-	-	-	-
Mass (g)	140	140	120	120	100	100	105	105	125	125	45	45	55	55	35	35	325	325	325
Size	Outer Diameter		60		60		60		60		35	35	40	40	35	35	121	121	121
	Overall Length (mm)		123		123		112		112		74	74	67	67	67	67	132	132	132

Table 4

	Product Full View		Metal Halide Lamp 400 W Class	Mercury Vapor Lamp 400 W Class	Mercury Vapor Lamp 250 W Class
Hitachi Appliances		Model	LME2101MN	LME1601MN	LME1101MN
		Rated Luminous Flux (lm)	21,500	16,800	11,600
		Luminaire Efficiency (lm/W)	134.4	138.8	139.1
		Date Launched	July 2014	July 2014	July 2014

Note: The preconditions for the calculations of reductions in electricity charges are 27 JPY/kWh for residential houses, and 21 JPY/kWh for industrial facilities.

See Table 5&6.

## 10. Market Situations and Conditions LED Ceiling Lights

### LED Ceiling Lights

(1) Penetration at present: Approximately 17 million lights (as of April 2014)

(2) Forecast of penetration in 2017 (or 2020): Not available

### LED Light Bulbs

(1) Penetration at present: Approximately 28%

(2) Forecast of penetration in 2017 (or 2020): Not available

## 11. Additional Information for Reference

(1) Patents and Utility Models

• Applications for patents planned

(2) History of Awards Received

N/A

## 12. Sites Adopting

This Technology Throughout Japan

## 13. Bibliography and Reference Information

N/A

## 14. For More Information, Please Contact:

Hitachi Appliances, Ltd. ■

Table 5

Trial Calculation of the Electricity Charge for Residential Houses	Fluorescent Ceiling Lights and Incandescent Bulbs	LED Ceiling Lights and LED Bulbs
Example of Luminaires	One ceiling light for each 23, 17, 13, and 10 m <sup>2</sup> room Light bulbs: 4 60 W-class bulbs, 1 100 W-class bulb	
Power Consumption (W/household)	666 W	207 W
Annual Power Consumption (kWh/year)	1,332	414
Annual Electricity Charge (JPY/year)	About 36,000 JPY	About 11,200 JPY
Reduction in Electricity Charges	Reduced by approximately 24,800 JPY (69%)	

Table 6

Trial Calculation of the Electricity Charge for Factories	Metal Halide Lamp, 400 W Class	LED Lamp, 400 W class
Example of Luminaires	30 metal halide lamps 400 W class	
Power Consumption (W/factory)	12,450	4,800
Annual Power Consumption (kWh/year)	37,350	14,400
Annual Electricity Charge (JPY/year)	About 785,000 JPY	About 303,000 JPY
Reduction in Electricity Charges	Reduced by approximately 480,000 JPY (61%)	



## BAT6-2: Premium Dimming Technology

### 1.Business Categories Adopting This Technology

Lighting equipment

### 2.Classification of Technology

High-efficiency lighting

### 3.Energy Source

Electricity

### 4.Year of Commercialization

2014

### 5.Overview

LED lamps have been widely accepted for use in recent years in relation to their high-efficiency performance and long life. Nevertheless, it is evident that the public is not entirely satisfied with the dimming application of LED lights, which causes light flickering and difficulties using the dimming function at a low level of lighting. These common problems are obstructing widespread change from use of incandescent lamps to LED lamps. Although some LED lamp manufacturers are developing new dimming technologies and dimmers, users of existing dimmers will

need to pay additional costs to replace current dimmers with the ones being newly developed. However, Toshiba Lighting & Technology Corp. has developed its own technologies and commercialized LED lamps that can be used with conventional dimmers. This technology ensures a minimal flickering of the light, and the bulbs can be dimmed in the range of 0 to 100%, which is the same range as that of incandescent lamps. The company further aims to expand the use of LED lamps with the use of this newly developed technology.

### 6.Principles and Operation

Toshiba Lighting & Technology Corp. organized project teams to address various technical challenges, enabling a developmental policy for each elemental technology. The technical challenges were then overcome through cooperation between relevant departments.

#### (1) Premium Dimming Control Program

Conventional dimmers were designed to dim incandescent lamps, and problems such as flickering or extinguishing of the light occur if a general LED lamp is used with a conventional dimmer. This is because the electrical characteristics of LED



lamps are different from those of an incandescent lamp and the dimmer cannot therefore function effectively.

The LED lamp introduced here can be controlled without the occurrence of light flicker, even when used with a conventional dimmer. This is achieved through the unique digital processing of a built-in microcomputer. The principal functions of the built-in microcomputer are as follows:

- 1) To determine the type of dimmer and to optimally control the LED lamp accordingly.
- 2) To monitor the waveform of the dimmer and to estimate its output.
- 3) To inform the lighting circuit of the current used in the LED.
- 4) To suppress any light output fluctuations, even when the dimmer operation is unstable or when the power supply voltage fluctuates.

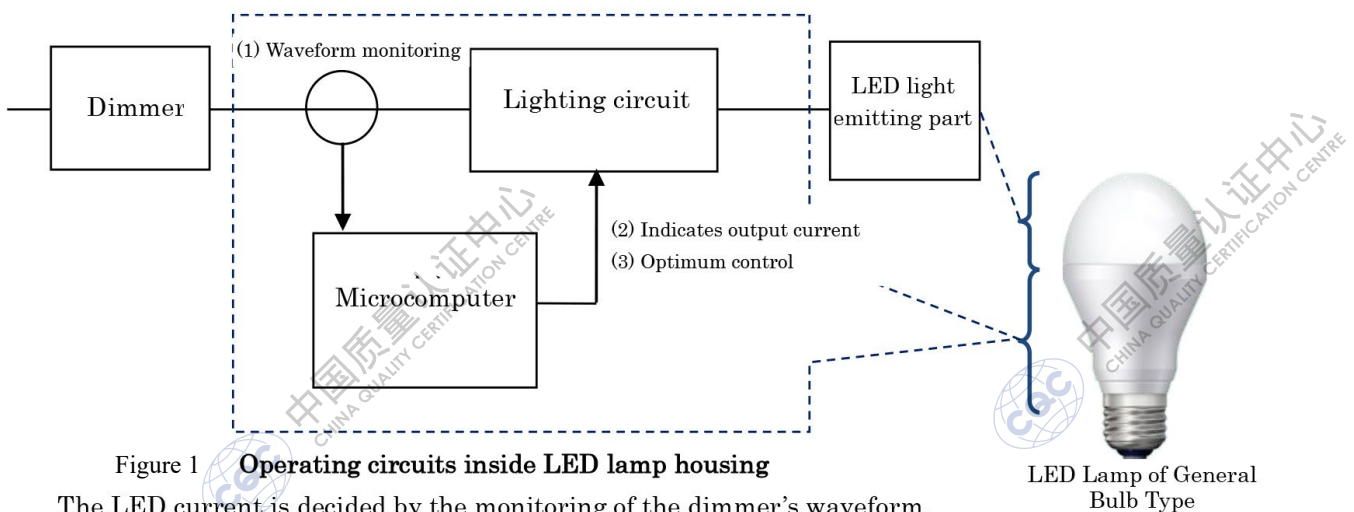
Such installed functions enable LED lamps to be used with various types of dimmers. The microcomputer can suppress light flicker near the lower limit of dimming, which is caused by drops in voltage when an electric home appliance of a large

capacity such as a hair dryer, vacuum cleaner, or induction heating equipment is used, or by distortion of the voltage waveform caused when a dimmer of other system is used. Smooth dimming is possible from full lighting to extinction, and fluctuations of light output can be controlled even near the lower limit of dimming. Furthermore, when combined with the dedicated dimmer for LED lamps manufactured by Toshiba Lighting & Technology, the buzzing sound generated by the dimmer can be mitigated.

See Figure 1.

## (2) Optical Design and Structural Design

LED lighting products require a combination of optical and thermal designs. In the optical design, thermal conditions are taken into consideration when selecting LED elements and their physical placement. The function of heat radiation provided by the LED elements is delivered by the lamp's housing, and the design structure that retains the form of an incandescent bulb has been sought in simulations. Such designs have enabled LED lamps to be mounted in closed apparatus, where it has not been



possible to install conventional LED lamps.

## 7.Improvements Made

### Before Improvement

Model No. LW100V54W55

Incandescent lamp manufactured by Toshiba Lighting & Technology in 2010

### After Improvements

Model No. LDA8L-G-K/D/50W

LED lamp manufactured by Toshiba Lighting & Technology  
(Color: Warm white,Equivalent to 50W incandescent lamp)

Model No. LDA8N-G-K/D/60W

LED lamp manufactured by Toshiba Lighting & Technology  
(Color: Neutral white,Equivalent to 60W incandescent lamp)

### Specifications:

See Table 1.

### Principal Features:

- (1)To be used with conventional dimmers for incandescent lamps (phase-control dimmer,of 2 wire type) with PREMIUM Dimming Technology
- (2)Energy saving of 85% in comparison with that of an incandescent lamp
- (3)Wide light distribution angle of 180 degrees
- (4)Compatible with enclosed fixtures
- (5)Long service life of 40,000 hours

### Full View and Package:

Refer to Figure 2.

## 8.Effects of Improvement - Improvement in Energy



Figure2 Full View and Package:LED LAMP-General Bulb Type

## Consumption Rate (Option for Improvement of Energy Conservation Rate)

A comparison of the energy consumption of LED lamps with that of incandescent lamps is shown below,demonstrating that power consumption can be reduced by 85%. Additionally,further energy conservation can be expected by using the dimming function.

See Table 2.

## 9.Economic Efficiency and Changes

### (1)Market Potential

By suppressing the light flicker caused by drops in voltage when an electric home appliance of a large capacity such as a hair dryer,vacuum cleaner,or induction heating equipment is used,or by distortion of the voltage waveform caused when a dimmer in another system is operated,the newly developed LED lamps can now be used in markets such as hotels and

Table 1 Specifications

Model	Light Source Color	Dimensions (mm)		Base	Total Luminous Flux (lm)	Rated Power Consumption (W)	Energy Efficiency (lm/W)
		Outside Diameter	Total Length				
LDA8L-G-K/D/50W	Warm white	60	113	E26	640	8.2	78.0
LDA8N-G-K/D/60W	Neutral white	60	113	E26	810	8.2	98.8

Table 2

	LED Lamp Under Application		Comparable Product	Reduction of Power Consumption (%)
Type and Model	Equal to 50W class LDA8L-G-K/D/50W	Equal to 60W class LDA8N-G-K/D/60W	LW100V54W55	
Energy Consumption Efficiency (lm/W)	78	98.8	15	-
Power Consumption (W)	8.2		54	-85

theaters (which were not previously able to adopt LED lamps). The total market is conservatively estimated at about 15 million lamps. (Lamps with the dimming function with an E26 base represent about 10% of total E26-base lamps in Japan. Source: Toshiba Lighting & Technology Corp.)

#### (2) Economic Efficiency

Compared with incandescent lamps, the newly developed LED lamps can reduce the energy consumption currently used by approximately 85%. By the end of 40,000 hours

of rated life, a total of approximately JPY 50,300 would have been saved in electricity costs. As illustrated below, the total expenses will equal that of one incandescent lamp when the LED lamp is used for about 4,200 hours, which is equal to approximately one year if the LED lamp is lit for ten hours per day.

Refer to Figure 3.

### 10. Market situations and Conditions Market volume (Estimated)

(1) 2014: Approx. 15 million lamps

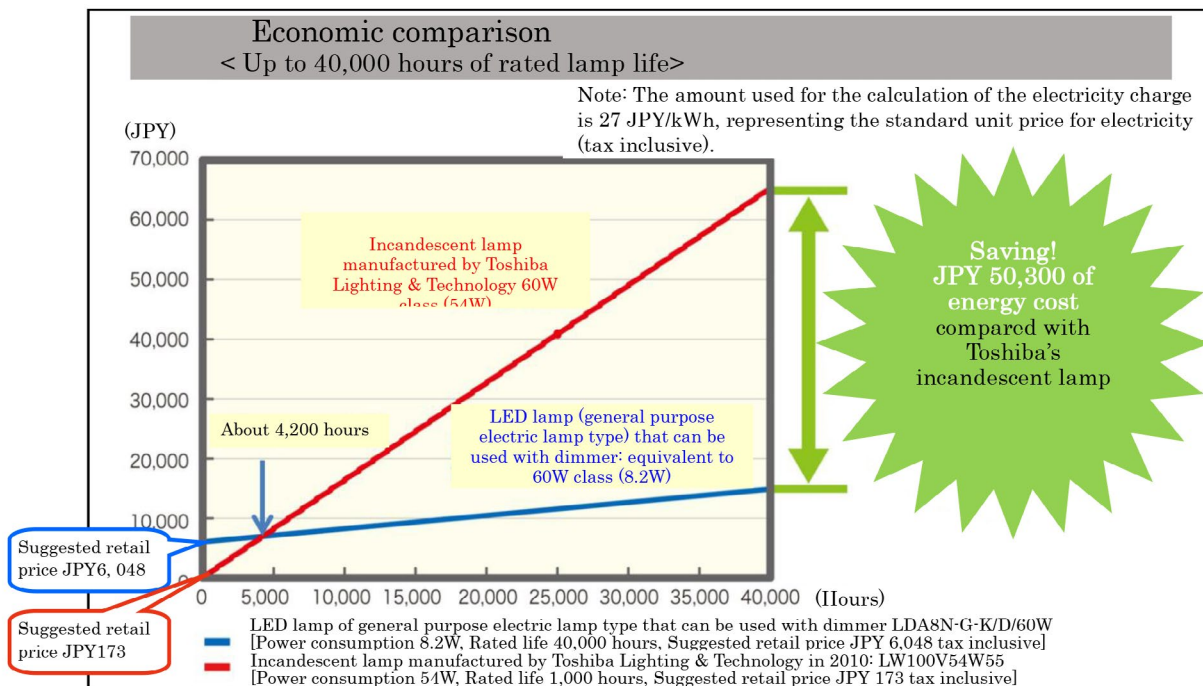


Figure 3



(2)2017 (or 2020) : Data not currently available

## 11. Additional Information for Reference

(1) Patent Applications and Patents Acquired under Development of This Technology

- Patent registration: 23 registrations (Applications filed)
- Trademark registration: 1 registration (Already registered) 'E-CORE'

(2) Status of External Evaluation such as Citations

- None

(3) Release of Information to Academic Societies and Press

- Press release made on February 26, 2014 (for the general purpose electric lamp type)

## 12. Bibliography and Reference Information

N/A.

## 13. For More Information, Please Contact :

The Toshiba Lighting & Technology Corp. ■

# First Batch of Domestic TOP TENS List

## Japan BP List

Edited by Quan Bai

BP1: Development and Introduction of Human/Environmentally  
Friendly Equipment with a Focus on Minimizing Power Consumption

### 1. Practice Overview

CO<sub>2</sub> emissions of labor-intensive assembly plants.  
(2011–2012 for overseas plants; 2013 for Japanese  
plants)

(1) Downsize the volume of plants ▲30%- ▲50%  
Reduction in light (LED) and air conditioning energy  
(while minimizing the line length and hanging of the  
equipment).

(2) Introduce thorough energy saving equipment  
▲40%- ▲56%

Achieved by Karakuri (gimmick)/Oki-Pon/  
Motionless/usage of renewable materials.

### 2. Schematic Diagram

See Figure 1 and 2.

### 3. Energy Saving

(1) Downsize the volume of plants

(a) Overseas plants; (b) Japanese plants

CO<sub>2</sub> emissions: (a) ▲30% (2000–2011)

(b) ▲50% (2000–2013)

Crude oil equivalent: (a) approx. 11,000 kL equivalent

(b) approx. 11,000 kL equivalent

(2) Introduce thorough energy saving equipment

CO<sub>2</sub> emissions: (a) ▲1% (2000–2011)

(b) ▲14% (2000–2013)

Crude oil equivalent: (a) approx. 1.000 kL equivalent

(b) approx. 280 kL equivalent

#### 4. Innovation Originality

For the introduction of thorough energy saving equipment, a Simple Smart Compact for Assembly Innovation (SSCI) team was formed with the aim of developing equipment that can be "created/fixed/changed on site." The development proceeded with the aim that difficult operations are to be thoroughly improved as we, the production engineers, create and use the products. We had reduced the load and instances of operation on the basis of manual operations, without power usage. Then, the equipment specifications were made to automate only the parts required for the reduction of man-hours with minimal power. The equipment rigidity was not achieved by targeting the minimum required strength,

with reinforcements when tryouts were not successful, ultimately leading to an increase in weight. Instead, simple/smart measures were taken, such as making the structure of the breakable portion flexible.

#### 5. Transferability Replicability

Equipment development that focused on minimizing power began in 2009, and the introduction of the completed equipment has been implemented in new plants since 2010.

Of the main equipment, 137 have been developed and 70% has so far been completed. For the remainder of the equipment, and with the creation of innovative engineering, we are responsible for more than 70 assembly lines around the world. In order to incorporate them promptly into the current lines and to see the effect, "SSCI Size Expansion" is in progress with the cooperation

Top Ten Best Practices and Best Available Technologies Task Group  
BEST PRACTICE

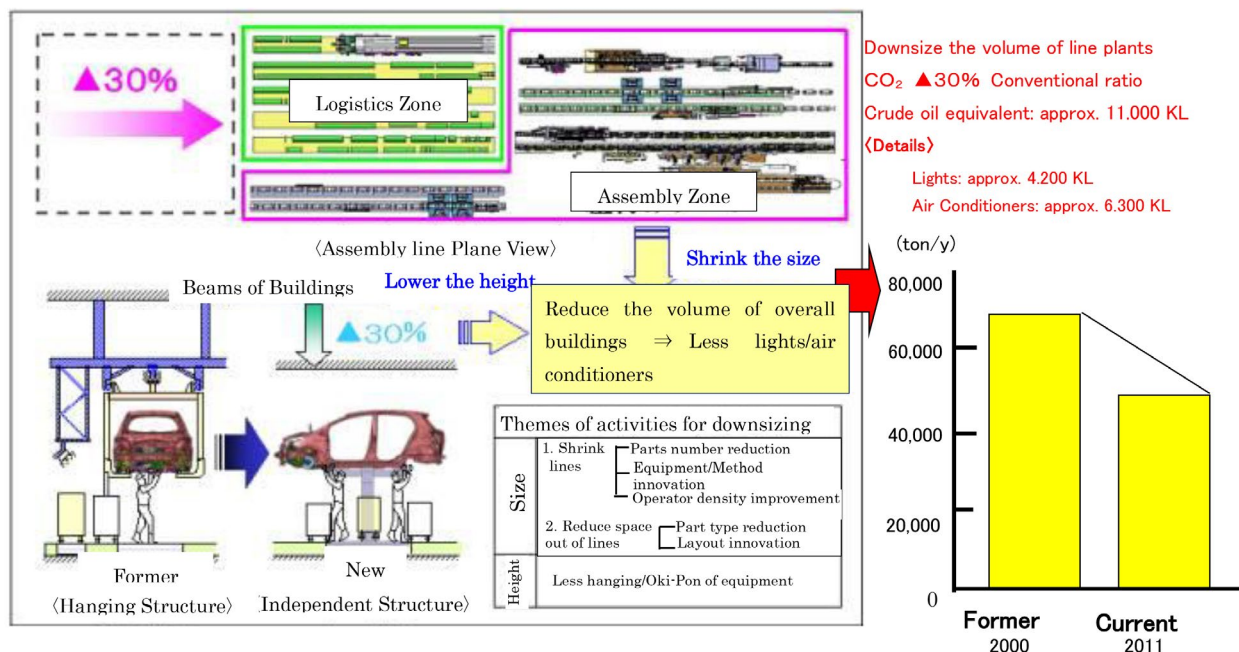


Figure 1 . Downsizing of Assembly Plants



of each assembly plant/equipment manufacturer.

## 6.Sustainability Continuity

Implementing our own equipment development, having energetic people and members from overseas (sowing), and promoting continuous KAIZEN for energy saving in the future. When assigned to an overseas branch, work as a core power for worldwide development (reaping).

## 7.Cost Effectiveness

- Cost Effectiveness: ▲30% (compared with the rate of the latest domestic plants).
- Payback Period: 7 y -5.5 y (▲20%)

## 8.Co-Benefits

### Patents, Awards, Publication:

- (1) Application of patent/utility model, 21 cases
- (2) Awards, six cases \*<sup>1</sup>
- (3) Newspapers publications, three cases \*<sup>2</sup>
- (4) Conference presentations nine cases \*<sup>3</sup>
- (5) Contribution to literature two cases \*<sup>4</sup>

(\*1. Minister Prize of Economic, Trade and Industry/ Japan Society of Mechanical Engineers etc.; \*2. Yomiuri-Shimbun/Nikkei Monozukuri; \*3. Japan Society of Precision Engineering/Robotic Society of Japan/Energy Conservation Grand Prize etc.; \*4. Robotic Society of Japan/Energy Conservation Grand Prize etc.) ■

Top Ten Best Practices and Best Available Technologies Task Group

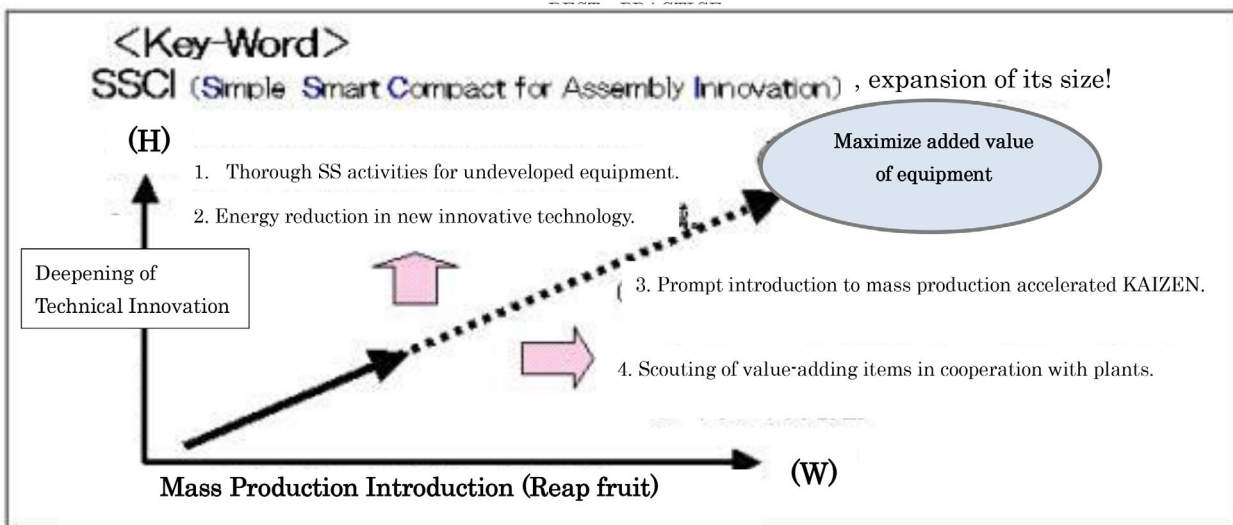


Figure 2 . SSCI Size Expansion Guidance

## BP2: New Painting Technology that Simultaneously Reduces Volatile Organic Compounds (VOC) and CO<sub>2</sub> Emissions

### 1.Details of case

Mazda has been continuously achieving process innovations to solve the conflicting demands of environmental protection, paint quality, and economic efficiency. At present, Mazda has developed the "Aqua-tech Paint System," which is a new painting technology that has been practically implemented in mass production. It consists of the following innovations:

- (1) High-function waterborne basecoat and 2K clear-coat paint that integrates the functions of primer coating into top coating.
- (2) Energy-saving air-conditioning system for the spray booth that controls water evaporation from waterborne basecoat with minimal energy during spray application.
- (3) High-efficient flash-off system, that evaporates water from wet paint film with minimal energy, after waterborne basecoat application but before the 2K clear-coat application
- (4) Space-saving cartridge system, which is compact and minimizes paint loss during color change.
- (5) Pipe cleaning technology, which utilizes solvent-borne paint pipes for waterborne paint.
- (6) Design of paint film structure and application

technologies that improve paint film smoothness on exterior panels and color matching on internal panels.

### 2.Diagrams and other illustrations

Refer to Figure 1.

### 3.Energy conservation performance

- High-function waterborne basecoat and 2K clear-coat paints: 2,000 t/y reductions in CO<sub>2</sub> emissions from primer booth, compared with the 3 Wet-on Paint System, as a result of process shortening.
- Energy-saving air-conditioning system: a 34% reduction in CO<sub>2</sub> emissions when compared with conventional booth air conditioning for waterborne painting.
- High-efficient flash-off system: a 17% reduction in CO<sub>2</sub> emissions when compared with conventional flash-off for waterborne painting.

### 4.Advanced nature and originality

- Aqua-tech Paint System is further developed with process integration and high-efficient technologies based on the 3 Wet-on Paint System.
- Paints: Adoption of waterborne, instead of solvent-borne, basecoats. Integration of primer functions through

the de-velopment of high-function basecoats and clear-coats.

- Facilities: Minimization of process length and resource consumption, through technology development that maximizes equipment functions for essential mechanisms, such as water evaporation.

## 5.Versatility and expandability

- World-leading VOC and CO<sub>2</sub> emission amounts
- Basic paint quality is equal or superior. In addition, paint appearance (gloss and smoothness) is improved.
- Economic efficiency: Vehicle production cost of primer and topcoat was reduced by approximately 18%, compared to conventional solvent-borne paint systems.
- Smooth introduction into existing plants: Conversion was conducted without plant shutdown, through the development of paint and process technologies that assume simultaneous production of solvent-borne and waterborne paint systems.
- This technology can be applied to all other painting industries as a new-generation painting technology that can achieve environmental protection without sacrificing economic efficiency.

## 6.Continuity and sustainability

The following activities are under consideration with the relevant departments in the company:

- Implementation of the Aqua-tech Paint System in other domestic and overseas plants.
- Development of the next new painting technology.

## 7.Investment efficiency

By minimization facility modifications while maximizing existing facility utilization, the introduction into an existing plant (Ujina No.1 Plant) was realized with approximately one tenth of the investment that would have been required for a new waterborne paint plant.

## 8.Secondary results

### Patents, awards and presentations:

- (1) Japanese patents: 19; patents outside Japan: 21.
- (2) Awards: not applicable.
- (3) Newspaper articles: eight articles (Asahi Shimbun, Yomiuri Shimbun, Nikkei, etc.).
- (4) Academic lectures: three lectures (The Society of Automotive Engineers of Japan, etc.).
- (5) Documents and other sources: three articles (Journal of the Society of Automotive Engineers of Japan; Mazda Technical Review).

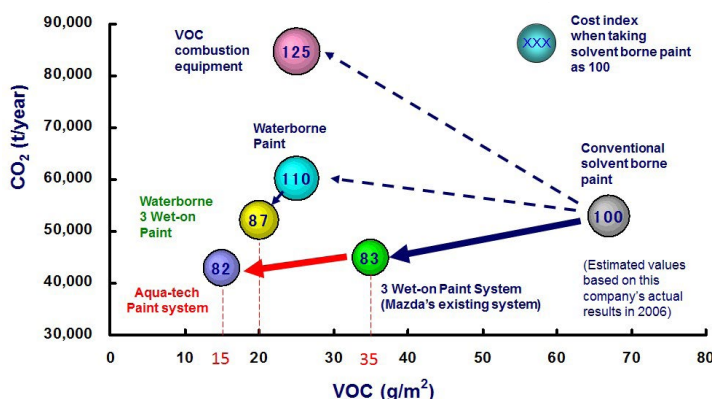


Figure 1



## BP3: Energy Conservation and Peak Power Containment Promoted by Everybody in the Factory

### 1.Details of case

As the Panasonic Yamagata Factory expanded the production of lenses as the base for the optical business of the company, drastic increase of CO<sub>2</sub> emission was predicted (production of lenses and CO<sub>2</sub> emissions in 2012 were expected to be 137% and 157%, respectively, of those in 2009). As the mission of Yamagata Factory was to expand the business while preserving environment, the CO<sub>2</sub> Emission-Reduction 3-Year Plan was formulated based on FY2009 actual results. The aim was a final reduction of emissions by 50%. Yamagata factory started a CO<sub>2</sub> emissions-reduction project not only to implement energy conservation, but also to improve production processes and create energy. To achieve these goals, the following objectives were detailed:

- (1) Promotion of visualization: analysis and minimization of energy intensity.
- (2) Improvement of production process: conservation of energy during vapor deposition, development of energy-saving, lens-forming machines.
- (3) Containment of peak power: prevention of increase in the air-conditioning load, improvement of factory air, prevention of increase in lighting, among others.
- (4) Energy creation: development of a power generation

system with conversion of exhaust-heat to electricity.

### 2.Diagrams

See Figure 1.

### 3.Energy conservation performance

#### Peak electric power

2010:5,800kW

2011:4,600kW [21% reduction]

#### CO<sub>2</sub> emissions

2010: 15,423 t

2011: 12,865 t

[17% reduction]

[Breakdown of activities]

- Energy conservation of vapor depositors: development of general types, development of standard films—productivity was improved 1.5 times.
- Development of energy-saving lens forming machines—electricity consumption was reduced by 25%.

### 4.Advanced nature and originality

- Energy creation: development and introduction of a power generation system for converting exhaust-heat to electricity.

### 5.Versatility and expandability

- Visualization of energy consumption

- Containment of air conditioning load
- Improvement of factory air
- Containment of lighting load
- Introduction of summertime improvement of OA equipment

The nature of the peak-power containment activities is general, so they can be implemented horizontally for other business types.

## 6.Continuity and sus-tainability

The steps to reduce CO<sub>2</sub>, reduce energy-consumption,

visualize project achievements and issues, continue cost-reduction activities and sustain improvement were promoted by organizing them in a 3-year plan.

## 7.Investment efficiency

Unknown

## 8.Secondary results

- Patents, awards and presentations
- Nothing more, in particular ■

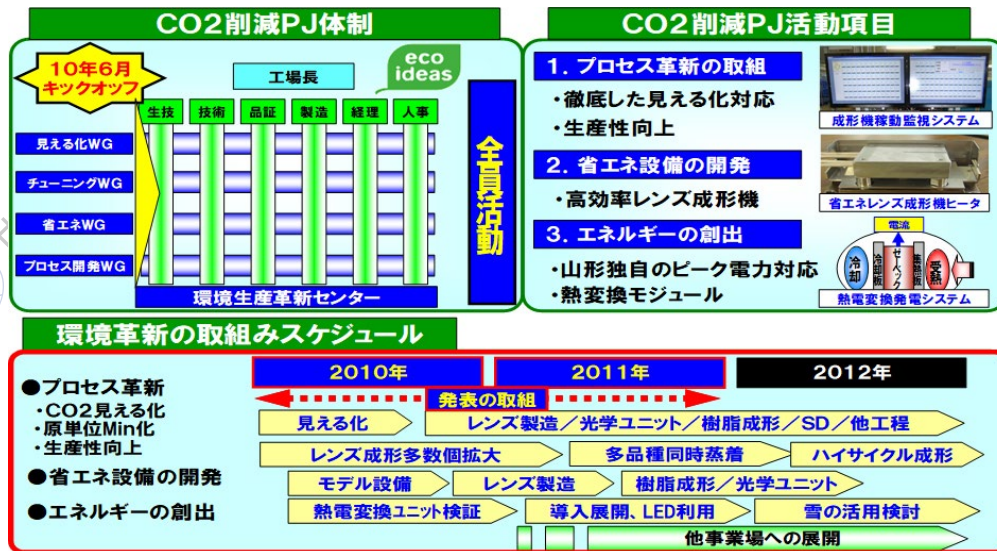


Figure 1



## BP4: Low Exergy Utilization System across Multiple Sites

### 1.Details of case

"Low Exergy Utilization System across Multiple Sites" (hereinafter referred to as 'this project') was developed, installed and initially operated in 2005, which intended to share and utilize low-grade heat (low exergy) in a cascading manner at Fuji Oil Co. and Sumitomo Chemical Co. up to further lower temperature beyond a conventional utilization limit. This project consists of the following three sub-systems: (Photo 1)

(1) Energy sharing system across multiple sites (Fig. 1)  
--- Ability to share the low-grade heat (150 oC) and maintain independent operation of each sites, based on Pinch technology (heat utilization methodology).

(2) Integrated energy monitoring system (Fig. 2)  
--- Comprehensive analyses and assessments of the optimum operating conditions for whole of sites (area-wide optimization) in conjunction with Energy sharing system across multiple sites mentioned in (1).  
(3) Low heat power generation system (Fig. 3)  
--- Highly efficient power generation system with highly concentrated ammonia water as a working fluid by using the low-grade heat (115 C) of the overhead

vapor from the distillation column in Fuji oil Co.

### 2.Diagrams

Photo 1 Overview of low exergy utilization system across multiple sites

Fig. 1 Energy sharing system across multiple sites

Fig. 2 Integrated energy monitoring system

Fig. 3 Low heat power generation system

### 3.Energy Conservation Performance

- Energy conservation amount in annual crude oil equivalent: 10,700 kiloliter (kL). Notes: 38.2 GJ is equivalent to one kL.

- Annual CO<sub>2</sub> emission reduction amount: 28,000 tons-CO<sub>2</sub>

(1) In Energy sharing system across multiple sites, the energy conservation amount is 4,900 kL, annual crude oil. This figure was calculated based on boiler fuel reduction amount in Sumitomo Chemical with the booster pump load subtracted.

(2) Outcomes of Integrated energy monitoring system are included in 4,900 kL mentioned in (1), as its operation is integrated with Energy sharing system.

(3) Low heat power generation system generates electric power. The energy conservation amount is 5,800 kL



according to the actual operation data in all year. This energy conservation amount is calculated by subtracting the energy increases from electric power generated. The energy increases are the working fluid circulation pump and the cooling water pump required for the condenser.

#### 4. Advantages and Originality

Supported by New Energy and Industrial Technology Development Organization (NEDO) in FY2000 to FY2002, Chiyoda Corporation developed new Pinch technology (Area-wide pinch technology) applicable to heavy chemical complexes out of the conventional pinch technology intended for individual site. This project is a case of a new, advanced, and creative energy conservation joint project based on results of applying area-wide pinch technology to the 23 target sites in Chiba heavy chemical complex. Specifically, this project was developed from analyses of low-grade heat utilization in the heavy chemical complex. It is not only Japan's but the world's first system designed to effectively utilize discarded low-grade heat across multiple sites beyond the conventional utilization limit.

- Energy sharing system across multiple sites utilizes low-grade heat (150 °C) discarded in process plants in Fuji Oil and supplies such heat to adjacent Sumitomo Chemical via the new pipelines across two sites. Using the low-grade heat, Sumitomo Chemical heats the boiler feed water to the deaerator of the utility boiler and enables to reduce boiler fuel consumption. Usually the power generation at the steam turbine decreases as the low-pressure steam demand for heating the boiler feed water decreases. This system could solve the problem

and maintain the power generation amount by installing the new high-pressure feed water preheater.

- Integrated energy monitoring system features a 2-level structure. The level 1 calculates the individual optimal operating condition for each site. The level 2 calculates the area-wide optimal operating conditions for whole of sites. And the level 2 collects the minimum required data from the level 1 and provides the solution result to the operators as an operation guide. The 2-level structure enables to achieve the following three important functions. i) secrecy, ii) expandability, iii) robustness. In addition, this system enables to calculate the allocation for each site in the energy conservation amount secured at both sites by Energy sharing system. (Patent No. 4389577; Integrated energy optimization method at multiple facilities)

- Low heat power generation system is the world's first developed system in the refinery field. This system makes use of the low-grade heat (115 °C) in the overhead vapor from the distillation column in Fuji Oil Co. Conventionally such heat was discarded to the atmosphere by air-fin coolers. But it became a heat source for this system and was exchanged with the highly concentrated ammonia water to produce the high pressure ammonia vapor at 3 MPaG by the newly developed heat exchanger. The vapor drives the power generation turbine to generate 4 MW in electricity. (K. Matsuda, Low heat power generation system, Applied Thermal Engineering 70 (2014) 1056-1061)

#### 5. Versatility and Expandability

Conventionally, it was believed that the individual site

in heavy chemical complexes had no more opportunity for energy conservation. Based on the result by area-wide pinch technology targeted on Chiba heavy chemical complex, however, it was found that there still was large energy conservation potential if the heavy chemical complex shared energy as if they were a single entity. This project of Chiba heavy chemical complex developed by area-wide pinch technology led to a turning point on a policy, the concept of “Promotion of Energy Conservation by Collaboration of Multiple Actors” appeared in the Basic Energy Plan formulated by Ministry of Economy, Trade and Industry in October 2003. With governmental support, similar systems have been actively introduced into many domestic heavy chemical complexes. Chiyoda Corporation applied area-wide pinch technology to five of the ten major domestic heavy chemical complexes and found out each of them still had a large energy conservation potential. Subsequently, based on the effects of this project introduced in Chiba complex, energy conservation joint projects across the sites have been expanded to Mizushima and Kashima heavy chemical complexes. In addition, area-wide pinch technology analysis has been applied to large-scale ironworks, which confirmed large energy conservation potential and identified several energy conservation measures.

## 6.Continuity and Sustainability

Area-wide pinch technology was applied to analyze the following areas:

- (1)Domestic heavy chemical complexes
  - Chiba heavy chemical complex
  - Kashima heavy chemical complex

- Mizushima heavy chemical complex
- Ube heavy chemical complex
- Oita heavy chemical complex
- (2)Overseas heavy chemical complexes
  - Map Ta Phut heavy chemical complex, Thailand

## 7.Investment Efficiency

- (1)Investment amount: Undisclosed
- (2) Recovery period for facility introduction
 

A simple payback period is approx. 5 years for

  - (a) Energy sharing system across multiple sites and
  - (b) Integrated en-ergy monitoring system, and approx. 8 years for (c) Low heat power generation system.

Nowadays economic evaluation has been greatly improved due to the subsequent increase of energy prices for crude oil and electric power.

## 8.Secondary Effects

- (1)Environmental Effect
 

Based on the results by area-wide pinch technology, large energy conservation potential was confirmed in each heavy chemical complex.

For instance;

  - 1) Chiba heavy chemical complex: 640,000 kL
  - 2) Mizushima Heavy chemical complex: 1,210,000 kL
  - 3) Map Ta Phut heavy chemical complex in Thailand: 880,000 kL

Figures amount up to 20 to 30% of the total energy consumption of each heavy chemical complex. It was found out that a large amount of energy conservation could be achieved by introducing a similar energy conservation project.

This project was implemented by the two sites in Chiba



Photo 1 Overview of Low Exergy Utilization System across Multiple Sites

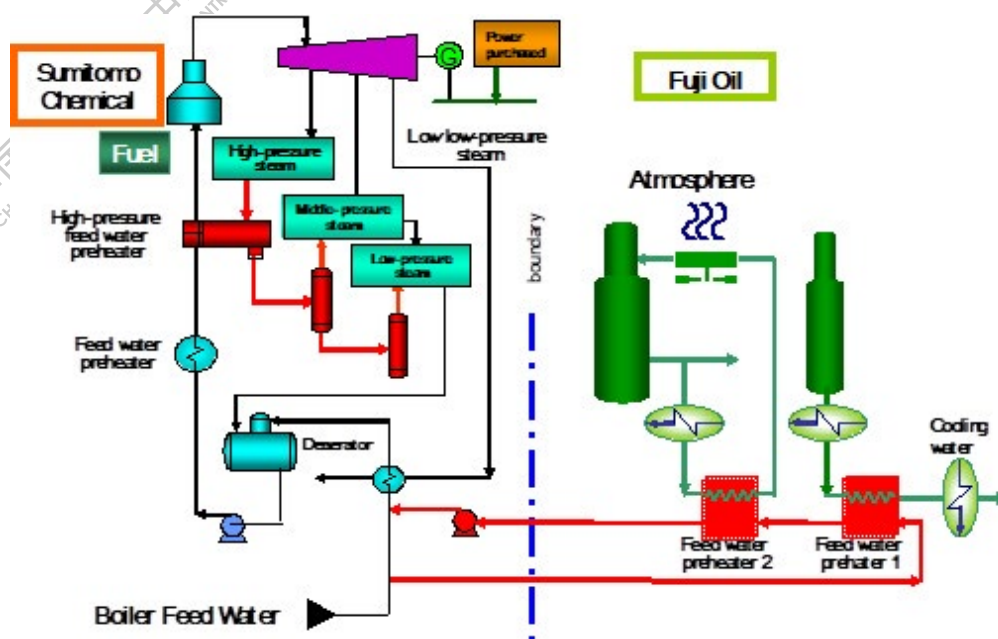


Fig. 1 Energy sharing system across multiple sites

heavy chemical complex, and its energy conservation amount is 10,700 kL (annual CO<sub>2</sub> emission reduction amount equivalent to 28,000 tons). It is now clear from this project that a huge amount of energy conservation (CO<sub>2</sub> reduction) can be expected if similar projects are introduced into other sites of the heavy chemical

complexes.

## (2) Human resource Development

In Japan, for the purpose of spreading the concept for energy conservation by sharing and effectively utilizing low-grade heat across multiple sites in the heavy chemical complexes, this has been announced at many occasions



in technical seminars and academic conferences, sponsored by public institutions such as New Energy and Industrial Technology Development Organization (NEDO), Society of Chemical Engineers, Japan (SCEJ), and Japan Society of Mechanical Engineers (JSME). With the support of NEDO, this project has also been announced overseas, in countries such as Thailand, Indonesia, China, Taiwan, Finland, and Czech. Each country had strong interest and was eager to introduce area-wide pinch technology. Consequently, Map Ta Phut heavy chemical complex in Thailand was selected as the next target site followed by the Japanese heavy chemical complexes. Its application has been already materialized, supported by NEDO.

### (3) Social Recognition

1) Awarded with "Agency for Natural Resources and Energy Director-General's Award" at Superior Energy-Saving Machines Commendation Ceremony of the Japan Machinery Federation. (FY2006)

2) Awarded with "Special Award for Energy Conservation Grand Prize" of Ministry of Economy, Trade and Industry. (FY2011)

3) Posted on NEDO webpage "NEDO PROJECT SUCCESS STORIES" as a successful case of a NEDO project. (FY2014)

### (4) Safety and Sanitation

This project has been improving the record for accident-free and stable operation since operation commencement in 2005. ■

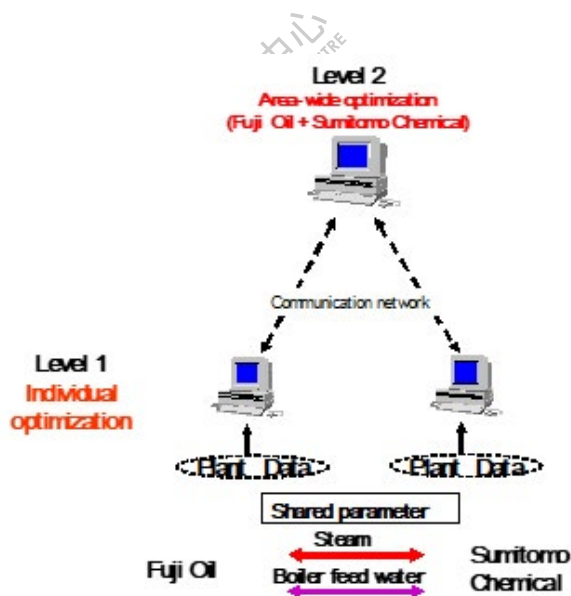


Fig. 2 Integrated energy monitoring system

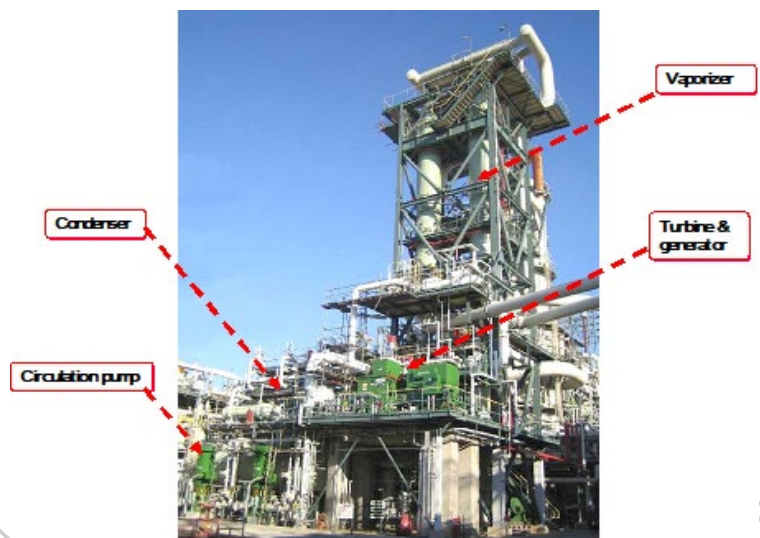


Fig. 3 Low heat power generation system

## BP5: Reduction in Steam Loss from 100,000 Steam Traps

### 1.Details of case

Reduction in energy loss from steam leaks (hereafter steam loss) is one of the main pillars of energy conservation activities. The proper maintenance and management of steam traps is especially important from this viewpoint. Our company has long been managing this on its own.

However, in addition to the fact that the judgment standards and confirmation methods, which primarily relied on the five senses of the operator to determine whether the trap function is normal, were unclear, the enormous number of units (100,000 from seven refineries) limited our ability to achieve proper maintenance.

Thus, we planned to build, in collaboration with TLV Co., Ltd., an effective and sustainable program for maintenance and management that would allow us to comprehensively and accurately audit the traps of each refinery every year, feed the audit results into a database, and repair/replace traps based on analysis of this database.

As Figure 1 shows, the clarity and continuity of our work procedures have been enhanced by the newly crafted maintenance and management program, which is now based on an annual work cycle comprised of "6 steps" recommended by TLV in BPSTM (Best Practice of Steam Trap Management). In implementing each step, the head office, each refinery, and TLV reviewed the past characteristics and issues, together with new ideas, and built an efficient and sustainable program.(See Figure 1.)

### 2.Energy conservation performance

- Energy conservation amount in annual crude oil equivalent: ▲18,000 kL
- Annual CO<sub>2</sub> emission reduction amount:  
▲46,000 t-CO<sub>2</sub>.

As you can see from the leak failure rates of major refineries (Muroran, Mizushima) and the example trends of steam loss volume shown in Figure 2, the failed trap rate has been steadily declining every year as a result of the development of this program at each refinery since 2005. It is now assumed that the



total steam loss from all seven refineries was reduced by approximately 37 tons per hour by 2008.(See Figure 2.)

### 3.Advanced nature and originality

For building this program, we sought opinions from internal experts and operators and a trap manufacturer (TLV) on the issues of, and possible improvements to, existing maintenance and management, and adopted ideas from new viewpoints outside of the existing framework so that the program would work efficiently and sustainably.

The following are the major ideas:

- (1) Validation of audit technique (accuracy of inspection device, skill level of inspector).
- (2) Outsourcing of inspection work (consignment of manpower tasks).
- (3) Efficient audit work (improved efficiency, labor savings by taking advantage of management tools such as use of IT technology).
- (4) Introduction of the database management system (continuous data updates and data analysis every year).
- (5) Selection of the best trap model is critical to the safe operation of equipment and for the prevention of repeated failures.

### 4.Versatility and expandability

In industries with large-scale facilities that use high volumes of steam for heating via piping and tanks, etc., large numbers of traps are installed causing many users to struggle with maintenance and management. In addition, in small and medium-sized factories and large buildings,

steam is used for heating. Therefore, energy-conservation activities include periodic surveys and maintenance of traps.

In our case, the energy-saving effect for 100,000 traps is 18,000 kL/year (crude oil equivalent) and the economic advantage is around 1 billion yen (fuel cost assumed as 58,000 yen/kL). On the other hand, the cost spent on audits and repairs was around 900 million yen, proving it is economically sound. Also, by introducing ideas that make the maintenance and management program viable, it is also possible to continue to keep the steam loss to a minimum from now on.

Though this activity does not introduce state-of-the-art energy-saving technology, it is a steady energy conservation activity that is sure to produce beneficial results. As a proverb says: "a penny saved is a penny earned."We think this activity is worth trying in other companies and industries. TLV is actually deploying this program as the 'BPSTM: Best Practice of Steam Trap Management®' Program in major oil refining, petrochemical, and steel companies as well as in small and medium-sized plants in Japan, and has steadily achieved reductions in the leak failure rates and steam losses in 91 facilities. Additionally, TLV is proceeding to implement this program in countries outside of Japan, and is planning to implement a wider range of energy conservation activities. The results are as shown below.

\* Actual implementation results as of 2014

(The figures show the steam loss reduction amounts and



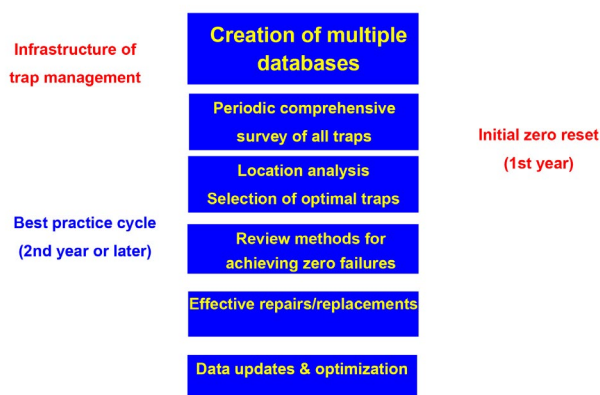


Fig. 1

CO<sub>2</sub> reduction amounts.)

(1) In Japan: 91 facilities, realizing reductions of 918,000 t/year and 134,000 t-CO<sub>2</sub>/year

(2) Outside Japan: 18 facilities, realizing reductions of 175,000 t/year and 26,000 t-CO<sub>2</sub>/year

## 5. Continuity and sustainability

This activity was launched at each refinery in 2005. We have been trying to tackle the existing issues related to maintenance management with new ideas, and have established an effective and sustainable program, which is now being sustained and managed.

Encouraged by the effects gained from trap activities, we have discovered overlooked energy losses, such as steam loss from unnoticed places and ineffective operations resulting from failures, and this has led to enhanced voluntary energy conservation activities.

In Muroran's case, to promote energy conservation by reducing steam losses, and implementing "5S" by

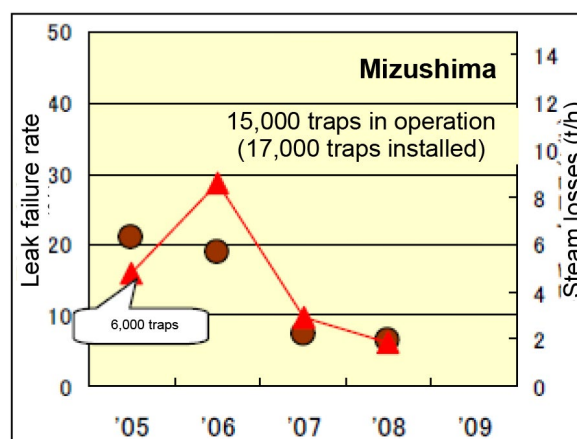
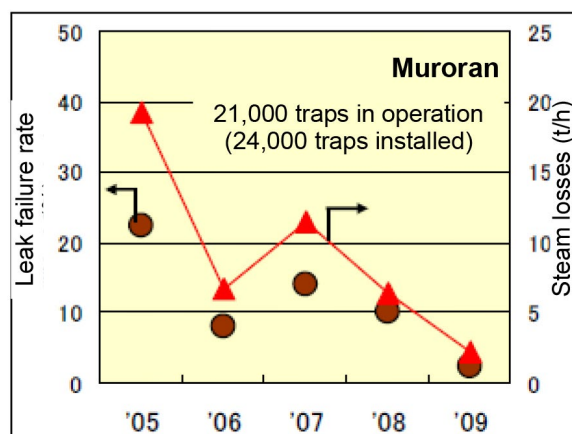


Fig. 2

improving the clouded environment around leak locations, a "Steam Cloud Search Group" was formed, which conducted voluntary activities to search for leak locations and do repair work.

This also resulted in an increase in employee motivation, leading to improved knowledge of steam and pursuit of energy conservation. There are some refineries that are actively participating in the steam-specialized energy conservation and technical surveys

conducted by TLV.

Through these activities, executives at our company (head office) are not only promoting energy conservation activities but are also supporting each refinery with: labor-savings in operations through use of IT, establishment of the program, education of personnel, set up of the systems, technical support, and securing the budget for these efforts. In addition, the results of these activities are disclosed internally and externally (making it visible), thereby, motivating the employees in terms of energy

conservation activities and contributing to continuity and sustainability.

#### 6.Investment efficiency

Refer to "the energy-saving effect for 100,000 traps" described in 6. "Versatility and expandability".

#### 7.Secondary results

Refer to "Actual implementation results as of 2014" described in 6. "Versatility and expandability," for CO<sub>2</sub> reduction amounts. ■

## BP6: Energy Just In Time (JIT) Activities

### 1.Details of case

(1) Supply JIT (model activity: optimal supply of industrial air)

Improvements were implemented with the following steps in order to adapt the energy JIT to the concepts of supplying; when necessary (at an appropriate time), only as much as is needed (in an appropriate quantity), where necessary (at an appropriate site), and what is necessary (appropriate material), etc.

STEP1: Required amount of air and production site location are recorded in the registry and energy map.

STEP2: Timing of when the air is needed is understood from the signboard information generated from the production side.

STEP3: Air supply schedule and estimated amounts are calculated according to the signboard information and energy register.

STEP4: Pneumatic equipment, which matches the estimated air amount, is chosen from the equipment performance curve.

Thus, “necessary air supply operation when necessary with the highest efficiency” is realized.

(2) Production JIT (model activity: idling stop of system)

An automatic system for energy reduction at times of no-production was developed. Whereby, if the work or the handling of a current process becomes faulty, due to issues with previous process, etc., then the power supply to the equipment of the current process is automatically cut. When work for the current process becomes unnecessary, as the previous process is restored, the power supply is automatically restored.

### 2.Energy conservation performance

(1) Supply JIT (model activity: optimal supply of industrial air)

Intensity at the time of low load:

▲ 7% ( $9.9 \rightarrow 10.6 \text{ m}^3/\text{kWh}$ )

Electric energy of the pneumatic equipment:

▲ 2% (Air supply pressure:  $480 \rightarrow 470 \text{ kPa}$ )

(2) Production JIT (model activity: idling stop of system)

Electricity reduction during the lunch break: ▲ 50%

Standby electricity during automatic operation:



▲70%

Daily power consumption: ▲approx. 7%

### 3. Advanced nature and originality

(1) Supply JIT (model activity: optimal supply of industrial air)

Besides traditional quantitative control using air pipe terminal pressure, a new pneumatic equipment control system was developed and standardized. It “calculates the air quantity requested by the factory by acquiring the production information then choosing and operating efficient pneumatic equipment that is the most suitable for the air amount calculated” (patent pending).

(2) Production JIT (model activity: Idling stop of system)

The “idling stop of system” was developed and standardized. It automatically shuts down the power supply of the standby power equipment when production is disabled, due to breakdown, etc., and automatically restores the power when it becomes necessary through the acquisition of the operational information of the preceding and subsequent processes (patent pending).

### 4. Versatility and expandability

(1) Supply JIT (model activity: optimal supply of industrial air)

The air JIT system has been implemented throughout the company since 2010, while establishing JIT tools such as the “energy signboard,” “energy registry,” “energy map,” and the “optimal operation control” so that it can

also be implemented in other workplaces.

(2) Production JIT (model activity: idling stop of system)

For the idling stop, the “application manuals” of the existing systems were prepared and distributed throughout the company. The idling stop for new systems was incorporated into the “design standard (DMS) for internal production systems” so that it is reflected in the design at the implementation stage.

### 5. Continuity and sustainability

Denso started the model demonstrations in FY2009. By verifying their effect, documenting the implementation method as manuals, and repeating explanatory meetings, the activities have been implemented in all of the Energy Workshops as an important energy conservation measure in the company. Furthermore, the Environment Committee considers energy JIT as one of the important energy conservation measures for development, and has implemented it in Group companies in Japan and overseas.

### 6. Investment efficiency

(1) Supply JIT (model activity: optimal supply of industrial air)

Investment amount of 52.92 million JPY; investment recovery for 2.8 y.

(2) Production JIT (model activity: idling stop of system)

Investment amount of 530,000 JPY; investment

recovery for 3.5 y.

## 7.Secondary results

### Estimation of the effects when implemented throughout the company:

- (1) 170 million JPY/y (electric energy for pneumatic equipment: ▲9%)
- (2) 1.4 billion JPY/y (electric energy consumed in the production line: ▲7%)

### Patents, awards, and presentations

- (1) Patent application: Application No. PN134438

(submitted on September 21, 2010)

Presentations: (a) presented at the traveling lecture program of the Energy Conservation Center, Japan, Tokai-Hokuriku branch (80 attendees); and (b) presented at Nikkei (February 4, 2010), and Nikkei Sangyo Shimbun (March 23, 2010)

- (2) Patent application: Application No. PN137669 (submitted on November 30, 2010)

Presentation: the Mid-Japan Economist (March 23, 2010) ■

## BP7: Integrating LNG Cold Energy into an Ethylene Plant

### 1.Details of case

Osaka Gas, a gas supplier, vaporizes LNG at the Senboku LNG Terminal (hereinafter referred to as "Senboku") adjacent to the Mitsui Chemicals Osaka Works and supplies it to six prefectures in the Kinki region as city gas. LNG is a  $-160\text{ }^{\circ}\text{C}$  cryogenic fluid and has considerable cold energy available for cooling substances. Its effective use helps energy conservation and  $\text{CO}_2$  emission reduction. Some plants in the precincts of the Mitsui Chemicals and Osaka Petro-chemical Industries input energy, such as electric power and steam, in order to generate cold energy through the refrigerators, and utilize it for separation, etc. during product manufacture. At present, the world's first large-scale energy conservation process has been introduced, which is capable of receiving LNG into the ethylene plant from Senboku I, making use of LNG cold energy in the most effective manner in the factory and greatly reducing the energy required for the refrigerators.

### 2.Diagrams and other illustrations

See Figure1.

### 3.Energy conservation performance

Test operations started in September 2010 and full-scale operations in January 2011, confirming the following substantial energy conservation effects:

- A 6% reduction in energy intensity at the ethylene plant of Osaka Petrochemical Industries.
- Total reduced crude oil equivalent energy of 13,000 kL/y at four factories, with a reduction rate of 1.4%.

### 4.Advanced nature and originality

- Realizes remarkable energy conservation at the ethylene plant by utilizing the capability of cascading the LNG cold energy in a phased manner within a wide temperature range from  $-100$  to  $20\text{ }^{\circ}\text{C}$ .
- Establishes a new process capable of high energy conservation performance with high operational stability, while continuously securing the required amount of cold energy by combining the LNG cold energy, refrigeration compressor, and expander, even when the LNG supply volume to the ethylene plant fluctuates.
- First example of the utilization of LNG cold energy on a



large scale at an ethylene plant in the world.

- Collaborative program comprehensively combining energy ranging over different types of industries, such as the gas and petrochemical industries, in an industrial complex.
- Realizes 100% LNG cold energy utilization at Senboku I (on a throughput basis) and improves exergy efficiency of the entire terminal by 14%.

5.Versatility and expandability

- Utilization of LNG cold energy has been attracting attention owing to higher environmental awareness and increased LNG introduction.
- Even when the LNG supply volume fluctuates, this process has high operational stability allowing the continuous operation of the ethylene plant by the combined use of a refrigeration compressor. It is widely applicable when making use of LNG cold energy as an alternative to a refrigerator at chemical plants, etc.
- This is a collaborative program comprehensively combining energy, for the gas and petrochemical industries, and a model case for business collaboration in

other regional industrial complexes. It is expected that the application of this technology in Japan and overseas will develop large-scale energy conservation in the future.

6.Continuity and sus-tainability

- Improvements to increase LNG cold energy usage will be examined to pursue further increases in energy conserva-tion.

7.Investment efficiency

Unknown

8.Secondary results

Patents, awards received and publications:

- (1) Press releases: Nikkan Kogyo Shimbun and eight other cases.
- (2) Official announcements: Kyodo press release and four other examples.
- (3) Document contributions: Ministry of Economy, Trade and Industry, “Chemical Vision Study Group” and two other cases. ■

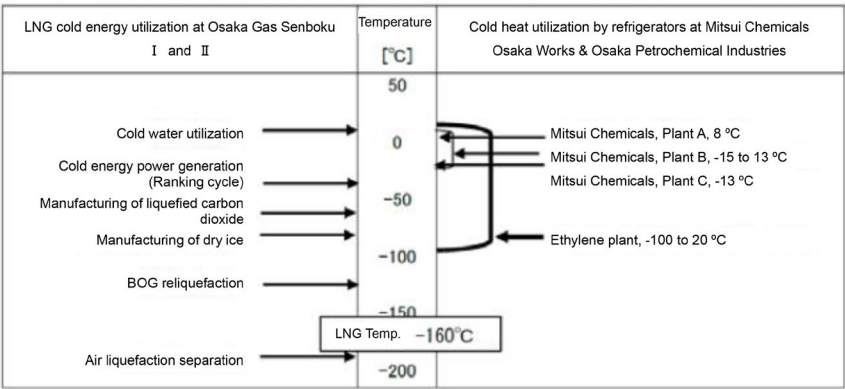


Fig. 1

## BP8: Electricity-saving Measures by Coca-Cola: Development and Popularization of Peak Shift Vending Machines

### 1.Details of case

In response to the decreased electric power supply after the Great East Japan Earthquake in 2011, a Power-saving Project Team was formed. By formulating power-saving measures that included halting cooling operations using three-group rotation and comprehensively implementing power-saving measures over a short period targeting approximately 350,000 vending machines, reductions in electric power consumption exceeding the government targets were achieved.

In order to further develop and continually promote the concept of "reduced electric power consumption during daytime in summer when electric power is insufficient," Co-ca-Cola (Japan) developed a "Peak Shift Vending Machine" jointly with Fuji Electric, Japan's largest vending machine manufacturer.

Aimed at wide and quick popularization of this new vending machine in the market, an installation

target of 25,000 units was determined for the current fiscal year(2013FY). Through strengthened cooperation with bottling companies, development and application of a variety of sales tools, and implementation of unique communication strategies and public relations activities in terms of society and consumers, the installation target was achieved ahead of the plan (by late September). In addition, a public awareness rate of 35% was achieved, with the media exposure also reaching an amount equivalent to 1.3 billion yen, indicating a widening circle of awareness.

### 2.Diagrams

See Figure1&2.

### 3.Energy conservation performance

- Actual energy conservation results realized for each vending machine
- The annual electric power consumption has been reduced to approximately one-third over the past 10

years.

- In addition, the introduction of the Peak Shift Vending Machine has reduced the electric power consumption by more than 10% compared to the vending machine previously used by Coca-Cola (FY2012 machine).

- Total electric power consumption by the vending machines in the market

- 40% reduction over a 10-year period (reduction of more than 1 billion kWh over a 10-year period)

- Energy conservation merits of Peak Shift Vending Machines

- For summer, when the electricity demand is generally high, 16 hours of daytime electric power consumption for cooling have been reduced to zero, i.e., the daytime electric power consumption has been reduced by 95%

#### 4. Technological advancement and originality

-In order to reduce the daytime electric power consumption for cooling to zero, all the products in the vending machine are cooled and utilized as cold storage materials.

-Improvements in terms of airtightness and efficient utilization of vacuum heat insulating materials in the vending machines have enabled cooling effect to be maintained over longer time periods.

#### 5. Versatility and expandability

-Technology disclosure commenced against the main vending machine manufacturers.

Market share to be expanded to 30% by 2020.

In 2014, production has been started by all four vending machine manufacturers in Japan, and they are trying to popularize it as a new energy-saving measure.

-Promoting awareness and education on the peak shift concept through positive public relations activities.

-A "47 Prefecture Electricity-saving Awareness Survey" was carried out targeting the whole of Japan, and the results were released to the public.

#### 6. Continuity and sustainability

- Implemented planned promotion of the Peak Shift Vending Machine functions as "standard functions."

#### 7. Investment efficiency

Unknown

#### 8. Secondary results

##### Patents, awards, and presentations:

- (1) Patents: 1 patent (Joint application with Fuji Electric)
- (2) Presentations (Television): Total 19 media including NHK
- (3) Presentations (News Agencies): Total 8 media including Kyodo News
- (4) Presentations (National Newspapers): Total 8 media including Asahi Shimbun
- (5) Presentations (English Newspapers): Total 3 media including The Japan Times
- (6) Magazines and Trade Journals: Total 88 media including The Economist and Energy Conservation
- (7) WEB: Total 744 media including NHK ONLINE



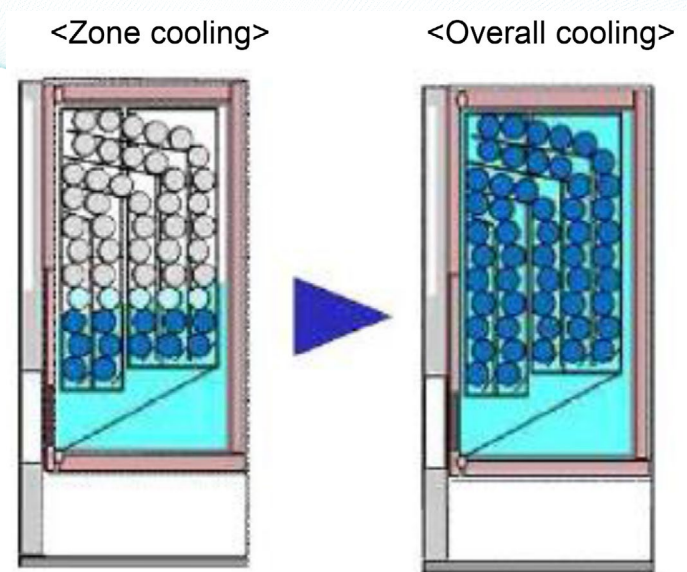


Fig. 1

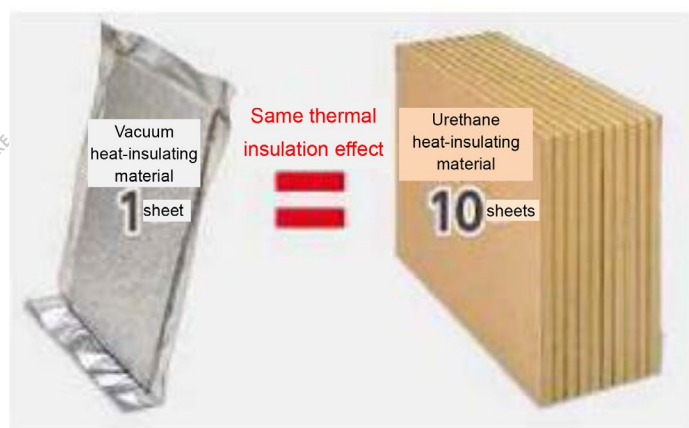


Fig. 2 ■

# First Batch of Domestic TOP TENS List

## U.S. BAT List

Edited by Sheng Xin

**BAT1: Flue gas heat recovery system (feedwater economizers and/or combustion air preheaters) for boilers**

### 1. Technology description

A flue gas heat recovery system can make boilers more efficient by capturing and re-using heat energy that would otherwise have escaped out of your flue or chimney. All boilers which burn fuel to produce heat create exhaust gases, and these need to be expelled outside. However, as these gases are hot (about 200°C), as much as 35% of the heat being produced by the boiler can be wasted when they are expelled.

This technology recovers available heat from exhaust gases and transfers it back into the system by preheating feedwater or combustion air<sup>[1]</sup>.

### 2. Level of Energy Savings

In most steam systems, this technology can improve the energy efficiency of the system 4% ~7% depending on the baseline efficiency of the system.

### 3. Market prospect

At the country level, most industrial steam systems, especially in the developing countries, have low to medium efficiency level. This indicates a significant

Notes:

[1] U.S. Department of Energy, Advanced Manufacturing Office (U.S. DOE/AMO). 2012. Improving Steam System Performance: A Sourcebook for Industry-Second Edition.

market prospect for this technology in the industry sector in various countries. The recent study by UNIDO and LBNL<sup>[2]</sup> on industrial steam systems showed that in steam systems with low efficiency level, often no flue gas heat recovery equipment is installed on the boiler resulting in elevated flue gas temperature and in steam systems with medium efficiency level, often the final flue gas temperature is elevated and a significant energy recovery potential remains. The flue gas heat recovery technology can improve the steam system efficiency by around 7% if the system has low system efficiency and by around 4% if the system has medium system efficiency.

#### 4. Reliability

Given that many installation of this technology is already working in different industries around the world, this technology has passed the reliability test. Although the quality and performance of the technology may vary by technology provider.

#### 5. Economic Characteristics

The cost of this technology will vary depending on the size of the steam system and the country it is installed and other factors. The recent study by UNIDO and LBNL show that for installation in China this technology will cost in the range of 72 – 1,160 thousand US dollars for system size ranging from <4 t steam/h to >94 t steam/h.

#### 6. Social Characteristics and co-benefits

- Reduced energy-related CO<sub>2</sub> emissions
- Reduced other air pollutants emissions resulted from fossil fuel use.

### BAT2: Flash-steam recovery technology

#### 1. Technology description

Flash steam is released from hot condensate when its pressure is reduced. The steam released by the flashing process is as useful as steam released from a steam boiler<sup>[3]</sup>.

In any steam system seeking to maximize efficiency, flash steam will be separated from the condensate, and used to supplement any low pressure heating application. Every kilogram of flash steam used in this way is a kilogram of steam that does not need to be supplied by the boiler. It is also a kilogram of steam not vented to atmosphere, from where it would otherwise be lost.

#### 2. Level of Energy Savings

In most steam systems, this technology can improve the energy efficiency of the system 2.5% ~4% depending on the baseline efficiency of the system.

#### 3. Market prospect

At the country level, most industrial steam

Notes:

[2] Hasanbeigi, A. Harrell, G. Schreck, B. (2014). Energy Efficiency Potentials in Industrial Steam Systems in China: Development of the Steam Systems Energy Efficiency Cost Curve. United Nations Industrial Development Organization (UNIDO), Vienna, Austria.

[3] U.S. Department of Energy, Advanced Manufacturing Office (U.S. DOE/AMO). 2012. Improving Steam System Performance: A Sourcebook for Industry-Second Edition.



systems, especially in the developing countries, have low to medium efficiency level. This indicates a significant market prospect for this technology in the industry sector in various countries. The recent study by UNIDO and LBNL<sup>[4]</sup> on industrial steam systems showed that in steam systems with low efficiency level, flash-steam is not recovered and in steam systems with medium efficiency level, flash-steam is partially recovered. Flash steam recovery technology can improve the steam system efficiency by around 4% if the system has low system efficiency and by around 2.5% if the system has medium system efficiency.

#### 4. Reliability

Given that many installation of this technology is already working in different industries around the world, this technology has passed the reliability test. Although the quality and performance of the technology may vary by technology provider.

#### 5. Economic Characteristics

The cost of this technology will vary depending on the size of the steam system and the country it is installed and other factors. The recent study by UNIDO and LBNL show that for installation in China this technology will cost in the range of 38 – 674 thousand US dollars for system size ranging from <4 t steam/h to >94 t steam/h.

#### 6. Social Characteristics and co-benefits

- Reduced energy-related CO<sub>2</sub> emissions
- Reduced other air pollutants emissions resulted from fossil fuel use.

#### BAT3: Loss on ignition (LOI) optimization technology for coal-fired boilers

##### 1. Technology description

Coal fired boilers have various sources of thermal energy loss. The main sources are the dry gas loss as well as the loss-on-ignition (LOI) of the ash leaving the boiler. The vast majority of the combustible portion of the ash that accounts for the energy loss is simply unburned carbon. The common approach in the past has been to keep the carbon as low as possible to minimize the combustible losses in the ash. However, the most efficient way to operate a boiler is to minimize the energy losses due to the fly ash LOI and the stack gases at the same time. LOI optimization technology which may have several features such as on line measurement of unburned carbon, ash reinjection, etc. can improve the energy efficiency of coal-fired steam systems significantly.

##### 2. Level of Energy Savings

In most steam systems, this technology can improve the

Notes:

[4] [ Hasanbeigi, A. Harrell, G. Schreck, B. (2014). Energy Efficiency Potentials in Industrial Steam Systems in China: Development of the Steam Systems Energy Efficiency Cost Curve. United Nations Industrial Development Organization (UNIDO), Vienna, Austria.

energy efficiency of the system 3% - 5% depending on the baseline efficiency of the system.

### 3. Market prospect

At the country level, most industrial steam systems, especially in the developing countries, have low to medium efficiency level. This indicates a significant market prospect for this technology in the industry sector in various countries. The recent study by UNIDO and LBNL<sup>[5]</sup> on industrial steam systems showed that in steam systems with low efficiency level, Loss On Ignition (LOI) is not monitored regularly and is managed poorly and in steam systems with medium efficiency level, LOI is monitored regularly but timing is infrequent and significant corrective actions are not clearly applied to reduce the LOI. Loss on ignition (LOI) optimization technology for coal-fired boilers can improve the steam system efficiency by around 5% if the system has low system efficiency and by around 3% if the system has medium system efficiency.

### 4. Reliability

Given that many installation of this technology is already working in different industries around the world, this technology has passed the reliability test. Although the quality and performance of the technology may vary by technology provider.

### 5. Economic Characteristics

The cost of this technology will vary depending on the size of the steam system and the country it is installed and other factors. The recent study by UNIDO and LBNL show that for installation in China this technology will cost in the range of 72 – 507 thousand US dollars for system size ranging from <4 t steam/h to >94 t steam/h.

### 6. Social Characteristics and co-benefits

- Reduced energy-related CO<sub>2</sub> emissions
- Reduced other air pollutants emissions resulted from fossil fuel use
- LOI optimization can also improve the fly ash quality. Fly ash becomes an even more attractive product if it is of consistent quality.

### BAT4: Variable frequency drives (VFDs)

#### 1. Technology description

An adjustable speed drive (ASD) is a device that controls the rotational speed of motor-driven equipment. Variable frequency drives (VFDs), the most common type of ASDs, efficiently meet varying process requirements by adjusting the frequency and voltage of the power supplied to an AC motor to enable it to operate over a wide speed range. External sensors monitor flow, liquid levels, or pressure and then transmit a signal to a controller that adjusts the frequency and speed to match process requirements.

Notes:

[5] [Hasanbeigi, A. Harrell, G. Schreck, B. (2014). Energy Efficiency Potentials in Industrial Steam Systems in China: Development of the Steam Systems Energy Efficiency Cost Curve. United Nations Industrial Development Organization (UNIDO), Vienna, Austria.]

## 2.Level of Energy Savings

In most cases, this technology can improve the energy efficiency of the system 15%~25% for pumping and compressed air systems and 20%~35% in fan systems depending on the baseline efficiency of the system.

## 3.Market prospect

A recent study by UNIDO and LBNL<sup>[6]</sup> on industrial motor systems showed that at the country level, most industrial motor systems have low to medium efficiency level. This indicates a significant market prospect for VFDs in the industry sector in various countries. The same study indicates that in motor systems with low efficiency level VFDs are not commonly used and in systems with medium efficiency level VFDs are only sometimes used as a solution for flow control. VFDs can improve the system efficiency by 15% - 25% for pumping and compressed air systems and 20% - 35% in fan systems, depending on the baseline system efficiency.

## 4.Reliability

Given that many installation of this technology is already working in different industries around the world, this technology has passed the reliability test. Although the quality and performance of the technology may vary by technology provider.

## 5.Economic Characteristics

The cost of this technology will vary depending on the

type and size of the system and the country it is installed and other factors. The UNIDO and LBNL study shows that for installation in the US, VFD technology will cost in the range of 4 – 65 thousand US dollars for pumping systems, 12 – 100 thousand US dollars for compressed air systems, and 8 – 150 thousand US dollars for fan systems with size ranging from <50 hp to 1000hp.

## 6.Social Characteristics and co-benefits

- Reduced energy-related CO<sub>2</sub> emissions
- Reduced other air pollutants emissions resulted from fossil fuel use.
- Improved system reliability in some application

## BAT5:Low-grade waste heat to power absorption chillers

### 1.Technology description

Absorption chillers use heat/waste heat, instead of mechanical energy, to provide cooling. The mechanical vapor compressor is replaced by a thermal compressor that consists of an absorber, a generator, a pump, and a throttling device.

Compared to mechanical chillers, absorption chillers have a low coefficient of performance (COP = chiller load/heat input). Nonetheless, they can substantially reduce operating costs if they are energized by low-grade waste

Notes:

[6] [ McKane, A. and Hasanbeigi, A. (2010). Motor System Efficiency Supply Curves. United Nations Industrial Development Organization (UNIDO). ]



heat, while vapor compression chillers must be motor or engine driven.

## 2. Level of Energy Savings

Energy saving achieved by implementation of this technology varies by industry, process, application, technology provider, etc.

Example:

In a plant where low-pressure steam is currently being exhausted to the atmosphere, a mechanical chiller with a COP of 4.0 is used 4,000 hours per year (hr/yr) to produce an average of 300 tons of refrigeration. An absorption unit requiring 5,400 pounds per hour of 15-psig steam could replace the mechanical chiller, providing annual electricity savings of 1,055 MWh.<sup>[7]</sup>

## 3. Market prospect

The current adoption rate of this technology varies in different industries and countries, but in general the current adoption rate is low in most countries. Therefore, there is a significant market potential for this technology.

## 4. Reliability

Given that many installations of this technology are already working in different industries around the world, this technology has passed the reliability test. Although the quality and performance of the technology may vary by technology provider.

## 5. Economic Characteristics

Below are some estimated ranges in capital costs for

select absorption chillers.<sup>[8]</sup>

Tons	Single-Effect Hot Water or Steam (\$/ton)	Double-Effect Hot Water or Steam (\$/ton)
100-400	\$1,110	\$1,970
400-800	\$820	\$1,470
800-1,200	\$730	\$1,300
1,200-1,600	\$680	\$1,220

## 6. Social Characteristics and co-benefits

- Reduced energy-related CO<sub>2</sub> emissions
- Reduced other air pollutants emissions resulted from fossil fuel use
- Avoids the use of any ozone-depleting fluorocarbons for cooling

## BAT6: Industrial combined heat and power (CHP)

### 1. Technology description

Combined heat and power (CHP), also known as cogeneration, is the concurrent production of electricity or mechanical power and useful thermal energy (heating and/or cooling) from a single source of energy. Instead of purchasing electricity from the grid and burning fuel in an on-site furnace or boiler to produce thermal energy, CHP provides both energy services to a facility in one energy-efficient step.

For smaller industrial plants, commercial microturbines, with outputs ranging from 30–600 kW, are also available.

Notes:

[7] [ US DOE. 2006. Use Low-Grade Waste Steam to Power Absorption Chillers, Energy Tips-Steam. Washington, DC.]

[8] Antares Group Inc. 2012 how to decide if an absorption chiller is right for you

## 2.Level of Energy Savings

It is reasonable to expect CHP applications to operate at 65-75% efficiency,a large improvement over the national average of 35%~45% for these services when separately provided.

## 3.Market prospect

In the United States,the Obama Administration has a goal to achieve 40 GW of new,cost-effective CHP by 2020. Achieving this goal would:

- Increase total CHP capacity in the United States by 50% in less than a decade
- Save energy users \$10 billion per year compared to current energy use
- Save 1 quadrillion Btu (Quad) of energy — the equivalent of 1% of all energy use in the United States
- Reduce emissions by 150 million metric tons of carbon dioxide (CO<sub>2</sub>) annually — equivalent to the emissions from over 25 million cars
- Result in \$40-\$80 billion in new capital investment in manufacturing and other U.S. facilities over the next decade.<sup>[9]</sup>

## 4.Reliability

Given that many installation of this technology is already working in different industries around the world,this technology has passed the reliability test. Although the quality and performance of the technology may vary by technology provider.

## 5.Economic Characteristics

The cost of this technology varies by industry,process,application,size,technology provider,etc.

The investment costs of a gas-turbine CHP plant ranges from \$900/kW to \$1500/kW,with a typical cost figure of \$1000/kW (US\$2008). The annual operation and maintenance (O&M) costs are approximately \$40/kW. The investment costs of a combined-cycle (CCGT) CHP plant range from \$1100/kW to \$1800/kW and more,with a typical cost figure of \$1300/kW. The annual O&M costs are approximately \$50/kW. The investment costs of a fluidized-bed combustion (FBC) CHP plant based on coal ranges from \$3000/kW to \$4000/kW and more,with a typical cost figure of \$3250/kW and annual O&M costs of approximately \$100/kW. The investment costs of a gas-engine CHP plant are in the range of \$850–1950/kW,with a typical cost figure of \$1,150/kW. Its annual O&M costs are about \$250/kW<sup>[10]</sup>.

## 6.Social Characteristics and co-benefits

- Reduced energy-related CO<sub>2</sub> emissions
- Reduced other air pollutants emissions resulted from fossil fuel use
- Reduced exposure to grid power cut and grid power disruptions

## BAT7: Recuperative or Regenerative Burners

### 1.Technology description

Notes:

[9] [ US DOE. Benefits of combined heat and power. <http://energy.gov/eere/amo/benefits-combined-heat-and-power>]

[10] [ IEA ETSAP. 2010. Combined heat and power. Paris,France.]



Application of recuperative or regenerative burners can substantially reduce energy consumption. A recuperator is a gas-to-gas heat exchanger placed on the stack of the furnace. There are numerous designs, but all rely on tubes or plates to transfer heat from the outgoing exhaust gas to the incoming combustion air, while keeping the two streams from mixing. Recuperative burners use the heat from the exhaust gas to preheat the combustion air.

Regenerators are basically rechargeable storage batteries for heat. During an operating cycle, process exhaust gases flow through the regenerator, heating a storage medium. After a while, the medium becomes fully heated (charged). The exhaust flow is shut off and cold combustion air extracts the heat from the storage medium, increasing in temperature before it enters the burners. For continuous operation, at least two regenerators and their associated burners are required.

## 2. Level of Energy Savings

- Recuperative burners can reduce fuel consumption by 10%~20% compared to furnaces without heat recovery.
- Regenerative burners can theoretically achieve savings of up to 35% compared to furnaces without heat recovery. The practical energy saving will be less than this depending on the plant-specific and process-specific condition.

As an example, in the steel industry, the use of this technology in hot mill reheating furnaces can typically

save around 0.7 GJ/ton hot rolled finished steel<sup>[11]</sup>.

## 3. Market prospect

The current adoption rate of this technology varies in different industries and countries. For the example given above on the use of recuperative or regenerative burners in hot mill reheating furnaces in the steel industry, in 2010, (based on the production capacity) only around 30% of steel plants in China and 40% of steel plants in India had installed this technology. Thus, there is significant potential for application of this technology in steel plants in those two countries (which account for over 50% of steel production in the world) and other countries.

## 4. Reliability

Given that many installations of this technology are already working in different industries around the world, this technology has passed the reliability test. Although the quality and performance of the technology may vary by technology provider.

## 5. Economic Characteristics

The cost of this technology varies by industry, process, application, technology provider, etc.

For the example given above on the use of recuperative or regenerative burners in hot mill reheating furnaces in the steel industry, the typical cost of the technology is around US\$4.3 per ton hot rolled finished steel.<sup>[12]</sup>

Notes:

[11] [ Worrell, E., P. Blinde, M. Neelis, E. Blomen, E. Masanet. 2010. Energy Efficiency Improvement and Cost Saving Opportunities for the U.S. Iron and Steel Industry: An ENERGY STAR Guide for Energy and Plant Managers. US EPA. Washington, DC.]

[12] [ Worrell, E., P. Blinde, M. Neelis, E. Blomen, E. Masanet. 2010. Energy Efficiency Improvement and Cost Saving Opportunities for the U.S. Iron and Steel Industry: An ENERGY STAR Guide for Energy and Plant Managers. US EPA. Washington, DC.]



## 6.Social Characteristics and co-benefits

- Reduced energy-related CO<sub>2</sub> emissions.
- Reduced other air pollutants emissions resulted from fossil fuel use.

### BAT8: Low temperature waste heat recovery for power generation in industry using Organic Rankine Cycles (ORC)

#### 1.Technology description

Organic Rankine Cycles (ORC) uses an organic working fluid that has a lower boiling point,higher vapor pressure,higher molecular mass,and higher mass flow compared to water. Together,these features enable higher turbine efficiencies than in conventional Steam Rankine Cycle (SRC). The ORC systems can be utilized for waste heat sources as low as 150 degree Celsius,whereas steam systems are limited to heat sources greater than 260 degree Celsius. ORCs make it possible for economical power generation from low temperature industrial waste heat.

#### 2.Level of Energy Savings

Energy saving achieved by implementation of this technology varies by industry,process,application,technology provider,etc.

As an example,this technology is used in hundreds of cement plants to recover waste heat from clinker making process to generate power. The electricity generated

by this technology in a cement plant is in the range of 20kWh/ton~40 kWh/ton clinker.<sup>[13]</sup>

#### 3.Market prospect

The current adoption rate of this technology varies in different countries. In 2010,(based on the production capacity) around 40% of cement plants in China and 30% of cement plants in India had installed this technology. Thus,there is significant potential for application of this technology in cement plants in those two countries (which account for over 50% of cement production in the world) and other countries.

#### 4.Reliability

Given that many installation of this technology is already working in different industries around the world,this technology has passed the reliability test. Although the quality and performance of the technology may vary by technology provider.

#### 5.Economic Characteristics

The cost of this technology varies by industry,process,application,technology provider,etc.

For an example given above for WHR power generation in the cement industry,the technology costs around 800-1,250 US\$/kW capacity.

## 6.Social Characteristics and co-benefits

- Reduced energy-related CO<sub>2</sub> emissions.
- Reduced other air pollutants emissions resulted from

Notes:

[13] [ Worrell,E.,C. Galitsky,L. Price. 2008. Energy Efficiency Improvement Opportunities for the Cement Industry. Berkeley CA: Lawrence Berkeley National Laboratory Report LBNL-72E. Berkeley,CA.]

fossil fuel use.

- Reduced exposure to grid power cut and grid power disruptions.

## BAT9: Wireless sensors for real time measurement and process monitoring

### 1. Technology description

An effective sampling and real-time control in manufacturing sensors and controls has been a long time issue in industry.

In recent year with the advancement in ICT technology and smart manufacturing, some technology providers have tried to tackle these issue by developing wireless sensors and process control systems.

For example, Honeywell, GE, Emerson Process management, and other companies have commercialized technologies, which can send measurements wirelessly to a base radio connected to a control or data acquisition system.

### 2. Level of Energy Savings

Energy saving achieved by implementation of this technology can varies widely by industry, process, application, technology provider, etc.

For example, Emerson Process Management claims that its Rosemount 708 wireless acoustic transmitter for steam traps monitoring can reduce the plant's fuel cost by 10%~20%.<sup>[14]</sup>

### 3. Market prospect

The current adoption rate of this technology varies in

different industries and countries, but in general the current adoption rate is low in most countries. Therefore, there is a significant market potential for this technology.

### 4. Reliability

Given that many installation of this technology is already working in different industries around the world, this technology has passed the reliability test. Although the quality and performance of the technology may vary by technology provider.

### 5. Economic Characteristics

The cost of this technology varies widely by industry, process, application, technology provider, etc.

### 6. Social Characteristics and co-benefits

- Reduced energy-related CO<sub>2</sub> emissions.
- Reduced other air pollutants emissions resulted from fossil fuel use.
- Improve product quality
- Ensure high uptime
- Reduce O&M costs
- Enhance flexibility

## BAT10: Plant or enterprise- level energy monitoring and management systems

### 1. Technology description

Energy is often lost through non-optimal process conditions or process management. Automated computer

Notes:

[14] Hand, A. 2011. Wireless Sensor Identifies Leaking Steam Traps.

control systems may help to optimize the processes and conditions' thereby save energy and reduce emissions. Improved process control may also help to improve the product quality, reduce downtime, and have other benefits. An example of such systems is GE's Power Management Control System (PMCS). PMCS is a customizable, fully integrated end-to-end energy management system. It can access GE's as well as third-party devices and systems in real-time for graphical representations of substation equipment status, energy trends, remote control of devices and automated responses to system conditions. By optimizing methods used to control both processes and equipment, energy efficiency is realized to utilize assets more effectively and efficiently.

## 2. Level of Energy Savings

Energy saving achieved by implementation of this technology can vary widely by industry, process, application, technology provider, etc.

## 3. Market prospect

The current adoption rate of this technology varies in different industries and countries, but in general the current adoption rate is low in most countries.

Therefore, there is a significant market potential for this technology.

## 4. Reliability

Given that many installations of this technology are already working in different industries around the world, this technology has passed the reliability test. Although the quality and performance of the technology may vary by technology provider.

## 5. Economic Characteristics

The cost of this technology varies widely by industry, process, application, technology provider, etc.

## 6. Social Characteristics and co-benefits

- Reduced energy-related CO<sub>2</sub> emissions
- Reduced other air pollutants emissions resulted from fossil fuel use
- Improved predictive maintenance for less downtime
- Faster problem determination in the process
- Increased safety
- Higher productivity
- Improved power quality ■



# First Batch of Domestic TOP TENS List

## Australia BAT List

Edited by Baorong Yuan

### BAT1: Pumping System Optimisation – Throttling

Its estimated current energy savings across the sectors are 60 petajoules per annum (PJpa) with prospective savings of 187 PJpa in 2017.

Pumping systems are used in various industrial systems, for example removal of groundwater from mines through dewatering, pumping of condensate or dosing, hot water circulation systems or for circulating liquids like fuel, water, wastewater, chemicals, oil, petroleum, sludge, slurry or reactants. Throttle controls typically restrict flow within the system to achieve a variable flow suitable from fixed pump speed. However this can result in an inefficient system as energy losses are incurred in the throttling valve and through loss of pump efficiency when it runs away from its most efficient operating point. With a variable speed drive, efficiency can be improved because

the speed of the pump and the pumping rate can more closely match the flow rate of the system as it varies over time, reducing or eliminating throttling losses and keeping the pump operating near its best efficiency point.

Pumping system optimisation – Throttling is a technology applicable to the following sectors:

- Electricity Generation – pumping of cooling water, condensate extraction pumps, and boiler feed pumps.
- Mining – pumping for mine dewatering, slurries and wastewater, flocculant dosing or provision of fire-fighting systems.
- Manufacturing – Boiler feed systems, hot water circulating systems, mixer pumping, condensate and dosing systems, as well as transfer systems, amongst others.

- Oil and Gas – pump systems for oil tankers and offshore platforms, dewatering systems, pumping of cooling water.

**Example 1:** Replace throttled pumps and gen-sets to improve efficiency

- A review of a company's dewatering bores on site revealed that many of the standard bore pumps are throttled as a means of reducing the water flow to a level the bore can sustain. Detailed analysis of the dewatering pump performance showed that highly throttled pumps consume significantly more diesel per megalitre of water pumped than pumps with little or no throttling.
- The assessment proposed to improve the energy efficiency of this dewatering function by creating a rateable store of spare pumps of varying sizes and replace heavily throttled pumps in the field with better matched pumps and generators.
- Pumps at the first mine have been progressively swapped to more appropriate sized equipment where possible and the same approach is now also planned for implementation at a second mine.
- Technology that allows pumps to run at variable speeds is being evaluated at present as a further improvement to the rateable store approach.

**Example 2:** Another company's scheme has very large electrical pumps which use considerable energy. The scheme consists of three major pumping stations: (2 x 80MW), (2 x 40MW) and (2 x 5MW) Squirrel Cage induction motor. When motors are operated at a constant speed with the flow and pressure of the pump controlled by a valve, optimal energy use is not achieved. Losses can be minimised and large savings realised with inverter 'speed control instead of control by valves. At the

pumping station, the variable speed drive can be installed at a cost of \$1,188,000. The energy saving will be around 6,219,427 kWh, giving a return of about 15% internal rate of return (IRR) provided it is a drought year when a lot of pumping occurs.

## BAT2: Cogeneration Plant

They are used in the Manufacturing sector and commercial buildings. Currently sector-wide energy savings are estimated to be 9 PJpa and 70 PJpa to 2017. This technology scored very well in investment per energy unit saved.

When fuel is combusted in an engine or turbine, energy not converted into useful mechanical energy is turned into heat. Typically in a turbine or engine, only 40%-50% of the energy in fuel is converted into mechanical energy. Cogeneration makes use of the waste heat from the turbine or engine and uses it for heating or cooling purposes. Overall efficiency for cogeneration plants can be greater than 80%.

Cogeneration is the combined production of electricity and heat. It is used in a variety of manufacturing processes and buildings where a fuel is available and both electricity and heating and/or cooling is required. Examples include production of electricity, heating and cooling for buildings or manufacturing known as tri-generation, production of electricity and steam that can be used in a manufacturing plant or passed through a steam turbine to generate further electricity and direct use of the hot exhaust gases from the



electricity generation in a process.

Electricity is generated from a fuel, usually natural gas, in a turbine or large engine. If a turbine is used, the exhaust gases can be used directly to heat ovens or dryers or the heat captured in a Heat Recovery Steam Generator (HRSG) to create steam. This steam can be fed into the site steam system or used in a steam turbine to generate further electricity. In the latter case, low pressure steam is often taken off part way along the steam turbine at different pressures to supply site demand. If an engine is used, energy can be captured from the exhaust gases to heat water or raise low pressure steam, while water from the closed loop cooling system can be used for heating duties around the site or building. These uses of waste heat displace other fuel sources that would otherwise be required to supply the heating and cooling demands.

If cooling not heating is required, the heat captured from the turbine or engine can be converted into cooling through the use of absorption chillers.

Cogeneration is used in the following industries:

- Manufacturing subsectors including paper, food manufacturing, small-scale electricity generation, chemical manufacturing
- Oil and gas production and processing facilities
- Commercial buildings to produce energy and heat or cool building

**Example 1:** As part of a recent upgrade, a food manufacturing site has installed a natural gas-fired cogeneration plant to provide both electricity and process steam to the facility. Energy efficiency is

achieved through the utilisation of waste heat from the exhaust of the electricity generator to produce steam in a boiler. By using natural gas to produce electricity, rather than purchasing electricity from the grid and by using waste heat to produce steam, it is estimated that the cogeneration system will reduce greenhouse gas emissions by 39,714 tonnes of carbon dioxide equivalent per year.

**Example 2:** Another Cogeneration project includes a 7.9 MW gas turbine and heat recovery steam generator. This will eliminate the use of coal on the site and significantly reduce Scope 1 and 2 greenhouse gas emissions. This project will also reduce energy use on the site by about 43,000 GJ.

**Example 3:** Another company installed a gas fired cogeneration plant on a Conti 1 Dryer within an MDF production line to capture steam generated by the dryer unit. The exhaust gas from the cogeneration plant is ducted to the mixing chamber of the Conti 1 Dryer where it is blended with flue gas from the hot gas generator and ambient air. The resulting mix of flue gases and air is used to dry fibre by direct contact with the fibre while it is transported in the air stream of the dryer.

### BAT3: Heat Recovery and conversion to Electricity

This sector coverage for this technology includes Mining, Manufacturing, Oil & Gas. Heat Recovery to Electricity has excellent sector-wide energy savings of 81 and 400 PJ per annum for current and estimated



savings respectively.

Heat recovery to electricity can be applied in almost any industrial setting where fuel is combusted as part of the industrial process or a chemical reaction takes place that produces heat (exothermic). This technology can be implemented wherever there is a waste heat stream (either liquid or gas) of adequate temperature and flow. The electricity generated can be returned as a source of power for running the process or used in a separate application.

To generate the electricity, the hot gas or liquid from the process is passed through a waste heat boiler to produce high pressure steam. This steam is then passed through a steam turbine to generate electricity. For lower temperature heat sources where steam of sufficient pressure cannot be created, low temperature electricity generation cycles can be used such as Organic Rankine Cycle (ORC).

Sectors that utilise heat recovery to electricity include:

- Mining, oil and gas – generators and cooling applications.
- Manufacturing – chemical reactions, cooling applications, boilers, ovens and kilns.

**Example :** A company proposed to adopt new sintering technology, heat treatment of the lead concentrate prior to smelting, which would allow for a potential increase in energy recovery. A waste heat boiler and co-generation facility to produce electricity could also potentially be part of this project. The project has completed the concept phase +/- 30%. The project has since secured funding to proceed to the next feasibility phase. The

project capital, operating costs and the amount of electricity generation is being determined to a +/- 12% accuracy level as part of the next phase (bankable feasibility study).

#### BAT4: Drying Optimisation

Drying optimization is used in the Mining and Manufacturing industries. Sector energy savings are estimated at 58 PJpa (current), and 283 PJpa for prospective energy savings.

Drying processes are a part of industrial applications, primarily in the manufacturing industry but also in mining and wastewater services. Optimisation of drying processes involves identifying efficiencies in the removal of water or other liquid from raw or processed materials or goods.

Efficiency improvements often involve the use of a mechanical process to remove additional liquid prior to drying with heat. Mechanical processes, such as filter presses, are a much more energy efficient way to remove moisture but are not always able to achieve final moisture content specifications. Natural drying using ambient air can also be used to reduce the amount of liquid to be removed.

Sectors and applications of drying optimisation are:

- Mining – drying raw mined materials before processing.
- Manufacturing – food products such as dried fruit, tablet coating (pharmaceuticals), paper manufacturing.
- Services – drying of sludge in wastewater treatment.

**Example:** Separating minerals via electrostatic separation requires the minerals to be completely dry. Drying of the minerals prior to electrostatic separation is accomplished using gas-fired fluidised bed dryers. The wetter the minerals entering the dryer, the more energy is required for the drying operation. To minimise energy required for drying, methods were introduced to processing plants to minimise the water content of the minerals entering the dryers.

### BAT5: Flotation Circuit Optimisation

This technology is used in the Mining sector. Its current and 2017 energy savings are estimated at 6 and 33 PJpa. Relative to other technologies Flotation Circuit Optimisation has a good level of energy efficiency and payback period. The mining sector uses flotation circuit optimisation in the mining of sulfide ores, carbonates, oxides, as well as phosphates and coal. It is also used in wastewater treatment services.

Flotation is a highly complex chemical process used to separate and concentrate a particular substance from the solid or liquid in which it resides. This includes metals from raw mined materials, but also removal of solids and other pollutants within wastewater. In mining processes, optimisation of flotation circuits to achieve optimum recovery rates and / or grade of materials from the process can involve tracking and changing level and aeration set points to change the concentrate flow rates, or manipulating the residence time and circulating flows in the circuit. Where flotation circuits have more complex instrumentation, optimisation can involve mass

pull, reagent concentrations, air flow rates as well as level and airflow setpoints.

Optimisation of flotation circuits is a technology that can involve reconsideration of the size and/or speed of selected motors for different processes. It is quite common for a process to be designed with higher speed motors than required, which results in an increase of energy consumption. A reduction in motor speed of coal pulverisers for example, has demonstrated reduction of 30% energy usage, as well as significantly increased life of grinding rings.

**Example 1:** In the gold production process, Run of Mine (ROM) ore is reclaimed from stockpiles and fed through a single-stage toggle jaw crusher where the crushed ore provides feed to a semi-autogenous grinding (SAG) Mill. Overflow from the SAG mill gravitates to a flotation circuit where gold containing sulphide minerals are concentrated. Naturally occurring bacteria is then used to separate the gold from the sulphide matrix in a process using the patented technology. The circuit contains six reactors, three primary (Tanks 2-4) and three secondary (Tanks 5 -7), all fitted with agitators driven by electric motors. In the original configuration, the first four reactors were fitted with agitators driven by 220kW motors connected to the agitator shaft with a fixed speed gearbox. Tank 6 has 185kW motor and Tank 7 has 110kW. It was discovered that the rotational speed of the agitators could be reduced by 20% by changing the gearboxes. Savings in energy were estimated at 11,180 GJ/year.

Due to the relative simplicity and high savings that this project generates, it was decided to implement this energy

efficiency opportunity. Following metallurgical test-work to ensure minimal risk to the oxidation process, Tank 5 gearbox motor was changed from a 220kW 4 pole motor to a 150kW 6 pole motor, thereby reducing the speed by 33%. In accordance with the processing department's shut-down schedule, it is planned to replace the 185kW 4 pole motor on Tank 6 with a 150kW 6 pole motor. Additional metallurgical testing is planned to review the impact of reduced agitation speed on the primary reactors.

**Example 2:** Another company decided that the current spirals-based circuit for reprocessing of flotation tailings at one of their mine's coal processing plants was sub-optimal. Replacing the spirals with a state-of-the-art fluidised bed separator (reflux classifier) to scavenge fines tailings will provide a more effective solution, and improve overall plant yield.

**Example 3:** Another company decided to improve the flotation yield of their mine's coal preparation plant through installation of Microcel launders and air compressors. This will increase plant yield, and reduce overburden removal, coal mining quantity and save (GJ) 156,220 of fuel use per tonne of final coal produced.

## BAT6: Grinding Optimisation

This technology is used in the Mining sector. Estimated energy savings are 18 and 66 PJpa to 2017. This technology scored well in its payback period and energy efficiency, relative to other technologies.

Grinding is used to reduce the size of mineral materials for use, transport or further processing. This size

reduction process is an integral part of each of the sub-processes from production of ore from the mine to the final finished particle size and includes: blasting, crushing, screening, grinding and separation. In many cases grinding is used to liberate valuable minerals from waste materials. The opportunity is to optimise this production chain to minimise the overall energy consumption but with consideration of product losses that can increase if waste is rejected earlier in the process.

Crushing and grinding uses more than 50% of the energy used in mining.

The blasting design affects the energy required in crushing. The size achieved in crushing impacts the amount of material that does not pass through screening and must be re-crushed. The size of material passing through the screen impacts on the energy use of milling. The amount of material that can be rejected as waste between stages impacts on the energy use of the system and the amount of product lost in the waste stream.

**Example 1:** SAG throughput improvement for milling at a Nickel Mine. A company analysed the energy efficiency of SAG milling at their nickel mine. Analysis indicated that one module had consistently outperformed another. Investigations identified design improvements to the pulp lifter and discharge grate, which were subsequently implemented on the other module. The design improvements resulted in an increased throughput and a reduction in energy consumption per tonne, corresponding to an annual energy saving of 59.6 TJ.

**Example 2:** Ore drying and grinding through use of alternate technologies. A mining company assessed that additional drying aided the energy efficiency of their



grinding circuit. The ore reclaimed from a solar drying area is further dried in three 34m long rotary kilns to a nominal moisture content of 6% before the grinding process. Two of the dryers are fuelled by coal and the other is fuelled by coal seam methane. Dried ore is then fed through two electrically driven ball mills. It is proposed that other technologies could replicate ore grinding and/or drying at a lower fuel cost.

#### BAT7:Boiler Economiser

Boiler Economiser technology is available to the Manufacturing and Oil & Gas sectors. This technology has 14 and 45 PJpa for estimated current and future energy savings,with placement on the Top Ten list largely due to its level of energy efficiency and investment per unit energy.

Boilers are used in a wide range of manufacturing industries,as well as oil and gas,to provide heat to an industrial process via the transfer of water or steam. Instead of discharging flue gases from the boiler directly,efficiency can be improved by first passing them through a heat exchanger,called an economiser. The flue gases passing through the economiser are usually used to heat boiler feedwater prior to being pumped to the boiler,thus saving fuel to raise steam and improving the thermal efficiency of the boiler. Economisers can also be used to heat other process streams such as liquid feeds into chemical reactors.

**Example:**Boiler Economiser Replacement - A boiler economizer is a hot gas to liquid heat exchanger that pre-heats boiler feedwater using the heat in the flue gas

exiting the boiler. The benefits of such a system are to improve the overall heat recovery of the combustion process and hence reduce fuel consumption. The economiser on the Number1 boiler of a sugar mill had been in poor condition and had led to a number of tube leaks. The reliability of the unit deteriorated such that it was by-passed in the previous crushing season.

The direct result of this was a reduction in steaming capacity of the boiler (- 28%) and an increase in the rate of bagasse consumed in the boiler (ie. boiler efficiency). Replacement of the economiser is expected to cost \$1.2 million but result in estimated benefits of higher boiler efficiency higher export of electricity from the site and improved boiler reliability. The overall payback of the project is expected to be 1.43 years.

#### BAT8:Chiller Controls

Chiller Controls can be applied in the Services and Manufacturing sectors. This technology has relatively good economic characteristics including payback period and investment per unit energy.It has energy savings estimated between 26 to 79 PJpa to 2017.

Chiller controls refer to controls on individual chiller units,chiller plant controls or building management system panels. Control of chillers can include chiller motor speed control (VSDs) or pressure control. Pressure control in chillers is achieved through changing the duty of the condenser side through speed control of the fans or switching fans on and off as required by demand and ambient conditions. In both cases,the

duty of the chiller is matched more closely to the cooling demand resulting in more efficient operation.

Changes in ambient conditions can affect both chiller demand and performance. As ambient temperatures and humidity increase, demand for cooling from occupied spaces, cool rooms, freezers and process cooling will also increase. In addition, the efficiency of the chiller will reduce under these conditions, caused by the reduction in the ability of the chiller to reject heat to the atmosphere.

The variability of loads and conditions must be taken into account when engineering and analysing chillers systems. Significant energy savings can be achieved by designing a flexible system that can respond to loads and conditions, through the use of multiple or variable speed fans on condensers for example. Systems without flexibility are likely to operate in a maximum output configuration that may only be required a few times a year, resulting in a less efficient process for the majority of the time.

**Example 1:** Extending usage of Variable Speed Drives. Implementation of this opportunity for one company saw extensive introduction of VSDs in key applications, however there is continuing opportunity for benefit in this area due to existing systems, new installations or changed circumstances. For example at one hospital a change in the sizes of chillers removes the previous optimisation by programmed selection of chiller call up, and necessitates use of some larger chillers away from their optimum efficiency, so retrofitting a VSD (which was previously determined to be unnecessary) is now desirable.

**Example 2:** Another company decided to install a regulation on ammonia compressors and condenser fans

to enable them to work according to the outside air and humidity conditions. This project will save on electricity consumption by reducing the load on the compressors and the condensers.

### BAT9: Road design

Road design is used in mining and construction. Estimated energy savings are 7 to 37 PJpa. Road design is relevant at sites where vehicles operate 24 hours, seven days per week. Fuel savings are achieved from road design that reduces rolling resistance through the use of improved surfaces, for example, paving a gravel road. Improved designs can allow vehicles to travel at their optimum speed with minimal stops and takes into consideration factors such as intersections expected load weights and uphill/downhill transport activities.

The energy savings achieved through improved road design are significant due to the type of vehicles used as well as the long operating hours in the mining and construction sectors. The most significant savings are made in mining haul trucks. These trucks carry up to 200 tonne of payload from the face of the mine to an onsite processing facility.

**Example 1:** Road design - removal of one stop per cycle per truck. The assessment identified an opportunity to review the haul road design to enable trucks to achieve and maintain an optimal trip speed. It was noted a considerable fuel saving would result if the road design could allow the removal of stop signs, where this does not compromise safety. The truck manufacturers were asked to do modelling for a fully loaded truck to accelerate from stationary for 100 metres and to advise the final speed at



this distance. They were also asked to model the same truck operating at this same final speed, but using this same speed for a distance of 1,000 metres, so that the steady state fuel consumption can be calculated. In this way the fuel saving as a result of the truck not having to stop is the difference between the two scenarios. Evaluation of this opportunity revealed that for each stop removed from the load cycle, estimated saving of 361 kL per annum for Caterpillar 777 haul trucks could be achieved and 407 kL per annum for the Terex 3700 AC haul trucks. Savings are based on the removal of one stop-sign intersection. However, with careful consideration of traffic safety, FMG will continue to look for opportunities to remove additional stop signs.

**Example 2:** Another company found a potential energy efficiency opportunity through optimising a haul road. The existing profile of the haul road comprises a combination of downhill and level sections. Real time monitoring of various truck variables on the truck fleet showed that the trucks consumed fuel on the level sections. Modelling of a modified haul road profile showed that fuel consumption could potentially be reduced on both downhill and uphill journeys for the truck fleet resulting in improved fuel consumption. The potential saving was estimated to be a saving of 750 kL of diesel per year for the truck fleet. This project is one of a number of projects to be considered by the site energy team in 2012 for practicality and implementation potential.

#### BAT10: Weight Reduction - Vehicles

This technology has estimated current energy savings of

27, increasing to 120 PJpa to 2017. This is a significant technology for the Construction, Services, Mining and Transport sectors.

Weight reduction of vehicles is a relatively simple approach to realising energy efficiencies for the transport, mining, construction and services sectors. Weight can be reduced through the use of new designs for mobile equipment and through the use of lightweight materials. Savings can also be achieved by reducing the amount of material that is transported unnecessarily, for example, reducing the amount of product that gets stuck to the tray of a dump truck.

**Example 1:** An opportunity was identified to fit lighter truck bodies to the haul truck fleet. This would reduce the weight of the vehicle and therefore allow the truck to carry more ore/waste thereby increasing the potential payload of the truck fleet. The project would require a large capital investment in the truck fleet with a payback period greater than four years.

**Example 2:** Light weight truck trays - A project is in progress to increase the payload capacity of one company's haul trucks. This has been accomplished through the use of light weight truck trays. As these trays are lighter than the previous trays, more ore can be hauled for the same fuel consumption - thus increasing fuel efficiency. The mine production reporting system and fuel management system have been used to confirm that the increase in fuel efficiency has been realised as predicted. ■



# First Batch of Domestic TOP TENS List

## Australia BP List

Edited by Baorong Yuan

### BP1: Optimising Generator Controls

Generator controls are used in the Electricity Generator sector, as well as manufacturing, oil and gas sectors. This technology has very good current (175 PJpa) and prospective (435 PJpa) estimated energy savings.

Generator controls are used in various ways. These include analysing operation of extraction or back-pressure steam control to optimise reuse of steam energy between electricity generation and process use. Monitoring of steam turbine discharge pressure can improve thermodynamic performance to optimise efficiency, power output and net heat rate.

Other controls include operation of individual or

multiple units to optimise heat rates, as well as monitoring of turbine performance deterioration and predictive maintenance programs for turbine and condenser.

This practice has good energy and cost savings, as well as good market contexts.

**Example:** Sliding Pressure Set-point - A reduction in the main steam pressure set point on one company's boiler would result in a reduction in the throttle losses across the turbine control valves. Investigation predicts this would save 154,526 GJ and 12,728 t CO<sub>2</sub>-e per year for the entity. The annual net financial saving is predicted to be \$88,900 over a four year period, equivalent to a payback period of less than one year.

### BP2:Flight Planning

Flight planning is utilised in the air transport sector and involves minimising taxi and flight times. Fuel burned while waiting to take off or in holding patterns waiting to land at a busy airport can be reduced through coordination of gate departure times with air traffic control. The aim is to have aircraft taxi straight from the gate to the take-off runway at the correct time so there is no waiting for a take-off opportunity and arrival is timed for the destination airport to minimise holding patterns before landing.

While its Transferability to other sectors is low, this practice scored well across all other indicators. It also has good energy savings estimates of 127 and 400 PJpa to 2017.

### BP3:Reducing Idle Running in Manufacturing

This practice is applicable to not only Manufacturing but also the Mining and Oil & Gas sectors. Energy savings of 61 – 200 PJpa reflect its relatively high score in energy and cost achievement. Other indicators in which this practice scored well were originality & innovation and market contexts.

Management of idle running of machinery is used primarily in the manufacturing sector, but also in mining and the oil and gas sectors. It involves turning off machinery rather than keeping them running idle in between active use, preventing energy wastage. Conveyor systems that run with no product, mining trucks and excavators left idling during downtime periods and pumps

recirculating when there is no demand are all examples of where idle running could be reduced to save energy.

**Example 1:** Energy Saving Mode (EMS) is a new mode of operation designed for a car-manufacturer's paint shop air supply system during non-production periods.

**Example 2:** Another company analysed 3 large product dryers & coolers' operational times and identified significant periods (2 hours/day) of running with no product in them. During these periods the dryers & coolers revert to idle mode but they still consume significant quantities of natural gas and electricity. A time based system to automatically shut down the dryers and coolers completely exists but continual use of a manual override system has limited its effectiveness. Optimisation of the auto shutdown feature & limiting manual override capability will deliver significant energy and cost savings.

### BP4:Optimising HVAC controls

HVAC Controls are used in the Services sector.

Heating, ventilation and cooling (HVAC) represent a large percentage of energy consumption within buildings and is therefore relevant in the services sector, for example hospitals, office space and institutional buildings. Energy efficiency can be improved through the adjustment of temperature set points, either year round or adjustment for seasonal conditions and using zone controls to provide comfortable conditions in every zone of the building. More careful control of the HVAC

systems outside of normal occupancy hours to avoid unnecessary heating and cooling can also provide significant energy savings.

Energy savings were scored relatively higher, although its estimated total, sector-wide current savings are low relative to other practices (19 to 59 PJpa to 2017). This reflects the lack of weighting for sector-wide energy savings in the methodology.

**Example:** Heating ventilation and air conditioning (HVAC) initiatives at seven stores of a national retailer. These have included night setback whereby the fans are turned off and the temperature band is widened to reduce heating and cooling requirements when the store is closed, networking all plant, which provides remote visibility to ensure any excess or irregular usage is investigated and rectified. Other initiatives are implementation of Variable Speed Drive which provides an adjustable speed setting on main ventilation fan, AC timer control for adjusting temperature according to the operational hours of individual areas/ departments, and hood controls. This latter initiative involved retrospectively connecting the activation of exhaust hoods to ovens. Over 200 stores have had these HVAC controls implemented.

#### BP5: Reducing Product Losses

Product loss is a practice that has good sector energy savings, the manufacturing, mining, oil and gas sectors. Reducing losses of product in a process can provide both energy savings and output improvements.

Depending on the stage of the process where the product is lost, varying amounts of energy will have already been used. For example, product lost into a waste stream or spilled during transport in a mining operation has a small energy loss associated. Contrast with the loss of a final product from a manufacturing process through spillage or off-specification product, where large amounts of energy have been invested to achieve the final form. Losses can arise from many sources including out of specification feedstock, spillage from transport systems such as conveyors, process upsets, breakdowns and incorrect operation of equipment.

**Example:** A coal mining company optimised their mining process which translated to an increase in coal recovery and reduction of coal product loss. A set of rules was developed to highlight the actions necessary to reduce coal loss and contamination. Losses of around 9% have been assessed at the mine and an annual target reduction of 7% per annum has been set. A reduction in losses results in significant reductions associated with additional mining, therefore reducing diesel and electricity consumption and GHG emissions. Project cost is 'low' because this is a part of normal operations.

#### BP6: Use of Driver Advisory Systems

This practice is applicable to Mining and Transport sectors. Its inclusion on the Top Ten list is attributed to its originality, innovation and transferability. Energy savings are estimated at 30 -130 PJpa to 2017.

Mining and transport sectors can implement driver advisory systems as a practice to improve the fuel



efficiency of their operations. Efficiency can be improved by providing feedback information to the driver so that they can make adjustments according to conditions. A driver advisory system can provide very precise information about the variables operating on a vehicle, such as payload and gradient, where the energy is going and where it is being wasted.

For example, by changing travelling speed according to factors such as payload or slope gradient, more efficient use of energy can be achieved. More sophisticated systems can involve sensors which track changes in the wind, acceleration or resistance on the vehicle and provide advice to the driver to achieve optimum energy efficiency in response to these changes.

**Example 1:** One company decided to trial a Driver Advisory System (DAS) to advise train drivers of the optimum driving speed and powering mode to reduce energy use. The trial showed an average energy saving of 8.5%. Trial results and implementation requirements are under review.

**Example 2:** Another company has commenced implementation of an advanced on-road driver management system in metropolitan areas to optimise pickup & delivery movements. This is designed to improve service and performance quality, and to minimise fuel use. It is anticipated that kilometres travelled by drivers will be reduced due to missed pick-ups as well as the minimisation of return to base volumes.

### BP7: Optimising Processes

Process optimization is available to Services, Mining and

Oil & Gas sectors. It has excellent energy savings across these sectors estimated at almost 800 PJpa in 2017.

Process optimisation achieves energy efficiencies through reducing process cycle times, wastage, or costs. This practice can include redesign of processes or revisions to the layout of a plant to improve material flows and production. In the services sector, process optimisation can involve improving performance and response times through identifying unnecessary delays in the service process or by introduction of more effective system operations.

**Example:** Seasonal, opportunistic reduction in aeration blowers based on suitable process conditions. One company assessed that the aeration levels of their activated sludge plant may be reduced for short periods of time during periods of high recycled water flows and suitable process conditions, without compromising the sewage treatment objectives or Environmental Protection Authority Victoria licence conditions. In these circumstances one of four large aeration blowers may be turned off for up to 2-3 months every year. This is not, however, a permanent solution that can be relied upon every year, but a good opportunity that can be taken advantage of where conditions allow, and will be reviewed every year moving forward.

### BP8: Cleaning Condensers and Heat Exchangers

This practice relates to maintenance in the Electricity Generation sector. Despite low scores for originality and innovation, this practice scored well across the other indicators. Energy savings are 17 to 44 PJpa between

current and 2017.

Condensers remove heat from steam exhausted in the electricity generation process using cooling water. The removal of heat from the exhausted steam is essential because it maintains the pressure gradient exiting the turbine. The surfaces of condensers can be polluted by dust, moisture, dirt or other contaminants within the cooling water stream. Over time these can decrease the heat transfer properties of the condenser and increase energy consumption.

Generally, condenser tube cleaning is carried out during a turbine maintenance outage. For large coal fired plant, this occurs every few years. For plants where condenser fouling is a significant issue, monitoring of condenser backpressure and cooling water and condensed steam temperatures can indicate that on line cleaning is required be undertaken.

Off line cleaning during an outage can be done using high pressure water jets or mechanical tube cleaners that scrape the fouling loose from the inside surface of the tubes. On line cleaning can be achieved by injecting plastic balls or bullets into the cooling water stream the loosen fouling as they pass through the condenser tubes. Cleaning condensers can also improve detection of leaks.

**Example:** Power Station condenser cleaning - A company undertook a series of offline condenser cleans across four of their units. This was the first time cleaning had been undertaken using a plastic bullet being passed through each tube. At the same time the acid dosing plant was re-established and a drain line which allowed dirty water to enter the cooling tower basin was also isolated. Significant improvement in condenser performance was

identified across all units, one with its original condenser.

### BP9: Removing Furnace Soot

Furnace Soot Removal and Soot-Blowing is used in the Manufacturing and Oil & Gas sectors. Over time, there is typically a build-up of soot inside furnaces. This soot is a layer of which effectively insulates the system and reduces efficiency.

Furnace soot removal scored relatively well for Market Contexts and individual Energy Savings. 38 to 100 PJpa sector-wide energy savings are predicted.

**Example:** Refinery Furnaces – The reformer unit upgrades the quality of crude oil products for use as gasoline. The process requires a number of large furnaces. Over time, soot and dust had built up in the furnaces of one company, resulting in decreased performance and efficiency of the furnace. In 2010 an opportunity was identified to clean this furnace to improve the efficiency, decreasing the fuel required. This work took a number of weeks, with an external company brought in to cut access ports in to the furnace wall and then carefully spraying a chemical mix on to the tube surfaces to remove built up soot and dust. After the clean, the temperature of the gas leaving the furnace decreased by 53 degrees Celsius, indicating significant improvements in heat recovery and furnace efficiency.

### BP10: Monitoring and Managing Data

Data Monitoring / Management is unique as it is applicable across all sectors. These have the potential to

realise 90 PJpa to 420 PJpa in energy savings to 2017.

Data monitoring and management can be applied in almost any industrial systems and involves measurement of critical energy related data. Data management refers to several approaches to use data once it has been measured. These include using energy baselines and energy-mass balances to estimate energy savings, determine the economic implications and wider benefits from energy efficiency initiatives, identify the level of accuracy for energy and financial savings predictions and to estimate payback periods.

**Example 1:** A structural assessment of management practices was undertaken by a large waste management company. This involved a review of management systems to identify key triggers for capturing, analysing and managing energy efficiency. This assessment identified improvements in processes to capture poor energy efficiency performance. The process is likely to provide improved consistency in the identification of performance and issues to improve responsiveness.

**Example 2:** A manufacturing company saw that provision of accurate and timely energy management

data was vital to the sustainability of their operations. Particularly the end use of steam which was not being reported (eg: digestion and evaporation steam energy). The aim of the opportunity was to identify and reduce inefficiencies resulting from poor information and subsequently improve decision making processes leading to improved energy efficiency. The tools developed by this project have been implemented and are used for online energy consumption monitoring and energy balance optimisation, i.e. for determining energy inputs, outputs and users around site. The resultant model of the plant for optimising plant operation and its applications for viewing and archiving plant data continues to be used successfully. It has proved to be a great benefit to the site for determining savings. While the direct energy savings associated with the project are small, the wider implications of the improved energy monitoring have enabled new opportunities to be identified which have major energy savings. ■



## Second Batch of Domestic TOP TENS List

### China Industrial BAT List

Edited by Yingjin Jiang

#### BAT1: The High-effective Energy-conservation Recovery Technology of the Excavator's Potential Energy

##### 1. Technical principle

The high-effective energy-conservation recovery technology of the excavator's potential energy is to use the inert gas energy storage system, utilize the potential energy that is generated when the excavator working device (boom) falling, compress the inert gas in the energy storage tank to recover the potential energy through driving the hydraulic oil in the energy

storage cylinder. Inversely, when the working device (boom) lifting, through the optimization technology of hydraulic valve and main pump ratio, the energy storage tank and the power cylinder tank work together to drive the working equipment realize the digging operation, improves the working speed and digging output of the excavator working device, so as to reduce the engine power in design, reduce the excavator excavation fuel consumption, and improve the overall

working efficiency of the excavator.

## 2.Main technical specifications

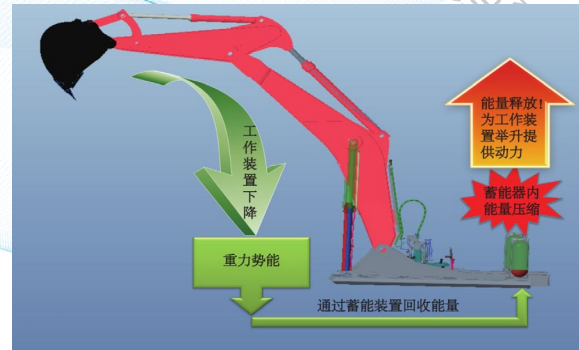
The energy storage system mainly includes an accumulator,an energy storage cylinder,and a control valve. The accumulator is filled with inert gas,which designed maximum pressure is 65MPa and working pressure is 25MPa.

## 3.Energy conservation effects

Compared with traditional excavators,the fuel consumption per unit excavation is reduced by 30%~50% by using this technology,and the output is increased by 50%~100% compared with the traditional excavator of same installed power.

## 4.Application areas

Applicable to all kinds of equipment that use oil cylinders to control lifting,such as excavators,loaders,and other construction machinery etc.,Applied to mining excavation,infrastructure,water conservancy projects,rescue and disaster relief and other emergency materials excavation and transfer,port hoisting,and military facilities Emergency launcher.



## 5.Technology Application Case

A company with an annual output of 30 million tons of coal,uses 5 energy-conservation and high-efficiency excavators with potential energy recovery technology to replace the traditional excavators of the same power. Compared with the same bucket capacity excavators in the industry,the annual energy saving is about 222.7 tons of standard coal,and the annual energy saving benefits is about 4.5 million RMB. ■



## BAT2: Energy Saving Technology Based on Three-phase Sampling and Fast Response

### 1. Technical principle

According to the energy conservation principle of motor voltage reduction, based on three-phase sampling and fast response motor energy conservation technology, adopts the closed-loop feedback system to adjust the voltage, accurately control the voltage and current of the motor to keep the motor working in the best efficiency state. Adopts core technologies, such as adjustable resistance network three-phase sampling, high frequency pulse train trigger SCR (Silicon Controlled Rectifier), induced voltage detection, effectively improve the detection accuracy and response speed of the power factor angle detection circuit, and ensure that the SCR can be more stable, accurate and fast triggered, ensures the motor start and running more smoothly, to reduce energy consumption of the motor.

### 2. Main technical specifications

Using high-frequency pulse train trigger SCR

technology, the pulse width is 18 microseconds, the interval is 40 microseconds, and the number of pulses exceeds 100, applicable for low-voltage 3-phase AC asynchronous motors with power from 7.5kW to 315kW.

### 3. Energy conservation effects

Impact load conditions: On mechanic equipment with large motor load variation, the active power saving rate is 20%~45%. Gradual load conditions: On mechanic equipment with less motor load variation, the active power saving rate is 15%~30%. Constant medium and high load conditions: On mechanic equipment with stable motor loads, the active power saving rate is 5%~7%.

### 4. Application areas

It can be widely used in metallurgy, petrochemical, coal, manufacturing, and other industries involving low-voltage three-phase AC asynchronous motors.



## 5. Technology Application Case

### Case I

Aiming at the actual working condition of a group company's stamping workshop where the original motor load with a large variation, uses the energy-saving technology based on three-phase sampling and fast response to transform 30 sets of 2.2kW stamping machines. During the implementation of the transformation, uses the intelligent motor control system to replace the original power distribution system, has realized the full-time stable control and effectively saved the active power of the motor. At the same time, the built-in solid-state intelligent soft start has improved loading start performance of the equipment. In this practical case, the active power saving rate is 21%, and the annual power saving is 26,850kWh.



### Case II

Combining the characteristics of plastic crushers, two 15kW plastic crushers have been transformed for energy saving. During the implementation of the transformation, uses the intelligent motor control system to replace the original power distribution system to achieve stable control of the plastic crushers. In this practical case, the effective power saving rate of the plastic crushers is 27% and 45% respectively, annual power saving is about 9132kWh. ■



## BAT3:Energy-saving Control Chip Technology on Body Voltage Sensor

### 1. Technical principle

The energy-saving control chip technology on body voltage sensor chooses to use an adjustable threshold four-terminal module, which is implanted in electrical appliances with standby power consumption, reducing the original standby power consumption of AC electrical appliances to zero, and the electrical appliances can start-up instantly by touch or light touch through human body induction voltage. The core technology is the four-terminal control technology, the source S and the substrate electrode B of the common three-terminal MOSFET (metal-oxide semiconductor field effect transistor) are opened up by a special process, a bias voltage VBS is added between the above mentioned two electrodes, which makes the MOSFET threshold voltage  $V_{th}$  has changing. The chip technology on body voltage sensor, adopts the modules of the above technology to implant into electrical appliances, realizes Zero power consumption of the appliances and the module after powering off the electrical appliances, and the electrical appliances can be

instantly activated by touch/light touch through human body induction voltage, without changing the original function of the electrical appliances to realize the energy-saving effects that no power consumption in standby mode of the appliances.

### 2. Main technical specifications

Applicable electrical parameters A.C.100V~240V, 50Hz/60Hz.  
Standby power consumption is 0 (the current standby power consumption of existing appliances is above 0.5 watts).

### 3. Energy conservation effects

Without changing the original functions of the electrical appliances, realizes zero power consumption in standby mode.

### 4. Application areas

Applicable to civil, industrial and other AC electrical appliances that have standby power consumption, in which, civil appliances include air conditioners, washing machines, TV sets, set-top boxes, computers, monitors,



stereos,microwave ovens,induction cookers,rice cookers,kettle s,dishwashers,humidifiers,etc. products that have standby power consumption.

## 5. Technical Application Case

### Case I

Using zero consumption power strip/socket to solve the problem of standby power consumption is applicable for old electrical appliances. When the electrical appliances are plug in the zero consumption power strip/socket,the standby zero power consumption can be realized without changing the original electrical system structure.

A company uses Energy-saving control chip technology on body voltage sensor to modify old household appliances (air conditioners,televisions,desktop computers,washing machines,electric water heaters) in a residential area,total 4680 households. After the modification,the standby power consumption is all reduced to 0W,and the turning on and off functions of the electrical appliances are normal. Annual power saving is 362.8kWh per household,and the total power saving is 1.698 million kWh of this residential area annually.

### Case II

A resort area uses the energy-saving control chip technology on body voltage sensor to modify a total of 352 electrical devices,such as air conditioners,televisions,computers,range hoods,substation consoles,and security systems. After the modifications,the standby power consumption of all the electrical devices is reduced to 0W,annual power saving 16,400 kWh. ■





## BAT4: Organic Rankine Cycle (ORC) Screw Expanding Generation System

### 1. Technical principle

Organic rankine cycle (ORC) screw expanding generation system combines organic Rankine cycle with screw expander for application, the entire system includes evaporator (including preheater), expander, condenser, liquid pump, uses R245fa as the working fluid. When recycling low-grade waste heat, the hot fluid heats the liquid working fluid of the expander when passing through the evaporator, produces high-temperature and high-pressure working fluid steam that enters the expander to push the expander to work, and then, the low-temperature and low-pressure working fluid discharged from the expander enters the condenser, releases heat to the environment and condense into liquid, and then the liquid is pumped into the evaporator to evaporate, thus completing a complete cycle.

Screw expander is a positive displacement expander, with compact structure, high strength, not easy to damage, extreme

strong variable working conditions' capabilities, able to run in stable operation within the load range of 10%~120%, suitable for residual heat, waste heat and other parameters with big variations energies' recycling and utilization.

### 2. Main technical specifications

For flue gas at 120°C~250°C, low/normal-pressure steam, and low-grade waste heat such as hot water at 80°C~160°C, the ORC unit's power generation efficiency is 8%~12%.

### 3. Energy conservation effects

The isentropic efficiency is as high as 85%-88%, and the thermal net power conversion efficiency is as high as 8.4%~12.8%.

### 4. Application areas

Low-grade waste heat utilization in machinery industry, building materials, chemicals, metallurgy, textiles, kilns, etc.

## 5. Technical Application Case

Comprehensively considering the heat source conditions of the implementing project and the development level of ORC waste heat generation technology, in order to improve the thermal efficiency and total power generation capacity of the hot water generator set, this project adopts the ORC screw expansion generator set, realizes the hot water side pressure drop is not greater than 0.1 MPa.

According to 643 tons of 115°C hot coal water that produced by the project owner, one ORC generator set is configured to achieve the net power generation of 2570 kWh, which annual power generation is 20.56 million kWh, annual power generation benefits of 14.392 million RMB, equivalent to 7196 tons of standard coal, 17,097.7 tons of CO<sub>2</sub> emission's reduction. The ORC system is equivalent to a main

cooler, which is a parallel connection with the air cooler in the original system, with split-range control. When the ORC is running, almost all the hot water flows through the ORC system for cooling, which saves power consumption of the original air cooler while generating electricity. When the ORC is out of service, the hot water flows through the original air cooler for cooling. ■



## BAT5: Energy Saving Technology of New Steady Flow and Heat Preservation Aluminum Reduction Cell

### 1. Technical principle

The energy-saving technology of new steady flow and heat preservation aluminum reduction cell, through simulation and theoretical calculation, optimizes the current distribution in the molten aluminum, reduces the flow rate and interface deformation of the molten aluminum, optimizes the current distribution in the cathode carbon block, improves the stability of the cathode aluminum liquid. Through optimizing the cathode structure and material selection, developing stable current and high-conductivity steel rods, combined with low cathode voltage drop assembly technology, reducing the cathode voltage drop and cell voltage. Through analyzing the self-consumable energy in the reduction cell area and the primary crystal temperature of electrolyte composition, optimizes the design of cell lining, optimizes the distribution of isotherms, forms an ideal furnace chamber, and reduces

the heat dissipation of the side lower part. Through reasonable configuration of the process technical parameters of the reduction cell, to finally achieve the purposes of stabilizing the fluctuation of the molten aluminum, reducing the horizontal current and the cell voltage, reduces the heat dissipation of the side lower part, to ensure stable operation of the reduction cell under low voltage and high efficiency, and reduces power consumption.

### 2. Main technical specifications

By this technology, the graphitized cathode experimental electrolytic cell aluminum liquid DC power consumption reaches 11805 kWh/t-Al, the average operating voltage after promotion is about 3.85V, the current efficiency is above 92%, the series aluminum liquid DC power consumption is below 12,500 kWh/t-Al. Compared with the current average level of the industry, it can save more than 500 kWh/t-Al, and the power utilization rate will



increase by 4%~5%.

### 3. Energy conservation effects

Compared with which before the technology is applied, the DC power consumption of molten aluminum is reduced by 500kWh.

### 4. Application areas

It is implemented for new or overhauled reduction cells in the aluminum smelting industry that uses alumina as raw material to produce electrolytic aluminum.

### 5. Technical Application case

This case involves 200 electrolysis cells with cell types of 400kA and 320kA, performs the energy-saving technical transformation with the new steady-flow and heat-preserving aluminum electrolysis cell. The main technical modifications include lining optimization, cathode optimization, furnace building management, process parameter matching, etc., The investment is 16 million RMB, and the construction period is 24 months.

After the implementation of the project, the DC power consumption is reduced from 13115 kWh/t-Al to 12450 kWh/t-Al, the average operating voltage is reduced to 3.82V, the current efficiency is 91.4%, the power saving 665kWh per ton of aluminum, and the annual power saving benefit is about 84 million

RMB, equivalent to about 64,000 tons of standard coal, reducing carbon dioxide emissions by about 150,000 tons, and the accumulated economic benefits of about 93 million RMB. ■



## BAT 6: Energy Saving Technology of Liquid Cooling and Heat Conduction in Electronic Equipment

### 1. Technical principle

Energy saving technology of liquid cooling and heat conduction in electronic equipment adopts the combination of heat pipe technique and water-cooling technique, couple the heat pipe cold-plate module with the server to achieve chip-level cooling, most of the heat generated by the server's high-heat-flux is conducted out of the server cabinets through the contact cooling channel by using this technology, a small part of the remaining heat is taken away through the non-contact cooling channel by traditional air-cooling technology, and then the heat of the cold-plate is continuously transferred to the plate heat exchanger through the internal circulating refrigerant conduction system, and then the heat is carried out to the cooling tower and dissipated naturally through the external circulating water cooling system. This technology does not require air-conditioning compressors in whole process, and

the power usage efficiency of data center is greatly reduced, realizes data center energy saving effectively.

### 2. Main technical specifications

The energy consumption of the refrigeration system of this technology is reduced by more than 80% compared with the traditional refrigeration system, accounting for only about 10% of the total energy consumption of the data center. the working temperature of the server CPU under the full load condition is lower than 60°C. the single rack installed capacity is adapting 5kW ~ 25kW.

### 3. Energy saving effects

This technology reduces the data center power usage efficiency to below 1.2, realizing energy saving about 40% in the data center.

### 4. Application areas

This technology is applicable for heat dissipation in data



centers and communication rooms of government, communication operators, IDC enterprises, Internet, finance etc. industries, also can be used in high-heat-flux cooling fields such as supercomputers, radars, lasers, large industrial control equipment, and LED large screens.

## 5. Technical application Case

### Case I

The cloud computing business of data center has the characteristics of high density and high energy consumption. The huge amount of data and calculations causes the power density of the server increasing greatly, so there are higher requirements for the cooling of data centers. One cloud computing center of a certain base has implemented the technology of liquid cooling and heat conduction in electronic equipment to solve the high-density heat dissipation problem of servers. The energy saving effects of the first phase of the project is good. The data center's electric energy usage efficiency is below 1.2. The annual power saving of the project is 588,672 kWh. The project gains annual power saving benefits of 529,800 RMB that is calculated by 0.9 RMB/kWh. During operation, there is no air-conditioning compressor required in whole process, and the maximum operating temperature of the CPU of the heat pipe water-cooled server does not exceed 44°C.



### case II

The IDC of a certain base owns a whole cabinet application system platform, has integrated multi-type servers from many mainstream server manufacturers, including box type, blade type, whole cabinet type, etc., which has many issues, such as high-heat-flux components of the server (such as CPU) account for a large proportion of heat, the heat distribution is relatively concentrated etc.

After implementing the technology of liquid cooling and heat conduction in electronic equipment in the base, the power consumption of the data center's computer room cooling system has dropped from 40% to 10%. Long-term running test results indicate that, under the condition of the wet-bulb temperature lower than 30°C, the server with actual power consumption of 4 racks totals 20kW (Note: After the 2<sup>nd</sup> time system expanding, the maximum installed power of the server reaches 48kW) as the load of IT business, achieves the effects that the CPU temperature is less than or equal to 60°C, and the power usage efficiency is less than 1.2. ■





## BAT7: Energy Balance and Scheduling Optimization Technology for Industrial Enterprises

### 1. Technical principle

Aiming at energy media such as steam, gas, hydrogen, water, wind, and electricity in industrial enterprises, uses a large real-time database to build a smart energy management and control platform, multi-energy media production - consumption forecast technology that combines time series and soft-sensing ideas, multi-period optimal scheduling method of energy system based on multi-energy media production-consumption forecast data and overall collaborative balance model, uncertainty mixed integer nonlinear programming solution technique, establishing an intelligent simulation of energy pipe network and energy system collaborative balance model, developing fuel-steam-power system multi-period collaborative balance and optimizing scheduling platform and software for large-scale processing enterprise, effectively improves the accuracy of

simulation and forecasting, quickly, stably, and accurately provides an optimized scheduling plan, realizes multi-period collaborative optimized scheduling of energy media.

### 2. Main technical specifications

The production - consumption forecast accuracy of the main energy medium is greater than 95%, the pipeline network simulation accuracy of the main energy medium is greater than 95%, the matching degree of the energy optimized scheduling model calculation result vs. actual state is more than 95%, the comprehensive energy consumption is reduced by more than 1.5%, and the waste gas emission is reduced by 5% or the above.

### 3. Energy conservation effects

Gas, coal gas, and steam emissions are generally reduced by 5%~10%. At present, this technology can achieve

energy saving about 530,000 tce/a.

#### 4.Application areas

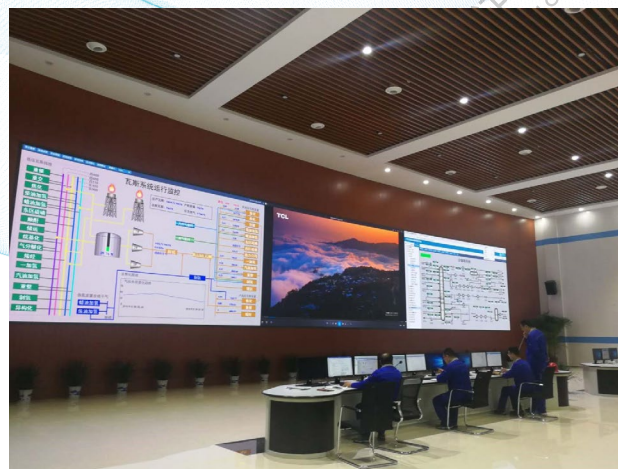
Applicable for high energy-consuming industries,such as petrochemical,chemical,non-ferrous,building materials.

#### 5.Technical Application Case

##### Case I

A petrochemical company has low utilization rate of hydrogen resource,large steam energy loss,frequent gas system fluctuations,etc. problems,by establishing a hydrogen,steam,and gas balance and optimization system that integrates real-time monitoring,statistical analysis,pipeline network simulation,scheduling optimization etc. functions,has effectively improved the enterprise informatization and intelligence level,realized the refined management and control of production,transportation,consumption,storage,etc.,reduced labor intensity,and provided a powerful support tool for improving the level of scheduling management and reducing operation costs of the system,has changed the traditional extensive management concept,continuously optimized production through simulation optimization,data analysis etc. methods.

After the expanding diameter renovation of thermal to wax oil hydrogenation,Low pressure of olefin delivery,Low pressure of Maleic anhydride conduction,the turbine working performance has been improved,creates benefits of 530,400 RMB/year,693,600 RMB/year,and 370,800 RMB/year respectively.



##### case II

A refining and chemical branch company carries out hydrogen and gas balance and optimization in accordance with the current operating status and business characteristics of the hydrogen and gas system in a certain district. This case uses mechanism modeling,data mining,optimization calculations and other techniques,has built up a informatic system that integrates real-time monitoring,statistical analysis,pipeline network simulation,production - consumption forecast,operation optimization,scheduling optimization etc. functions,concentrates on key points of production,consumption,and recovery of hydrogen and gas systems,has realized the fine control of hydrogen and gas,realized the optimized operation and running based on the model.

Aims to the technical problem that it is difficult to identify and supervise abnormal low-pressure gas emissions,the project uses big data analysis techniques such as pattern recognition to construct the low-pressure gas abnormal emission recognition model,has realized

the pattern recognition of low-pressure gas abnormal emission, effectively improved the supervision of low-pressure gas abnormal emissions, reduced fuel consumption in the refining process. Based on the optimization model of the hydrogen devices and the optimization model of the heating furnace operation, guiding the operation process optimization for production equipment, has improved the operation efficiency of the heating furnace, reduced the loss of hydrogen resources, and reduced the waste hydrogen emissions of the hydrogen devices, supports the energy conservation and emission reduction and tapping the

potential and improving efficiency in the enterprise.

After the implementation of this project, it has reduced fuel gas consumption accounts for about 1.0% of the total fuel gas consumption, saved 350 Nm<sup>3</sup>/h of fuel gas resource consumption, and reduced low-pressure gas emissions by 2255 Nm<sup>3</sup>/h. It effectively improves the refined management of hydrogen resources, reduces the company's hydrogen resource consumption, improves the utilization of hydrogen resources, reduces the fluctuation of the hydrogen pipeline network, has reduced the hydrogen emission loss by 702 Nm<sup>3</sup>/h. ■



## BAT8: Waste Heat Recovery from Industrial Waste Water by Low Vacuum Phase Change Principle

### 1. Technical principle

The technology of waste heat recovery from industrial waste water by low vacuum phase change principle, flashes medium - high temperature waste water, generates negative pressure steam and transports the vaporized latent heat to the condenser to release heat to low-temperature media (such as heating water), realizing heat exchange between industrial wastewater and low-temperature fluids without wall contact, solves the technical problems such as corrosion, crystallization, scaling and blockage of traditional recuperators as well. Multi-stage continuous flashing heat exchange technology is adopted to realize large temperature difference heat exchange, improves heat transfer efficiency, reduces system energy consumption, and maximizes the

utilization of industrial wastewater heat.

### 2. Main technical specifications

Rated heat 5000kW. unit input power 17.2kW.  
condenser heat transfer coefficient  $\geq 1800 \text{ W}/(\text{m}^2 \cdot ^\circ\text{C})$ .  
condenser slag water side/system water side pressure drop 47.4KPa/60KPa.

### 3. Energy conservation effects

Using waste heat recovery to replace traditional coal boilers (boiler thermal efficiency is calculated as 70%), the energy saving rate is above 90%.

### 4. Application areas

This technology can be applied to industrial waste heat recovery in petrochemical, coal, power, steel, metal lurgy, textile, papermaking and other industries, supply

industrial and domestic hot water, or heating buildings.

### 5. Technical Application Case

A steel company, Ltd. extracts waste heat from blast furnace slag water as the heat source to provide heating services for the surrounding area by using this technology. While the waste heat is recovered, the circulation temperature of the slag flushing water is reduced, the stability of the blast furnace slag flushing is improved, and utilizes the characteristics of phase change heat extraction, effectively recovers part of the moisture that originally evaporated into the air environment.

The overall installed capacity of the system is 57.5MW, which meets the heating demand of 170,000 m<sup>2</sup> in the plant and 530,000m<sup>2</sup> outside the plant. The project recovers a total of 1.043 million GJ of waste heat in one heating season. By using industrial waste heat system for heating, the annual energy consumption is reduced by about 50,000 tons of standard coal and the emission of atmospheric pollutants such as CO<sup>2</sup> and SO<sup>2</sup> by nearly 130,000 tons. ■





## BAT9: Energy-saving Copper Rotation-floatation Smelting Technology

### 1. Technical principle

Energy-saving copper rotation-floatation smelting technology strengthens the mixing of oxygen-enriched gas and material particles through rotation flow, and at the same time strengthens the secondary reaction of peroxide particles and suboxide particles produced by the primary reaction, enhances the heat and mass transfer process in the flame zone, ensures sufficient complete reaction. Based on this principle, it has researched and developed core equipment, such as cyclone pulsating nozzles, intelligent production mathematical model, and corresponding computer online control system to realize intelligent rotation-floatation smelting and self-heating smelting.

### 2. Main technical specifications

The material feed rate is increased from 200t/h to 350t/h, the maximum annual production capacity of a single furnace can be increased to 500,000 tons, the heat load of the reaction tower is  $2600\text{MJ}/\text{m}^3\cdot\text{h}\sim 2900\text{MJ}/\text{m}^3\cdot\text{h}$ , and the

operation rate of the smelting furnace and converting furnace reaches 98% and 97% respectively, the comprehensive energy consumption of blister copper is 150kgce/t, and the copper matte grade can reach 70%.

### 3. Energy conservation effects

Compared with the technology before its implementation, the natural gas consumption has dropped by more than 50%, and the comprehensive energy consumption of blister copper has dropped by about 20% compared with the industry average level.

### 4. Application areas

Applicable in the copper smelting industry that uses copper concentrates as raw materials to produce matte.

### 5. Technical Application Case

A copper industry co., Ltd. build a 400,000-ton copper smelting plant newly, using energy-saving copper



rotation-floatation smelting technology - Rotation  
- floatation smelting and converting process &  
equipment, which production is stable with high  
efficiency and significant energy saving effects.  
Calculated by annual output of 400,000 tons cathode  
copper, the natural gas saving is 57,143kNm<sup>3</sup>  
annually, equivalents to 76,000 tons of standard  
coal, CO<sub>2</sub> emission reduction of 118,560 tons, has  
achieved good environmental and social benefits. ■



# BAT10: Modular Cascade Regenerative Clean Combustion Coal Gasification Technology

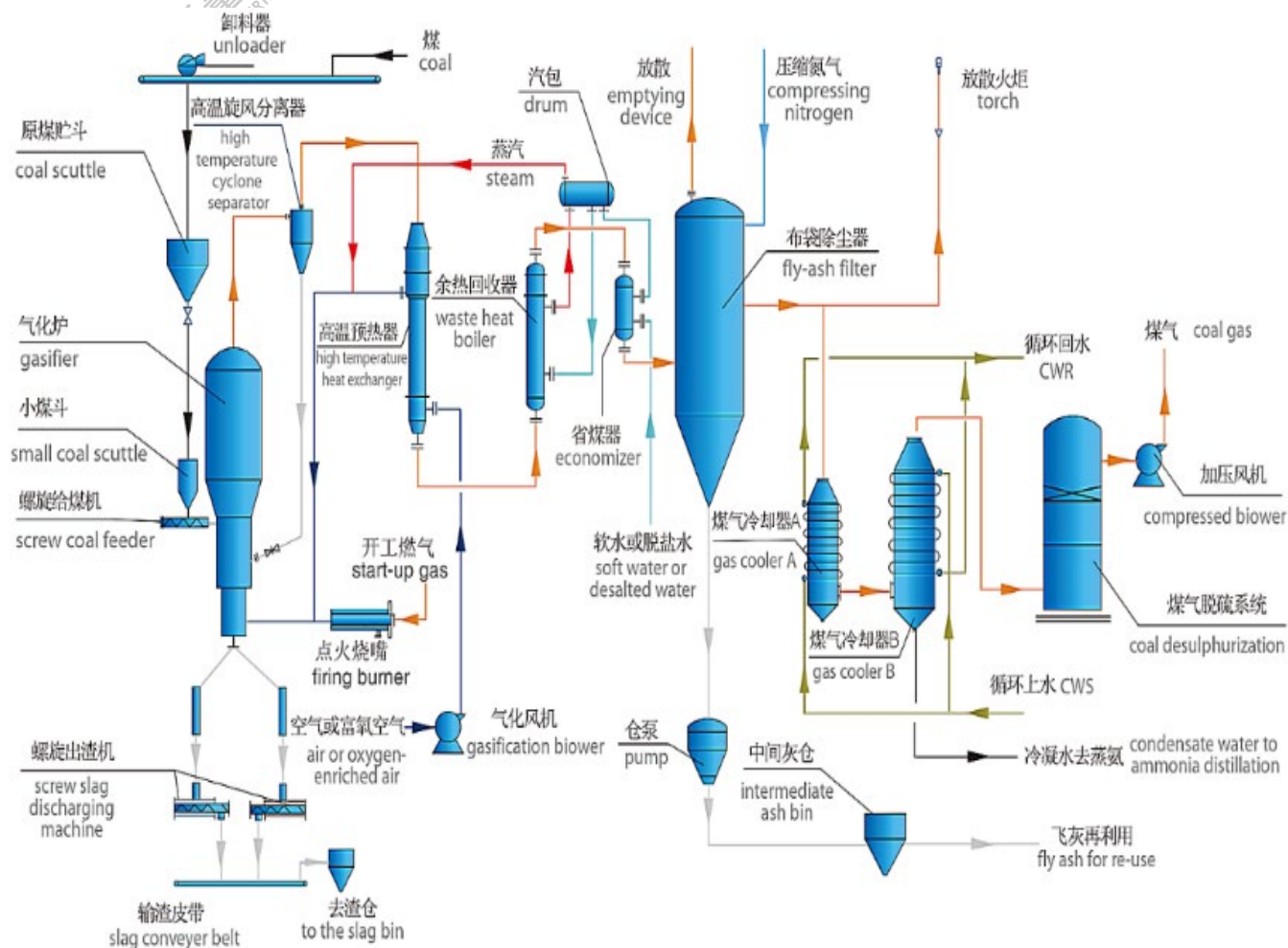
## 1. Technical principle

Modular cascade regenerative clean combustion coal gasification technology is a process that uses crushed coal and pulverized coal as raw materials to produce coal gas, based on the principle of circulating fluidized bed gasification. Utilizes the advantages of sufficient mixing and temperature evenness of the fluidized reactor, adopts 'cascade waste heat recovery' technology, optimizes the heat exchange step of the gasification system, and the large amount of waste heat of the crude gas is utilized to generate high-temperature gasification agent to achieve 'high-temperature combustion supporting', has reduced the irreversible loss of the reaction and improved the efficiency of cold coal gas. In addition, under the condition of higher reaction temperature, the volatiles of the raw coal are

decomposed by heating, the heavy hydrocarbons are decomposed more completely, the crude gas contains no tar, thereby reducing the difficulty of purification. This technology can also configure the fly ash forced circulation module and the coupled gasification module to proceed the secondary utilization of the incompletely converted residual carbon, thereby achieving an ultra-high carbon conversion rate, and further improving the cold gas efficiency of the system.

## 2. Main technical specifications

The primary carbon conversion rate is 85%~90%, the primary cold gas efficiency is 70%~80%, the comprehensive carbon conversion rate is 95%~99%, the comprehensive cold gas efficiency is 80%~90%, and the thermal efficiency is  $\geq 90\%$ .



### 3. Energy conservation effects

The traditional fixed-bed gasification process will produce a large amount of tar that is easy to block equipment and pipelines, causes difficulties to recycle the waste heat in the production process, which carbon conversion rate is only 70%~80%, cold gas efficiency is only 60%~70%, unconverted carbon and heat loss are discharged into the environment, causes a lot of energy waste. This technology not only effectively improves the thermal efficiency and cold coal gas efficiency of the system through adopting cascade waste heat

recovery and utilization, forced circulation and coupled gasification etc. techniques, but also avoids the black water creation, gains good environmental benefits.

### 4. Application areas

Applicable in high energy consumption industries such as building materials, metallurgy, and chemical industry.

### 5. Technical Application Case

#### Case I

A chemical company has deployed multiple sets of



oxidation furnace,roasting furnace and equipped with circulating fluidized bed coal gasification devices in the two phases of the project engineering. After the project implementation,it can filter fine dust above 0.5 $\mu$ m,the dust collection efficiency reaches 99.99%,which dust density is less than 10mg/Nm<sup>3</sup>,the thermal value is  $\geq$ 1385kcal/Nm<sup>3</sup>,the H<sub>2</sub>S concentration is less than 50mg/m<sup>3</sup>,and the carbon conversion rate under normal pressure is 86%~90%,coal processing capacity (single furnace) reaches 67t/h.

According to calculations,after the transformation of implementing circulating fluidized bed,it reduces coal consumption is equivalent to 30,094 tce of standard coal,the annual comprehensive energy consumption is reduced by 26,550 tce.

This project has annual clean coal gas output of 1,166.4 million Nm<sup>3</sup>,which saves 83,498 tce of coal per year,compared to traditional fixed-bed water gas furnaces,gains energy saving benefits of 50.1 million

RMB a year,that is calculated by standard coal unit price of 600 RMB/ton.

#### Case II

An aluminum company adopts several sets of fluidized bed gasification systems,and the DCS control system is configured to realize the remote control of the gasification system,pressurization system,pneumatic conveying system,desulfurization system,water treatment system and other major systems,able to perform real-time measurement of coal consumption,water consumption,and power consumption in production.

This project has annual clean coal gas output of 1,036.8 million Nm<sup>3</sup>,which saves 74,221 tce. of coal per year compared to traditional fixed-bed water gas furnaces,gains energy saving benefits of 44.53 million RMB a year,that is calculated by standard coal unit price of 600 RMB/ton. ■



## Second Batch of Domestic TOP TENS List

### China Industrial BP List

Edited by Yingjin Jiang

#### BP1: Energy Management System Construction Case

China National Heavy-Duty Truck Group Corp.,Ltd. (hereinafter referred to as: SINOTRUK) has planned and established an energy management system according to the characteristics of the enterprise. The energy management center covers the main production units and more than 75% of the major energy consumption units. It has achieved fruitful results in the coordinated promotion of energy conservation in management, process, and technical transformations, and has won many honors at the international, national, provincial, and ministerial levels, leads the important role of value and demonstration.

In terms of energy conservation in process, new

materials, new equipment, new process and new technology are adopted to reduce energy consumption. Through continuous verification and optimization of process parameters, SINOTRUK has effectively reduced energy consumption. In terms of energy conservation in management, each production unit has implemented continuous production, partial continuous production, increased economic batch size, centralized production scheduling, accelerated production cycle, standardized on-site operation and many other energy conservation ideas in management, SINOTRUK has explored energy-saving potential, innovated energy conservation management, achieved significant





performance. In addition, SINOTRUK has also carried out electricity DSM, through rational allocation of resources and effective control on-peak load to save basic power cost, has increased the utilization rate of off-peak electricity, reduced the unit price of electricity to realize power conservation, rational use, plan use, and smart use of power, has gained economic benefits of more than 30 million RMB annually. In terms of energy conservation in technical transformation, SINOTRUK has implemented air compressor waste heat utilization, chilled-water

thermal storage, and ground source heat pumps etc. large-scale technological transformation, gained significant benefits.

Through the establishment and operation of the energy management system, SINOTRUK has established a long-term mechanism, significantly improved the awareness of energy conservation. The annual reduction in comprehensive energy consumption of vehicle set has exceeded 5%, which has strongly promoted the sustainable development of the company. ■



## BP2: Energy-saving Practical Case Through Centralized Management and Control by Yanggu Xiangguang Copper

Yanggu Xiangguang Copper Co.,Ltd. (hereinafter referred to as: Yanggu Xiangguang Copper) according to its enterprise characteristics: To achieve systemization of energy management with the establishment and operation of the energy management system as the core. to achieve flat energy management with the construction of an energy management and control center as the tool. to train energy management masters as a starting point to develop a high-quality energy management team. This project has laid a solid foundation for energy conservation,improved the level of energy management,and achieved a good demonstration effect on the construction of a centralized energy management and control system in the non-ferrous metal industry.

Yanggu Xiangguang Copper has organically integrated the construction of hardware facilities and the corresponding energy management system,realized synchronous planning and synchronous

construction,which makes the sufficient combination of energy management system and the energy control center. Thus,has established a modern energy management mode,integrates online process monitoring,energy scheduling,and energy management as a whole,has realized centralized and flat energy management based on real and accurate energy measurement data. The enterprise has set up energy management positions,recruited energy management leaders,and carried out training on laws,regulations and professional knowledge for energy management leaders and related personnel,has improved their awareness of energy conservation and environmental protection.

Benefiting from systematic energy management,Yanggu Xiangguang Copper has achieved a reduction of 112.69 Kgce/t of cathode copper energy consumption per ton of product,energy saving rate of 6.1%,unit energy



saving cost of 3,200 RMB per ton of standard coal, realized annual energy saving of 25,900 tce.. Through the promotion of energy management mode, in 2018, the output of copper cathode has achieved 1.35 million tons, the annual energy saving

of 256,500 tce., equivalent to annual CO<sub>2</sub> emission reduction 400,000 tons. In 2019, the output of copper cathode was 2.15 million tons and the annual energy saving of 408,500 tce., equivalent to annual CO<sub>2</sub> emission reduction 640,000 tons. ■

## BP3: Shagang Group 2500kW Dust Exhausting Fan Energy-saving Reconstruction Project

The power saving rate of the winding type permanent magnet coupling governor system is obviously better than that of the traditional hydraulic coupling, variable frequency and eddy current permanent magnet governor technology, which is at the international leading level among similar products, has provided a brand-new technical option for power saving of motor governor, which can be widely used to improve energy saving and transmission efficiency of motor in various industries, can significantly improve the efficiency of motor system, has a relatively broad market prospect.

In Jiangsu Shagang Group, EAF Steel Plant has adopted winding type permanent magnet coupling governor technology to perform the technical transformation for the 2500kW secondary dust removal fan in No.2 workshop. Aims to the actual situations of the original fans, such as large vibration, oil leakage, many mechanical troubles, long response time of speed control, low accuracy, and small range of speed control etc., formulated a corresponding technical schemes and energy-saving evaluation for the transformation. When implementing the onsite transformation, the hydraulic coupling was directly

replaced at the original place, without adding space and foundation rework, without adding cooling facilities such as oil cooling or water cooling. After replacing the original variable speed hydraulic coupling with the winding type permanent magnet coupling governor, the system has no hydraulic oil loss issue, high reliability, can isolate vibration and noise effectively, reduces impact load damage of all equipment in the entire transmission chain, and low maintenance cost.

In this practical case, according to the on-site measurement by Jiangsu Shagang Group, under the working condition of 645 rpm/min. of the dust removal fan, the power saving rate is 41%, annual power saving of the project is 4.305 million kWh. ■





## BP4: Energy-saving Transformation of Permanent Magnet Eddy Current Flexible Transmission Energy-saving Device for Dust Removal Fan

Dust removal fan is a major power consumer among all the auxiliary facilities in steel plants, which directly affects the economic benefits of steel companies. This practice case uses permanent magnet eddy current flexible transmission energy-saving device to replace hydraulic coupler, carries out energy-saving transformation to the blast furnace primary dust removal fan, which further taps the energy-saving potential and fills the gap in the application of high-power permanent magnet transmission technology at home and abroad.

Jiangxi Xinyu Iron and Steel Co., Ltd. has upgraded the primary dust removal fan of the blast furnace that used hydraulic coupling originally for energy-saving speed regulation. The minimum speed of the fan has been reduced from 600rpm to 300rpm, the power saving rate has been increased by 45% more based on the energy

saving of the hydraulic coupler, and the safety of the equipment has also been improved effectively.

This project is the first application of permanent magnet eddy current flexible transmission energy-saving device in high-power equipment (3500kW). According to measurement and calculation, the energy saving rate of this project in 2018 and 2019 reaches 31.3% in average. ■



## BP5: Application of Energy-saving Optimization Technology in Compressed Air System

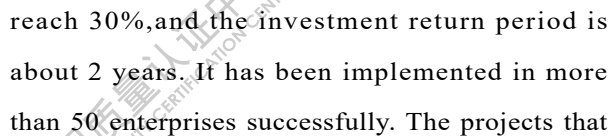
There are only 60% of the energy consumption is valid utilized for production, and the remain 40% of the energy is consumed loss when the compressed air is used in industry. Through air compressor system energy-saving optimization technology, including air compressor energy-saving, air-compression pipe network energy-saving management and control system, dedicated terminal energy-saving management and control system, etc., improves the utilization efficiency of air compressors, increases power efficiency, and improves the automation management level of enterprise. The energy-saving benefits produced by this technology are far greater than the benefits of general energy-saving equipment, which has huge social and economic benefits.

Beijing Aisuo Energy Technology Co., Ltd. has carried out innovative work from energy-consuming equipment to energy-saving calculation and diagnosis of the entire system of energy-

consuming air compressors, and invented and developed corresponding devices. Through efficient, intelligent, regulated and standardized configuration design, optimizing the station layout, replacing inefficient equipment, stabilizing output pressure, improving purification quality, promoting green and low-carbon concept, reducing operating costs, to realize a new type of air compressor station for intelligent energy consuming. The construction of the air compressor station adopts BOO operation mode, the investment, construction, operation and maintenance of the air compressor station are all undertaken by the company.

The application of energy-saving optimization technology in compressed air system provides an overall energy-saving solution for compressed air system from the power source to the terminal gas using equipment. The energy-saving rate can





implemented of this technology have saved 163,100 tons of standard coal in 2018 and 165,200 tons of standard coal in 2019. ■





中国质量认证中心  
CHINA QUALITY CERTIFICATION CENTRE

## BP6: A Case of Energy Management System Construction in Beijing Capital Airport



中国质量认证中心  
CHINA QUALITY CERTIFICATION CENTRE

Beijing Capital International Airport Co.,Ltd. (hereinafter referred to as the Capital Airport),as the 'First Country Gate',is also a key energy-consuming unit in Beijing. Capital Airport follows the systematic management of 'Plan-Do-Check-Act/Improvement',strives to implement every important section of energy management into practice,continuously reducing energy consumption and improving energy efficiency. Capital Airport is the first domestic enterprise in the airport industry that owns the energy management system certification,whose management concept provides a demonstration to improve energy efficiency in the airport industry.

The Capital Airport regards the construction of the energy management system as the foundation and core of energy conservation,strictly implements energy conservation operations,continuously optimizes the

operation scheme,has provided effective refined management tools to achieve energy conservation targets,and effectively improves energy efficiency. According to the characteristics of the aviation industry,relying on the energy management system,implements refined management of the terminal lighting system,formulates the special operation plan for the baggage system,control the operation modes according to different seasons and environmental conditions,adjusts the air conditioning operation mode,has realized continuous energy consumption reduction. Uses market-oriented energy conservation mechanisms and business models,gives full play to the expertise of professional institutions,adopts contract energy management mechanisms,builds photovoltaic power generation,carries out clean energy utilization,promotes bridge-mounted power supplies



and other measures to significantly reduce energy consumption. Capital Airport splits the overall targets of energy consumption and emission reduction to each department, links to departmental KPIs, and set

up awards named 'Double increase' and 'Double reduce' to commend departments and individuals who have performed outstanding energy conservation and made important contributions. ■

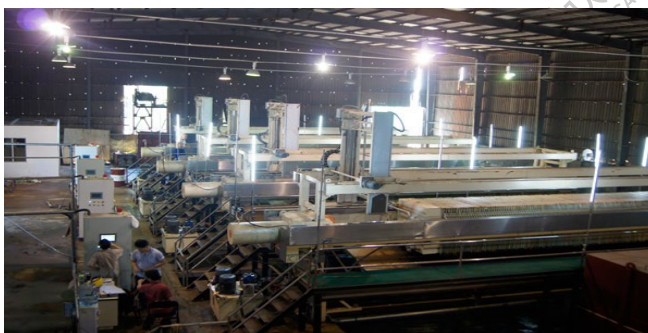
## BP7: Energy-saving Transformation of Textiles Wastewater Treatment and Recovery of Waste Heat from Waste Gas of Setting Machines

Hutai (Panyu) Textile Printing and Dyeing Co.,Ltd. (hereinafter referred to as Hutai Textile) attaches great importance to technological innovation and energy conservation & environmental protection,vigorously promotes clean production in the enterprise. Through implementing energy-saving transformation in the treatment process of wastewater of printing and dyeing and waste gas of setting machines,it has effectively realized refined operation and intensive management,provides a good demonstration case for energy conservation and environmental protection in the textile printing and dyeing industry.

Hutai Textile monitors textile waste water and waste gas treatment in real time,realizes on line collection,transmission and analysis of the key parameters of waste water's physical and chemical treatment,biochemical treatment,deep level treatment and waste gas pretreatment,etc.,adopts corresponding measures through automatic dosing,precise aeration,automation transformation and waste gas heat

recovery from the setting machine,improves the stability of equipment operation,optimizes the operation of the overall system,improves efficiency, reduces operation costs,and has achieved the targets that combining energy conservation and environmental protection.

This practical case enables Pacific Textiles to realize power saving 525,600 kWh,chemical dosage cost saving 9.75 million RMB,and 384,000 RMB in labor costs. The total annual energy saving reaches 10,800 tons of standard coal,the comprehensive energy consumption per unit product is 973.8kgce/t and 1097.5kgce/t in 2018 and 2019 respectively,keeps the advanced level in the industry. ■





## BP8: Shengli Oilfield Branch Dong Sanlian Regional Integration Energy Efficiency Improvement Project

In response to the national energy conservation and emission reduction policy, Shengli Oilfield Branch has implemented Sinopec's 'Energy Efficiency Doubling' plan. In Dong Sanlian region of Gudong Oil Production Plant, in accordance with the integrated energy efficiency improvement concept of 'underground priority, wellbore optimization, and onground support', has analyzed oil reservoirs, Process, gathering and transportation, water injection and other oilfield development nodes, defined the factors that affect the energy using of the system, innovated and integrated 15 energy-saving technologies, realized the balance of oil reservoir fluid production, improved the system efficiency, and reduced the energy consumption.

In terms of oil reservoirs, through the comprehensive application of numerical simulation analysis and research technology, well pattern adjustment turning to streamline technique, injection-production parameter

optimization technique, etc., the fluid volume was reduced by 2,500 m<sup>3</sup>/day, and the combined station processing fluid volume was reduced by 2,500 m<sup>3</sup>/day, reduce the water injection volume by 2,300 m<sup>3</sup>/day. In terms of technology, through the technical application of integrated power reduction, high-percolation sand control, oil well real-time monitoring and auto-diagnosis, large-displacement tubular pump lifting, energy-saving motors and other techniques, reduces the motor capacity by 793 kW, single well daily power saving is 26.7 kWh in average. In terms of water injection, through implementing step pump combination, pipeline descaling, and eccentric side adjustment integration etc. techniques, optimizes production-fluid water injection structure, the water injection volume is reduced by 2,300 m<sup>3</sup>/day, the unit consumption of water injection is reduced by 0.07 kWh/ton, Pipeline descaling pressure loss



is reduced by 0.84 MPa in average. In terms of gathering and transportation, through the applications of electromagnetic coalescence water separation, back pressure reduction, automatic oil-water contact control, and fzq etc., the back pressure of oil wells is reduced by 0.2 MPa, the heating load is reduced by 2030 kW.

As of the end of 2019, in the project implementation

area, the comprehensive water cut has dropped by 0.3%, the cumulative oil increase is 62,000 tons, the cumulative power saving is 17.6153 million kWh, the fuel oil and gas saving equivalent to 2525.29 tons of standard coal, the cumulative energy saving is 4790.46 tons of standard coal, gains energy saving benefit of 14.9308 million RMB. ■



## BP9: Low Temperature Waste Heat Power Generation Technology Case for 2# S-zorb Unit in Yanshan Refinery

SINOPEC Yanshan Petrochemical Company's newly-built S-Zorb device waste heat comprehensive utilization system is the first set of devices established by Sinopec Corporation to recover low-temperature heat of gasoline products and connect to the grid for power generation. The designed capacity of the waste heat comprehensive utilization system is 650KW, the designed annual operating time is 8,400 hours.

In the S-Zorb device, the gasoline temperature at the bottom of the tower is relatively high, about  $130^{\circ}\text{C}\sim 150^{\circ}\text{C}$ , while the required temperature of the gasoline that exits the device into the storage tank is about  $50^{\circ}\text{C}$ . If adopts air cooling and water cooling, this part of the low temperature heat is not effectively utilized. In this energy-saving transformation, the bottom oil out from the stabilization tower directly enters the evaporator of

the organic Rankine cycle (ORC) system, transfers the heat to the circulating working fluid (R245fa) in the ORC system, and then connect to the air cooling device after the temperature of bottom gasoline is reduced to  $70^{\circ}\text{C}$ . The working fluid (R245fa) steam from the evaporator enters the screw expander to perform work and drives the generator to generate power. The exhausted steam of the working fluid (R245fa) after working enters the condenser, which is cooled and condensed by the air cooler. The condensed R245fa circulates again in the system after boosting by the working fluid pump. According to project measurements, the output power of the unit is about 677kW, the net power generation of the unit is about 535kW, which can meet about 50% of the total power load of the device.

By this practice case, it has annual saving 1.68



million tons of standard coal, the energy consumption of the device is reduced by about 5%, and the project return period is 5 years. In 2018 and 2019, the annual generating capacity of the unit is 5,252,735kW and 5,602,917kW, equivalent to 625kW and 667kW per hour that matches the design targets. This practice case can be promoted to other domestic S-Zorb devices, and the waste heat utilization technology that adopted in this practice can be further promoted and applied to reforming units and diesel hydrogenation units that have the similar low-temperature waste heat resources in the petrochemical industry. ■



## BP10: Large Temperature Difference Cogeneration Heating Technology

Shanxi Datang International Yungang Thermal Power Co.,Ltd. relies on the urban central heating project of Datong City,utilizes absorption heat pump technology to form a large temperature difference in the primary pipe network,recovers the waste heat of the turbine exhaust steam at the heat source end,which serves the urban central heating,solves the serious problem of heat sources shortage, reduces the total energy consumption of cogeneration. This practice has explored an effective way to solve the contradiction problem that the urban central heating main network cannot meet the needs of urban development,has a good significance for promotion and prospect for application.

There are multiple heat sources and urban heating networks in Datong City,according to this actual situation,the hydraulic conditions model of the pipe network has been established for the first time,has defined the layout plan of the absorption heat pump for the heating station of the secondary network,and

the return water temperature of the heating network in the heating area is decreased from 65°C to 39°C,the temperature difference between the supply and return water of the primary network is increased from 55°C to 76°C,the heat transfer capacity of the pipe network is increased by 38%. In the first station of heating network,a series-parallel combination mode is adopted in the heating system process. Through the three-stage,series connected pre-heat exchanger - parallel connected absorption heat pump - the peak heater,heating the circulating water in the network,which makes the energy grades more matched between the return water of low temperature heating network and the waste heat of low temperature exhaust steam. So that,the two units of the same model form different high and low operating back pressures,which reduces the average operating back pressure of the two units, reduces the disadvantaged effects in the initial and end cold periods on the power generation,improves



the energy efficiency of the system and the safety of the air cooling island, reduces the irreversible loss of heat transferring.

Through the implementation of the project, there are 9 million m<sup>2</sup> heating area added. In 2018, the heat supplying has increased by 5,415,900 GJ, and energy

saving by 222,200 tons of standard coal compared with which before the project implementation. In 2019, the heat supplying has increased by 6,879,600 GJ and the energy saving by 227,400 tons of standard coal compared with which before the project implementation. ■



# Second Batch of Domestic TOP TENS List

## China Building BAT List

Edited by Yingjin Jiang

### BAT1: Intelligent District Heating Platform with Monitoring and Operation Optimization Technology in Heating System

#### 1. Technical principle

Intelligent heating network monitoring and operation optimization technology, through the integration of Internet of Things (IoT), Internet, cloud computing and automatic control related technologies, build an intelligent heating management platform to realize centralized monitoring and heat measurement of the entire heating system from heat sources, heating stations, pipe networks to heat users, and using the built-in analysis model to automatically analyze historical data, summarize the heating operation rules, economic flux, thermal

indicators, energy consumption indicators, etc., simulate and predict the operation and development trend of the heating system, and give early warning to optimize heating network dispatch, improve the operation and management level of thermal power enterprises and the safety and reliability level of heating systems. Combining big data and artificial intelligence (AI) technology to realize the control and optimization based on the user's indoor temperature, finally achieve the energy conservation of heat source, the operation safety of heating network and supplying comfortable heating to heat users.

## 2. Main technical specifications

The upper limit of the cluster monitoring capability is greater than 1 million resident users. The algorithm is able to conclude the characteristics of the heating pipe network based on the accumulated heating system operation data, pipe network data, and heat users' operation data, combining the meteorological parameters and in-door temperature requirements, is able to predict the future 72 hours' heat load.

## 3. Energy conservation effects

After adopting the intelligent heating network management platform, the heating energy consumption in northern China urban areas will be reduced by about  $0.04\text{GJ}/(\text{m}^2\cdot\text{a})$ , the average energy saving rate is 9%~15%.

## 4. Application areas

This technology can be widely used in cogeneration central heating systems and district boiler central heating systems.

## 5. Technology Application Case

### Case I

A power generation plant, which original heating network had maximum heating capacity was 1.37 million square meters, could not meet the heating demand, and the heating network was a large-scale direct supply network, was difficult to adjust the water conditions, resulting in poor heating quality for end users. Moreover, the power consumption of the mixing pump and relay pump in its heat exchange core station was relatively high. In order to meet the development needs of heating load, the original heating pipe network has been reformed by intelligent heating network monitoring and operation optimization

technology, implemented direct connection water mixing transformation, and build an intelligent heating network monitoring center to solve the problem of primary network hydraulic imbalance. aim to the 6 heating stations with poor heating efficiency, implemented buildings' balance reconstruction, and in-door temperature monitoring to typical users in parallel.

After the transformation, the consumption of water, heat and power all dropped significantly compared with the same period, of which heat was saved by 14.76%, power was saved by 14.76%, and water consumption was saved by 40.42%. There were total 12.64 million RMB operation costs saving from the above 3 indicators, has improved the heating capacity of the heating pipe network, solved the problem of new users accessing the network, and increased the revenue of new users in network.

### Case II

The heating period undertaken by a heating supply company is about 150 days from November to April, which heating area is nearly 15 million square meters, 110 heat exchange stations in total. The average temperature in this district in January is  $-15.2^{\circ}\text{C}$ , and the extreme temperature can be as low as  $-41.5^{\circ}\text{C}$ . The heating network covers a large area, the wide implementation area, accurate data transmission and completion of data monitoring at the same time are all difficult problems for the project. The heating supply company has two heat sources, the No. 1 heat source plant has 4 pcs 70MW gas boilers, and the No. 2 heat source plant has 6 pcs 70MW gas boilers. After the reformation, there is one large-scale IDH intelligent heating network dispatch center was established, more than 500 public building heat metering and control

systems were built, and 110 heat exchange stations realized Distributed Variable-frequency self-service energy-saving control, reduced water consumption and gas consumption effectively. The project has realized a remote automatic self-service operation mode, energy-saving rate is about 15%. ■





## BAT2: Key Technologies of Centrifugal Units Based on Temperature and Humidity Independent Control System

### 1. Technical Principle

Temperature and Humidity Independent Control Technologies of Centrifugal Units can process the heat and moisture load separately, so that the cooling water supply temperature of sensible heat system can be increased from 7°C in conventional condensation dehumidification air conditioning system to 16°C-18°C, improves the unit efficiency. In view of the cooling and oil return problems caused by the higher outlet water temperature, the 'small compression ratio' centrifugal refrigeration compressor adopts the new 'micro differential pressure' automatic oil return technology and the cooling technology that combines the orifice plate and the electronic expansion

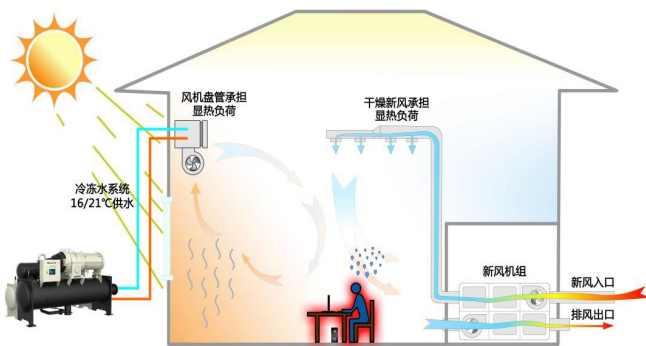
valve to meet the requirements of high temperature operation conditions and improve the efficiency of the compressor. The new high-efficiency water chiller which was developed based on the above technology causes the higher water supply temperature than indoor dew point temperature, has no risk of condensation, achieves efficient and reliable operation under the higher temperature conditions.

### 2. Main technical specifications

This technology keeps the chilled water outlet temperature from 16°C to 18°C, independently takes the sensible heat load. The COP (Coefficient Of Performance) reaches 8.6 with outlet water at 16°C and COP reaches 9.1 with outlet water at 18°C, which comprehensive performance reaches the international leading level.

### 3. Energy conservation effects

Compared with traditional centrifuges with the same cooling capacity, the energy efficiency of this technology at different outlet water temperatures is increased by about 30% in average, and the energy saving rate reaches more than 20%.



#### 4.Application Areas

This technology can be applied to air-conditioning systems in large-scale public buildings and data centers, effectively reducing energy consumption, and contributes to the sustainable development of air-conditioning systems in public buildings.

#### 5.Technology Application Case

##### Case I

Wuhan Tianhe Airport T3 has complex exterior shape and complex indoor space structure, which has design characteristics with the streamlined integrated roof, significant shading by the building itself, and a large space connected vertically. The building air conditioning loads include indoor sensible heat load, indoor latent heat load, and fresh air sensible heat load and fresh air latent heat load. The large spaces such as international terminal, domestic entry and exit passages, and corridors have been designed and simulated to adopt the combined temperature and humidity independent control air conditioning system of 'fresh air humidity control + capillary tube + floor convection + full air'. The centralized cooling and heating source system undertakes the most of the indoor cooling sensible heat load of air conditioning in summer and all indoor sensible heat load of air conditioning in winter. The water system adopts a distributed pump variable flow and two-pipe remote system in order to reduce the transmission power consumption of the water pump as much as possible while ensuring the normal operation of the system. The cooling source of the system adopts 3 pcs of high-outlet temperature centrifugal chillers, which single cooling capacity is 3,516kW and the cooling capacity of air conditioning units is 10,548kW. According to the needs

of this system, the unit technically design the 'small compression ratio' variable frequency pneumatic for the 16°C-18°C water outlet condition, which improves the operating performance of the conventional fixed frequency unit in the medium temperature condition by 25%.

The air-conditioning area of the independent temperature and humidity control system for this project is nearly 140,000 square meters, accounting for 35% of the total air-conditioning area. The operating COP under the design conditions of the unit reaches 8.45, and the total annual electricity cost is 1.2468 million RMB, compare with the fixed-frequency unit, it saves 549,600 kWh per year, and the energy saving rate reaches 30.6%.



##### Case II

China Mobile International Information Port, Phase II IDC data-control room project has long-term construction scale of 1.3 million square meters, and the short-term construction scale is about 0.41 million square meters, including R&D center, data center, call center and academic exchange center, which final target number of the air conditioning units is about 2000.

The buildings adopt apartment-style modular design, the

structural safety level is level 1, the fire resistance and roof waterproof level is level 1, and the air conditioning system adopts the N+1 redundancy mode. Based on the characteristics of high heat generation and low moisture dissipation of the air conditioning load in large scale data centers, and the high precision requirements of the cooling temperature and humidity control of the computer room, this project adopts an independent temperature and humidity control air conditioning system. The system separately processes the heating load and the moisture load, so that the cooling water supply temperature of the sensible heat system is increased from 7°C in the conventional condensing dehumidification air-conditioning system to 14°C, efficiently utilize the energy saving potentiality generated by the higher outlet water temperature and has improved the unit efficiency. The cooling source of the system adopts two 3516kW high

outlet water temperature centrifuges, as for the cooling and oil return problems caused by the higher outlet water temperature, the unit adopts a 'small compression ratio' centrifugal refrigeration compressor, a new type of "micro differential pressure" automatic oil return technology and the cooling technology that combines the orifice plate and the electronic expansion valve, so as to meet the requirements of high temperature operation conditions and improve the efficiency of the compressor.

The units of this project were installed in 2016, the operating COP has reached 7.60 under design conditions. Compare with the traditional centrifuges, which energy efficiency has improved 20%, has achieved significant energy-saving effects. ■



## BAT3: Treatment Process of the Prefabricated Directly Buried Thermal Insulating Pipes

### 1. Technical principle

Treatment process of the prefabricated directly buried thermal insulating pipes is to adopt the cyclopentane foaming agent with ODP of 0 and GWP <25, through high-pressure foaming equipment and spraying equipment, spray rigid polyurethane on the surface of the steel pipe to form an insulation layer after steel pipe quality inspection, shot blast cleaning and temperature increasing control, and then, spray the special bonding material on the surface of the insulation layer through the bonding device and bonding process, and finally, wind the HDPE (High Density Polyethylene) sheet materials on the surface of the thermal insulation layer to form an outer protective layer by extruder equipment, winding device and guiding process, and simultaneously, pass through the cooling device and the circulation process, which is once cooled to form the prefabricated directly buried thermal insulating pipe with integrally strengthened and stable structure.

### 2. Main technical specifications

The thermal conductivity of the thermal insulation layer  $<0.029 \text{ W}/(\text{m} \cdot \text{K})$ , the density  $>60 \text{ kg}/\text{m}^3$ , the compressive stress  $>0.35 \text{ MPa}$ , the average cell size  $<0.5 \text{ mm}$ , and the service life  $>30$  years under the condition of continuous operation at  $120^\circ\text{C}$ .

### 3. Energy conservation effects

The heat loss is reduced by more than 30% in the heating pipe network, the energy consumption is reduced by more than 3% compared with the traditional thermal insulation pipe.

### 4. Application areas

This technology is applicable for pipeline networks that transport liquid and gas media, including central heating, district cooling, petroleum and petrochemical, marine ships and other urban operations and industrial production areas.

## 5. Technical Application Case

Before the energy-saving transformation, the heating pipe network DN800 of a heating company in a certain group provided heat of 4,583,797 GJ, the heat loss of the water supply pipe network was 484,103 GJ, the heat loss of the return water pipe network was 434,461 GJ, and the total heat loss of the pipe network was 868,561 GJ, the average efficiency of the heating pipe network was 81.05%.

After the prefabricated directly buried thermal insulating pipe is used to renovate the DN800 double-circuit heating pipeline of about 5 kilometers, the average efficiency of the heating pipeline is 89.41%, the energy saving is 383,205 GJ, which is equivalent to 13,074 tons of standard coal, and the energy saving benefit is 4.57 million RMB, the energy saving rate is 44.12%, and the return period is about 3.1 years. ■



# BAT4: Integrated Low-nitrogen Combustion Condensing Technology Based on New Type of Heat Transfer Structure

## 1. Technical principle

The integrated low-nitrogen combustion and condensing technology based on new heat transfer structure integrates the four core technologies, such as flue gas side enhanced heat transfer technology, heating surface self-cleaning technology, condensed water anti-corrosion technology and low-nitrogen furnace body structure design technology, with the characteristics of stable, efficient, energy conservation and environmental protection. Based on the principle of maximizing energy utilization, the pipeline network system is optimized for low loss to achieve the maximum energy saving of the system. Adopting a three-in-one intelligent heating control system, combining cloud, big data collection and intelligent analysis, mastering system operating data, making optimization and upgrade recommendations to ensure the continuous and efficient operation of the system.

## 2. Main technical specifications

When return water at 30°C, the full load thermal efficiency

is 106.7%, and the minimum load thermal efficiency is 109.5%. When return water at 40°C, the full load thermal efficiency is 102.2%, and the minimum load thermal efficiency is 105.1%. When return water at 50°C, the full load thermal efficiency is 98.5%, and the minimum load thermal efficiency is 100.5%. The nitrogen oxide emissions by using this technology are reduced by about 40% compared to conventional emissions by using diffusion burners.

## 3. Energy conservation effects

This technology can recover about 8% of the sensible heat and 10% of the latent heat of flue gas, which is more efficient than the existing domestic condensing gas boilers, can save energy more than 15% compared with the normal gas boilers.

## 4. Application areas

Applicable for the buildings of natural gas heating, includes heating and hot water supply for civil buildings (office buildings, commercial buildings, public



buildings in the fields of science, education, culture and health, and residential buildings) and industrial buildings.

## 5. Technical Application Case

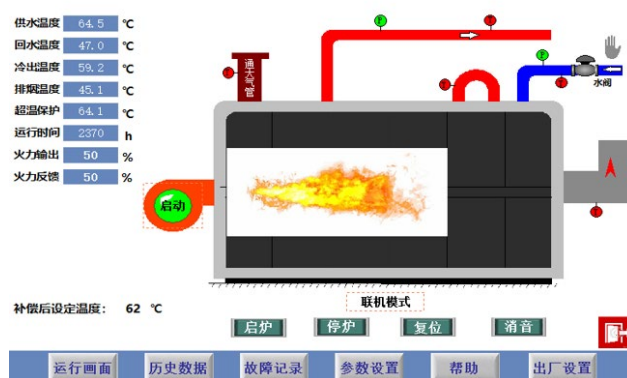
### Case I

Before 'coal-to-gas' project implementation in a certain village, decentralized coal-fired boilers were used for heating mainly. Under the national policy of the "coal-to-gas" guidance, the heating method of the village has transformed, including pipe network laying, boiler installation, 800kW transformer installation, construction of water wells with continuous water output of 70 m<sup>3</sup> per hour, the laying of DN500 medium pressure natural gas pipelines, the installation of gas pressure regulator box, the optimization of the heating pipe network, as well as adding an intelligent control system for boiler heating system intelligent control, which heating area reaches 800,000 square meters. This project uses a condensing gas boiler, single heating capacity of 7MW, efficiently utilize the latent heat of vaporization of the steam in flue gas. By testing and measuring, within the output range of 30%~100% of the boiler, the average thermal efficiency is 97%~105%, has significant energy saving effects. In this practice, the energy saving of each heating season is 1641.7 tons of standard coal, 2655.3 tons of CO<sub>2</sub> emission reduction, and the NO<sub>x</sub> emission is less than 15mg/m<sup>3</sup> that is less than the national standard of 30mg/m<sup>3</sup>.



### Case II

Before the transformation in a certain university, coal-fired boilers were used for heating. During the transformation process, it adopts the integrated low-nitrogen combustion and condensing technology, has equipped 4 pcs of condensing gas boilers, which single heating capacity is 2.8MW, an intelligent control system is added to intelligently control the boiler heating system, and the heating area reaches 161,000 square meters. By testing and measuring, the average water supply temperature of boiler is between 55°C~65°C, the average return water temperature is between 30°C~40°C, the average boiler efficiency is about 105%. In this practice, the energy saving of each heating season is 404.8 tons of standard coal and 654.7 tons of CO<sub>2</sub> emissions reduction. ■



## BAT5: Skid-mounted Heat Exchange Station Technology Based on All-welded High-efficiency Heat Exchanger

### 1. Technical principle

The skid-mounted heat exchange station technology based on all-welded high-efficiency heat exchanger is based on the theory of heat transfer, process control, and numerical calculation methods, and integrates all-welded high-efficiency plate shell type of heat exchangers, intelligent water treatment equipment, intelligent electrical control Equipment, intelligent operation monitoring equipment and other techniques, completes a new generation of 'new high-efficiency energy-saving intelligent heat transfer station' with functions of 'simulation', 'data modeling', and 'mobile Internet' to realize online monitoring of the operation of the heat transfer station and the optimization of heating system's full-condition operation, proceed second time utilization of the low-grade heat (the low-temperature return water of the primary heating network), and the cascade utilization of energy. It also integrates water treatment devices, circulating water pumps, supplementary water pumps and other driving devices, control systems etc. equipment, has the characteristics of high heat exchange efficiency, less land occupation, high temperature and pressure resistance etc. The inlet and outlet on the primary side, the inlet and outlet on the secondary side, the

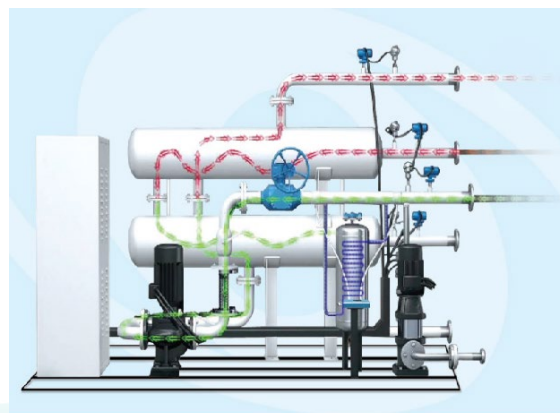
water supplementary inlet, and the sewage outlet are designed on one side, to facilitate on-site construction and installation easily. Adopting advanced heat preservation technology, the entire heat exchange station can be placed outdoors to realize safe and stable operation.

### 2. Main technical specifications

Compared with traditional detachable heat exchanger, the utilization rate of the heat exchange plate is increased by more than 30%, the specific pressure drop  $\Delta P$  is reduced to 40, and the heat exchange efficiency reaches 97%.

### 3. Energy conservation effects

Besides of land space saving of the heat exchanger and reducing the operation and maintenance man-hours etc.



advantages, the average energy saving rate of each heat exchanger is increased by 5%~11%.

#### 4. Application areas

It is applicable for the heat exchanger stations of the central heating system in cities and towns.

#### 5. Technical Application Case

##### Case I

There are two communities of a thermal power group have realized the functions of primary return water's secondary utilization and climate compensation, time and temperature division by adopting all-welded high-efficiency heat exchanger in skid-mounted heat exchange station. At the same time, it integrates modern intelligent control and mobile communication technologies to achieve online monitoring, has achieved the effects of balanced heating, rational use of heating, and supplying on demand, ensures the heating safety. The heating area of the two heat exchange stations totally reaches 360,000 square meters. After two new high-efficiency and energy-saving intelligent heat exchange stations are used for transformation, the energy saving rate is estimated to be 13.3%, the cost saving in one heating season is about 1.6 million RMB, and the investment return period is about 2.5 years. Compared with the traditional heat exchanger

station, energy saving is increased by 30%, land space is saved by 70%, comprehensive investment is saved by 30%, and operating cost is saved by 80%.

##### Case II

The heating supply area of the heat exchange station of a heating supply company is 45767 square meters, has no change before and after the transformation. This project adopts a skid-mounted heat exchange station with all-welded high-efficiency heat exchangers to replace the original plate heat exchange system, by using high-efficiency heat exchangers, frequency variable control, climate compensation, time and temperature division, PID control, intelligent water treatment devices, etc. techniques, by operation parameters setting, operation frequency controlling of the water pump, the opening of the electric control valve of the primary network, etc. operations, realized water flow adjustment, has achieved the purpose to reduce energy consumption under the pre-conditions of ensuring user's indoor temperature meets the relevant regulations. After the transformation, the skid-mounted heat exchange station of the fully welded high-efficiency heat exchanger has an overall energy saving rate of 24.03% compared with the original heat exchange system. ■





# BAT6: Energy-saving Synthetic Resin Curtain Wall Decoration System Technology

## 1. Technical principle

Energy-saving synthetic resin curtain wall decoration system technology is based on inorganic modified polymer technology, with oily organic resin or high polymer as the main body, through biomimetic chemical synthesis technology, grafting or inlaid inorganic functional groups, forming an inorganic modified polymer that combines inorganic and organic as an integration. synthetic resin is used as the main bonding material, mixed with pigments, fillers and additives to prepare various coating materials such as putty, and painted in layers on the building wall to form a building decoration layer with the appearance of a curtain wall, to realize the replacement of traditional decorative building materials such as aluminum-plastic panels, stone and ceramics. The whole system adopts hydrogen bond association reaction, and can have a certain penetration function on cement-based materials, thereby forming an organic whole, realizing energy conservation and environmental protection in its whole life cycle from production, installation, applying to renovation.

## 2. Main technical specifications

The solar reflectance of reflective heat insulation products reaches above 0.85, the hemispherical reflectance is above 0.88, and the thermal conductivity of the thermal insulation decoration material is  $0.018 \text{ W}/(\text{m} \cdot \text{K})$ .

## 3. Energy conservation effects

It achieves 65% energy saving rate when the product is applied to the reflective insulation in South China. achieves 75% energy saving rate when applied to the prefabricated thermal insulation decoration in the Northeast. achieves 75% energy saving rate when applied to the reflective insulation + thermal insulation decoration in other areas.

## 4. Application areas

It is mainly applicable to the fields of public building energy conservation, such as office buildings, commercial buildings, tourism buildings, buildings in science, education, culture and public health area, and transportation buildings.

## 5. Technical Application Case

### Case I

The exterior wall decoration project of a surgical inpatient building in a certain hospital utilizes energy-saving synthetic resin curtain wall decoration system technology, adopts liquid ceramics to replace traditional ceramic tiles and other building decoration materials, creates the decorative effect of traditional ceramic tile curtain walls. This project meets the requirements of cost saving and 'Four conservations and One environment', fulfill the appearance effects requirements as well. At the same time, the system surface layer is compounded with reflective heat insulation and photocatalytic self-cleaning material technology. Through the reflective heat insulation material technology, the heat gain of the building is effectively reduced, avoiding the high cost of traditional thermal insulation technology and the problem that the indoor heat cannot be dissipated due to thermal insulation. Through the photocatalytic self-cleaning material technology, the photocatalytic reaction of ultraviolet rays and self-cleaning materials is used to decompose oily pollutants, and the 'super-hydrophilic effect' is generated under light induction, causing the pollutants are easily washed and cleaned by rain, and the above mentioned two effects produces a 'self-cleaning' effect, which can extend the cleaning cycle of the building's exterior wall, reduce water consumption, and ensure that the curtain wall system keeps as new.

Based on the integrated applications of the above material technologies and processes, the synthetic

resin curtain wall decoration system has achieved many technical advantages such as energy saving, environmental protection, simple installation, safety and reliability, long lifecycle, recycling, light weight, and rich colors. This project has building area of 20,000 square meters. Through using energy-saving synthetic resin curtain wall liquid ceramics, can reduce the energy consumption of traditional ceramic tile production and installation processes, which has saved 160.4 tons of standard coal.



### Case II

An affordable housing in a city adopts energy-saving synthetic resin curtain wall decoration system, compounded with reflective heat insulation technology, selects heat insulation pigments according to the nano spectrum, and achieves heat insulation through the principle of rapid emission of reflecting and absorbing heat in the infrared band of sunlight. At the same time, it adopts the inorganic modified polymer resin as the base material to carry out systematic design and flexible gradual design, forming a good penetration association with base material, has super





weather resistance and good fineness and color retention.

In terms of energy efficiency indicators, the visible light reflectance is above 0.89, and the near-infrared reflectance is above 85%, which meets the requirements of 65% of energy saving in South China. In terms of economic indicators and environmental protection indicators, it is better than traditional thermal insulation boards and thermal insulation mortars etc. insulation systems. In addition, this practice adopts systematic construction technology, which is convenient for construction, high safety, and convenient for maintenance and renovation.

The project has a total building area of 602,150 square meters, of which a residential area of 564,000 square meters (12,363 units in total). Through the transformation of the project, the investment cost has been reduced by 20%, the comprehensive energy saving of the building has reached 20%, improves the management efficiency by 15%. It laid the foundation of 'Intelligent Community' and further improved the ultra-low energy consumption design and operation level of green buildings in hot summer and warm winter district. ■



## BAT7: Modular Central Air-conditioning Energy Saving Technology Based on Variable Flow Control of Cooling Tower Group

### 1. Technical principle

Modular central air-conditioning energy-saving technology based on variable flow control of cooling tower group adopts cooling tower group variable flow technology to make full use of the valid heat exchange area of cooling tower, improve cooling efficiency, reduce cooling water flow demand, and reduce the energy consumption of main engine and cooling water pump. After independent data collection of temperature, pressure, flow and other related equipment signals, each equipment is directly driven, and operates according to pre-settings to achieve modular control and system efficient operation.

### 2. Main technical specifications

Even water distribution between the cooling towers, the water tray in the tower distributes water evenly, reducing the floating water loss, cooling water temperature is reduced by an average of  $1.5^{\circ}\text{C} \sim 3^{\circ}\text{C}$ , cooling efficiency is increased by 1 to 2 times, cooling fan energy consumption is reduced by more than 40%, the energy consumption of cooling pump is reduced by 20% ~

30%, the energy consumption of main engine is reduced by 4% to 8%, and the adaptive flow demand range is 20% to 100%.

### 3. Energy conservation effects

For the objects that have already implemented energy-saving control, the comprehensive energy-saving rate can be improved about 10% more if the relevant optimization measures of this technology can be applied.

### 4. Application areas

This technology can be applied to water-cooling central air-conditioning systems with cooling tower group.

### 5. Technical Application Case

#### Case I

A shopping mall adopts the cooling tower transformation technology, installs hydraulic regulators, variable flow nozzles, and modular energy efficiency control cabinets to realize the combined frequency variation of all fans to achieve the minimum power consumption for efficient cooling. Uses cooling water pump transformation technology, installs cooling water pump energy

efficiency control cabinet,to achieve the variable flow effect that meets the flow demand of the main engine. uses chilled water pump transformation technology to achieve constant flow operation at the main engine side and automatic variable flow operation at the load side. uses main engine transformation technology,installs energy efficiency strategy control cabinets to achieve real-time monitoring effects. uses intelligent control platform technology to realize centralized management and one-stop service.

This project has building area of 240,000 square meters. The comprehensive energy efficiency of the cooling system has been improved to 5.11 by the integrated transformation,compared with the system before the transformation,the efficiency has increased by 34%,the annual operation cost saving of 940,000 RMB,the annual power saving of 1.38 million kWh,that is equivalent to 456 tons of standard coal and 1379 tons of CO<sub>2</sub> emissions reduction per year.



## Case II

The energy-saving transformation of a hospital's central air-conditioning system adopts a water-cooling system consists of a steam-type lithium bromide main engine,cross-flow cooling tower,and chilled and cooling

water pumps. At the same time,it uses intelligent variable flow cooling tower technology,two-way variable flow technology,and one pump to multiple machine technology,hydraulic balance technology,modular control technology. The building area of this project is 80,000 square meters. Compared with the system before the transformation,the operating energy consumption has been greatly reduced,and the comprehensive energy saving rate has reached 52%,annually save 884 tons of standard coal,reduce 2,334 tons of CO<sub>2</sub> emissions,gains economic benefits of 2.2 million RMB annually. The hospital has reduced energy consumption,reduced operating costs,and achieved the effects of energy conservation and emission reduction. ■



## BAT8: Flow Passage Style Heat Exchange Technology for Sewage-source Heat Pump System

### 1. Technical principle

The flow passage style heat exchange technology for sewage-source heat pump system is a complete set of technology for sewage source heat exchange equipment, which can extract water and heat exchange in the main pipeline of public sewage to realize the on-site extraction of sewage heat. The flow passage heat exchanger is the key equipment for extracting heat from sewage. At sewage side, it adopts single flow passage, large cross-section, no contact structure design, with anti-blocking and anti-scaling performance. At clean water side (media water), adopts compact, small cross-section, multi-supporting points, multi-layer parallel connected and then serial connected structure. This technology ensures the overall pressure-bearing capacity and deflection resistance of the heat exchange equipment, reduces the volume size and land occupation of the equipment, solves a series of problems such as blocking and corrosion of the equipment in the heat exchange process, realizes efficient heat exchange.

### 2. Main technical specifications

The pressure bearing capacity of the equipment is  $> 1.0 \text{ Mpa}$ . the heat transfer coefficient in the clean water condition is  $> 3000 \text{ W/m}^2 \cdot \text{k}$ . the designed water volume of single unit is  $20^2/\text{h} \sim 100 \text{ m}^3/\text{h}$ . the resistance of the heat exchanger is  $40 \text{ kPa} \sim 80 \text{ kPa}$ . the cycle time of cleaning maintenance is  $> 180$  days (Single unit cleaning requires about 1 labor-day).

### 3. Energy conservation effects

The heating COP of the system reaches 3.4-4.5, has significant energy saving benefits.

### 4. Application areas

Applicable to winter heating, summer cooling and domestic hot water supplying in various public and civil buildings. At the same time, it can be applied to industrial production such as sludge heating, heat exchange from oily sewage or waste water with high content of impurities.



## 5. Technical Application Case

### Case I

The total building area of a certain estate project is about 10 million  $\text{m}^2$ , a sewage source heat pump system is one of the main heat sources of the project's commercial complex. This application case adopts flow passage style heat exchange technology for sewage-source heat pump system to undertake one-third of the heating load and all the cooling load of the overall heating area, uses the flow passage style heat exchanger to extract the waste heat resources of the public sewage along the pipeline to meet the heating demand of the system in winter. by switching the system operating direction, to meet the cooling demand of the commercial part in summer.

The total planned heating area of the sewage source heat pump energy station is about 3.5 million  $\text{m}^2$ , provide heating and cooling service for hotels, apartments, office buildings and other buildings of the commercial complex, the operating service area is more than 2 million  $\text{m}^2$ . In one heating season, a total of 1.037 million GJ of waste heat is recovered. By using sewage source heat pump technology, the annual energy consumption is reduced by about 32,000 tons of standard coal, reduces atmospheric pollution emissions such as carbon dioxide and sulfur dioxide by nearly 90,000 tons.



### Case II

Using flow passage style heat exchange technology for sewage-source heat pump system, a certain college has built a sewage source heat pump energy station that uses public sewage as the heat source. The heat is extracted from the public sewage through the flow passage heat exchanger, transferred to the media water. The clean media water circulates and transfers heat between the heat pump unit and the flow passage heat exchanger, avoids the problems such as pollution and corrosion of the heat pump unit caused by the sewage entering the heat pump, efficiency reduction of the heat pump etc. ensuring the efficient and stable operation of the system as a whole. The energy station has a total heating area of nearly 300,000  $\text{m}^2$ , and adopts geothermal heating to supply heats to student apartments, faculty residences, teaching office buildings and other buildings in the college. In one heating season, saves a total of 114,000 GJ of heat (has recovered 148,000 GJ of waste heat, consumes 9.32 million kWh, equivalent to 33,000 GJ of heat). Through using sewage source heat pump technology, the annual energy consumption is reduced by about 3,900 tons of standard coal, reduces nearly 10,000 tons of atmospheric pollution emissions such as carbon dioxide and sulfur dioxide. ■



## BAT9: CO<sub>2</sub> Air Source Heat Pump Heating Technology

### 1. Technical principle

The CO<sub>2</sub> air source heat pump heating technology has the characteristics of strong adaptability to outdoor temperature in cold areas and high temperature of outlet water, has a higher heating coefficient under the condition of large temperature difference between supply and return water. Compared with the traditional Freon heat pump, the outlet water temperature of the CO<sub>2</sub> heat pump can reach 70°C or higher, meets the needs of various radiators to realize the heating and domestic hot water supply.

### 2. Main technical specifications

Under the nominal working condition (outdoor dry bulb temperature 7°C) reaches the hot water inlet/outlet temperature 50°C/70°C, COP is 2.46. Under low temperature conditions (outdoor dry bulb temperature -20°C), the hot water inlet/outlet temperature reaches 50°C/70°C, COP reaches 1.66.

### 3. Energy conservation effects

Compared with heating equipment such as oil boilers, gas boilers, and electric boilers, the energy saving rate is more

than 50%.

### 4. Application areas

Applicable to construction industry, including civil buildings, office buildings, commercial buildings, science, education, culture, public health and other public buildings and residential buildings, for centralized or distributed heating and domestic hot water supply.

### 5. Technical Application Case

#### Case I

An office building has a total heating area of 8,640 square meters, which is divided into two building groups - a new building and an old building. The new building has a 7-story frame structure, and the old building has a 3-story brick-concrete structure. The original heating source is a coal-fired boiler. During the transformation process, the project has selected 10 pcs of CO<sub>2</sub> air source heat pump heating units to replace the coal-fired boilers, and equipped with circulating pump unit, water softening device and constant pressure device. The project has invested 1.81 million RMB in total, realized energy



saving of 128tce,annual carbon emission reduction of 301 tons,gains annual energy saving benefits of 280,000 RMB about.



#### Case II

A certain railway section is equipped with a CO<sub>2</sub> heat pump heating unit to replace the original traditional heating equipment,involving 5 stations,about 10,000 square meters in total. The CO<sub>2</sub> air source heat pump heating unit can meet the heating requirements of end users,can still efficiently and stably operates under

low temperature conditions of -15°C,and the outlet water temperature reaches 65°C or more. After the transformation,the actual indoor temperature was stably controlled at 21°C ~ 23°C in average,base on the monitoring results of the heating operation status in one station of the railway section. Compared with the oil boiler,the economic cost saving is about 414,700 RMB/134 days,energy saving of 86tce,carbon emission reduction of 227 tons. ■





## Second Batch of Domestic TOP TENS List

### China Building BP List

Edited by Yingjin Jiang

#### BP1: Case of Guangzhou White Swan Hotel Energy Saving Reconstruction

As the representative of the earliest high-end hotels in China, Guangzhou White Swan Hotel, has implemented fine transformation, management and operation based on the systematic energy diagnosis and design, has gained 3 benefits: service quality improvement, significant energy consumption reduction, and operation costs saving, has made a good demonstration for China's high-end hotels to improve the level of energy efficiency, and provided a model for reference.

Before the renovation, Guangzhou White Swan Hotel carried out energy diagnosis to clarify the current state of energy consumption of the hotel. During the reformation, the main goal is to improve system efficiency, has implemented a variety of technical methods comprehensively: Adopting ultra-efficient refrigeration engine room technology, ensure the efficient operation of the engine throughout the year. adopting low-resistance water system and chilled water with large



temperature difference operation, while improving the energy efficiency of the system, it brings three benefits of material saving, energy saving and good outlook. Adopting high-efficiency gas steam boilers to replace fuel steam boilers, increasing the heating efficiency of the system from 60% to 90%. Adopting high-efficiency hot water system with heat recovery by electric heat pump to replace fuel hot water system, which heating efficiency up to 8.0. The system operation have the performance Real-time monitoring, automatic adjustment of equipment operating strategies, mutual coordination and optimization. Adopting the ensuring mechanism of target control in whole process, implementing energy-saving targets to each energy-using system and each stage of design, construction, commissioning and operation, ensuring the overall goal achievement.

For this practical case, the building area is about

100,000 m<sup>2</sup>, through the overall renovation, the operating energy consumption has been significantly reduced. In 2016, the annual energy cost was saved by more than 17 million RMB. the annual average energy efficiency of the air-conditioning refrigeration engine room was as high as 5.91. the annual average thermal efficiency of the steam boiler system was 92.3% . The heat pump system with heat recovery utilized the waste heat of air conditioning, meet more than 80% of the daily hot water demand. The annual comprehensive energy consumption per unit area of the hotel is 121kWh/m<sup>2</sup>, which is far lower than the guide value of the Energy Consumption Standard for Civil Buildings.

In the recent three years, while hotel's turnover has increased year by year, the total energy consumption and which costs have decreased year by year. From 2017 to 2019, the hotel's energy consumption costs accounted for as low as 5.76%, 4.79%, and 4.24% of turnover. ■

## BP2: China Academy of Building Research Nearly Zero Energy Building

China Academy of Building Research (CABR) has developed a Nearly-zero energy consumption demonstration building, which is guided by Demand reduction in passive priority, Efficiency improvement in active priority', fully plays the advantages of intelligent operation and management, and fully mobilize the coordinated operation of various building energy-saving technologies, achieves 'near-zero energy consumption', has embarked on the independent way of building energy conservation in China.

In the architectural design, this practice adopts an integrated design method to improve the insulation performance of the external wall of the building, the insulation performance of the external window and the airtight performance of the building, and control the building load from the architectural plan. In the energy system, the overall efficiency of the system is improved through the design optimization of the HVAC system and high-efficiency lighting system. Regarding the use of renewable energy, optimize the operation strategy of the energy system, make full use of solar energy and geothermal energy, and reduce the consumption of fossil energy. In terms of energy management and building automation, combined with the requirements of the building's indoor environment, an intelligent operation

management system is adopted to achieve fine control and optimized operation of the system and equipment. In terms of behavioral energy conservation, complete and perfect rules and regulations, combine systematic guidance and behavioral voluntariness, improve personnel awareness of energy conservation, cultivate energy conservation habits, and reduce energy waste.

The practical building area is 4,025 square meters, and the annual operating power consumption is 34.2 kWh/m<sup>2</sup>. The annual energy consumption of the air conditioning system and lighting system is 21.6 kWh/m<sup>2</sup>, the operating efficiency of the ground source heat pump is up to 5.1, and the operating efficiency of the solar absorption chiller is 0.65. ■





## BP3: Passive House Technology Center of Sino-German Ecopark

The passive house technology center of Sino-German Ecopark adopts key energy-saving technologies according to local conditions, combines scientific operation and fine management concept to create a healthy and comfortable indoor environment while greatly reducing operation energy consumption and the use of fossil energy. It is an exemplary ultra-low energy consumption public building, has a positive demonstration effects on the promotion of passive house technology in cold region.

The passive house technology center of Sino-German Ecopark applies the green - energy saving concept throughout the architectural design, selects high-performance envelope structural materials to reduce the cooling and heating loads from the demand side. adopts high-performance heat recovery ground source heat pump unit to improve the energy-saving effects of air conditioning system. combines local climate characteristics and energy endowments, rationally utilizes renewable energy such as geothermal and solar photovoltaics. optimizes the design and selects the appropriate air conditioner terminals, combined with temperature and humidity independent control technology, provides cold and heat sources with different water temperatures for the fresh air unit and the chilled beam system to maximize the system efficiency.

Rationally design the airflow structure, ventilates the air from each room sufficiently flows through the public area, effectively improving the quality of the cold and hot environment in the public area. Intelligently manages lamps and lanterns and other equipment to achieve efficient lighting and avoid waste of electricity.

In this practice case, the building area is 13,769 square meters, the energy consumption per unit building area in 2017, 2018, 2019 is 34.24 kWh/(m<sup>2</sup>a), 29.75 kWh/(m<sup>2</sup>a), 27.75 kWh/(m<sup>2</sup>a) respectively. Through refined operation and maintenance, the energy consumption intensity of this practice has been reduced by 19% in three years. Under the precondition of meeting the first-class comfort level, it achieves energy saving 85% compared with conventional buildings of the same type, achieves annual power saving of 720,000 kWh, saving power expenses of 550,000 RMB, saving 88 tce of standard coal, reducing carbon emissions by 220 tons annually. ■



## BP4: Life-cycle Management of Energy Efficiency Target— "Joy City" Project in Chengdu

Joy City in Chengdu is the first large-scale public building project to implement target management of power consumption and energy efficiency throughout the entire process from design to operation, has always implemented the concepts of green development and has achieved significant energy-saving effects. The whole project has lasted about 50 months, accumulated rich experiences and data, provided a model for the green construction and operation of commercial complex in China.

At the beginning of the project, Chengdu Joy City has clarified the energy consumption and energy efficiency targets, and then, the design team coordinated the design, construction, and operation etc. stages to ensure the effective delivery of energy-saving control targets. At the stage of design, using actual operation data of similar projects as the reference to establish energy consumption and efficiency targets, optimizes the design plan. At the stage of construction and installation, carries out construction quality inspection to ensure achieving

the technical requirements of the design plan. At the stage of equipment commissioning, strictly controls the quality of the equipment system and carries out full performance testing and debugging. At the stage of system operation and maintenance, adjustment and continuous improvement, builds the energy management platform, develops an energy consumption and energy efficiency evaluation index system, monitoring operation performance in real time, realizing on-demand adjustment, avoiding excessive supply, and carries out coordinated system adjustment and optimized operation to ensure the energy efficiency targets can be realized.

In this practice case, the building area is 180,000 square meters. Since the project was put into operation in December 2015, under the premise of ensuring indoor environment comfort and customer's satisfaction, the actual energy consumption and energy efficiency have reached the design targets of 'cooling station comprehensive energy efficiency of 4.40 of the air-conditioning system, public area energy consumption



of 15 million kWh/y',and the average annual power consumption per unit commercial building area is 208kWh/m<sup>2</sup>,which is lower than the guide value of 'Energy Consumption Standard for Civil Buildings'. In 2017,2018,and 2019,the cumulated energy saving

is about 13.28 million kWh,and the cumulative reduction of carbon emissions is about 10,066 tons,has achieved significant economic and social benefits. ■



## BP5: Zhuhai Singyes Renewable Energy R&D Building

The R&D building of Zhuhai Singyes New Energy Industrial Park relies on building energy-saving key technologies of the Sino-US Clean Energy Joint Research Center, focuses on energy conservation and water-saving and creating a healthy and comfortable indoor environment, sufficiently utilizes renewable energy and have a demonstrative effect on the ultra-low energy consumption design and operation of green buildings in hot summer and warm winter districts.

According to the climate characteristics of current season, sufficiently utilizes natural conditions to create indoor environments, formulates the energy-saving control plan based on energy consumption monitoring platform to accurately control and efficiently match energy demands. In the air-conditioning season, uses high-efficiency frequency variable chiller units to meet the cooling demands. in the transitional season, the fresh air system is selectively turned on according to the weather conditions, adopts the joint mode of natural ventilation and mechanical ventilation to greatly reduce cooling energy consumption of the building. combines natural lighting and LED lighting, while improving the comfort of the indoor environment, significantly reducing

lighting energy consumption. Based on the structural characteristics of the building body, fully utilizes solar resources, installing solar photovoltaic and solar thermal components according to local conditions, and combining smart micro-energy grid technology to realize the linkage between renewable energy and the power grid, reducing the consumption of fossil energy.

The building area of this project is 23546 m<sup>2</sup>. In three consecutive years from 2017 to 2019, the power consumption per unit area (kWh/m<sup>2</sup>) are measured as: 39.8, 35.4, 33.8. the energy consumption per unit of HVAC and lighting equipment (kWh/m<sup>2</sup>) as: 23, 14.8, 13.2, the energy consumption has shown an obvious decreasing trend. ■



## BP6: Application Case of the Whole-process Management of Near-zero Energy of No.9 Building of Shanghai Hongqiao State Guest Hotel

No.9 Building of Shanghai Hongqiao State Guest Hotel,in the whole process of project approval,design ,construction,completion acceptance,commissioning and operation,has always been guided by the energy consumption targets,carried out energy conservation management work,and promoted the design and operation management of near-zero carbon emission buildings,has played a good demonstration role for similar building projects.

In the design stage,of No. 9 Building of Shanghai Hongqiao State Guest Hotel,according to energy consumption and energy efficiency management targets,the passive energy-saving technique is introduced to optimize the thermal insulation effects of the envelope structure and reduce the actual heating and cooling demands of the building. fully utilizes natural lighting,combined with LED high-efficiency energy-saving lamps,through intelligent control of lighting power density to meet indoor lighting requirements. adopts high-efficiency air-conditioning equipment,combined with building intelligent integrated control system,and according to the actual environmental requirements of the building,implements the on-demand matching and efficient supply of fresh air heat exchange system,all-

air system,and window magnetic auto-control system,to realize intelligent control of the air-conditioning system. fully utilizes renewable energy such as solar photovoltaics,simultaneously establish a renewable energy monitoring system to achieve efficient complementarity between fossil energy and renewable energy. The project focuses on construction process management,completion acceptance and commissioning,and operation management at trial run stage,ensure the building always have the goal to achieve nearly zero carbon emissions.

The building area of the project is 2866 square meters. In 2018,the operating power consumption is 34.57 kWh/m<sup>2</sup>,equivalent to annual carbon emission of 24.89 kg/m<sup>2</sup>. in 2019,the operating power consumption in is 34.25 kWh/m<sup>2</sup>,equivalent to annual carbon emission of 24.66 kg/m<sup>2</sup>. ■





## BP7: CECEP–Green Building Museum

Aiming at the characteristics of hot summer and cold winter districts in China, the CECEP Green Building Museum presents an ecological, intelligent and environment friendly architectural form to the society, with its advanced technology and perfect system integration, explores the developments and applications of green, energy-saving technologies in hot summer and cold winter districts. It has demonstrated and promoted the applications of efficient, ecological and intelligent technologies in public buildings, and has a good demonstration effect.

The Green Building Museum project integrates the building function, architecture form, and the latest domestic and foreign technologies according to local conditions, sufficiently utilizes natural ventilation and lighting, combines low energy consumption, ecological, humanized architecture forms and advanced technologies, integrated applies Green building technologies such as 'building self-shading system', 'passive natural ventilation system', 'temperature and humidity independent control air conditioning system', 'daylight lighting system', 'building intelligent control system', has greatly reduced building energy

consumption. After being put into operation, it proceeds real-time monitoring of indoor and outdoor environment and energy consumption, etc., optimizes operation strategies, has created the healthy and comfortable environment, promoted the harmonious development of man, building, and nature.

The building area of the project is 4,679 square meters. The final renewable energy utilization rate of the project reaches 17.4%, the utilization rate of non-traditional water resources reaches 40.2%, and the ratio of recyclable building materials reaches 13.5%. Compared with similar buildings, the annual power saving is about 320,000 kWh, the energy saving rate is as high as 72%. ■





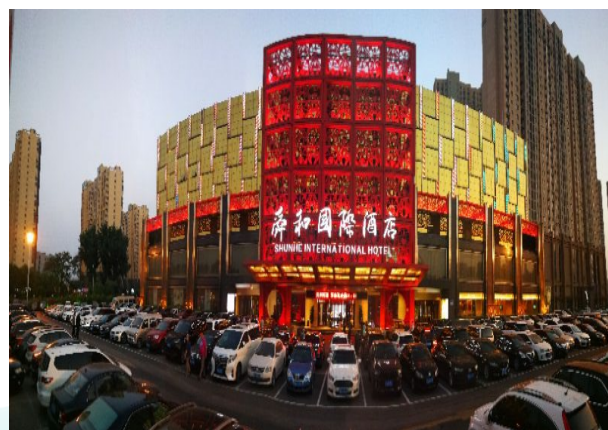
## BP8: Energy Saving Lean Management Case of Shunhe International Hotel in Shandong

Shandong Shunhe International Hotel, is based on the energy use characteristics of hotel industry, combines appropriate high-efficiency energy-saving technologies, carries out lean management to achieve good energy-saving and emission-reduction benefits, as well as, it also improves the hotel's profit margin and plays a good demonstration role.

According to the characteristics of hotel industry, Shandong Shunhe International Hotel adopts energy-efficiency gas boilers to recover waste heat from flue gas, greatly improves the boiler efficiency. Selects cooler units with heat recovery device to recover the cooling heat and supply the heat to the bath water system to realize the sufficient utilization of waste heat. Installs an extra air source heat pump to recover the waste heat of the boiler room and ice maker to produce domestic hot water, and at the same time, provides cooled air for the power distribution room, which gains multiple benefits by one act, has improved energy efficiency and the working environment. Transforming the gas evaporator to provide stable steam for the kitchen while reducing operating energy consumption. Replacement of LED lights greatly reduces lighting energy consumption. While adopting

various energy-saving technologies, Shandong Shunhe International Hotel has established an energy sub-metering system to clearly control the energy consumption of the project and reduce energy waste. Actively carries out energy-saving management and training, takes benefits of energy-saving as a performance evaluation indicator to establish energy-saving and environmental protection awareness in the minds of every employee.

This project has the building area of 40,575 square meters, power saving of 74,200 kWh, and saving 53,000 m<sup>3</sup> of natural gas each year. The energy cost proportion in 10,000 RMB revenue of the hotel has dropped from 6.29% in 2011 to 4.58% in 2019. ■



## BP9: Smart Energy Conservation Renovation Project in the Headquarter Building of SPIC

The Smart Energy Demonstration Project of SPIC applies integrated smart energy technology to the building energy conservation and consumption reduction project. It has innovated the photovoltaic energy-saving curtain wall technology firstly, realized the multi-level comprehensive utilization of energy, keeps an effective complementary status between building energy-conservation & consumption-reduction and photovoltaic power generation. While greatly reducing the energy consumption of buildings, it also relieves the power supply pressure of the power grid, improves the reliability of building power supply, improves the comfort of the working environment in the building, and plays a demonstrative effect on the construction of smart energy buildings.

The headquarter building of SPIC fully utilizes the valid area of the building's curtain wall and roof, replaces the original LOW-E glass with photovoltaic building integrated components and high

transmittance and low radiation double silver coated glass. Combined with photovoltaic power generation technology, it not only utilizes the sunlight shining on the surface of the building to generate power, but also reduces the solar radiation entering the room to achieve the cooling effects, has saved the building's cooling energy consumption. At the same time, the photovoltaic components constructed by the integration of photovoltaic modules and building materials have improved the thermal insulation performance of the building, further saved the energy consumption of the building's cooling in summer and heating in winter, and realized multiple effects, such as photovoltaic power generation, cooling, thermal insulation, energy conservation and consumption reduction.

This project has the renovation area of building curtain wall is 4200 square meters, involving 8600 square meters of indoor area. The renovated photovoltaic energy-saving curtain wall has an installed capacity





of 131 kWp in total. In 2018, the power generation of photovoltaic energy-saving curtain wall is 107,600 kWh, the annual power consumption of the building air conditioning and cooling system is reduced by 385,200 kWh, and the annual energy consumption of the building heating system is reduced by 357,200 kWh. In 2019, the power generation of photovoltaic energy-saving curtain

wall is 105,400 kWh, the annual power consumption of the building air conditioning and cooling system is reduced by 406,300 kWh, and the annual energy consumption of the building heating system is reduced by 371,100 kWh. ■



## Second Batch of Domestic TOP TENS List

### Japan Industrial BAT List

Edited by Jianfu Wang

#### BAT1: Optimum Control of High Efficiency Inverter Centrifugal Chillers Using a Heat Source Integrated Control System

##### 1. Category of industry

Air conditioning

##### 2. Category of technology

High efficiency next-generation air conditioning technology

##### 3. Source of energy

Electrical equipment

##### 4. Practical application

April 2010

##### 5. Summary

This product is an optimizing controller that implements

centralized control of heat source systems including the control of auxiliary equipment in order to realize the optimum energy conservation performance of inverter centrifugal chillers. By implementing optimized control, an energy conservation effect can be realized that is even greater than before, not only through applying high efficiency inverter centrifugal chillers as heat source equipment, but also by integrating air conditioning systems including auxiliary equipment such as pumps and cooling towers. In particular, the development of a plain control algorithm for overall optimization was outstandingly innovative, aiming to implement control of multiple centrifugal chillers and independently control the various auxiliary equipment to realize high COP values. Additionally, in contrast to the fact

that the heat source system control was previously an integral-style program optimized to the site, the use of a mass-produced-type standard built-in control program realized quality improvements and reductions in the introduction costs for each case. In an actual case of introducing this system, an annual average system COP of 7.7 was achieved (compared to COP 5.9 before the introduction), realizing a 23% reduction in electric power consumption (corresponding to 378 MWh/year).

## 6. Principle and operation

As a controller of the heat source system, the product has the following three features.

(1) Extraction of the best performance from the centrifugal chillers

By conducting communications with the chillers, operating data including the optimum load area is obtained. Using this acquired data, control of the number of units and distribution of the cooling water flow rates are implemented to enable operation of the equipment at a high COP. In addition, utilization of the chiller communications data will also help to make it unnecessary to mount sensors such as thermometers and flow meters on the equipment.

(2) Incorporation of various energy conservation control functions

Six main types of control software for heat source equipment are incorporated as a package, allowing customers to freely set combinations according to their needs. Further, whichever combination type is selected, the best energy conservation control is offered for that combination. This reduces the work load for the system design and equipment installation required for the realization.

<1> Multiple chiller unit control <2> Cooling water variable flow control <3> Chilled water variable flow control <4> Cooling tower control <5> Chilled water bypass valve control

<6> Main pipe bypass valve control

(3) External communications functions

The product incorporates external communications functions (Internet LAN interface and programmable logic controller (PLC)) which makes it possible to easily monitor the status from remote locations. Communications are possible with upstream control systems, which also makes it convenient for use as a sub-system for large-scale heat sources.

## 7. Description of improvement

### Before Improvement

(1) Control design and operation

Because the performance characteristics of inverter centrifugal chillers depend on the cooling water temperature setting, chilled water temperature, loads, and equipment models, it was very difficult for the facility designer to gain an understanding of these characteristics beforehand in order to plan the most suitable operation and also to apply the system according to the plan at the installation site.

(2) Product quality and cost

Control programs of heat source systems are often integral items that need to be set up by an engineer according to the connection conditions of the site equipment. This caused variations in the quality and increased the man-hours required.

### After Improvement

(1) Methods were developed using engineering theoretical formulas for calculating the load region (optimum load area) under which the inverter centrifugal chillers achieve high COP values, and it became possible to aim to realize energy conservation easily by implementing control of multiple chiller units based on these calculated values. In addition, a plain control algorithm was developed, enabling overall control while maintaining individual control of each item of auxiliary equipment. Due to these developments, complicated design

planning is no longer required before introduction, allowing large energy conservation to be made.

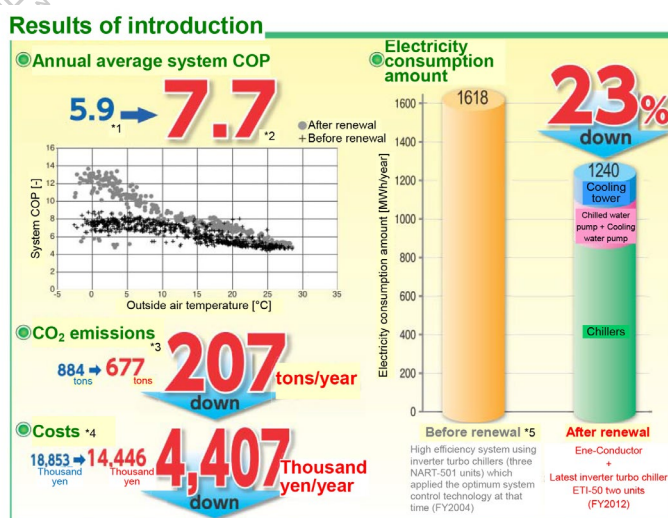
(2) This product is a standard control program which has only one pattern. By narrowing down to the targeted system configuration (by for example supporting less than six chillers, six types of control functions, a double pipe system, etc.), it has been incorporated as a standard built-in control program. The specifications of each system supporting the user and the differences in configurations are switched using the setting parameters. By changing from an integral type program optimized for each site to a mass-production-type program, it was planned to improve quality, reduce design

costs, and lower the site work costs.

## 8. Effect of improvement

Improvement of energy consumption intensity (Option for improving energy conservation ratio).

In a customer's facility where this product was introduced during renovation work, the performance verification results realized an annual average system COP of 7.7 in FY2012. As a result of comparing with the system before the product introduction, energy conservation of 23% was achieved, and it is planned to achieve a reduction in CO<sub>2</sub> emissions of 207 tons/year and cost reductions of 4,407,000 yen/year.



\*1 Source : Kuwahara and five others: 'Energy Saving Performance and Effective Operation Methods for a Heat Source System for Air Conditioning using Inverter Chillers', Report Part 1, Report Part 2, The Society of Heating, Air Conditioning and Sanitary Engineers of Japan, 47th Academic Technical Papers Chapter, 2009

\*2 Source : Tai (Kyushu University) and eight others: 'Development of Performance Evaluation Method for Optimal Controlled Heat Source System' Report Part 2: Analysis of Measurement Data in FY2013, The Society of Heating, Air Conditioning and Sanitary Engineers of Japan, 2013

\*3: CO<sub>2</sub> emissions amount calculated using the Tohoku Electric Power Company, Inc. FY2011 CO<sub>2</sub> emissions coefficient of 0.546 kg-CO<sub>2</sub>/kWh

\*4: Calculated from the Tohoku Electric Power Company, Inc. high voltage electricity rate of 11.65 yen/kWh (summer period) (June 2013)

\*5: The electric power amount before the introduction is based on the FY2012 data, and back-calculated using the FY2004 system COP of 5.9 before the product introduction (=FY2012 electric power x FY2012 COP / FY2004 COP)



## 9. Economic efficiency and its trend

(1) Equipment investment costs: Unknown

(2) Remodeling costs: Unknown

(3) Running costs:

18,853,000 yen/year → 14,446,000 yen/year

Saving of 4,407,000 yen/year (Based on the actual results at an introduction case site)

(4) Payback period:

3 years\* Calculated from the suggested price of 12,500,000 yen (differs from the actual price) and the running cost improvement amount.

(5) Investment costs for energy conservation per unit: Unknown.

## 10. Trend in market

(1) Diffusion rate

From the start of sales in 2010, units have been introduced in a total of 41 cases (as of the end of August 2017)

(2) Prediction for 2018

Expected to reach a total of 50-60 cases

## 11. Reference information

(1) CO<sub>2</sub> reductions

Reduction of 207 tons/year (Based on the actual results at an introduction case site).

(2) Social impact

1) Awards

-FY2013 Energy Conservation Grand Prize for excellent energy conservation equipment (Minister Prize of Economic, Trade and Industry (Electricity-saving Award)).

Sponsored by: The Energy Conservation Center, Japan.

2) Documents, etc.

-FY2013 Energy Conservation Grand Prize for excellent energy conservation equipment Award-winning Entry Abstracts [Products and Business Models Category], The Energy Conservation Center, Japan, p20-21.

-Mitsubishi Heavy Industries Technical Review Vol. 51 No. 2 (2014), p4-9.

(3) Patents

Patents relating to control of multiple chillers: 4 patents, patents relating to controlling the auxiliary equipment: 8 patents, patents relating to attached functions: 4 patents, display screen design registrations: 2 registrations (Includes items under application).

## 12. Implementation sites

As of the end of August 2017, there were 35 cases of product introductions in Japan and 6 cases overseas (in Malaysia, Thailand, Singapore, United Arab Emirates, and Turkey)

## 13. Cited documents

(1) Tai (Kyushu University) and six others: 'Study on performance management methods of a heat source system using simulation : Part 2. Development of fault detection tool for refrigerators', The Society of Heating, Air Conditioning and Sanitary Engineers of Japan, 20th Kyushu Branch Technical Research Paper Presentation, 2013.

(2) Kuwahara and five others: 'Energy Saving Performance and Effective Operation Strategies of Cooling Plant System Using an Inverter Chiller for Building Air-Conditioning : Part2-A System Performance Evaluation Based on Model-Based Simulation Analysis and Effective Operation Strategies', Report Part 1, Report Part 2, The Society of Heating, Air Conditioning and Sanitary Engineers of Japan, 47th Technical Papers Chapter, 2009.

## 14. Contact information

Mitsubishi Heavy Industries Thermal Systems, Ltd. Air Conditioning and Refrigeration Division Machinery, Equipment & Infrastructure Domain.

13th Floor, Igarashi Building, 2-11-5, Shibaura, Minato-ku, Tokyo, Japan ■

## BAT2: Large–Capacity Storage Battery 'NAS Battery'

### 1. Category of industry

N/A

### 2. Category of technology

Large-capacity storage battery

### 3. Source of energy

N/A

### 4. Practical application

Since 2002

### 5. Summary

NGK Insulators, Ltd., top manufacturer of ceramic products, is the first company in the world to provide sodium sulfur battery (NAS battery) which is capable for storing large amounts of electric energy. There are various types of applications such as load leveling, emergency power supply, compensation of fluctuating renewable power, stabilization of network, etc. and it contributes to energy savings and to reduce environmental load.

### 6. Principle and operation

NAS battery uses beta alumina as solid electrolyte, sulfur (S)

for the positive electrode and sodium (Na) as the negative electrode. During discharge, the sodium ions pass through the solid electrolyte and generates sodium polysulfide at positive electrode. During charging, the opposite reaction occurs. NAS battery has following characteristics.

- (1) Large-capacity: Capable of 6 hours discharge at rated power
- (2) High energy density: Approximately three times greater than lead acid battery.
- (3) High-speed response: Less than 1ms.
- (4) Long life: 15 years or 4,500 fully discharged cycles.  
(No limitation for simple short time discharge/charge cycle.)
- (5) No self-discharge: No uniform charging required.
- (6) High temperature operation type: Automatically temperature controlled by heater.

### 7. Description of improvement

See Figure 1 and Figure 2.

### 8. Benefit by NAS battery

- (1) Reduction of CO<sub>2</sub> emissions by peak shaving  
Decreasing the peak demand could result in stopping some thermal power plants using fossil fuel in the networks, which stand by for day time peak. In other words leveled demand could result in high efficiency operation of thermal power



plants, and in these way NAS battery could contribute to reduction of CO<sub>2</sub> emissions.

#### (2) Promotion of renewable energy

NAS battery compensates output fluctuation of renewable energy in the network. It helps further introduction of renewable energy with efficient use.

#### (3) Efficient operation of diesel generator in micro grid

In a remote island, fuel cost is very high and its micro grid is supported by old diesel generator. Introduction of renewable energy causes instability in the network, and gen sets should be operated irregularly sometimes at low output power to balance the power supply and demand, which results in low efficient operation. NAS battery can balance the power supply and demand with efficient operation of diesel generators and renewable energy. This will contribute to the reduction of energy costs and CO<sub>2</sub> emissions.

### 9. Economic efficiency and its trend

#### (1) Equipment investment costs in 2017:

40,000-50,000 yen/kWh

In 2020: 23,000 yen/kWh

\* NAS battery system equipment costs only; variable according to individual specifications

#### (2) Remodeling costs                      Unknown

#### (3) Running costs                      Differs according to the usage method (Operating expenses + repair expenses)

#### (4) Payback period                      Unknown

#### (5) Investment costs for energy conservation per unit:

Unknown

### 10. Trend in market

#### (1) Current diffusion rate of NAS battery: Approximately 200

locations worldwide, with a total output of 530,000 kW

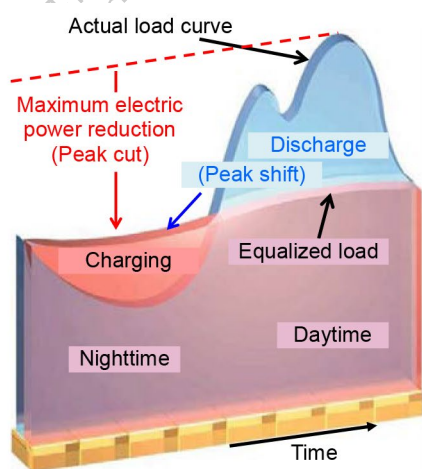


Figure 1 Peak shaving by load equalization

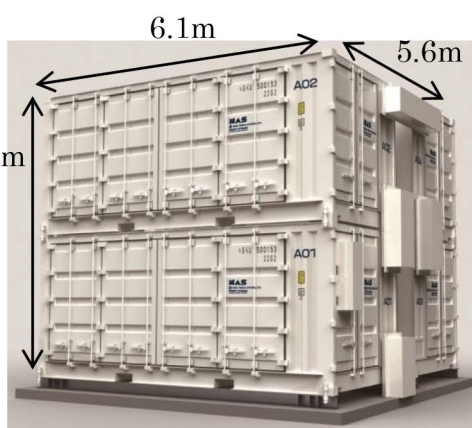


Figure 2 Exterior view of standard 800 kW NAS battery system



(2) Prediction for 2017 (or 2020): Unknown

#### 11. Reference information

N/A

#### 12. Implementation sites

N/A

#### 13. Cited documents

N/A

#### 14. Contact information

NGK Insulators, Ltd.

Tokyo Sales Office, Domestic Sales Department, Power Business  
Group. ■

# BAT3: High-strength and Low Thermal Conductivity Heat Insulating Materials 'ROSLIM™Board GH'

## 1. Category of industry

Heat insulating materials

## 2. Category of technology

High-strength and low thermal conductivity heat insulating materials (energy conservation)

## 3. Source of energy

N/A

## 4. Practical application

2011

## 5. Summary

'ROSLIM™Board GH' is a high-strength and high heat insulating performance material made of a nanopore silica including a heat-resistant reinforcing fiber and a radiation scattering material. The product provides higher workability and handling performance than conventional low thermal conductivity heat insulating materials. The product has

following features:

- (1) Higher heat insulating performance than still air
- (2) Excellent handling performance among low thermal conductivity materials
- (3) Excellent workability dispensing with special tools

## 6. Principle and operation

The physical properties of 'ROSLIM™Board GH' are shown in Table 1 and the comparison of thermal conductivities of various heat insulating materials is shown in Figure 1. As shown in Figure 2, the structure of 'ROSLIM™Board GH' including microscopic airspaces smaller than the mean free path of still air suppresses the heat conduction through gas and provides the lower thermal conductivity.

In addition, the radiated heat is scattered and attenuated by the effect of the radiation scattering material in the high temperature regions, and the thermal conductivity of 'ROSLIM™Board GH' at 600°C is half of that of quiescent air, showing its excellence.

Figure 3 shows the workability of 'ROSLIM™Board GH'.

The conventional low thermal conductivity heat insulating materials are brittle and fragile and require careful handling on account of the strength degradation caused by the forming. The high bond strength among particles of 'ROSLIM™Board GH' owing to the original manufacturing process enhances the strength of the whole member and enables easy handling of even formed materials or large sheets (25mm in thickness x 600mm x 900mm). This strength facilitates the precise forming, dispensing with special tools even in the complex forming.

## 7. Description of improvement

(1) Energy conservation utilizing excellent heat insulating performance

'ROSLIM™Board GH' in equal heat insulating thickness to the conventional heat insulating materials (calcium silicate boards etc.) used in the industrial furnaces can reduce heat radiation from the furnace to drastically save the energy consumption. For example, as shown in Figure 4, 'ROSLIM™Board GH' in 50 mm heat insulating thickness installed in the industrial furnace with the furnace temperature of 1000°C reduces the energy consumption by 50% compared with the conventional heat

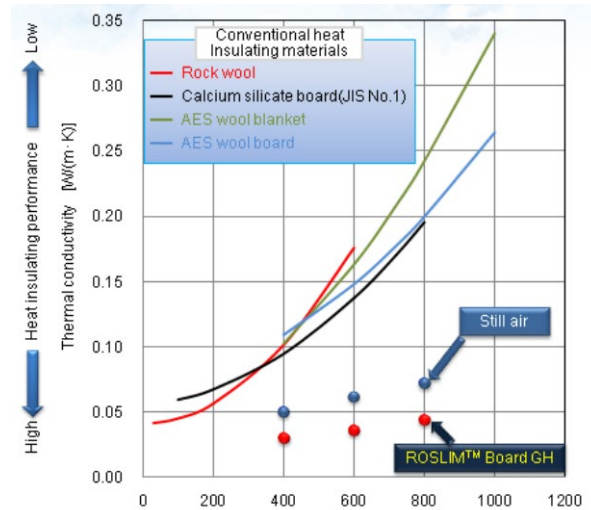


Figure 1 Thermal conductivities of heat insulating materials

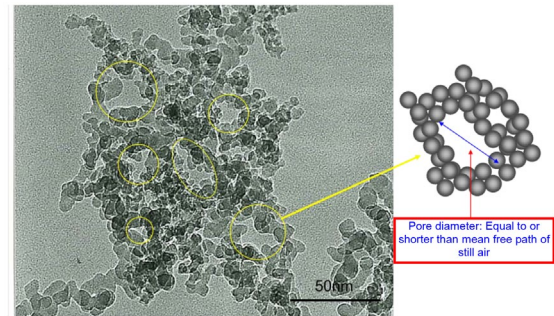


Figure 2 Inner structure of 'ROSLIM™Board GH' (TEM image)

Table 1 Physical properties of 'ROSLIM™Board GH'	
Density [kg/m³]	250
Thermal conductivity [W/(m·K)]	
at 400°C	0.030
at 600°C	0.036
at 800°C	0.044
Compressive strength [MPa]	
(10% Compressive strain)	1.02
Contraction factor in heating [%]	
at 800°C × 24 h r	0.6
at 1000°C × 24 h r	2.5
Highest heating temperature [°C]	1000

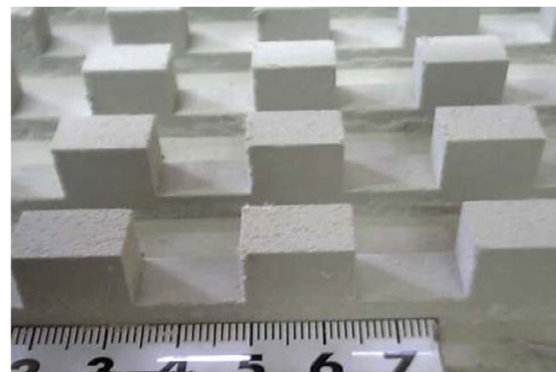


Figure 3 Example of complex forming



insulating materials.

(2) Downsized configuration utilizing excellent heat insulating performance

Figure 4 shows the example of the downsized heat insulating configuration. At equal outer surface temperature, excellent low thermal conductivity of 'ROSLIM™Board GH' can reduce the thickness of heat insulating materials and downsize the furnace and the devices. For example, as shown in Figure 5, 'ROSLIM™Board GH' installed in the industrial furnace with the furnace temperature of 1000°C and the surface temperature of 57°C reduces the thickness by 200 mm compared with the conventional heat insulating materials.

## 8. Effect of improvement

See Figure 4.

## 9. Economic efficiency and its trend

The preliminary calculation results of the payback period for heat insulating installation under the conditions of the furnace temperature of 1000°C, the heat insulating thickness of 350mm and the surface temperature of 40°C (outside atmosphere temperature 25°C) are as follows:

(1) 70% use of 'ROSLIM™Board GH': Payback period 2.2 years (preliminary)

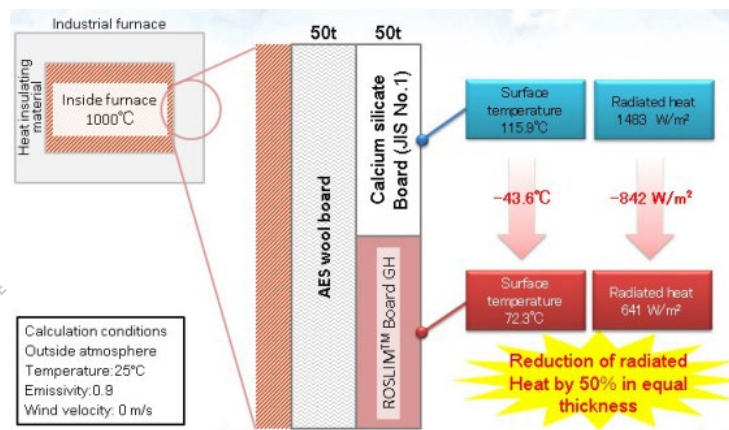


Figure 4 Example of energy-saving heat insulating configuration

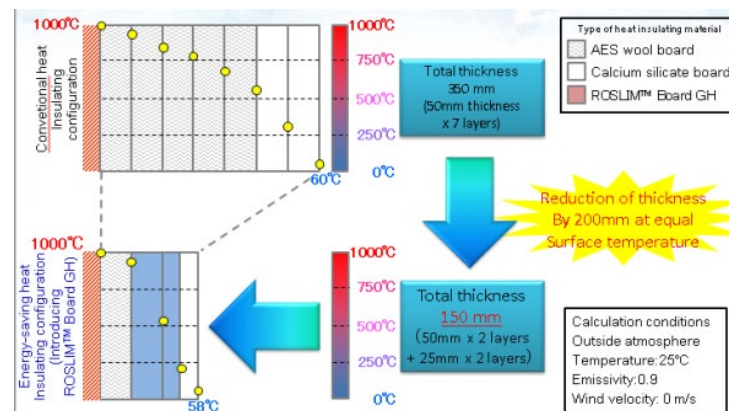


Figure 5 Example of the downsized heat insulating configuration

(2)45% use of 'ROSLIM™Board GH': Payback period 1.2 years (preliminary)

(3) 30% use of 'ROSLIM™Board GH': Payback period 0.6 years (preliminary)

## 10. Trend in market

(1)Current diffusion rate: 10%

(2)Prediction for 2020: 40%

## 11. Reference information

(1)Patents and utility models

1)Makio Naito,Yasuo Ito,Takahiro Ohmura:

Porous body coated particle,precursor for heat insulating material containing the porous body coated particle and heat insulating material,Japanese published patent application 2003-316772.

2)Makio Naito,Yasuo Ito,Takahiro Ohmura:

Porous body-coated fiber and heat-insulating material,Japanese published patent application 2003-152877

3)Makio Naito,Hiroya Abe,Yasuo Ito,Daiji Tahara:

Composite porous body,molded body of and thermal insulating material of this composite porous body,Japanese published patent application 2004-102578.

4)Yasuo Ito,Yoshihiko Goto,Shigeru Nakama,Takahiro Ohmura,Isami Abe: Thermal insulation and method of producing the same,Japanese published patent application 2009-239326.

5)Yasuo Ito,Yoshihiko Goto,Shigeru Nakama,Takahiro Ohmura,Isami Abe: Heat insulating material and method of producing the same,Japanese published patent application 2009-239327.

6)Yoshihiko Goto,Yasuo Ito,Ken Maeda,Akifumi Sakamoto,Thermal insulation material,Japanese published patent application 2010-187403.

7)Akifumi Sakamoto,Yasuo Ito,Ken Maeda:

Heat insulating material and method of manufacturing the same,Japanese published patent application 2010-231753

8)Akifumi Sakamoto,Yoshihiko Goto,Yasuo Ito,Ken Maeda: Heat insulating material and method for manufacturing the same,Japanese published patent application 2011-006475

9)Yasuo Ito,Yoshihiko Goto,Akifumi Sakamoto,Ken Maeda: Heat insulating material and method for manufacturing the same,Japanese published patent application 2011-088318

10)Yasuo Ito,Shigeru Nakama,Isami Abe,Jyunichi Numura: Method of producing heat insulating material for reformer,Japanese published patent application 2012-034214

11)Yasuo Ito,Ken Maeda:

Heat insulating material and method for producing the same,Japanese published patent application 2012-240721

12)Ken Maeda,Yoshihiko Gotoh,Kazuyuki Kii,Yasuo Ito:

Heat insulation unit,manufacturing method of heat insulation unit and heating furnace,Japanese published patent application 2013-175592.

(2)Awards

Chairman Prize of ECCJ in the Energy Conservation Grand Prize for excellent energy conservation equipment in FY2015 (Products and Business Models Category) Sponsored by: The Energy Conservation Center,Japan.

Supported by: Ministry of Economy,Trade and Industry.

(3)Documents

Presentations of papers and lectures

1)Hiroya Abe,Makio Naito,Yasuo Ito and Daiji Tahara: 'Design of Porous Materials by Dry Processing',The 8th IUMRS International Conference on Advanced Materials (Yokohama,October 2003).

2)Hiroya Abe,Makio Naito,Daiji Tahara,Yasuo Ito:

'Creation of nanoporous molded body by nanoparticle



bonding',The Ceramic Society of Japan Annual Meeting 2004,March 2004,Shonan Institute of Technology.

3)Isami Abe,Hiroya Abe,Makio Naito:

'Manufacture and structure of nanoporous fiber by nanoparticle bonding',The Ceramic Society of Japan 17th Fall Meeting,2004

4)Isami Abe,Kazuyoshi Sato,Hiroya Abe,Makio Naito:

'Effect of atmosphere in mechanical composition of silica nanoparticles and inorganic fiber',The Ceramic Society of Japan Annual Meeting 2005,March 2005,Okayama University.

5)Hiroya Abe,Isami Abe,Yasuo Ito,Kazuyoshi Sato,Makio Naito: 'Dry Powder Processing of High Porosity Microporous Composites',107th annual meeting id The American Ceramic Society (Baltimore,MI) Papers.

1)D. Tahara,Y. Ito,T. Ohmura,H. Abe and M. Naito,'Formation of Nano Structure on Glass Fiber by Advanced Mechanical Method,' Ceramic Transactions,Vol.146,p.173-177(2004).

2)H. Abe,I. Abe,K. Sato and M. Naito,'Dry Powder Processing of Fibrous Fumed Silica Compacts for Thermal Insulation,' Journal of American Ceramic Society,in press.

3)M. Naito and H. Abe,'Particle Bonding Technology for Composite Materials-Microstructure Control and Its Characterization,' Ceramic Transactions,Vol.157,p.69-76(2004).

## 12.Implementation sites

NICHIAS webpage: <http://www.nichias.co.jp/>

## 13.Cited documents

\*'TOMBO' is a registered trademark or trademark of NICHIAS Corporation.

\*'ROSLIM'is a trademark of NICHIAS Corporation.

\*The measured values in this document are used only for reference and not guaranteed. The calculation results of the payback period are preliminary and do not warrant the payback period.

## 14.Contact information

NICHIAS Corporation. ■



## BAT4: By-product Gas-fired Gas Turbine Technology

### 1. Category of industry

Thermal power Industry

### 2. Category of technology

BFG Fired Gas Turbine Technology

### 3. Source of energy

By-product gases from steel industry (BFG: Blast Furnace Gas, COG: Coke Oven Gas).

### 4. Practical application

Since 2004 (Application to high efficiency F class gas turbines).

### 5. Summary

In the global movement to realize environmental load reduction, the steel industry is also strongly required to reduce its CO<sub>2</sub> emissions as a countermeasure for global warming. Further, the global move to reduce consumption of primary energy resources represented by fossil fuels, BFG-fired gas turbines effectively utilizes by-product gases generated by the steel plants. The BFG fired gas turbines contributes for

the reduction of CO<sub>2</sub> emissions, thereby achieving change to a higher efficiency and higher power output.

### 6. Principle and operation

Figure 1 shows the overview system of the BFG-fired gas turbine combined cycle plant. The primary equipment's consist of Gas compressor, Step up gear, Gas turbine, Generator and Steam turbine arranged on a single shaft configuration mode. The mixture of BFG gas and COG gas is compressed in the gas compressor and supplied as a fuel for the gas turbine. Due to the low calorific value of BFG gas, additional source of COG gas is supplied to increase the calorific value of mixed gas mixture to 4.4 MJ/m<sup>3</sup>N-dry (LHV). The startup of gas turbine is driven by the steam turbine using steam from an existing boiler.

The BFG gas that is generated in the blast furnace (of steel plants) has the characteristics of having a lower calorific value than natural gas (LNG) which is generally known as a gas turbine fuel, and also that its combustion speed is low and combustion range is narrow due to the high proportion of inert gases comprising of nitrogen and carbon dioxide. With regards to fuel characteristics of BFG gas and to realize

high combustion efficiency over complete operation range, the combustor unit (refer figure 2) is designed to use same multi-can system with air bypass valve as used in dry low-NOx combustors thus allowing optimum utilization of fuel-air ratio. Further, the combustion efficiency is improved by mixing high calorie COG gas into the BFG gas using flow control method. With regards to the air compressor and turbine where the turbine inlet temperature is constant, the amount of combustion gas passing through the low-calorie gas-fired turbines is higher than the normal high-calorie fuel-fired gas turbines due to the increase in the amount of fuel. In conventional low calorie gas-fired turbines using gases including BFG gas, the air compressor is made smaller than the standard machines and the air intake volume is reduced to realize a similar flow through the turbine as in the standard machines, which makes it possible to utilize the standard turbine blade lattice. Additionally, because BFG gas includes large amounts of dust than LNG, there is a concern regarding degradation over time and blockages. To prevent this an electrostatic precipitator (EP) is installed on the BFG supply line, thereby improving the reliability and availability.

## 7. Description of improvement

Figure 3 shows examples of the energy balance in a BFG-fired gas turbine combined .

cycle plant (GTCC) and in a conventional plant (known below as BTG). Additionally,

Figure 4 shows graphs comparing the plant efficiency and power output.

When the amount of heat input is set to be same as in BTG and GTCC plants, using BFG .

and COG mixed gas as the fuel, the plant heat efficiency is estimated to be 36% in the BTG plant and 45% in the GTCC plant on LHV basis. It can therefore be anticipated that there will be an increase of 29 MW in the power output in the GTCC plant compared to the BTG plant (Comparison using a 150 MW class plant).

## 8. Effect of improvement

Improvement of energy consumption intensity (Option for improving energy conservation ratio) .

The amount of CO<sub>2</sub> emission is mutually related to the amount

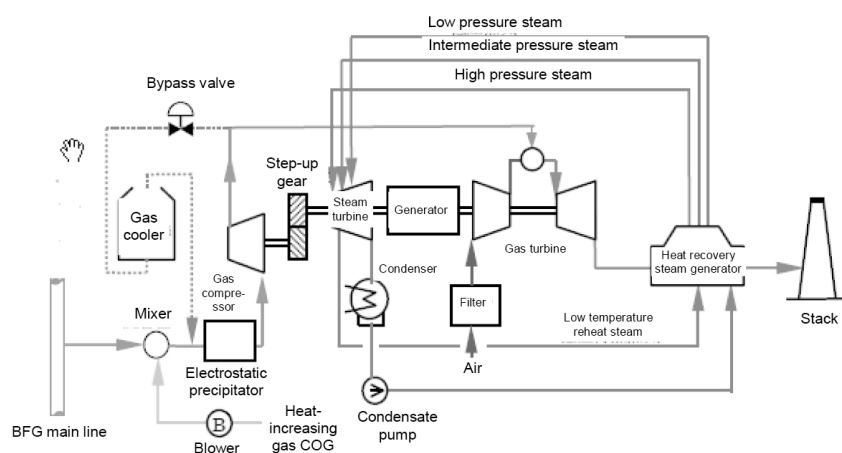


Figure 1 Overview system of a BFG-fired GTCC plant

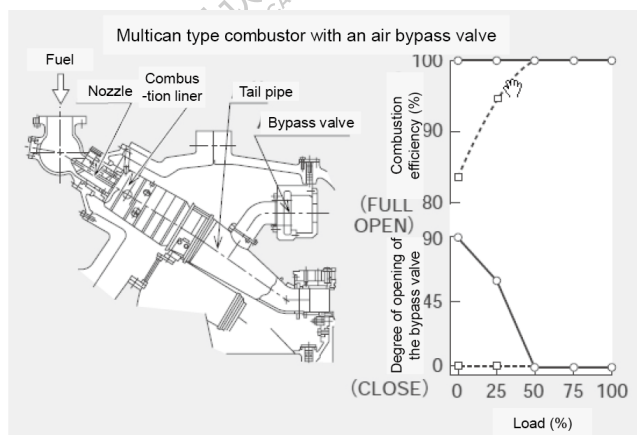


Figure 2 Multi-can type combustor with an air bypass valve  
(After optimizing the pipe diameter and length, the welding at each stage was eliminated.)

of BFG/COG gas generated by the steel industry as by-product gases. To minimize the CO<sub>2</sub> emissions it is necessary to evaluate not only the power generating equipment utilizing these by-product gases, but also to include the surrounding facilities. The proposed evaluation Plant heat efficiency (% LHV) Plant power generation end output (MW) is shown below.

In developing countries, BFG is not currently being used for power generation, and is being released into the atmosphere. A comparison between the current situation and the situation after introducing the BFG fired gas turbine combined cycle plant (GTCC) is shown in Figure 5. By generating 145 MW of electric power using the BFG fired GTCC, it will be possible to reduce 145 MW of the portion generated by the existing coal-fired boiler power plant (BTG). If the power is assumed to be generated for 8,000 hours annually, the CO<sub>2</sub> reduction of this coal-fired BTG is 1,040,000 tons of CO<sub>2</sub> per year. As shown in Figure 6, compared to building a new BTG, the GTCC will also be advantageous by an amount of approximately 210,000 tons of CO<sub>2</sub> year. In this way, it is possible to view the superiorities of

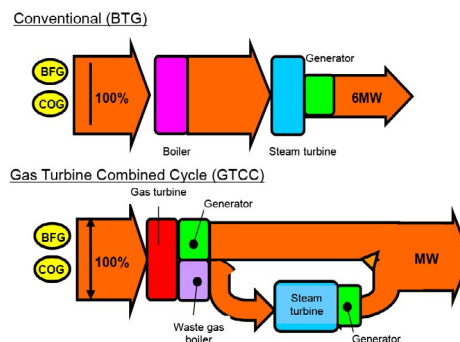


Figure 3 Energy balance diagram

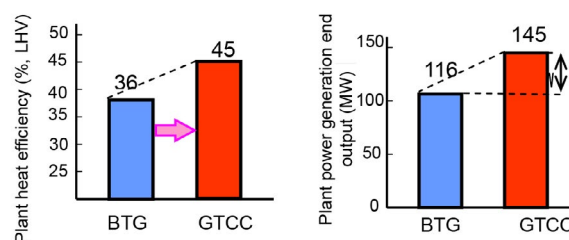


Figure 4 Comparison of BTG and GTCC plant efficiency and power output

GTCC plants as being the effective utilization of BFG from the viewpoints of realizing the high efficiency operation of plants and the control of CO<sub>2</sub> emissions.

## 9. Trend in market

Actual delivery results of low calorie gas-fired gas turbines (Since 1958) by MHPS include Japan: 28 units, China: 29 units, South Korea: 5 units, Netherlands: 4 units, Ukraine: 4 units. Total: 70 units.

## 10. Reference information

CO<sub>2</sub> reduction Refer to section 8.

## 11. Implementation sites



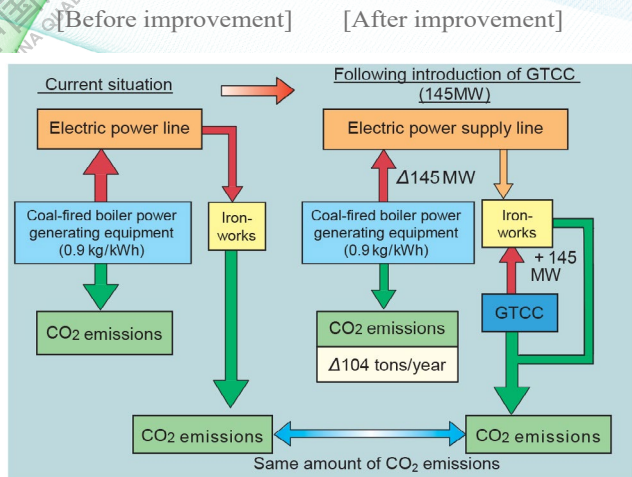


Figure 5 Figure showing an image of CO<sub>2</sub> reductions in a steel plant

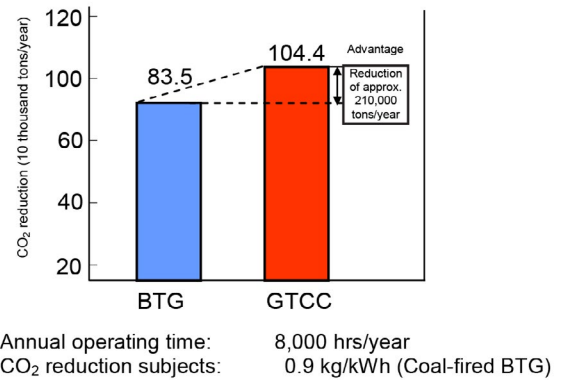


Figure 6 Comparison of CO<sub>2</sub> emissions

Refer to section 9 .

## 12. Cited documents

Mitsubishi Heavy Industries Technical Review Vol. 41 No. 5 (2004) .

Mitsubishi Heavy Industries Technical Review Vol. 44 No. 1 (2007) .

Mitsubishi Heavy Industries Technical Review Vol. 48 No. 3 (2011) .

Other

## 13. Contact information

Mitsubishi Hitachi Power Systems,Ltd. ■

## BAT5: Matrix Converter U1000

### 1. Category of industry

Power converters

### 2. Category of technology

Regenerative energy utilization type

### 3. Source of energy

Electricity

### 4. Practical application

April, 2014

### 5. Summary

Variable speed motor drives using inverters are becoming popular for energy conservation in the industrial field. However, there is a need to suppress power line harmonics based on the basic principles of the inverter and to process the regenerated energy created by the load side revolutions. In order to solve these problems, devices such as a regenerative power converter, an AC reactor, a harmonic filtering reactor, a condenser and others are coupled to the inverter.

On the other hand, these devices require much space for installation because of the increased number of components. This product enables both the suppression of the harmonics and utilization of the regenerated energy in a single unit, does not require additional space for the installation and drastically reduces cost. The product reduces workload drastically, improves the energy conservation rate in operation by 2%, and reduces the capacity of generator by 50% and the capacity of power supply unit by 20%. Thus, the product deserves to be called as the next-generation motor drive that solves the problems of the conventional general purpose inverters and contributes to the customer's energy conservation by its efficiencies which are higher than the inverters.

### 6. Principle and operation

The matrix converter U1000 comprises a circuit configuration shown in the right-hand figure, and supplies sine-wave voltage and current to a motor by direct PWM control of 3-phase AC voltage with 9 bidirectional switches located on a matrix between a power supply and the motor.

Refer to Figure 1.

## 7. Description of improvement

### Before improvement

Suppressing harmonics and utilizing regenerated energy used to require the regenerative power converter, the AC reactor, the harmonic filtering reactor and condenser. However, the additional components and wirings called for more space in the control panel, increasing the installation cost.

Refer to Figure 2.

### After improvement

The product enables the suppression of harmonics and utilizing of regenerated energy in one unit, and drastically reduces space for installation. Not only the energy is saved by utilizing the regenerated energy of the surroundings but also the cost is estimated to be reduced drastically.

Refer to Figure 3.

## 8. Effect of improvement

Improvement of energy consumption intensity (Option for improving energy conservation ratio)

Utilizing regenerated energy, one of the features of the product, is

very effective for large scale cranes and elevators.

In the case of single inverter, the regenerated energy during unloading is wasted as a heat from a braking resistor. The product allows recycling of the wasted regenerated energy at the power supply and utilization of the energy as an additional energy source. In the case of the 10ton-crane, 110,000 yen is saved annually as converted to the electric power charge.

Refer to Figure 4.

## 9. Economic efficiency and its trend

### (1) Equipment investment costs

- Reducing the installation cost by about 40% (in the case of 400 V 45 kW)
- Reducing the cost of the control panel by about 50%
- Reducing the cost of the generator and the power supply unit by about 50%

In the case of power supply to a generator, normally the generator requires capacity of about 4 times as much as the power capacity consumed at the inverter (with no reactor).

On the other hand, in the case of the Matrix Converter, the generator requires only about twice the capacity for operation.

### (2) Running costs

- In the case of the 10ton-crane, 110,000 yen is saved annually as converted to the electric power charge.

### (3) Payback period

The payback period depends on types of devices, capacity of the motor and the operation cycle. The payback period calculated based on the product cost was about 3 years at the earliest.

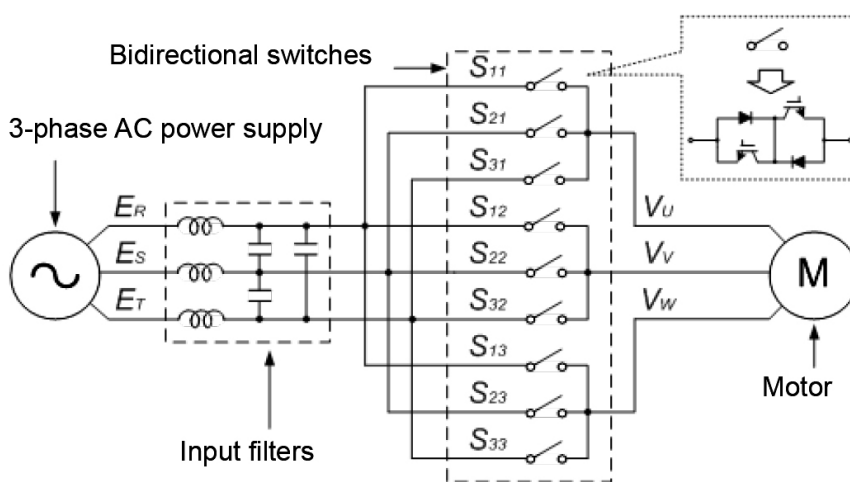


Figure 1



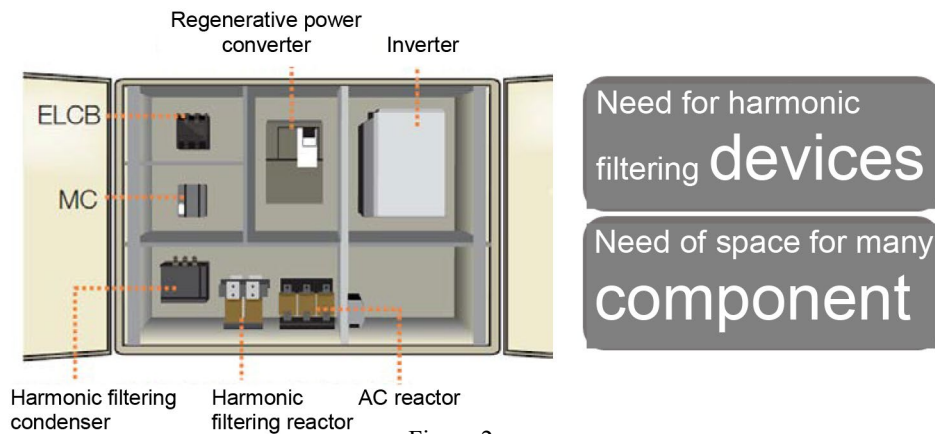
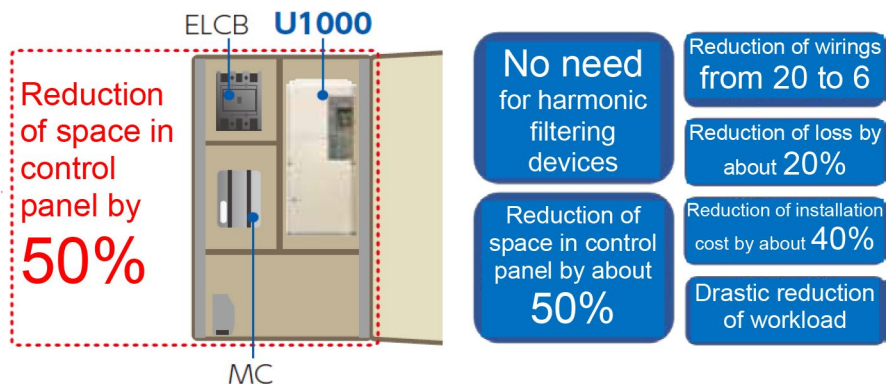


Figure 2



Example with installing and wiring space: 400 V 185 kW, efficiency: 400 V 15 kW, and installation cost: 400 V 45 kW

\*Installation cost is calculated using market prices.

Figure 3

## 10. Trend in market

Number of shipments: Increasing at an annual rate of 150-200%.

## 11. Reference information

### Social impact by CO<sub>2</sub> reduction

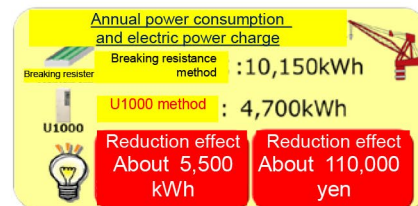
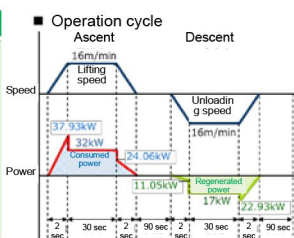
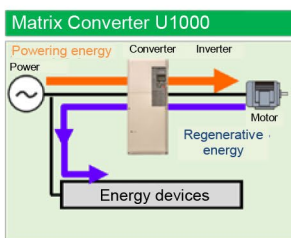
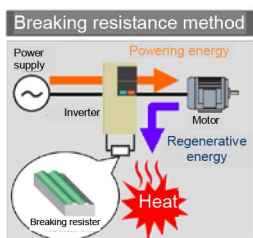
In the case of application to the overhead crane, the estimated energy conservation is 558,232 MWh/unit, and estimated CO<sub>2</sub>

reduction is 111.5 million liters (crude oil equivalent). The CO<sub>2</sub> reduction is equivalent to annual CO<sub>2</sub> emissions by 133,000 people, assuming that a person emits 6 kg of CO<sub>2</sub> per day.

Refer to Table 1.

## 12. Implementation sites

- Cranes in seaports
- Cranes in steel works



(Conditions) 10ton crane, 16m/min, Unit power price

Figure 4

Table 1

Hanging weight	Number of installed overhead	Energy-saving effect of U1000 [kWh/Unit]	Energy-saving effect of U1000[kWh/Unit]	Reduction of CO <sub>2</sub> [ton]
Total	95,550	1,363	558,232,000	292,000
3t or more and less than	16,581	2,725	22,592,000	11,800
5t or more and less than 10t or	32,943	5,450	89,770,000	46,900
more and less than 20t 20t or	26,399	10,900	143,875,000	75,200
more and less than 50t	15,428	21,800	168,165,000	88,000
50t or more and less than	2,887	43,600	62,937,000	32,900
100t or more and less than 200t	1,014	87,200	44,210,000	23,100
200t or more and less than 500t	290	174,400	25,288,000	13,200
500t or more and less than	8	348,800	1,395,000	700
1000t or more	0		0	0

\*1: Figures in the table above are extracted from the data "Number of installed cranes by model" provided by Japan Crane Association.

-Cranes in waste disposal sites

### 13.Cited documents

- The Energy Conservation (August 2014)
- YASKAWA Technical Review Vol.78 No.4 Special issue for environment and energy (February 10,2015)
- The Energy Conservation (February 2016)

### 14.Contact information

YASKAWA Electric Corporation, Inverter Division, Business Promotion Department, Sales Promotion Section  
Phone: +81-930-25-2548 Fax.: +81-930-25-3431 ■

## BAT6: High Efficiency Motor Control

### 1. Category of industry

Inverters

### 2. Category of technology

Motor control

### 3. Source of energy

Electricity

### 4. Practical application (Commercialization)

July 2014

### 5. Summary

In recent years, as measures for preventing global warming and against the exhaustion of energy resources, efficient energy use is required in various industries including the following: the strengthening of regulations on energy use through legal amendment of the Act on the Rational Use of Energy and the introducing regulations on motors for high efficiency. Interest in energy saving is also growing among energy consumers from the viewpoint of global environmental conservation and also of a cost reduction, and

the demand for as driving motors with high efficiency using inverters energy saving is increasing. According to that, the technologies and engineering for energy saving in inverters have been progressing year after year.

### 6. Principle and operation

The electric power supplied by electric power companies is generally an alternating current, and the frequency and voltage are fixed. When a motor is driven by the commercial power supply, its rotation speed is constant. However, it is possible to change the motor rotation speed by using inverters, which is motor control engineering. By converting the commercial power into a direct current (in the converter unit), and temporarily re-converting it into a variable frequency alternating current (in the inverter unit), inverters change frequency and voltage in any magnitude.

Because the motor rotation speed is proportional to the frequency, motors can be operated at variable speeds by varying the frequency and voltage applied to the motor by using the inverter.

In the equipment of reduced torque load characteristics including fans and pumps, the load torque is proportional to



the square of the rotation speed (air volume), while the output is proportional to the cube of the rotation speed (air volume).

For this reason, when an inverter controls an operation of reduced torque load equipment, a large energy saving effect can be anticipated compared to the commercial power operation (with damper control).

In addition, a variety of high-efficiency motor control technologies are incorporated in the latest inverters for realizing energy saving.

#### (1) High efficiency IPM motor driving

Recently, high efficiency interior permanent magnet (IPM) motors have received attention for a reason that they produce higher energy conservation effects than induction motors. IPM motors are synchronous motors that have permanent magnets embedded inside the rotor. Induction motors generate magnetic flux by passing current through the rotor conductor to obtain the rotary force (torque), which causes a loss (secondary copper loss) occurrence in the rotor. In contrast, because current does not pass through the rotor in IPM motors which utilize magnets, loss (secondary copper loss) does not occur, and the efficiency will be better than that of induction motors.

#### (2) Optimum excitation control (Induction motor high efficiency control)

High efficiency control system was also devised for induction motors. V/F control is generally used, which fixes the ratio of the output frequency and output voltage to the motor. However, in optimum excitation control, the excitation current and the torque current are diverted from the motor current. The excitation current is controlled so that the motor efficiency reaches its maximum efficiency and the output voltage is determined.

## 7. Description of improvement

(1) Mitsubishi Electric Corporation developed the technology to control IPM motor with high performance and high efficiency, and achieved the operation of the IPM motor with our general-purpose inverter.

Controlling the operation of the IPM motor with high efficiency attains, approximately 10% more efficiency than operating the induction motor by the inverter in a 5.5 kW motor example due to product integration. Additionally, it allows to replace only the conventional motor with the IPM motor at the timing if renewing motors in the future, which brings about advantages to facilitate the adoption of further energy saving.

The actualization of operation of the IPM motor as well as induction motor by the general-purpose inverter contributes to the simplification of customer's stock control. Additionally, our development of the auto-tuning function which can measure the circuit constant of IPM motor as well as conventional induction motor enables optimal operation of motors, increasing the range of suitable applications for motors.

(2) Mitsubishi Electric Corporation developed and as in actual use the control method (optimum excitation control) that maximizes the efficiency of induction motors.

For the fan and pump applications, because the low-speed torque is not required, the motor excitation current is controlled for maximization of motor efficiency to give higher priority on the improvement of the motor efficiency than the torque generation.

With a small load torque, further energy saving is enabled. In example of a freezer operation, at 10% motor load torque which is common torque level for a normal operation, the motor efficiency under optimum excitation control is about 15% higher than the motor efficiency under V/F control.

During the newly developed advanced optimum excitation control, it is possible to generate a large starting torque while maintaining the motor efficiency under the optimum excitation control. This is applicable to the cases when a large torque is required at startup, such as for the fan with large inertia.

## 8. Effect of improvement

Improvement of energy consumption intensity (Option for improving energy conservation ratio)

### (1) IPM control

Refer to Figure 1.

### (2) Induction motor optimum excitation control

Refer to Figure 2.

## 9. Economic efficiency and its trend

Economic efficiency: IPM motor life cycle cost (LCC) simulation (Comparison with general-purpose motor driven by the commercial power supply).

[Usage conditions] Motor capacity: 15 kW, Air Volume: 70%  
Operation time: 16 hours/day x 250 days/year = 4,000 hours/year.

Refer to Figure 3.

## 10. Trend in market

Inverter installation rate: 26% ("Progress in Inverters 2016")  
Japan Electrical Manufacturers' Association)

## 11. Reference information (Application example)

Refer to the attached appendix documents (1) Air conditioning in buildings, and (2) Water-cooling pump.

## 12. Implementation sites

Mitsubishi Electric FA website [www.mitsubishielectric.co.jp/fa](http://www.mitsubishielectric.co.jp/fa)

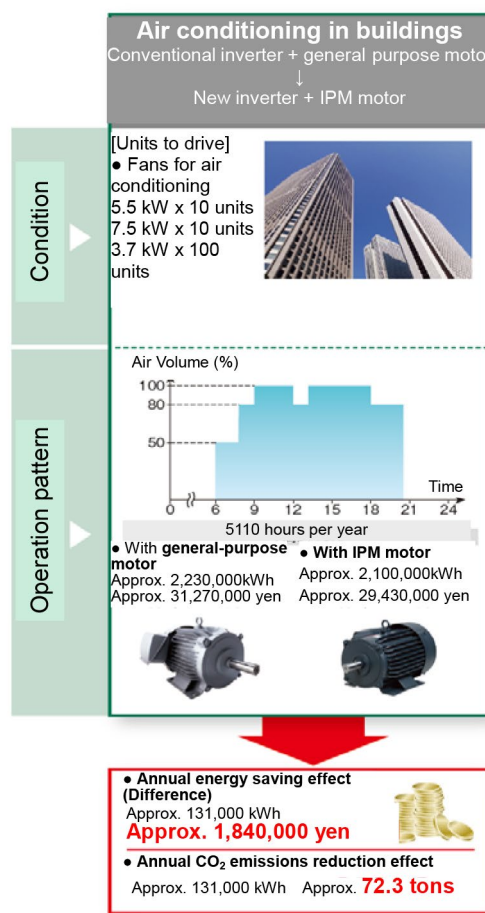


Figure 1

## 13. Cited documents (Reference information)

- The Japan Electrical Manufacturers' Association bulletin "Denki" February 2014, "Progress in Inverters 2016" The Japan Electrical Manufacturers' Association
- Mitsubishi Electric Technical Review, April 2014, Mitsubishi Electric Corporation

## 14. Contact information

Mitsubishi Electric Corporation. ■

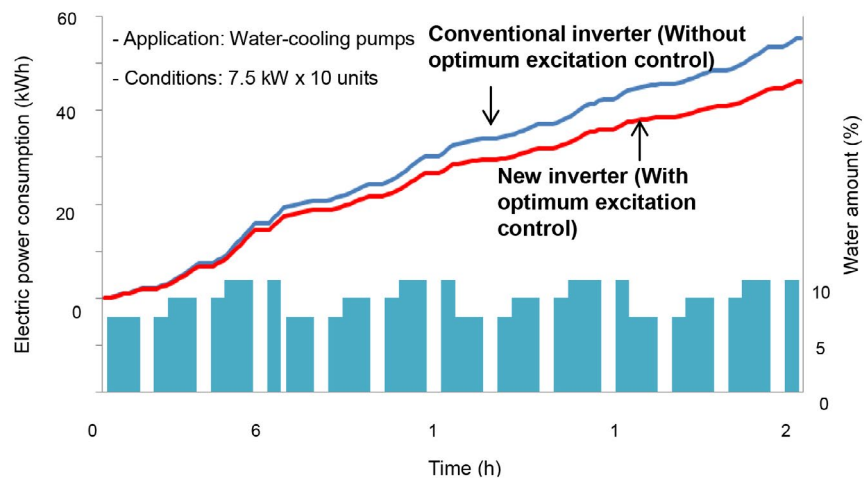


Figure 2

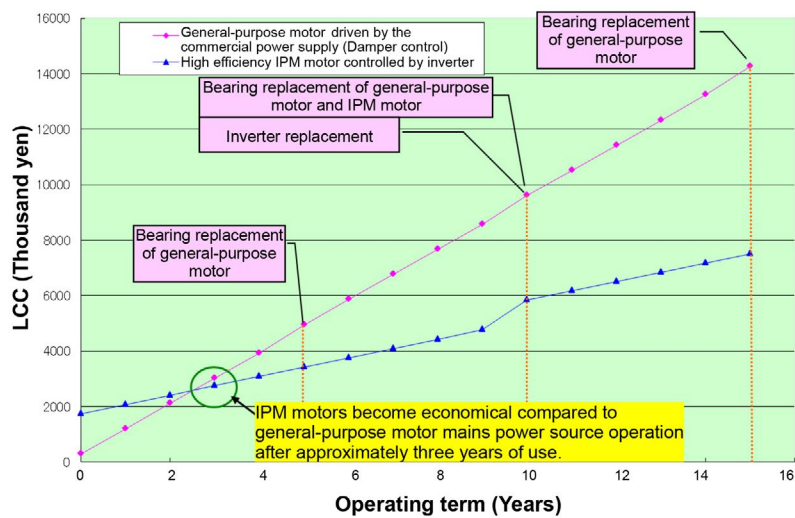


Figure 3



## BAT6-1: Air Conditioning in Buildings

### 1. Category of industry

Fans

### 2. Principle and operation (Features and advantages)

In recent years, the energy-saving tendency has been increasing, which is promoting the introduction of laws and regulations in countries worldwide making it obligatory the manufacture and sale of high-efficiency motors. In particular, because interior permanent magnet (IPM) motors operate at higher efficiency than induction motors, their high energy-saving effect has been attracting attention.

Mitsubishi Electric Corporation developed the technology to control IPM motor with high performance and high efficiency, and achieved the operation of the IPM motor with our general-purpose inverter.

Controlling the operation of the IPM motor with high efficiency attains, approximately 10% more efficiency than operating the induction motor by the inverter, and 5% more efficiency than operating the high efficiency induction motor by the inverter, in a 5.5 kW motor example.

The actualization of operation of the IPM motor as

well as induction motor by the general-purpose inverter contributes to the simplification of customer's stock control. Additionally, our development of the auto-tuning function which can measure the circuit constant of IPM motor as well as conventional induction motor enables optimal operation of motors, increasing the range of suitable applications for motors.

Refer to Figure 1.

### 3. Effect of improvement

Refer to Figure 2.

### 4. Reference information

#### (1) Awards

-Good Design Award 2014 Organizer: The Japan Institute of Design Promotion

#### (2) Documents, etc.

-The Japan Electrical Manufacturers' Association bulletin "Denki" February 2014, The Japan Electrical Manufacturers' Association

-Mitsubishi Electric Corporation Technical Review, April 2014, Mitsubishi Electric Corporation

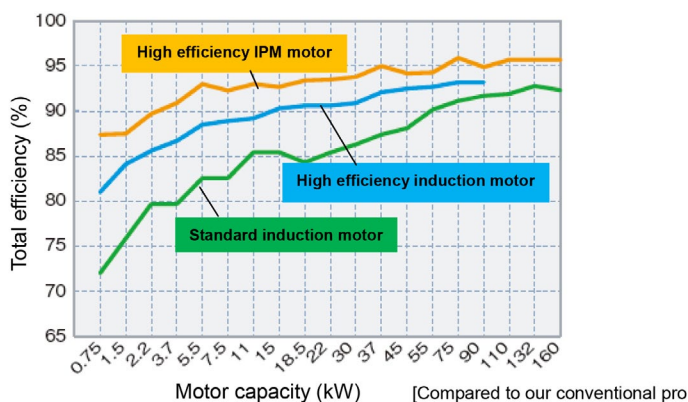


Figure 1 Comparison example in total efficiency of motors

## 5.Contact information

Mitsubishi Electric Corporation ■

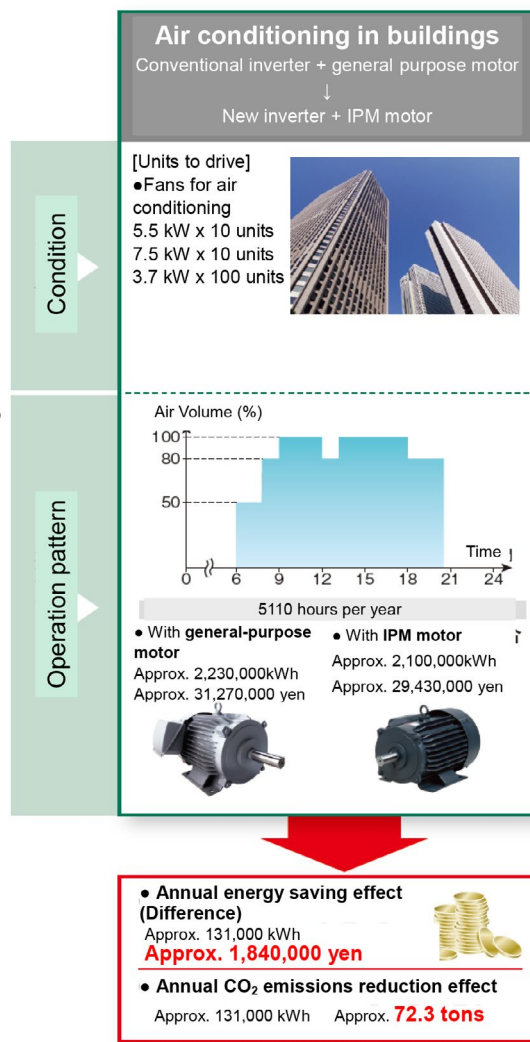


Figure 2

## BAT6-2: Water-cooling Pump

### 1. Category of industry

Pumps

### 2. Principle and operation (Features and advantages)

Mitsubishi Electric Corporation developed the control method (optimum excitation control) that maximizes the efficiency of induction motors.

For the fan and pump applications, because the low-speed torque is not required, the motor excitation current is controlled for minimization of motor loss to give higher priority on the improvement of the motor efficiency than the torque generation.

With a small load torque, further energy saving is enabled. In example of a freezer operation, at 10% motor load torque which is common torque level for a normal operation, the motor efficiency under optimum excitation control is about 15% higher than the motor efficiency under V/F control. (Figure 1)

During the newly developed advanced optimum excitation

control, it is possible to generate a large starting torque while maintaining the motor efficiency under the optimum excitation control. This is applicable to the cases when a large torque is required at startup, such as for the fan with large inertia.

### 3. Effect of improvement

-Application: Water-cooling pump

-Conditions: 7.5 kW x 10 units

Refer to Figure 2&3.

### 4. Reference information

(1) Awards

-Good Design Award 2014 Organizer: the Japan Institute of Design Promotion

(2) Documents, etc.

-The Japan Electrical Manufacturers' Association bulletin "Denki" February 2014, The Japan Electrical Manufacturers' Association



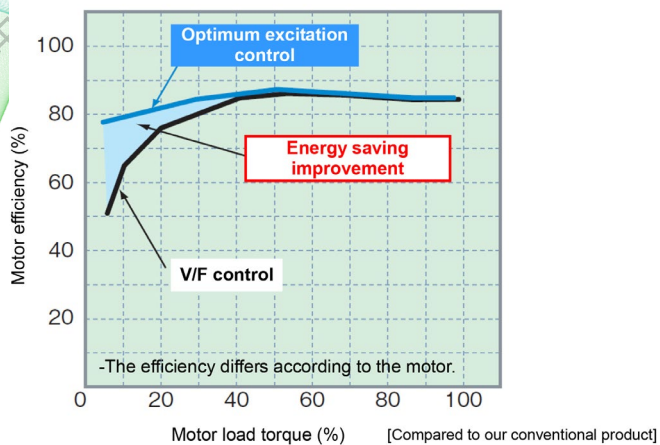


Figure 1 Motor efficiency during optimum excitation control (Example when an inverter running frequency is 60 Hz and a 3.7 kW motor is used.)

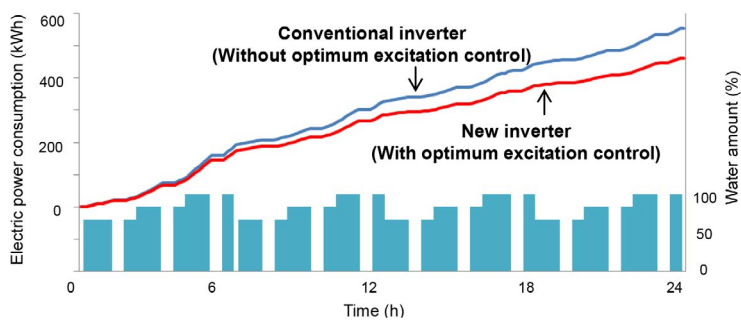



Figure 2

Annual electric power consumption	
• <b>With conventional inverter</b>	
Approx. 200,000 kWh	
Approx. 2,800,000 yen	
• <b>With new inverter</b>	
Approx. 170,000 kWh	
Approx. 2,400,000 yen	

- **Annual energy saving effect (Difference)**  
Approx. 30,000 kWh **Approx. 400,000 yen**
- **Annual CO<sub>2</sub> emissions reduction effect**  
Approx. 30,000 kWh **Approx. 16.5 tons**

Figure 3

-Mitsubishi Electric Corporation Technical Review, April 2014, Mitsubishi Electric Corporation

## 5. Contact information

Mitsubishi Electric Corporation ■

## Second Batch of Domestic TOP TENS List

### Japan Industrial BP List

Edited by Jianfu Wang

#### BP1: Promotion of Energy Conservation by Circle Activities at a Paperboard Manufacturing Plant

##### 1.Details

Under the slogan of “Less Weight, Less Carbon”, Rengo Co., Ltd. is making efforts to reduce the weight of corrugated boards and paperboards. The company has developed a cutting edge product, C-flute corrugated board and is promoting marketing of the product. At its Yashio Mill, Rengo is manufacturing thin inner sheet to reinforce lightweight corrugated board. Although energy conservation per area can be achieved as a packaging material, the Yashio Mill needed to improve its production method urgently to achieve energy conservation by weight.

In addition, Saitama Prefecture, where the Yashio Mill is located, has enforced an ordinance to promote the measures against global warming. Depending on the conditions certified by the prefecture, companies in Saitama Prefecture were required to reduce their CO<sub>2</sub> emissions significantly by 6%-15% from the base year of FY2002-FY2004.

In order to comply with the ordinance, the Yashio Mill implemented the followings:

- (1) Promoted the development and production of thin and lightweight corrugating medium
- (2) Promoted energy conservation by introducing the high nip



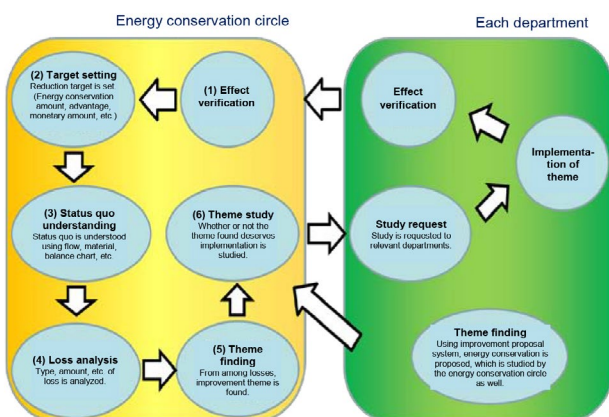
load shoe press prior to the drying process

(3) Implemented energy conservation activities in the material preparation process by actively introducing energy-saving facilities, a conventional method of small-group activities

(4) Grass-roots activities to find and implement energy-saving measures by a newly established energy conservation circle (Team Low Emission Yashio) with the participation of all members of the circle

The results are: (compared with 2011; crude oil equivalent)

(1) Weight reduction of "Less Weight, Less Carbon" corrugated boards and paperboards: A reduction of 89 kl/year



(2) Reduction of energy consumption of paperboard machines: A reduction of 1,435 kl/year

(3) Energy conservation activities in the material preparation process: A reduction of 3,239 kl/year

(4) Grass-roots activities of a small-group energy conservation circle with the cooperation of business departments: A reduction of 3,900 kl/year

The total reduction reached 8,663 kl/year, achieving a 8% reduction of total energy consumption of the mill.

## 2. Diagrams, etc.

- Consultants are invited so that the members can learn the

basics of the activity. → Establishment of PDCA cycle

## 3. Energy conservation performance

(Crude oil equivalent)

(1) Weight reduction of "Less Weight, Less Carbon" corrugated boards and paperboards: A reduction of 89 kl/year

(2) Reduction of energy consumption of paperboard machines: A reduction of 1,435 kl/year

(3) Energy conservation activities in the material preparation process: A reduction of 3,239 kl/year

(4) Grass-roots activities of a small-group energy conservation circle with the cooperation of business departments: A reduction of 3,900 kl/year

Sum total of the above: 8,663 kl/year

The total reduction reached 8,663 kl/year, achieving an 8% reduction of total energy consumption of the mill.

## 4. Advanced nature and originality

(1) Rengo is the leader in the industry in the efforts to reduce the weight of corrugated boards and paperboards. The company has worked to develop and manufacture C-flute corrugated board, which has become the standard in Europe and the U.S. but is still considered a cutting-edge technology in Japan. It also developed a proprietary technology to manufacture thin corrugating medium for corrugated boards.

(2) After investigating and considering the usage outside Japan and technical information, Rengo has introduced the high nip load shoe press of the highest linear pressure in Japan. This helped the company achieve energy conservation.

(3) Considered technologies of energy-saving equipment utilizing advanced technologies in the material preparation process and expanded the technologies to similar facilities in the mill.



(4) Based on a newly established energy conservation circle (Team Low Emission Yashio), learned the basics of small-group activities, established a procedure so that all the employees in the mill can participate, implemented a PDCA cycle to find and implement continuous efforts of energy conservation.

## 5. Versatility and expandability

(1) Compatible with the existing corrugated boards and paperboards. Weight reduction is becoming an important issue in the industry.

(2) A new press machine had been introduced to corrugating medium making machine. Also, the press machine was introduced to liner making machine, too. Introduction and optimization of new press machine is possible, irrespective of the type of paperboard.

(3) Optimizing the facility specification will enable updating from the existing facility and expansion to similar facilities.

(4) Based on a newly established energy conservation circle (Team Low Emission Yashio), learned the basics of small-group activities, established a procedure so that all the employees in the mill can participate and advanced the efforts as mill-wide grass-roots activities.

## 6. Continuity and sustainability

Based on the energy conservation circle (Team Low Emission Yashio), implemented mill-wide information sharing from management to rank-and-file employees, through ISO activities, Environmental Committee and the efforts at workplace, implemented and continued a PDCA cycle of energy conservation activities.

## 7. Investment efficiency

Vary by case.

## 8. Secondary results

**Environmental effect:** Reduction of CO<sub>2</sub> emissions

(1) 233 t/year

(2) 3,758 t/year

(3) 8,483 t/year

(4) 10,214 t/year

22,688 t/year in total

**Awards:**

Minister Prize of Economy, Trade and Industry in the FY2014 Energy Conservation Grand Prize for excellent energy conservation equipment

**Human resources development:**

Energy conservation circle consists mainly of young employees from various workplaces. Through acquiring knowledge on the structure of equipment, verification of energy usage, gathering information, and creation and implementation of a plan, the circle nurtures human resources able to promote energy conservation and other improvements. The participants can also gain knowledge from other business departments. From a medium- to long-term view, they can broaden their perspectives necessary when making judgments.

At workplaces, the employees became more aware of the problems, through the verification and implementation of the ideas they have suggested, and also understanding the effects of such ideas. ■

## BP2: ECO Activities to Actualize "Visualization(energy audit)" and "Optimization" Using EQS-AD10 (Environmental Andon System)

### 1.Details

After obtaining an Environmental Management System(EMS) in 1996,the company's facility management department has implemented energy-saving activities such as controlling operation of air conditioners and lighting. However,such activities were not introduced to manufacturing sites due to concerns over a possible negative impact on quality and productivity. With the aim of reducing total costs and preparing for addressing energy problems,which will be a future challenge in manufacturing factories,the company has launched activities to achieve (optimization) both "energy conservation" and the "improvement of quality and productivity" in 2010. The target was to become the No.1 eco factory in the industry in three years.

(1)Under the concept of "optimization" and"visualization" various sensors were installed on equipment. The collected data are aggregated by Environmental Andon System (EQS-AD10) monitoring system.

(2)Environmental Andon System (EQS-AD10),originally

developed at OMRON's Ayabe Factory,creates graphs and makes analysis based on gathered data,and also detects gaps between the current state and the ideal state,thereby supporting energy audit for appropriate control and prevention of wasteful use of energy. In addition,all employees at the factory,from those in charge of factory management to equipment operators,can select the layer to check for the status of production and the environment. This enables energy audit with the participation of all employees at the factory.

### 2.Diagrams,etc.

Refer to Figure 1.

### 3.Energy conservation performance

(1)Power consumption for production of the factory (compared with FY2010): A 27.3% reduction (2,741,000 kWh → 1,993,000 kWh).

(2)Electricity intensity per unit production of the factory (compared with FY2010): A 20.1% reduction.

<Major cases of improvement>58 cases in total.

(3)Electricity intensity per unit production of the clean room:

## Environmental Andon System (EQS-AD10) Visualization System (Patent No. 4377353)

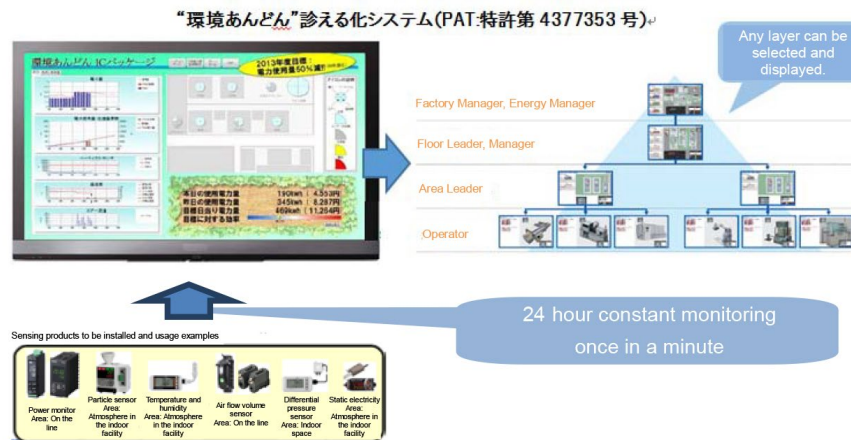


Figure 1

Down by 50%.

(4)Power consumption of the booth in the printing process:  
Down by 50%.

(5)Power consumption of the clean booth using the fan filter unit: Down by 40%.

(6)Power consumption by lowering temperature setting when the forming machine is not in operation: Down by 35%.

(7)Power consumption by improving compressed air:Down by 28% and others.

### 4.Advanced nature and originality

(1)Develop and operate an original system,not only for detect electricity consumption,but also to constantly monitor information on electricity consumption,the environment and production once in every minute in real time for 24 hours a day,compare the information with past data for integrated monitoring.

(2)Implement total ECO activities aimed at optimizing all energy conservation,the environment,quality,productivity,saf

ety and reliability.

### 5.Versatility and expandability

(1)Our activity is not just for visualization of energy usage but also for auditing energy consumption. It can provide new findings and know-how from a new perspective,and is expandable as a value-added energy conservation activity.

(2)A real-time goal can be set to Environmental Andon System (EQS-AD10) . Its function to give a forecast or an alarm when an abnormal condition of electricity and environmental data is detected and take an appropriate measure improves the environment for energy conservation.

(3)Environmental Andon System (EQS-AD10) has beencommercialized in June 2013 to meet the market needs,so that our customers can use the system in their worksites.

### 6.Continuity and sustainability

(1)Energy conservation at manufacturing sites is considered difficult due to concerns over possible deterioration of



productivity and quality. For this reason, we presented measurement data to verify that energy conservation measures have no negative impact on productivity and quality and established an ideal environment in which the manufacturing sites can implement energy conservation measures without concerns.

(2) In order to solve problems at manufacturing sites, Environmental Andon System (EQS-AD10) has been introduced to be used by all employees at the site to promote energy audit and enhance communication in the workplace.

## 7. Investment efficiency

(1) Investment amounts Recovery periods.

(2) Investment amount: 14.8 million yen Investment recovery: 1.5 years.

## 8. Secondary results

(1) Since its commercial launch as standard software in June 2013, Environmental Andon System (EQS-AD10) has been accepted by and introduced to more than 160 manufacturing companies and their offices. It is an environmentally-friendly ECO activity that leads to social contribution.

(2) It presented a concept of energy conservation at manufacturing sites, tips and know-how of energy

conservation and also introduced energy conservation and environmentally-friendly contents not only to the customers that purchased Environmental Andon System (EQS-AD10) and also to other companies and factories, contributing to society on a continuous basis.

(3) In terms of human resources development, 'ECO Ayakurian' (The dojo to study about ECO for the education on the environment and handing down knowledge to the next generation was established, to promote factory-wide energy conservation activities.

1) Patents: 1 patent

2) Awards: 3 in total, Minister Prize of Economy, Trade and Industries in the FY2012 Energy Conservation Grand Prize for excellent energy conservation equipment, Keidanren Chairman's Award at the 23rd Grand Prize for the Global Environment Award, etc.

3) Release on newspapers: 8 times (Nikkan Kogyo Shimbun, Nikkei Monozukuri, etc.)

4) Inspection tours and lectures outside the company:

About 100 times a year ■

## BP3: Reduction of Base-load Energy Usage

### 1.Details

After the Great East Japan Earthquake in 2011, business environment surrounding the company changed dramatically, pushing down the operation rate of its plants significantly. This resulted in the deterioration of energy use per unit of output. This was due to high base-load energy usage rate of approximately 70% necessary for maintaining clean rooms and other utility facilities. Sharp Corporation Kameyama Plant developed factory-wide efforts to lower the rate.

**Effort 1:** Energy-saving measures introduced to outdoor air-processing units Recovered heat by flowing heated water (waste heat) generated in the plant to reheating coils and also cold/cool water coils even in winter. This resulted in the reduction of the amount of both cold/cool and hot/warm water.

**Effort 2:** A reduction of circulating air volume in clean rooms In cooperation with the production and

engineering departments, determined six conditions that must not be changed while maintaining interior conditions (cleanliness, temperature and humidity, air current, chamber pressure). This reduced circulating air volume and also decreased energy consumption.

**Effort 3:** Energy-saving measures utilizing free cooling effect in winter on formerly low-loaded cooling towers In order to maintain high operation rate of the cooling tower, rearranged piping so that the function of the towers can be switched by season (summer or winter), to reduce energy consumption.

**Effort 4:** Modification of software to control backup fans and pumps in the production process (production units)

Modified software to control the fans and pumps in the production units so that all the inverter-type fans and pumps, including ones formerly not in operation as for backup use, can be operated constantly and also the non-inverter-type fans and pumps can be changed to work as

backup,instead.

This reduced the loss of pressure of dampers and valves,cutting energy consumption.

**Effort 5:** Reduction of power consumption by introducing LED lightings in the plant and offices The liquid crystal plant operates 24 hours a day,365 days a year,consuming a large amount of electricity for lighting. 20,050 fluorescent lamps and mercury lamps in the plant and offices were replaced by LED lamps to reduce energy consumption.

## 2.Diagrams,etc.

N/A.

## 3.Energy conservation performance

Other than listed above,302 measures to save energy were taken during three years. As a result,energy usage per unit of output for FY2013 improved by 43.3% from FY2011.

Effort 1 Reduction: 2,568 kl/year

Effort 2 Reduction: 1,091 kl/ year

Effort 3 Reduction: 233 kl/ year

Effort 4 Reduction: 458 kl/ year

Effort 5 Reduction: 1,155 kl/ year

Total 5,505 kl/ year 7,359 ton-CO<sub>2</sub>/year

## 4.Advanced nature and originality

Keeping the plant-building concept since its foundation,grasped and analyzed the current situation and future challenges and switched the function of equipment and coil sections by season. Through utilizing the potential of each facility/equipment to the full,we

sought for total optimization by flexible thinking.

(1)Development of outer air processing technology (Effort 1)

-Supplied waste heat from the plant to reheating coil and also cold/cool water coil even in winter. This established a system to reduce the usage of both cold/cool and hot/warm water.

-Established an effective heat recovery system for spring and autumn periods by controlling the amount of cold/cool water (waste heat).

(2)Enhancement of operation rate of the cooling towers (Effort 3)

-Established a system to improve the operation rate of the cooling towers by switching the function of the towers by season (summer or winter).

## 5.Versatility and expandability

(1)All the measures listed above can be implemented just by modifying the existing facilities. This concept can be applied and is expandable not only to device factories but also to other industries.

(2)Four measures except for Effort 5 (ESCO) are cost effective,requiring less than one year to recover the cost.

## 6.Continuity and sustainability

(1)Energy conservation measures are continuing through small-group activities (under the company-wide system called R-cats).

(2)The progress of measures implemented and considered at each factory and each process in the Kameyama site is reported at the site's energy-saving



WG every month, so that the report can be utilized by other processes or the other factory in the site.

(3) Organize study meetings on energy conservation periodically to raise the knowledge level of the employees in charge of promoting energy conservation.

(4) Actively promote information sharing with regard to implementation of energy-saving measures and activities, including participation in the energy-saving meetings held by other plants.

## 7. Investment efficiency

Refer to table below.

Energy saving (1,000 yen/year)	Investment (1,000 yen)	Years required for recovery
Effort 1 45,558	39,400	0.86 years
Effort 2 43,238	—	—
Effort 3 5,883	3,000	0.51 years
Effort 4 18,166	16,600	0.91 years
Effort 5 45,748	—	ESCO contract: 5 years
Total 158,593	59,000	0.52 years
(Calculation excluded ESCO in Effort 5)		

## 8. Secondary results

(1) CO<sub>2</sub> reduction: 7,359 ton-CO<sub>2</sub>/year

(2) Release (newspapers): 4 times including Mainichi Shimbun

(3) Posting literature: 4 times including ENECO

(4) Accepting a site visit to our energy-saving facilities: 7 times

(5) Joining in a study meeting with other companies:

Once. ■

## BP4: Reducing CO<sub>2</sub> Emissions in the Supply Chain

### 1.Details

(1)Cutting CO<sub>2</sub> emissions is a pressing issue because it increases temperature and causes an abnormal climate,resulting in global warming. In its new business vision 'FUSO 2015 Program' released in 2011,Mitsubishi Fuso Truck and Bus Corporation sets the target 'Leader in Green Innovation' as one of its goals. Under the goal,the company launched activities to reduce CO<sub>2</sub> emissions in its entire business operations.

(2)The activities aiming to achieve the target 'Leader in Green Innovation' were implemented by five teams for 'products','plants and facilities','supply chain','sales

and maintenance',and 'awareness and activities of the employees'.

(3)Our distribution department takes the lead in advancing activities to reduce CO<sub>2</sub> emissions in the supply chain. Since 2011,the company has quantified and controlled CO<sub>2</sub> emissions from cargo transport by trucks and railroad,cargo handling using forklifts,and distribution using our trucks.

<Major energy conservation activities>

- Modal shift to milk run or rail transport
- Introduce electric-powered forklifts to the plants
- Utilize carrier cars to transport finished vehicles and enhance direct delivery rate by reducing stopovers

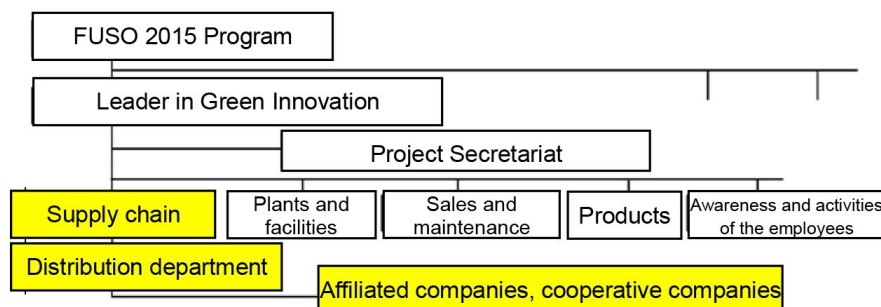


Figure 1

-Eco-friendly driving training

## 2. Diagrams, etc.

Refer to Figure 1.

## 3. Energy conservation performance

The company set a target to reduce CO<sub>2</sub> emissions by 5% in 2015 from 2010 level by introducing milk run, modal shift, improving the ratio of consolidated cargoes and direct delivery and introducing electric-powered forklifts. To achieve this target, the company advanced many projects.

Numerical target: reduce CO<sub>2</sub> emissions by 5% in 2015 from 2010 level. It means that target value is 1500 tCO<sub>2</sub> reduction and year target level is 375 tCO<sub>2</sub> reduction.

In 2012 as activity starting year, 418 tCO<sub>2</sub> reduction is achieved and it means over 10% reduction as compared with the target.

## 4. Advanced nature and originality

(1) Our core business is the development, production and sales of trucks. Since the introduction of the modal shift to rail transport of the delivery of parts in the supply chain, which encompasses receiving parts from the suppliers, production and the delivery of vehicles to the customers, may have a negative impact on the company's production plan, some people in and outside the company had a feeling of resistance to the introduction of the modal shift. Focus on the benefits of reducing CO<sub>2</sub> emissions by introducing the modal shift (change from truck delivery to rail transport) lowered the resistance, achieving a reduction

of CO<sub>2</sub> emissions.

(2) Transport of trucks using carrier cars is considered to be difficult because trucks are larger than passenger vehicles. The company manufactured eight units of the carrier car that can carry up to four light-duty trucks at a time. This further contributed to the reduction of CO<sub>2</sub> emissions.

(3) The company also implemented eco-friendly driving training for the truck drivers at affiliated companies and cooperative companies. This was a new initiative to reduce CO<sub>2</sub> emissions from a different point view.

## 5. Versatility and expandability

(1) Efforts to improve the loading ratio were also made in the distribution of repair parts within the company and containerized transportation to overseas production bases, and achieving an effect. This will be especially effective for containerized transportation to overseas production bases, since in many cases cargoes are divided or loaded inefficiently for the convenience of the customers or the destinations.

(2) Milk run is becoming increasingly popular in the corporate distribution as a standard method to reduce CO<sub>2</sub> emissions. It is expected to prevail further as it reduces fuel consumption, CO<sub>2</sub> emissions and also costs.

## 6. Continuity and sustainability

(1) Improving distribution is an important issue for the manufacturing sector in terms of environmental preservation and cost cutting. The activities were managed using database to continue the activities.



(2)Eco-friendly driving training for the truck drivers at affiliates and cooperative companies,which aims at enhancing eco-driving techniques and awareness toward eco-driving,targets to reduce CO<sub>2</sub> emissions on a continuous basis.

(3)Long-lasting effect can be expected because the company improved the distribution process itself and equipment and facilities.

#### 7.Investment efficiency

N/A.

#### 8.Secondary results

(1)Eco-friendly driving training provided to a total of 200 truck drivers at our 150 cooperative companies has enhanced awareness toward energy conservation and got it entrenched in our supply chain.

(2)In many cases the efforts to reduce CO<sub>2</sub> emissions also reduce energy cost and production costs.

(3)Electric-powered forklifts emit no exhaust gas and less noise,expected to improve the environment in and outside the plants. ■

## Second Batch of Domestic TOP TENS List

### Japan Buiding BAT List

Edited by Jianfu Wang

#### BAT1: Split-type Air Conditioner 'Kirigamine FZ Series'

##### 1.Category of industry

Electrical equipment

##### 2.Category of technology

Air conditioner

##### 3.Source of energy

Electrical equipment

##### 4.Practical application

November 1,2015

##### 5.Summary

This product is the split-type air conditioner in which the internal configuration of the indoor unit has been radically

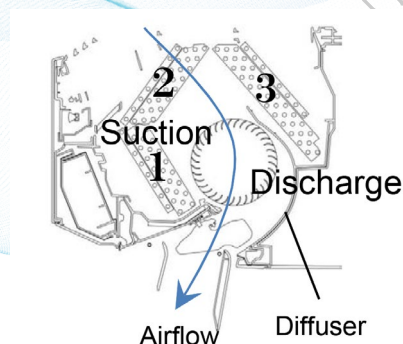
reviewed. In recent years,improvements have been made to the energy conservation efficiency of air conditioners by increasing the heat exchanger equipping capacity of the air conditioner indoor units through enlarging the depth dimension,but currently there is little room to further increase the depth of the housing. Therefore,in these products the ventilating efficiency has been greatly improved while realizing an increase in the equipping capacity of the heat exchangers by changing the blowers of the indoor unit from cross flow fans to high efficiency propeller fans,and changing the layout of the heat exchangers from a shape to a W shape. As a result,the models with cooling capacities between 4.0 kW and 9.0 kW have achieved the industry's leading APF (Annual Performance Factor) energy conservation efficiency. In addition,these

products realize twin temperature air conditioning by driving the two propellers independently and incorporate the newly developed software technology for energy conservation that reference differences in the perceived temperature of the persons in the room, indicating the new concept of air conditioners going forward.

## 6. Principle and operation

In order to improve the energy conservation (APF: Annual Performance Factor) of the air conditioner hardware, it will be important to reduce the input of the blower, which consumes the second largest electric power after the compressor. The blower consists of an electronic circuit board, a motor, and a cross flow fan. From measurements of the efficiency (loss analyses) of each component it was confirmed that the greatest losses are caused by the fan. Here it would be possible to drastically reduce the electric power consumption if the cross flow fan, which has a poor blowing efficiency, could be changed for a highly efficient propeller fan. However, propeller fans generally have the characteristic of being vulnerable to the pressure rise, so it was previously difficult to incorporate them particularly in indoor units which incorporate many heat exchangers. In addition, there were no small-sized high-efficiency motors, which meant that the reduction of the indoor unit electric power consumption could not be realized.

In the new products this time, the basic shape of the blower was radically improved by improving the pressure-raising characteristics of the propeller fans as well as by newly developing high efficiency small-sized motors that can be built in to the small boss unit of the propeller fan. Further, because the heat exchanger incorporating space could be enlarged due to discontinuing the use of the cross flow fans, it was possible to



achieve a large improvement in the energy conservation efficiency.

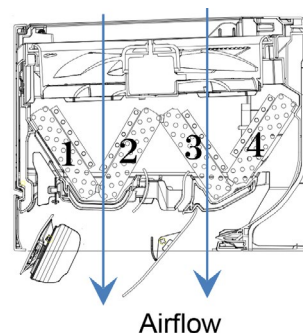
By additionally replacing the cross flow fan with two propeller units, it became possible to drive the rotation of the right and left fans independently to control the strength of the discharged airflow. This has led to the development of an energy conservation software technology that enables the creation of two temperature zones in a single room.

## 7. Description of improvement

### Before improvement

- (1) Arrangement in which the heat exchanger is arranged enclosing the suction side.
- (2) In order to output the breeze, a slide plate (diffuser) will be essential.

### After improvement



- (1) The restrictions on the arrangements are eliminated, making it possible to have a W-shaped heat exchanger.



(2) Due to the increase in the surface area, ventilation resistance is reduced.

## 8. Effect of improvement

Improvement of energy consumption intensity (Option for improving energy conservation ratio)

-The blower was changed from a cross flow fan to propeller fans, reducing the electric power consumption during ventilation by 31%. (Comparison at an airflow of 18 m<sup>3</sup>/min)

-In the large capacity class, the highest rank in energy conservation labeling of '★★★★★' was achieved by the models between 4.0 kW and 8.0 kW.

-The shape of the heat exchanger was changed from a shape to a W shape, increasing the equipping capacity for the same profile by 15%. (27% increase in the actual equipping capacity).

-In the 5.6 kW, 6.3 kW, and 8.0 kW classes, the industry's leading energy conservation performance was achieved. (As of February 19, 2016).

-A five-year portion of the cross flow fan energy conservation improvement rate (13.2%) was achieved in one year. (Improvement rate: 13.3%).

-By increasing the resolution of the thermopile sensor from the previous fiscal year's 4052 pixels to 18392 pixels, a technology that detects the perceived temperature of the persons in the room was developed.

-By individually driving two propeller fans to realize twin temperature air conditioning, the comfort of users was improved while reducing the electric power consumption by 7% (in the MSZ-FZ6316S model).

## 9. Economic efficiency and its trend

(1) Not disclosed

(2) Unknown

(3) Reduction of 11.7% in the annual electricity charge (Model MSZ-FZ5616S, compared to the previous fiscal year's model MSZ-ZW565S)

(4) Payback period: Approximately three years

(5) Not disclosed

## 10. Trend in market

(1) Number of units to be produced in 2016 (Planned): 10,000 units/year.

(2) Number of units to be produced in 2017 (Predicted): 20,000 units/year.

## 11. Reference information

(1) CO<sub>2</sub> reduction amount: 11.7% (Model: MSZ-FZ5616S; comparison with the previous fiscal year's model MSZ-ZW565S)

Due to the right and left independent air flow control, twin temperature air conditioning is realized, and the electric power consumption is reduced by 7% (in model MSZ-FZ5616S).

(2) By realizing twin temperature air conditioning while observing the perceived temperature (comfort) of two persons in the room, the ideal for new air conditioners going forward is indicated.

## 12. Implementation sites

Mitsubishi Electric Shizuoka Laboratory.

## 13. Cited documents

-FY2015 Energy Conservation Grand Prize for excellent energy conservation equipment.

Award-winning Entry Abstracts [Products and Business Models Category], The Energy Conservation Center, Japan

-Mitsubishi Denki Giho January 2016, Mitsubishi Electric

Corporation.

-'Energy Conservation',February 2016 edition,The Energy Conservation Center,Japan.

-Next Generation Split-type Air Conditioner 'Kirigamine FZ Series' Journal of the Japan Institute of Energy,95,318-326,2016.

-The Energy Conservation Technology and Airflow Control of Split-type Air Conditioner with Twin-Propeller Fans.

Japan Society of Refrigerating and Air Conditioning Engineers,Annual Conference 2016.

#### 14.Contact information

Mitsubishi Electric Corporation,Shizuoka Works,Room Air Conditioner Department,Engineering Section A. ■

## BAT2: Carbon Dioxide (CO<sub>2</sub>) Heat Pump Water Heaters for Home Use EcoCute 'ESTIA Premium Model'

### 1. Category of industry

CO<sub>2</sub> Refrigerant High Efficiency Heat Pump Water Heating System.

### 2. Category of technology

EcoCute System for Home Use

### 3. Source of energy

Electrical equipment

### 4. Practical application

Jun 2016

### 5. Summary

These products are heat pump hot water heaters for home use (EcoCute\*) that use carbon dioxide (CO<sub>2</sub>) as a natural refrigerant to realize a high efficiency energy-saving water heater. They realize a value of 3.6 in the energy conservation Top Runner standards (2017 targets), which is an achievement rate of 109%. In addition to the characteristics of EcoCute

which contribute to peak shifting of electric power demand by heating water mainly during the nighttime band, the system is newly provided with a power-saving additional boiling mode which enables the reduction of electric power consumption in the daytime additional boiling mode by 25% to limit the daytime peak electric power demand. Further, by connecting with HEMS, it is possible to select an operation control that makes practical use of photovoltaic power generation in response to weather forecasts. Control has also been provided that enables operation of the water heater in response to notifications of electric power restrictions.

\* EcoCute: Registered trade mark of the Kansai Electric Power Company.

### 6. Principle and operation

EcoCute is a hot water storage type water heater that produces hot water by transferring heat from the air to water using heat pump technology utilizing carbon dioxide (CO<sub>2</sub>) which is a natural refrigerant. The annual water heating and heat retention efficiency (JIS) is an index stipulated according



to Japan Industrial Standard (JIS C 9220:2011) showing the hot water supply system efficiency that is assumed for the actual use of residential heat pump water heaters, including the thermal insulation performance of the hot water storage unit and the heat retention of the bath. The full auto type is a type that has functions in which a bath is prepared by adding a set temperature and amount of hot water to the bathtub, and it additionally has a function (temperature maintaining function) for maintaining the temperature of the hot bath water for a set time.

In these products, reviews were implemented of the heating stage where the cold water is heated to make hot water (efficiency of the heat pump unit), and of the temperature-maintaining and usage stage including the hot water storage and supply (hot water storage unit radiation loss reduction). This resulted in improving the equipment efficiency and increasing the annual water heating and heat retention efficiency. Additionally, by connecting to an HEMS, it was intended to realize energy conservation also as a system for the portion that

is not reflected in the annual water heating and heat retention efficiency.

## 7. Description of improvement

### Before improvement

See Figure below.

### After improvement

Compared to the previous models, energy conservation was realized by making the following improvements.

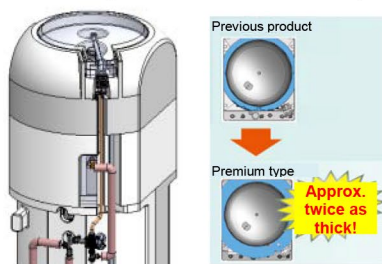
(1) Improvement of the heating efficiency (Heat pump unit performance improvement).

1) New CO<sub>2</sub> rotary compressor: Improvement of the motor efficiency such as by increasing the coil winding and motor electromagnetic steel sheet lamination thickness.

2) New inverter: Implementation of electric current control and optimum motor tuning.

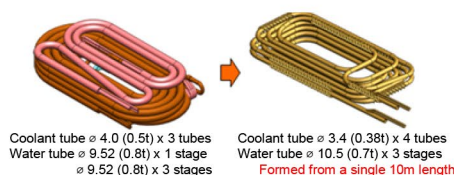
3) New water heat exchanger: Change of refrigerant piping to a thinner diameter and multi-pathing, change of water pipes to a large diameter, and unification of the water heat exchanger.

### Warm cap thermal insulation



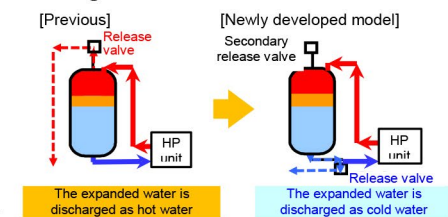
### Unification of water heat exchanger

After optimizing the pipe diameter and length, the welding at each stage was eliminated.

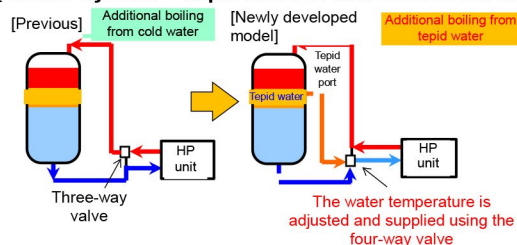


### Keep and reuse system

**Keeping control** The expanded water during the additional boiling is discharged as cold water to maintain the heat.



### Reuse system



4) New air heat exchanger: Utilization and duplication of new heat transferring pipe shape for carbon dioxide.

(2) Improvement of heat usage efficiency (Reduction of heat loss of the hot water storage unit).

1) Improvement of tank can body thermal insulation performance using warm cap thermal insulation.

2) Reduction of heat loss due to the keep and reuse system.

3) Power-saving additional boiling operation.

(3) Promotion of energy conservation such as by connecting with HEMS, etc.

1) Demand control by using HEMS connection (Effective application of photovoltaic power generation in response to weather forecasts, etc.).

2) Light touch remote control (Improvement of user interface, and enhancement of visualization).

3) Reducing the heat loss during bathtub heat retention in 'Assisted heat retention'.

## 8. Effect of improvement

Improvement of energy consumption intensity (Option for improving energy conservation ratio)

EcoCute systems for home use have become energy conservation Top Runner subject appliances, and target values have been determined for FY2017. For these products, with regard to the target value of 3.3 for full auto model types (classification 17), both the 370L and 460L model types have achieved an annual water heating and heat retention efficiency of 3.6 (an achievement rate of 109%). The CO<sub>2</sub> emissions amount can be reduced by approximately 15% compared to previous model types when converted from the annual water heating and heat retention efficiency. By additionally connecting with HEMS, there will be an approximately 5% CO<sub>2</sub> reduction effect, and if the items are

added that promote energy-saving behavior by users there will be an approximately 10% CO<sub>2</sub> reduction effect in the portion that is not reflected in the annual water heating and heat retention efficiency. Therefore, a total CO<sub>2</sub> reduction effect that is approximately 30% better than previous model types can be provided.

## 9. Economic efficiency and its trend

In these products, the achievement rates with regard to the FY2017 energy conservation standards have been improved to 109% both for the 460L class models for 4 to 7-person families and the 370L class models for 2 to 5-person families. As a result, compared to this company's previous models, a reduction of approximately 3,200 yen, corresponding to approximately 12%, can be made to a family's annual lighting and heating expenditures. In addition, compared with electric water heaters, an annual difference of 40,000 yen or more can be achieved (approximately 68,000 yen as the value calculated using the 370L fully automatic type), showing the large merits that can be realized by using these products.

## 10. Trend in market

In the overall market for heat pump water heaters for home use (EcoCute), there are the following conditions.

(1) The accumulated total number of unit shipments since 2001 have been approximately 5,000,000 units (predicted at March 2016). This corresponds to a diffusion rate of approximately 9.1% (52,000,000 households, residual rate of 95%).

(2) With shipments of 450,000 units/year, in 2017 the accumulated total unit shipments will reach 5,900,000 units and the diffusion rate will reach 10.8% (52,000,000



households,residual rate of 95%).

#### 11.Reference information

N/A

#### 12.Implementation sites

N/A

#### 13.Cited documents

-Statistics Bureau,Ministry of Internal Affairs and Communications 'Statistical Handbook of Japan' (Number of households).

-The Japan Refrigeration and Air Conditioning Industry

Association 'Actual shipments of residential heat pump water heaters'.

#### 14.Contact information

Toshiba Carrier Corporation.

Technical Planning Department,Technical Planning Manager

Mr. Yasunari Daijogo.

yasunari.daijogo@toshiba.co.jp Phone: +81-44-331-7482. ■



## BAT3: Carbon Dioxide (CO<sub>2</sub>) Refrigerant Heat Pump Water Heater Using a New Thermal Insulation Structure

### 1. Category of industry

Water Heaters

### 2. Category of technology

High Efficiency Water Heaters

### 3. Source of energy

Electricity

### 4. Practical application

2014

### 5. Summary

In response to global warming countermeasures and the increasing energy consumption in the household sector, the promotion of energy conservation in housing and related equipment occupies an important position in Japan's energy policy. In addition, for the hot water supply application that takes up 30% when considering the energy consumption of each application in households, a CO<sub>2</sub> emissions reduction

effect is anticipated due to the popularization of high efficiency water heaters. Hitachi Appliance concentrated on the development of CO<sub>2</sub> refrigerant heat pump water heaters that have industry-leading high energy conservation efficiencies. In FY2013, new technologies were developed relating to compressors, evaporators, and water refrigerant heat converters which are the components of heat pump units, and the all-new products attained the Top Runner standards (FY2017 target fiscal year) under the Act on the Rational Use of Energy. In the following FY2014, the industry's first hot water storage unit with a urethane foam-filled heat insulation structure was developed, and the high efficiency type 370L model realized the industry's top annual water heating and heat retention efficiency (JIS) value of 3.9.

### 6. Principle and operation

CO<sub>2</sub> refrigerant heat pump water heaters consist of a heat pump unit that heats cold water to generate hot water and a hot water storage unit that thermally stores the heated water. During the heating of the cold water to make hot water, stored

water is sent from the lower part of the storage tank to the water refrigerant heat exchanger where the water receives the heat from the refrigerant. After heating to a temperature between 65°C and 90°C according to the settings, the water is returned to the upper part of the storage tank. When using the thermally stored hot water, hot water taken from the top part of the hot water storage tank is used to adjust tap water to the temperature set using the hot water supply heat exchanger and the tap water is supplied from the hot water supply faucet (in the case of the 'tap water direct pressure hot water supply' system). The heat pump cycle is a mechanism in which a flow path mainly consisting of a compressor, evaporator, water refrigerant heat exchanger and an expansion valve is filled with the carbon dioxide refrigerant. The heat obtained from the outside air using the evaporator is changed to a high temperature by the compressor, and passes through the water refrigerant heat exchanger where the heat is transferred to the water. The efficiency of CO<sub>2</sub> refrigerant heat pump water heaters mainly depends on the heat retaining performance of the hot water storage unit and the efficiency of the heat pump unit (compression efficiency of the compressor, efficiency of absorbing heat from the outside air by the evaporator, and efficiency of heating the water in the water refrigerant heat exchanger). Therefore, in order to increase the annual water heating and heat retention efficiency (JIS), it will be important to improve the hot water storage tank heat retaining efficiency, compressor efficiency, evaporator heat-absorbing efficiency, and the water refrigerant heat exchanger heating efficiency. Hitachi Appliances therefore promoted development which focused on these topics. In FY2013, improvements were made to the compressor, evaporator, and water refrigerant heat exchanger of the heat pump unit, and in FY2014 the hot water storage tank was completely covered with urethane foam in a

new thermal insulating structure used in the industry for the first time. The details of the improvements shown below relate to the new thermal insulation structure implemented in FY2014.

## 7. Description of improvement

### Before improvement

Previously, thermal insulation was provided by incorporating and mounting separate pieces of expanded bead polystyrene (known below as EPS) surrounding the hot water storage tank which stores the hot water. In addition, metal plates were incorporated surrounding the expanded polystyrene to form an enclosure.

See Figure 1.

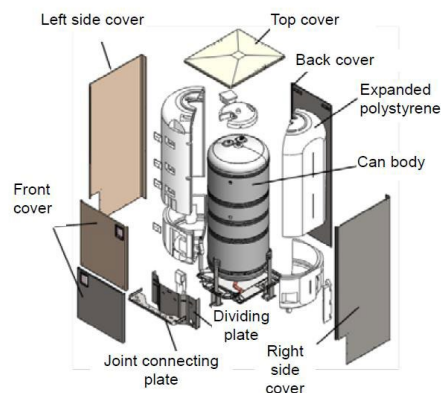


Figure 1

### After improvement

In the new thermal insulating configuration, urethane is injected into the outer panel which encloses the hot water storage tank. The urethane is foamed inside the outer panel in a configuration that completely fills the surroundings of the hot water storage tank with heat insulating material. Due to this, hardened urethane foam with an outstanding thermal insulation performance will surround the hot water storage tank, and will also be bonded to the outer panel, enabling the formation of a solid and integrated structure.

See Figure 2.

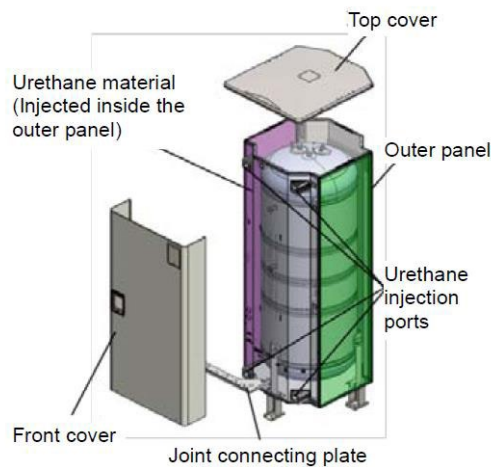


Figure 2

## 8. Effect of improvement

Improvement of energy consumption intensity (Option for improving energy conservation ratio)

Calculation of the primary energy consumption was made using the Building Research Institute's primary energy calculation program (Housing and Building Energy Conservation Performance Evaluation Program Ver. 1.12) disclosed under the revised energy conservation standards (Standards of Judgment for Construction Clients, etc. and Owners of Specified Buildings Relating to the Rational Use of Energy). The primary energy consumption are shown in the figure below. The annual water heating and heat retention efficiency (JIS) of the FY2014 'tap water direct pressure hot water supply system' high efficiency type (370L) was 3.9, and the primary energy consumption was 14.95 GJ/year. This product realized a primary energy efficiency which was better than the hybrid type water heater (100L type FY2013 model) with small primary energy consumption.

See Figure 3.

## 9. Economic efficiency and its trend

(1) Marketability

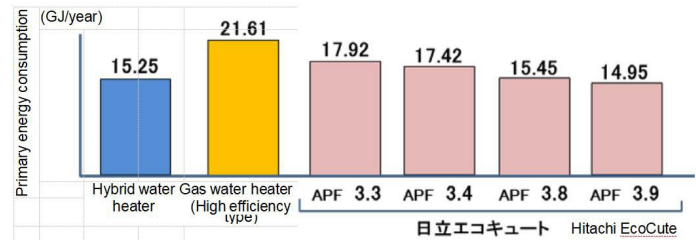


Figure 3

\*The APF values in the figure show the annual water heating and heat retention efficiency (JIS)

Improvements in efficiency obtained by the high efficiency type utilizing the new thermal insulation structure:

- High efficiency type 370L

FY2013 APF 3.6    FY2014 APF 3.9

- High efficiency type 460L

FY2013 APF 3.5    FY2014 APF 3.8

[Test conditions] As of July 2014, investigated by Hitachi.

(1) The primary energy consumption of the CO<sub>2</sub> refrigerant heat pump water heater was calculated using the next-generation energy conservation standards in six regions (Region IVb).

(2) The gas water heater (high efficiency type) thermal efficiency was calculated as 92.5% using the mode efficiency based on JIS S 2075.

All new products of Hitachi Appliance's FY2014 CO<sub>2</sub> refrigerant heat pump water

heaters achieved 100% or more in the Top Runner standards taking FY2017 as the target fiscal year. Due to the spread of the energy conservation labeling system (according to JIS C9901) and the implementation of corporate public relations activities, it can be expected that awareness of the products will increase, improving their marketability.

(2) Economic efficiency

The results of calculating the running costs of hybrid water heaters, high efficiency type gas water heaters, and CO<sub>2</sub> refrigerant heat pump water heaters are shown in the figure



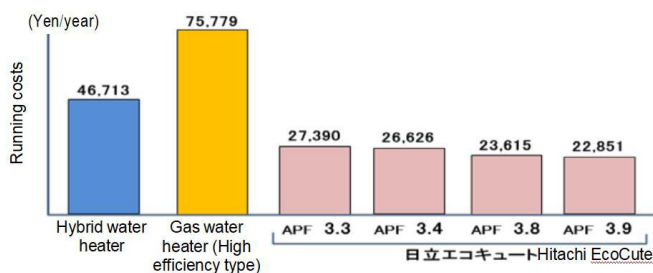


Figure 4

\*The APF values in the figure show the annual water supply thermal insulation efficiency (JIS).

[Test conditions] As of July 2014, investigated by Hitachi.

(1) Calculation from the primary energy consumption calculated using the program in section (1) of Fig. 9.

(2) Calculation was made taking the proportion of gas and electricity in the hybrid water heater as 40% gas to 60% electricity.

(3) Calculation conditions: Calorific value of city gas: 45MJ/m<sup>3</sup> (Tokyo Gas city gas, Tokyo region calorific value).

(4) The electricity receiving end efficiency was calculated at 36.9% (From the Energy Conservation Center, Japan online glossary entry 'Primary Energy [Electric Power]').

(5) Calculation was made taking the nighttime electricity consumption ratio for CO<sub>2</sub> refrigerant heat pump water heaters of 80%.

(6) City gas charge: 157.8 yen/m<sup>3</sup> (Tokyo Gas July 2014 charge when the amount is between 20-80m<sup>3</sup> [Not including the basic charge]).

(7) Electricity charge: Hybrid water heater: 27 yen/kWh (Home Electric Appliances Fair Trade Conference standard rate) [April 28, 2014].

(8) Electricity charge: CO<sub>2</sub> refrigerant heat pump water heater: Morning and evening 25.92 yen/kWh, nighttime 12.16 yen/kWh (Morning and evening rates and nighttime rates of Tokyo Electric Power Company's 'Denka Jozu' season-and-time-specific lighting plan).

below. CO<sub>2</sub> refrigerant heat pump water heaters, which make effective use of reduced-rate nighttime electricity, can be expected to achieve a greater reduction in hot water supply, lighting and heating costs than hybrid water heaters and high efficiency type gas water heaters.

See Figure 4.

## 10. Trend in market

[CO<sub>2</sub> refrigerant heat pump water heater for home use].

(1) Current diffusion rate: Approximately 10%.

(2) Prediction for 2017 (or 2020): Unknown.

## 11. Reference information

(1) Industrial property rights including patents

Patents relating to electric water heaters, hot water storage units, and heat pump units Registered: Japanese Patent No. 5753961, Japanese Patent No. 5760052

Under application: 22 patent applications.

(2) Awards

FY2014 Energy Conservation Grand Prize for excellent energy conservation equipment, Chairman Prize of ECCJ FY2015 Japan Society of Refrigerating and Air Conditioning Engineers, Technology Award.

## 12. Implementation sites

Throughout Japan.

## 13. Cited documents

N/A

## 14. Contact information

Hitachi Appliances, Inc. ■

## BAT4: Technology for Virtually Operating Multiple Storage Batteries as One Large Storage Battery, and Using for Adjusting the Electric Power Receiving Balance

### 1. Category of industry

Energy storage

### 2. Category of technology

Promotion of renewable energy introduction

### 3. Source of energy

N/A

### 4. Practical application

Around 2020 (Anticipated)

### 5. Summary

System instability phenomena create problems and require countermeasures when there is an increase in the introduction amounts of renewable energies such as photovoltaic power generation. Among the countermeasures, the utilization of storage batteries is effective. While it is believed that these will be introduced going forward, issues will occur in the future regarding how to implement control of such

large numbers of batteries. The battery SCADA virtually aggregates multiple storage batteries and implements control of individual batteries so that they behave as though they are one storage battery. This supports the system operation on the upper system, and also enables the introduction of seamless storage batteries regardless of the scope and the introduction location.

### 6. Principle and operation

The storage battery SCADA is positioned below the upper EMS (Energy Management System), for example the automatic load dispatching system of the power system control center of an electric power business operator. It receives the commands corresponding to the functions for moderate Demand Response (DR) and Spinning Reserve (SR), such as Load Frequency Control (LFC) and peak cut, and based on these commands it virtually aggregates many storage batteries and handles them as if they were a single large-scale storage battery (virtual battery).

The storage battery SCADA comprehends the specifications



and statuses of individual storage batteries,appropriately allocates each of the storage batteries according to the functions,and gives the battery charging and discharging instructions. For example,in order to make use of the portion of consumer side storage batteries that are not being used,the battery charging and discharging schedules of the consumer side storage batteries are collected. Then,if there is available capacity and spare time in the storage batteries of each consumer,the peak cut and peak shifting of the electricity demand is realized through coordinating the charging and discharging of these battery portions.

See Figure 1.

## 7.Description of improvement

This system is not an improvement,but a proposal of a system based on a new concept. Functionally,the system will become a substitute for pumped storage power plants. However,because there are already no locations in Japan where large capacity pumped storage power plants can be constructed,this type of software will become necessary. As the merit of utilizing this system,because it is possible to introduce only the necessary amount at the required timing,the threshold of facility investment plans can be lowered with regard to the introduction

compared to large facilities such as pumped storage power plants.

## 8.Effect of improvement

Improvement of energy consumption intensity (Option for improving energy conservation ratio)

There is no energy conservation effect in the batteries or in the battery SCADA itself. However,because it will become possible to increase the use of renewable energies by introducing these systems,this will consequently lead to reductions in CO2 emissions.

## 9.Economic efficiency and its trend

Although these are not actual result values,calculation is carried out of a model using consumer side storage batteries (with a capacity around 2 GWh) as described below as a substitute for a 200,000 kW thermal power generator that is being actively used as a peak power source. Although 200,000 kW was assumed as the target value,it is believed that the scale of the introduction can be adjusted. This trial calculation created a realistic plan that enabled investment payback in 10 years,and it is thought that depending on the operation method it may be possible to keep the expenses even lower than this.

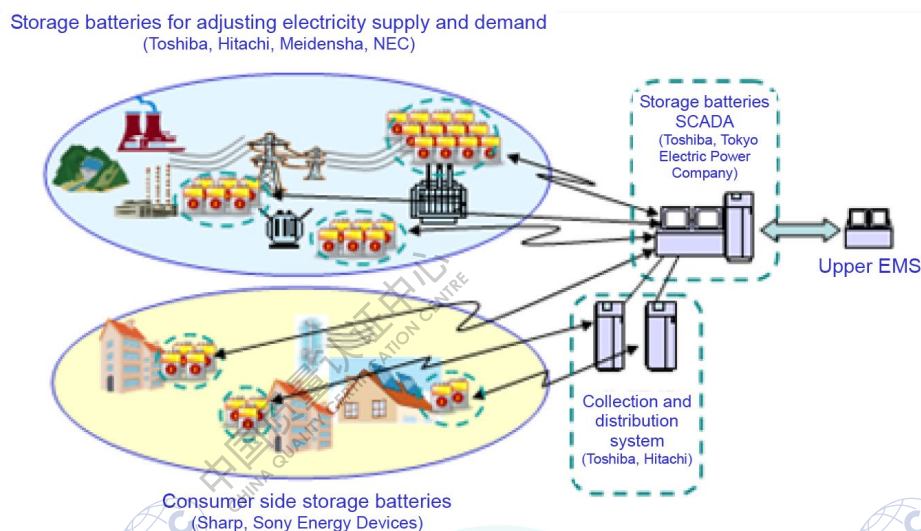


Figure 1



- (1) Equipment investment costs: 1.4 billion yen (Not including the expenses of the consumer side storage batteries)
- (2) Remodeling costs: Included in the above description
- (3) Running costs: 1.4 billion yen/year 1.4 billion yen/year
- (4) Payback period: 10 years

## 10. Trend in market

- (1) Current diffusion rate None
- (2) Prediction for 2020 Unclear

## 11. Reference information

- (1) CO<sub>2</sub> emissions reduction amount Unclear
- (2) Social impact, other
  - 1) Patents and utility models
    - Operation method, operation apparatus of power system, and storage battery management device  
(Japanese patent No. P6088737, registration date: February 10, 2017)
    - Rechargeable battery surplus capability borrowing method, power system operation method, power operation system, consumer side controller, program used for consumer side controller, system side controller and program used for system side controller  
(Japanese patent application No. P2012-039203, application date: February 24, 2012)
  - 2) Awards
    - None in particular
  - 3) Documents, etc.
    - Isono, E. 2013 Development of battery aggregation technology for smart grid. PowerTech (POWERTECH), 2013 IEEE Grenoble pp.1-6
    - Ebata et al, 2014 'Creation of a virtually aggregated storage

battery using the storage battery SCADA, and LFC verification testing', Proceedings of the 2014 Annual Conference of Power and Energy Society, IEEJ, September 2014

- Ebata et al, 2015 'Demonstration and Business Method of Peak Shifting using Battery Aggregation Technology by Demand Response without Restriction of Customer's Electricity Usage', IEEJ Transactions on Power and Energy Vol. 135 No. 1 (2015), Special Issue of 2014 Annual Conference of Power and Energy Society, IEEJ pp.78-84.

## 12. Implementation sites

The storage battery SCADA, collection and distribution system, and stationary batteries for large-scale supply and demand adjustment have been installed in a verification center located in Kohoku Ward, Yokohama City, while storage batteries for consumers have been installed in offices and consumers' houses in Yokohama City, and verification testing is conducted. (Currently implemented under the framework of the Yokohama Smart City Project (YSCP))

## 13. Cited documents

Advisory Committee for Natural Resources and Energy, Agency of Natural Resources and Energy, 8th Basic Problem Committee 'Report of Verification Committee for Costs, etc.' [http://www.enecho.meti.go.jp/committee/council/basic\\_problem\\_committee/008/pdf/8-3.pdf](http://www.enecho.meti.go.jp/committee/council/basic_problem_committee/008/pdf/8-3.pdf)

## 14. Contact information

Toshiba Corporation  
Tokyo Electric Power Company ■

## BAT5: Ultrafine Fiber High Heat Insulating Glass Wool 'Aclear $\alpha$ ' series

### 1. Category of industry

Ceramic engineering

### 2. Category of technology

Glass wool heat insulating material

### 3. Source of energy

N/A

### 4. Practical application

July 2014

### 5. Summary

'Aclear  $\alpha$ ' is mat type glass wool heat insulating material with the world's first approx. 3 $\mu$ m fiber diameter. In the case of mat type glass wool manufactured by the centrifugal spinning method, 4 $\mu$ m was considered as the limit value of the fiber diameter; however, development of fiberizing and forming

technologies has enabled continuous production of the 3 $\mu$ m fiber diameter glass wool.

'Aclear  $\alpha$ ' high density 36 kg/m<sup>3</sup> model attains thermal conductivity ( $\lambda$  value) of 0.032 W/mK, which is at the world's lowest level for the general glass wool heat insulating material for houses. The product is the only glass wool heat insulating material which establishes thermal resistance value (R value) of 3.3 m<sup>2</sup>K/W requested for the 2013 energy conservation standards for walls of wooden houses in cold areas such as Hokkaido, by only filling in walls of the wooden houses with normal 105 mm thickness wooden pillars.

'Aclear  $\alpha$ ' low density 20 kg/m<sup>3</sup> model facilitates the application to the houses requiring higher heat insulating performance such as the certified low carbon houses and the Zero Energy Houses (ZEH) in Honshu and southward, and drives the construction of the houses with higher heat insulating performance than the highest grade houses certified in energy conservation standards.

## Lineup of 2 models, 36K and 20K

Model 36K is appropriate for high heat insulating houses in cold areas, and model 20K is suitable for higher heat insulating houses in Honshu and southward. These two models facilitate building of high performance heat insulating houses such as certified low carbon houses and Zero Energy Houses.

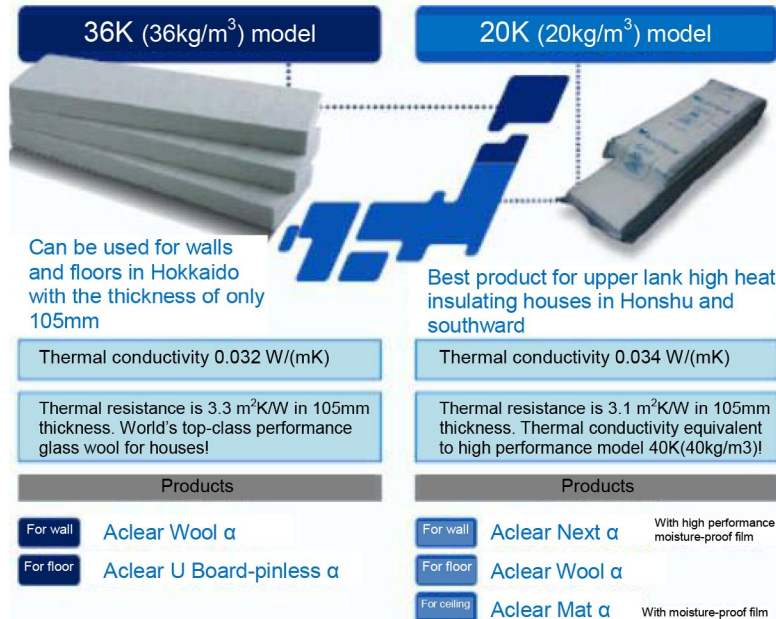


Figure 1

'Aclear α' contains no formaldehyde to keep health and environment, has good workability for easy cutting, and ultrafine fiber prevents glass wool's unique itchy touch. These features are supported by carpenters and construction workers and are expected to facilitate the spread of the product in the future. See Figure 1.

### 6. Principle and operation

N/A

### 7. Description of improvement

[Technological features]

Progressiveness and originality

'Aclear α' was developed using the following two progressive and original technologies.

(1) Fiberizing technology for 3μm fibers.

Glass wools are manufactured by 'the centrifugal spinning method'. In the case of the batt type glass wool that can be manufactured using this method, 4μm was considered as the limit value of the fiber diameter. Development of the newly designed device assemblies and the manufacturing conditions has enabled the production of glass wool of 3μm fiber diameter having a sufficient length for the mat type.

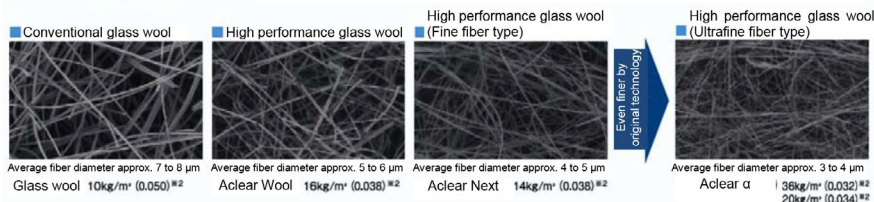
(2) Forming technology for high density board using ultrafine glass wool of 3μm diameter.

Collection of fiberized fiber by suction is required in order to form glass fiber into mat. However, in the case of forming ultrafine fiber (equal to or less than 3μm in diameter) into thick glass wool mat, large suction load in the fiber collecting zone prevents the manufacturing of the intended thickness of the



36kg/m<sup>3</sup> model

World's first!<sup>\*1</sup> The approx. 3μm ultrafine fiber realizes thermal conductivity of 0.032 W/mK.



20kg/m<sup>3</sup> model

Realizing thermal conductivity of 0.034 W/mK, which is equivalent to that of high performance glass wool 40 kg/m<sup>3</sup>.

<sup>\*1</sup> As glass wool heat insulating material for houses (formed) as of July 1, 2014. Researched by Asahi Fiber Glass Co., Ltd.  
<sup>\*2</sup> Reference value, thermal conductivity at 23°C [W/mK]

Figure 2

product.

In order to solve this problem, a new manufacturing method, which forms thin blanket at first and laminates them to create a thick batt, instead of directly forming a thick batt, was developed and newly designed manufacturing device was put into practical use.

See Figure 2.

## 8. Effect of improvement

Improvement of energy consumption intensity (Option for improving energy conservation ratio)

[Energy conservation]

- Annual energy cost reduction per house

<Comparison between a Grade 3 house certified in energy

conservation standards and an Aclear α-installed house with thermal resistance value of 3.3 m<sup>2</sup>K/W>

Area 1: about 25,000 yen Area 3 to 5: about 145,000 yen

Area 6 and southward: about 57,000 yen

(Area 1: Northernmost region, e.g. Hokkaido, Area 3, 4: Northern Honsyu region, Area 6: Southern Honsyu region)

See Table 1.

- Reduction effect of primary energy consumption

< Calculation results for model houses of Autonomous Circulating House Development Project using Aclear α (Annual)>

See Table 2.

Table 1

	Area 1		Area 3		Area 4		Area 6	
	KWH	MJ	KWH	MJ	KWH	MJ	KWH	MJ
Primary energy	1,016	3,656.0	5,899	21,220	5,663	20,371	2,317	8,334
Converted into money	¥25,409		¥147,479		¥141,578		¥57,921	

(1MJ = 0.278 kWh, Electricity charge: 25 yen/kWh)

Table 2

Heat insulating specifications	Area 1		Area 3		Area 4		Area 6	
	Average outer surface thermal transmittance UA value	Primary energy consumption	Average outer surface thermal transmittance UA value	Primary energy consumption	Average outer surface thermal transmittance UA value	Primary energy consumption	Average outer surface thermal transmittance UA value	Primary energy consumption
Grade 3	0.54	156,180MJ	1.04	114,237MJ	1.25	112,947MJ	1.54	86,724MJ
Aclear α: R3.3	0.52	152,524MJ	0.50	92,733MJ	0.66	92,359MJ	0.77	78,298MJ
Aclear α: R3.1	—	—	0.50	93,017MJ	0.66	92,576MJ	0.78	78,390MJ

(1MJ = 0.278 kWh, Electricity charge: 25 yen/kWh)

Reduction of electricity charge by up to 147,000 yen per house

Reduction of primary energy consumption per house by up to approx. 19%

## 9. Economic efficiency and its trend

[Economic efficiency and marketability]

(1) On account of the imposition of New Energy Conservation Standards for 2020, ratio of the high grade energy-saving houses (provisional title: super next-generation houses), i.e. ZEH (Zero Energy House), LCCM (Life Cycle Carbon Minus House), etc., is estimated to reach approx. 10% of detached residences.

(2) Popularization of super next-generation houses is expected to reduce annual primary energy consumption of houses in 2020 by 176,000 GJ, which is about 4,600 kl as crude oil equivalent.

Reduction of primary energy consumption by introducing super next-generation houses

< Comparison with Grade 3 houses > \* Estimated by Asahi Fiber Glass Co., Ltd.

See Table 3.

## 10. Reference information

(1) Awards

-Energy Conservation Grand Prize 2014, Products and Business Models Department, Director General Prize of Agency of

Natural Resources and Energy

Sponsor: The Energy Conservation Center, Japan,

The Annual Grand Prize of the ECHO CITY Product 2014

Sponsor: NIKKEI Architecture, NIKKEI Homebuilder

(2) Documents, etc.

The Energy Conservation (April 2015), P.56

"Ultrafine fiber high heat insulating glass wool 'Aclear α' series"

## 11. Implementation sites

N/A

## 12. Cited documents

Application documents and presentation documents for the Energy Conservation Grand Prize 2014

Asahi Fiber Glass Products Catalogue

## 13. Contact information

Asahi Fiber Glass Co., Ltd. ■

Table 3: Reduction of primary energy consumption by introducing super next-generation houses

< Comparison with Grade 3 houses >

\* Estimated by Asahi Fiber Glass Co., Ltd.

	2014	2015	2016	2017	2018	2019	2020
Total reduction of primary energy consumption by super next-generation houses (GJ)	223	5,533	15,130	33,051	59,491	107,084	176,803
Area 3 to 5 (GJ)	74	1,842	5,037	11,003	19,805	35,649	58,458
Area 6 and southward (GJ)	149	3,691	10,093	22,048	39,686	71,434	118,345
Converted to crude oil (kl) (by 0.0258 kl/GJ)	6	143	390	853	1,535	2,763	4,562



## BAT6: High-performance Triple-glazed Vinyl Windows APW430

### 1. Category of industry

Nonferrous metals and metal products

### 2. Category of technology

High-performance thermal insulation materials (for construction use)

### 3. Source of energy

N/A

### 4. Practical application

2014

### 5. Summary

APW430 windows comprise YKK AP original low-E triple-glazing (three layers of glass) having a total thickness of 41mm and a high thermal insulation vinyl frame. They realize a world top-class thermal insulation performance with a heat-transfer coefficient of  $0.90\text{W}/\text{m}^2\text{K}$ . (This corresponds to an approximately 75% smaller value than the heat-transfer

coefficient values of the windows currently most popular in Japan consisting of aluminum frames and multilayer glass.) They greatly limit the inflow and outflow of heat from building openings, enabling a large reduction in the cooling and heating energy consumption. Additionally, the product lineup also includes the high-end APW430Kr model with a heat-transfer coefficient of  $0.78\text{W}/\text{m}^2\text{K}$ .

Further, the lineup of products also contains glass that is designed to enhance the acquisition of solar radiation in wintertime, and "wind-catching multiple windows" which are suitable for generating breezes and providing ventilation in summertime and in the evenings, as optimum windows for realizing lifestyles that avoid using energy as far as possible.

### 6. Principle and operation

(1) New frame and glass designs for realizing U-values which are less than  $1.0\text{W}/\text{m}^2\text{K}$  Low-E triple-glazing (three-layer glass) is utilized, and the optimum air layers are set to obtain the highest thermal insulation performance. Argon gas and krypton gas are used as the gases contained inside the air



layers, which maintain a high thermal insulation effect.

It was also intended to improve the thermal insulation performance of the frame itself by giving the frame a large depth dimension and by adopting an exclusive design (multi-chamber structure) in which the number of chambers (number of hollow gaps (partitions) which prevent the transfer of heat between the inside and outside of the room) have been increased. Compared to standard double-glazed vinyl window frames, the heat-transfer coefficient has been reduced by 13%. (Refer to Fig. 1)

(2) Development of glass types that enhance the solar radiation heat acquisition rates (Best balance of heat-transfer coefficient and solar radiation heat acquisition rate)

The heat-transfer coefficient and solar radiation heat acquisition rate have a reciprocal relationship. That is, although the heat-transfer coefficient will be enhanced if a blue or bronze-colored low-E film is utilized, the use of this film will cause a large reduction in the solar radiation heat acquisition rate. In the APW430, as a result of seeking the “best balance” between the heat-transfer coefficient and solar radiation heat acquisition rate where the energy reduction effect will become the highest, rather

than simply enhancing only the heat-transfer coefficient, two types of triple-glazing were developed utilizing low-E films. (Refer to Fig. 2)

(3) Development of window opening forms, functional parts, and screens that are suited to acquiring breezes and ventilation  
Special devices have been incorporated which make it easy to realize energy reductions by opening the windows, such as a “wind-catching multiple window” that positively introduces breezes, and by providing a half-locking function as standard equipment to enable ventilation without worrying about security. In addition, the windows incorporate YKK AP’s original Clear Net screens which acquire a 20% greater ventilation amount than previous types of window screens, enhancing comfort when the windows are open.

## 7. Description of improvement

### Before improvement

In general houses, the greatest amount of inflow and outflow of heat occurs at the openings. In houses with standard aluminum windows (multilayer glass), as much as 52% of the heat in wintertime flows out through the windows.

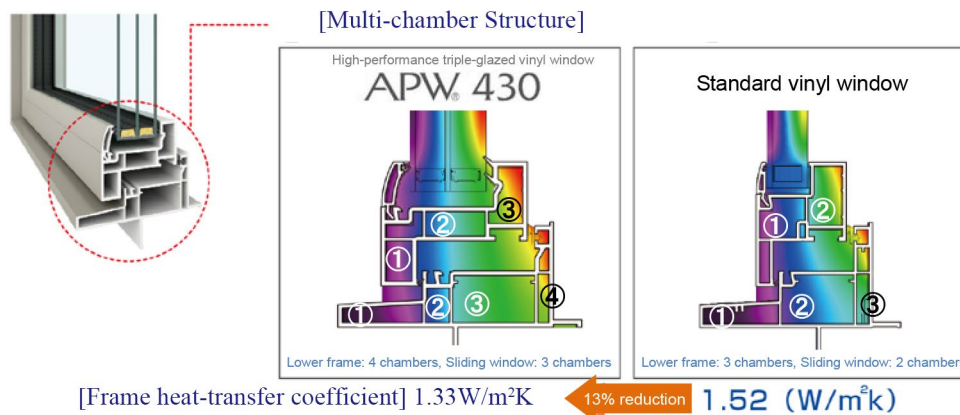


Fig. 1 Improvement in frame thermal insulation performance due to the adoption of a multi-chamber structure

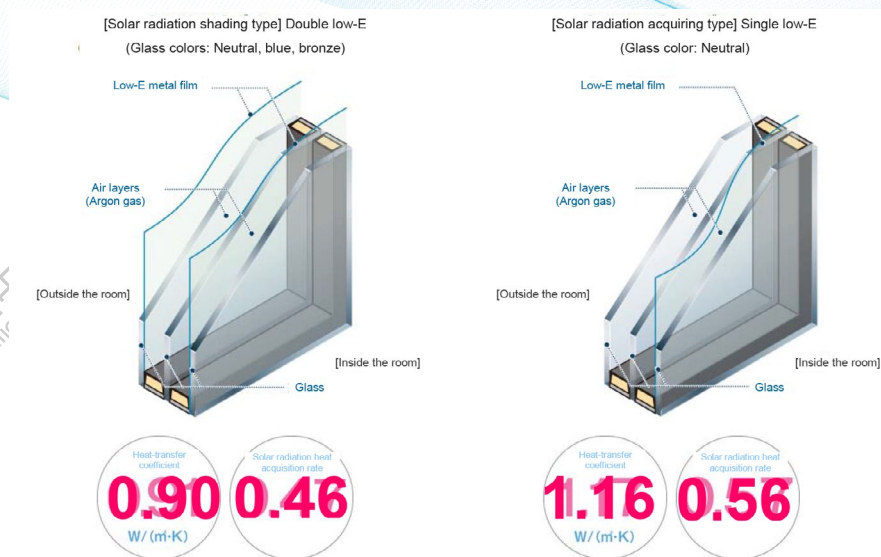


Fig. 2 Glass specifications realizing an outstanding balance between thermal insulation and solar radiation heat acquisition

### After improvement

When the high-performance triple-glazed vinyl windows are used, the outflow of heat from the windows is limited to 12%. Refer to Figure 3.

### 8. Effect of improvement

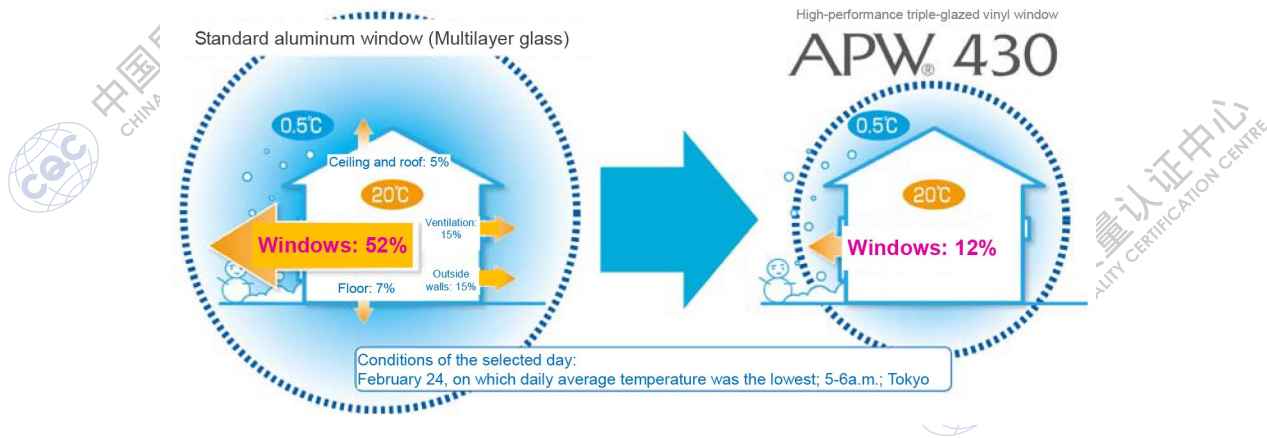
Improvement of energy consumption intensity (Option for improving energy conservation ratio)

As the cooling and heating energy reduction effect, taking the case of Tokyo as an example, APW430 windows are capable of realizing a value of 184MJ/m<sup>2</sup>, a 32% reduction from the value of 275MJ/m<sup>2</sup> achieved when using aluminum multilayer glass windows. (Converted to an electricity charge, this is a reduction from 71,104 yen/year to 48,388 yen/year.) In the case where the air conditioning is additionally stopped and ventilation is carried out, a value of 152MJ/m<sup>2</sup> is realized by the APW430 windows, which is a reduction of 45%. (When converted to an electricity charge, this is a reduction from 71,104 yen/year to 39,539 yen/year.) There will also be a

similar reduction effect on the CO<sub>2</sub> emissions.

### 9. Economic efficiency and its trend

In the housing design and construction aspects, merits will be realized with regard to resource-saving and to costs. By simply utilizing APW430 windows without needing to change the frame structure, integration and construction methods, it will be possible to realize a large energy reduction effect. For example, in the case of reducing the cooling and heating energy by 10%, which is the standard for certified low carbon housing, when using the method of utilizing aluminum multilayer glass windows while changing the thickness of the wall thermal insulating materials, it is expected that there will be cost increases of 1,000,000 yen or more due to the materials and construction expenses. Implementation will also be difficult from a construction point of view. In contrast, if APW430 windows are utilized instead while leaving the building frame unchanged, it will be possible to realize a 23% reduction in the cooling and heating energy compared to the use of aluminum multilayer glass



[Calculation Conditions] · Housing thermal insulation specification: Level compatible with next-generation energy conservation standards · Housing model: Complies with calculation models in the "Explanation of energy consumption calculation methods in the standards for judgment of residential construction clients", two stories, floor area: 120.08m<sup>2</sup>, proportion of openings: 21.0% (Regions I and II), 26.8% (Regions III to VI) · Used software: AE-Sim/Heat (Building heat environment simulation program)/Architecture Environment Solutions Inc. · Weather data: "Expanded AMeDAS Weather Data" 2000 Edition, Reference year/(one company) Architectural Institute of Japan (Tokyo) · Assumed number of residents: 4 persons · Assumed cooling and heating equipment: Air conditioners · Air conditioner settings: Heating 20°C, cooling 27°C 60% humidity, all-building integrated operation (Operation in which cooling and heating is implemented continuously 24 hours in each living room and non-residential room, including times when residents are not in the rooms.)

Fig. 3 Proportions of heat outflow in the winter

windows. In addition, the costs will consist only of the difference in window costs, so the amount will be limited to around 500,000 yen. Further, because the thermal insulation performances of the walls and the windows will become closer, it will be possible to achieve uniform temperatures in the rooms. This will not only realize an energy conservation effect, but also creates merits with regard to comfort. (Refer to Fig. 4).

## 10. Trend in market

### (1) Current diffusion rate:

Japan: In the overall industry, the rate of change to the

use of vinyl windows in detached housing was 17% in FY2016 and 13% in FY2014. (Survey by the Japan Sash Manufacturers Association)

Overseas diffusion rate: Germany 64%, China 30%, United States 65%

### (2) Prediction for 2017 and afterwards

YKK AP has cited the target of achieving a diffusion rate for vinyl windows of 30% of the market by 2020, and is aiming to make further contributions to preserving the earth's environment while realizing people's healthy and comfortable lives.



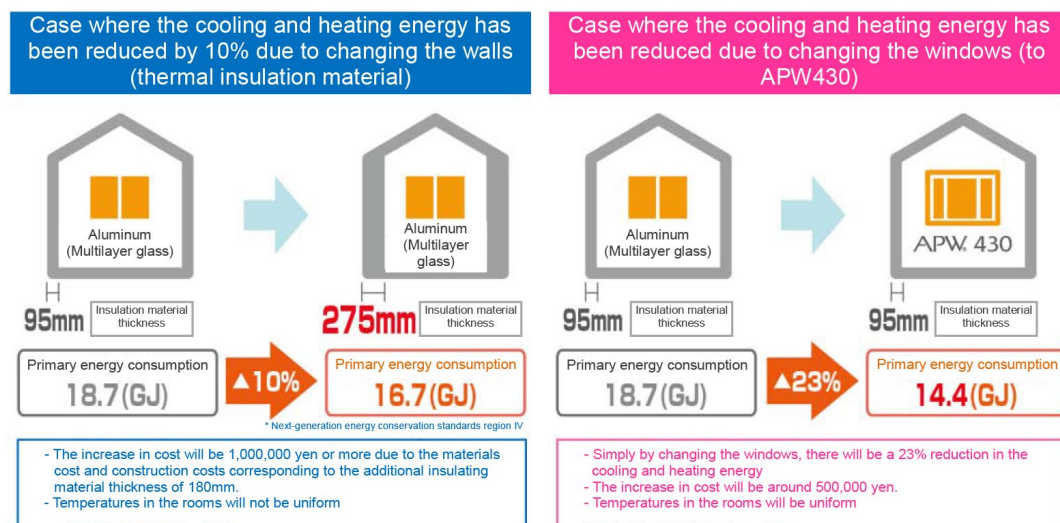


Fig. 4 Resource-saving and cost effectiveness from the housing design and construction aspects

## 11. Reference information

### (1) Social impact

The diffusion of vinyl windows will greatly contribute to the reduction of Japan's overall energy consumption. According to the Energy White Paper 2015, the amount of energy consumed in the household sector made up 14.4% (2,014PJ in FY2013) of Japan's total energy consumption. Out of this amount, 25.7% was used in cooling and heating applications, which corresponds to 3.7% of Japan's total energy consumption. Because changing from aluminum windows (multilayer glass) to vinyl windows will result in a 45% energy reduction, the reduction contribution amount will be  $3.7\% \times 0.45 = 1.7\%$  (238PJ). (In the case of nuclear power generation, the calorific value of each reactor is 9.76MJ/kWh (from the Act on the Rational Use of Energy), so 238PJ will equate to  $2.44 \times 10^{10}$  kWh.) This will be equivalent to the energy generated by 3.4 nuclear reactors (when the annual electric power generated by

one nuclear reactor is 7 billion kWh (Source: Agency for Natural Resources and Energy)), or the consumption by 6,800,000 general households (when the annual electric power consumption of a general household is 3,600kWh (Calculation by the Federation of Electric Power Companies of Japan)).

(2) Development of APW430Kr windows with a thermal insulating performance further improved from the world top-class APW430

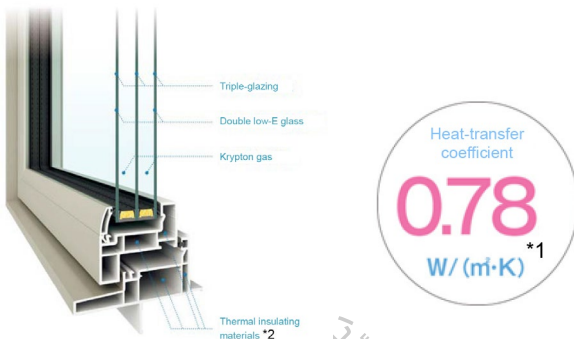
APW430Kr windows were developed, in which thermal insulating materials are inserted inside the APW430 frame, and krypton gas which has an outstanding thermal insulating performance is injected into the air layers. (Refer to Fig. 5) The APW430Kr is a high-performance triple-glazed vinyl window that realizes a heat-transfer coefficient (U-value) of  $0.78 \text{ W/m}^2\text{K}^*1$ , and is available with glass colors of blue and bronze.

(3) Patents, awards, etc.

-Two patent applications submitted [Awards]

-Good Design Award (2011)

Name of awarded item: "Window Business and APW  
Brand [APW]"



\*1: The heat-transfer coefficient is a value that indicates the ease by which heat is transferred, in which smaller numbers indicate a better performance. (In-house method/ Results of in-house testing compliant with JIS A 4710:2004)

\*2: The thermal insulation material insertion locations differ depending on the window type.

Fig. 5 APW430Kr

-4th HEAD (Home Environment Advanced Design) Best Selection Award (2014)

-Kitaguni Energy Conservation and New Energy Grand Prize 2015 (Hokkaido Bureau of Economy, Trade and Industry, METI)

-25th Grand Prize for the Global Environment Award, Minister Prize of Economy, Trade and Industry (2016)

## 12. Implementation sites

Throughout Japan

## 13. Cited documents

N/A

## 14. Contact information

YKK AP Inc. ■

## BAT7: High Performance Heat Insulating Plastic Windows

### 1. Category of industry

Architectural material

### 2. Category of technology

High performance heat insulating materials

### 3. Source of energy

N/A

### 4. Practical application

2014

### 5. Summary

Generally high-efficiency air conditioners and hot water suppliers are introduced in order to save energy in houses. However, no matter how high the performance of installed air conditioner is, poor performance of heat insulation of house causes leakage of the conditioned air to the outdoors and results in the waste of energy. Thus, improvement of the heat

insulating performance of windows, at which the largest heat loss in houses occurs (71% of heat enters in summer and 48% of heat in the warmed up rooms escapes in winter through windows) is quite effective in order to save energy in houses. Accordingly, a plastic sash with high performance and high functionality was developed. The product has high heat insulating performance with thermal transmittance U value of  $0.80\text{W/m}^2\text{K}$ , about 5 times as high as the next-generation standard for window sashes, and provides the additional functions for untroubled living conditions such as high security performance with certified CP mark, disaster preventing ability and sound insulating properties (JIS classification T-2). The products include all types (casement, double sliding, fixed fitting etc.) and size of sashes designed for any part of the house.

### 6. Principle and operation

(1) Development of the 3-layer glass with optimized midair layer thickness



The product comprises 3 sheets of glass and enhances heat insulating performance by filling 2 midair layers with krypton gas, which has large specific gravity, low thermal conductivity of 2.6 times as high as dry air, 1.7 times as high as argon gas, and thermal transmittance of  $0.009 \text{ W/m}^2\text{K}$ . The thermal resistance increases in proportion to the thickness of the midair layer, but wider thickness eventually causes convection which suppresses the thermal resistance. Hence, the thickness of 10mm was selected, which results in minimum convection and high thermal resistance, by a computer simulation and an evaluation test using a heat flow meter. Further, the 3-layer glass structure with 2 sheet of Low-E glass and a sheet of laminated glass enables to suppress the resonance and provides the excellent sound insulating properties (JIS classification T-2).

Refer to Figure 1.

#### (2) Development of plastic spacers

Generally spacers forming a midair layer are made of aluminum to secure strength. The newly developed plastic spacers with adequate strength can eliminate metal members which easily conduct heat and can increase heat insulating performance by  $0.1 \text{ W/m}^2\text{K}$  (about 12%).

(3) Using 2 types of Low-E glass with different insulation properties 2 types of Low-E glass with different insulation properties are applied. They are coated with 'special metal

film', which retains heat in winter and shields heat from sun light in summer. The 'cold area type (solar radiation heat acquisition rate of 0.47)' positively collects solar heat and the 'warm area type (solar radiation heat acquisition rate of 0.31)' shields solar heat, and the performance of the heat insulation and the heat shielding is improved by selecting a proper type of glass depending on the living area. In addition, synergy effect with laminated glass enables filtering out 99% of UV rays.

#### (4) Development of high performance plastic sashes

The heat insulating performance is improved by expanding dimensions of glasses which have excellent heat insulating efficiency, finding optimum cross sectional design which retains both the strength of plastic members and the heat insulating performance, reducing the ratio of the plastic members and increasing the number of the frame chambers and the midair layers to suppress heat conduction.

## 7. Description of improvement

### Before improvement

- Multi-layer glass
- Single Low-E
- Filling with argon gas
- Aluminum spacer

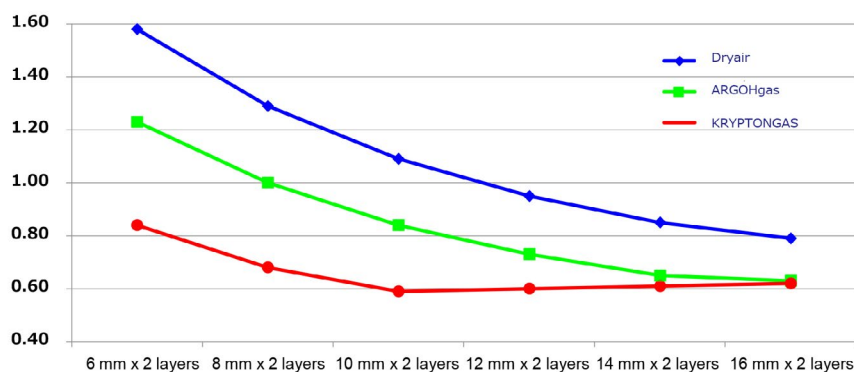
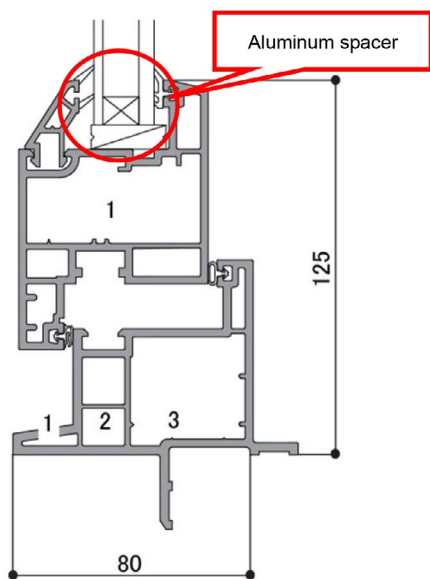


Fig. 1

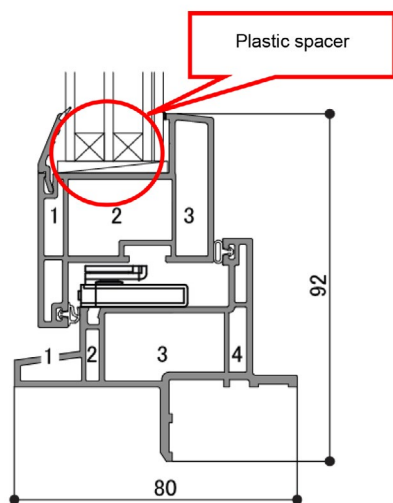
-Chamber (Sash 1,Frame 3)



Thermal transmittance U value Casement,Fixed fitting: 1.40 W/m<sup>2</sup>K Double sliding: 1.50 W/m<sup>2</sup>K

#### After improvement

- 3-layer glass
- Double Low-E



Thermal transmittance U value Casement,Fixed fitting: 0.80 W/m<sup>2</sup>K Double sliding: 1.00 W/m<sup>2</sup>K

-Filling with krypton gas

-Plastic spacer

-Multi-layer chamber (Sash 3,Frame 4)

-Downsizing of plastic frame by 26%

#### 8.Effect of improvement

Improvement of energy consumption intensity (Option for improving energy conservation ratio).

Comparison with single glass aluminum sash which is most popular in Japan.

Refer to Table 1.

#### 9.Economic efficiency and its trend

Payback period: 8 years by replacing from the aluminum sash and the single sheet glass.

#### 10.Trend in market

##### (1)Current diffusion rate

Ichijo Co.,Ltd has a 15% share of the domestic plastic sash supply. However,the domestic plastic sash market is about 17.0% of the total sash market and the adoption rate is still very low.

##### (2)Prediction for future

Recently,aluminum sash suppliers are changing their main products to the plastic sashes.

Because the adoption rate of the plastic sash is increased 9% more than 3years before,it can be expected that it depends from now on and is being increased.

#### 11.Reference information

##### Social impact

The crime-prevention laminated glass can secure family

members and household goods by preventing intrusion of sneak thief and protecting from ballistic fragments during abnormal climate (typhoon,tornado).

## 12.Implementation sites

All over Japan (except Okinawa Prefecture)

## 13.Cited documents

### References

Vinyl Environmental Council,"A study for delightful windows"

Japan Sash Manufacturers Association,"Usage survey of house construction materials"

PVC Windows Industries Association webpage

## 14.Contact information

Ichijo Co.,Ltd ■

Table 1

Items	This product	Single glass This productaluminum sash	Difference in performance
Basic primary energy consumption (MJ/year)		18,749	—
Performance of sash (Thermal transmittance)	0.8W/m <sup>2</sup> • K	6.51W/m <sup>2</sup> • K	-5.71W/m <sup>2</sup> • K
Primary energy consumption for refrigerated air conditioning (MJ/year)	12,716	21,596	-8,880
Primary energy consumption for refrigerated air conditioning (kWh/year)	3,533	6,000	-2,467
Electric power charge (yen/year)	95,378	16,198	-79,180
Energy conservation achievement rate (%)	147	87	—
Calculated CO <sub>2</sub> emissions (ton-CO <sub>2</sub> /year)	1.88	3.19	-1.31

\*1 Calculated with an online program provided by Building Research Institute,using the company's housing specification as the conditions for standard model plans of the business operator.

\*2 Calculated using standard unit electricity price of 27 yen/kWh (tax included) based on "About the Revision of 'Standard Unit Electricity Price' "issued by Home Electric Appliances Fair Trade Conference on April 28th 2014.

\*3 Calculated using actual CO<sub>2</sub> emission factor of 0.000531 (ton-CO<sub>2</sub>/kWh) by Tokyo Electric Power Company,based on "CO<sub>2</sub> Emission Factors by Electric Business Operators (Actual results of FY2013)".



## BAT8: Light-Weight, Small-Sized, Low-Cost High Efficiency High-Bay Lighting Fixtures

### 1.Category of industry

N/A

### 2.Category of technology

Lighting

### 3.Source of energy

Electrical equipment

### 4.Practical application

February 1,2015

### 5.Summary

These products are LED lighting fixtures for use in buildings with high ceilings. Improvements have been made to applicability by reducing their weight and size and lowering the prices. Although the switch to LED utilization in high-bay lighting fixtures used in factories,warehouses,etc. has been progressing,improvements in the weights and prices of

the fixtures and the realization of higher outputs have been required. By changing the unified structure of the previous LED high-bay lighting fixtures to a separate unit structure,and by utilizing an extruded heat sink made from a high-purity aluminum material,these products realized an approximately 66% reduction in weight,51% reduction in size,and a 44% lowering in prices compared to the previous products. In addition,due to the use of an optimum structural design that took advantage of heat simulations,the heat dissipating efficiency was improved to achieve an energy consumption efficiency of 159.4 lm/W (a 49% improvement compared to the previous products),and a high output model lineup was also realized. The improvement in energy conservation efficiency and applicability,together with the reduction in prices realized by these products can be expected to result in promoting the change to utilize LED high-bay lighting fixtures.

### 6.Principle and operation

(1)Development of compact fixture units with favorable heat

dissipation.

Compact high-output fixture units with favorable heat dissipation were developed. By combining these units, fixtures achieving at most a high flux equivalent to that of 1 kW metal halide lamp fixtures were realized in compact forms that did not exceed the dimensions of high-bay light fixture types with previous light sources. In particular, focus was placed on realizing the optimum heat sink design within the limited dimensions of compact, high-output fixture units, and the design also gave consideration to the ease of production and installation as well as the manufacturing cost. Due to this, the high-output fixture unit realized a favorable heat dissipating performance. Further, by combining high-output fixture units, product variations with various types of light output were developed.

#### (2) Reduction in weight of the fixture structure

It was attempted to optimize the strength, material quality, and form not only of the heat sink and the surrounding structure, but also the materials of the fixture main frame, etc., and a structure was realized that secured an adequate functional strength when the fixture has been fixed while still realizing a lightweight structure.

## 7. Description of improvement

### Before improvement

Although the energy conservation efficiency of previous high-bay LED lighting was outstanding when compared to that of previous light sources (such as discharge lamps), there were also inferior elements compared to previous light source products such as the aspects of cost and weight, and these aspects adversely affected the appeal of the product in the sales promotion process. Particularly when used as lighting fixtures for indoor facilities, for the reason that the number of units installed often becomes large, the applicability becomes a key

point in addition to the price and performance for increasing the merchantability.

### After improvement

It was attempted to make the weight and size smaller than previous products, to enhance the applicability, and also to reduce the costs. In particular, the merchantability was to be improved from the aspect of applicability, which could not be said to be comparable with that of lighting fixtures incorporating previous light sources. This was to allow a strong appeal to be made for the total merchantability of LED lighting which has an outstanding environmental performance. Additionally, the energy conservation performance was further improved to develop lighting fixtures with specifications that will decide the dramatic popularization of the products.

## 8. Effect of improvement

Improvement of energy consumption intensity (Option for improving energy conservation ratio).

While aiming to reduce the weight and size of products and reduce the costs, it was also intended to improve the energy conservation performance at the same time.

In Phase 1 of the product development, in early 2015 the specific energy consumption efficiency was improved by realizing a 134.9 lm/W LED high-bay lighting fixture (equivalent to a 400 W type mercury lamp lighting fixture). Additionally, in Phase 2 in July 2015 the specific energy consumption efficiency was further improved to 158.8 lm/W due to the utilization of high efficiency LED elements, an optimal LED element arrangement, and a newly designed power source unit.

## 9. Economic efficiency and its trend

As these products make it possible to replace almost all of the HID lamp high-bay fixtures that are widely used



for lighting indoor facilities with high ceilings, including factories, warehouses, gymnasiums and commercial facilities, the marketability is extremely high. In addition, an economic efficiency can be realized that enables recovery of the difference in initial costs in approximately two years, by limiting the initial costs to approximately 2.4 times the amount when compared with mercury lamp ceiling fixtures, and by achieving the running costs of approximately a quarter of the mercury lamp's costs as a result of the 74% energy conservation effect.

The economic effect is shown in figure 1 below, which takes the model in the product lineup with the most outstanding specific energy consumption efficiency as an example. As can be understood from this cost-comparison graph, even in the case with renewal investment, the calculations show that the investment can be recovered in 3.3 years.

## 10. Trend in market

(1) Actual sales results between April 2015 and September 2015: 25,347 units

(2) Prediction for 2017: 100,000 units/year

## 11. Reference information

[Example]

Case showing the effect of using these LED high-bay light fixtures instead of 400 W mercury lamp fixtures for 45 high-bay light fixture units in a factory for approximately eight hours a day over a one-year period.

Electric power consumption: Reduction of approximately 40,000 kWh.

Electricity charges: Reduction of approximately 1,100,000 yen

-CO<sub>2</sub>: Reduction of approximately 17t.

-Corresponds to the CO<sub>2</sub> annual absorption amount of approximately 1500 beech trees.

-Calculated at the used electricity charge unit price of 27 yen (New Electric Power Charge Standard Unit Price)

-The CO<sub>2</sub> emissions amount is calculated by multiplying the consumed electric power amount by the emissions

- Reversal of total costs of HID high bay fixtures (mercury lamp fixtures) in approximately 3.3 years
- Possible to make savings of approximately 8,000,000 yen over 10 years

(10 thousand yen) Comparison with 400 W mercury lamp fixtures (Initial + running costs)

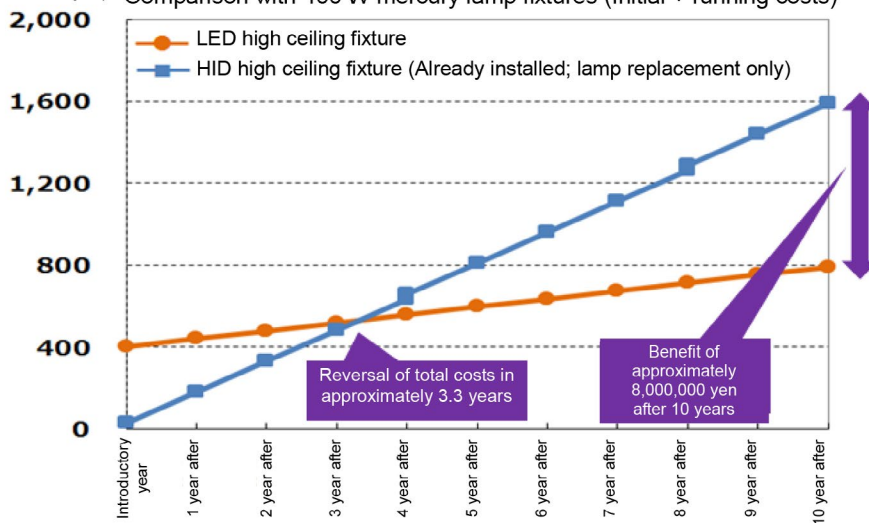


Figure 1



factor of 0.43 kg-CO<sub>2</sub>/kWh.

(Based on the Industrial Structural Council, Committee on industrial Science and Technology Policy and Environment, Global Environment Subcommittee, Natural Resources and Energy Working Group of the Ministry of Economy, Trade and Industry in FY2009).

-Calculated from the approximately 11kg annual amount of CO<sub>2</sub> absorbed by a single beech tree.

## 12. Implementation sites

N/A

## 13. Cited documents

Announcements made to academic societies and newspapers.

-Dempa Shimbun Daily (LED high-bay lighting fixtures) November 15, 2012.

-Nikkei Sangyo Shimbun (Nikkei Industrial Journal) (LED high-bay lighting fixtures) November 16, 2012.

-2013 CJK Lighting Conference (Gwangju) (LED high-bay lighting fixtures) August 23, 2013.

## 14. Contact information

Toshiba Lighting & Technology Corporation

Planning Manager, Technical Planning Department, Technology and Product Quality Management Division.

Phone: +81-46-862-2165 FAX: +81-46-861-5164 ■

# Second Batch of Domestic TOP TENS List

## Japan Building BP List

Edited by Jianfu Wang

BP1: Promotion of Super Energy-saving Construction by Achieving "Japan's First Urban-style Zero Energy Building (ZEB)"

### 1. Details

In order to combat global warming, the Japanese government targets a 26% cut in greenhouse gas emissions by 2030. The country's private sector is required to achieve an even tougher goal of approx. 40% reduction from FY2013 levels.

Zero Energy Buildings (ZEBs) that achieves significant energy conservation are expected to contribute greatly to achieve these goals. ZEBs are environmentally-friendly buildings whose annual primary energy consumption is

net zero, which is achieved by combining ultimate energy conservation efforts and the creation of energy. Taisei Corporation built a ZEB demo building in May 2014 at its Technology Center. It achieved ZEB (net ZEB), meaning net zero of primary energy consumption, during three consecutive years from 2014 to 2016.

The following technologies were introduced:

(1) A system combining equipment to use natural light and high efficiency LED lightings to achieve sufficient brightness with low luminance: energy consumption for


lighting reduced by about 86% .

(2) Task and ambient air conditioning combining air conditioning by radiation from the building structure utilizing exhaust heat from fuel cells and personal floor air outlet control: energy consumption for air conditioning reduced by about 76% .

(3) Energy creation by installing high efficiency single crystal silicon solar power panels on the roof and introducing outer wall units of organic thin-film photovoltaics,an essential unit to realize an urban-type ZEB .

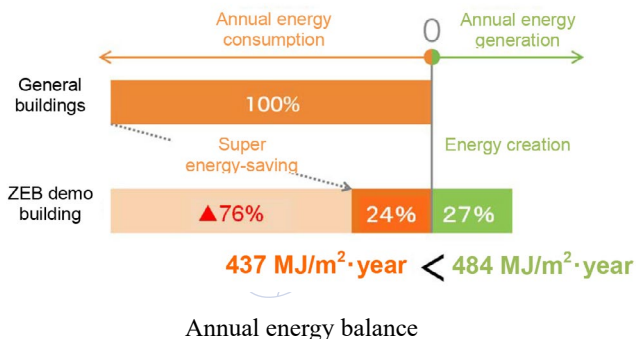
(4) Optimum operation control using the company's proprietary next-generation T-Green BEMS.

## 2.Diagrams,etc.



Use	Office
Location	Totsuka-ku, Yokohama City
Site area	34,821.92m <sup>2</sup>
Total floor space	1,277.32m <sup>2</sup>
Structure	Reinforced concrete
Levels	3 levels above ground
Completed	May 2014

Taisei Corporation's ZEB demo building



## 3.Energy conservation performance

(1)ZEB demo building (demonstrated values):

Energy consumption: 437 [MJ/m<sup>2</sup>d · year],energy creation: 484 [MJ/m<sup>2</sup>·year]

(2)Energy conservation of 103% attained in annual energy balance(energy conservation: 76%,energy creation: 27%)

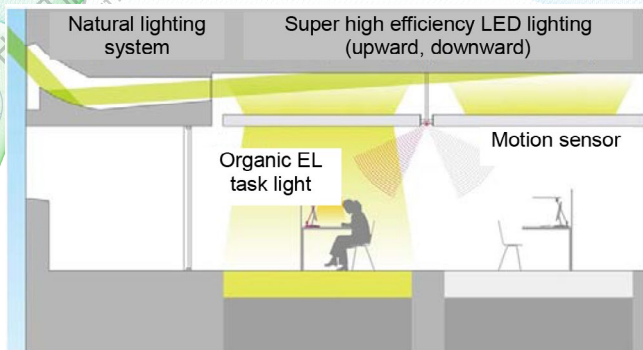
(3)Reduction of energy consumption: 62 kL/year  
(Gap of primary energy consumption with that of a standard building\* x crude oil conversion factor)

\* Standard building:1817 MJ/m<sup>2</sup>·year

## 4.Advanced nature and originality

So-called ZEBs can also be found outside Japan. Many of them feature solar power generation in a vast area or energy creation using biofuel brought in from outside the building. Meanwhile,our demo building achieves zero energy balance combining the latest energy conservation technologies and solar power generation. The state-of-the-art technologies include the system to bring in natural light to the back of the office space,the task and ambient lighting system considering brightness to the eye,and air conditioning by radiation from the building structure utilizing exhaust heat from fuel cells. It is one of the few cases that realize net ZEB in a small land area,where sufficient energy creation is difficult,without relying on the supply of renewable energy from outside the building.





Task and ambient lighting system

### 5. Versatility and expandability

In April 2014, the Japanese cabinet has adopted the basic plan on energy, which includes the target for ZEB. This case is a demonstration of an urban-type ZEB and verified the feasibility of ZEBs. For this reason, this case is versatile and expandable to other buildings that wish to be ZEB.

### 6. Continuity and sustainability

'T-ZEB simulator', a planning tool, has been developed after consideration of the achievement of ZEB (net ZEB) at the ZEB demo building. It is a unique technology to enable consideration of energy balance and cost study in a short period of time depending on the ZEB level. For the future, the company will continuously develop ZEB promotion activities, while addressing cost issues.

### 7. Investment efficiency

The target of initial cost in 2020 when compared with a standard building: 120%, and that cost reduction for operation: 80% (excluding the base rate).

### 8. Secondary results

- (1) CO<sub>2</sub> reduction: 122 t-CO<sub>2</sub>/year [0.1 t-CO<sub>2</sub>/m<sup>2</sup> · year]  
(Gap of CO<sub>2</sub> emissions compared with that of a standard building x CO<sub>2</sub> emissions conversion factor)
- (2) No. of visitors: 12,000 (June 2014–May 2017)
- (3) Patents and utility models: 11 (energy-saving air conditioning systems, etc.)
- (4) Certifications: BELS ★★★★★  
LEED-NC Platinum certification, etc.
- (5) Awards:
  - Environment Minister's Award for Global Warming Prevention Activity (2014)
  - 5th Energy-Efficient Lighting Design Awards (2014)
  - Japan Resilience Award (2015)
  - Good Design Award (2015)
- (6) Literatures:
  - FY2015 Annual Convention of Architectural Institute of Japan, etc.
  - 'Zaikai'
  - 'Nikkei Architecture'
  - 'Shinkenchiku'
  - 'Building Mechanical and Electrical Engineer'
  - 'Electrical construction & maintenance'
  - 'Nikkei Electronics'
- (7) Newspaper release:
  - Nihon Keizai Shimbun [ZEB demo building] (June 17, 2014), and others. 70 articles in total.
- (8) The Wall Street Journal of the U.S.
  - 'Japan Pushes Zero-Energy Structures' (Sept. 29, 2014) ■

## BP2: Energy Conservation Activities at a Next-generation Green Hospital

### 1.Details

It is a project advanced by a large general hospital to create a next-generation green hospital.

In order to build a next-generation green hospital utilizing abundant natural environment, hospital director himself took the initiative to build an ideal hospital that can reduce energy consumption and CO<sub>2</sub> emissions, with the cooperation of the building designers and facility designers.

Major efforts include the establishment of a distributed local heat source system, the use of abundant well water for the heat pump system, the application of radiant heaters and coolers, minimizing the ventilation, the introduction of vaporizing humidifier control, energy management utilizing an automatic reporting function BEMS, and visualization using digital signage.

In promoting energy conservation, continuous efforts were made including eco patrols mainly by the Eco

Committee and performance verification by designers.

As a result, the average primary energy intensity after opening the hospital stood at 2,240 MJ/m<sup>2</sup> year, representing about 45% reduction compared with average intensity of large hospitals.

### 2.Diagrams,etc.

Energy conservation and reduction of CO<sub>2</sub> emissions at Japanese Red Cross Ashikaga Hospital.

Refer to Figure 1.

### 3.Energy conservation performance

(1)Energy intensity: 2,240 MJ/m<sup>2</sup> year (average of FY2012 and 2013) → About 45% reduction compared with average intensity of large hospitals.

(2)Amount of energy conservation: Crude oil equivalent 2,315 kL/year (average of FY2012 and 2013).

(3)CO<sub>2</sub> reduction: 3,930 t-CO<sub>2</sub>/year (average of FY 2012 and 2013).

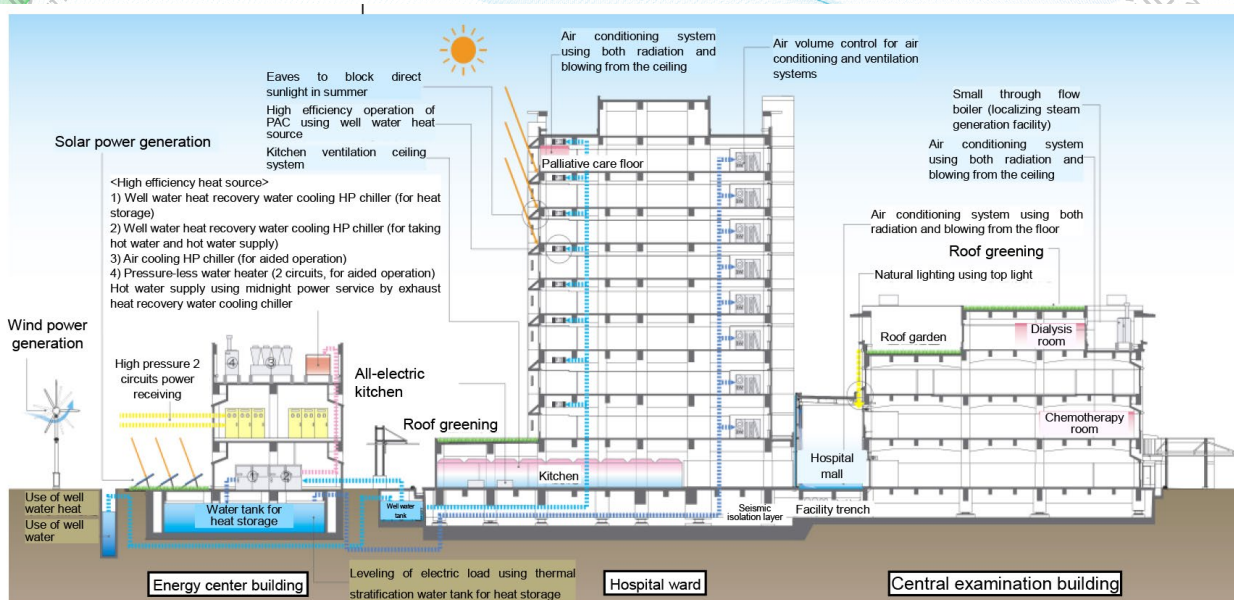


Figure 1

(4)Ratio of energy consumption: Electricity (daytime): 60.6%,electricity (nighttime): 33.9%,gas: 5.4%,oil: 0.1%  
→ Contract electricity: 2,500 kW (48 W/m<sup>2</sup>),significantly contribute to the leveling of electric load.

#### 4.Advanced nature and originality

Introduced as many energy conservation and CO<sub>2</sub> reduction technologies as possible that are applicable to hospitals,under the concept of 'next-generation green hospital'.

(1)The use of steam was limited to medical use,and built a high efficiency heat source system for air conditioning and hot water supply.

(2)Heat pump system utilizing abundant supply of well water: adopted a well water heat recovery system for air conditioning and hot water supply to improve efficiency.

(3)Use of wind and solar power generation for

enlightenment: installed wind and solar power generation system for display for the people coming to the hospital as a symbol of a green hospital.

(4)Body-friendly radiation cooling and heating system: radiation-type cooling and heating system achieving both energy conservation and comfort,to provide a comfortable environment for the inpatients.

(5)Minimizing ventilation when outer temperature hits peak or during nighttime: control outer air volume to reduce energy consumption for heat source and ventilation.

(6)Total energy conservation for the kitchen: kitchen ventilation ceiling system (displacement air conditioning) + electric kitchen (low heat radiation) + control of ventilation volume.

(7)Automatic reporting function BEMS system: energy



data can be output automatically in an excel format report.

### 5. Versatility and expandability

(1) Transmission of information of a green hospital: hospital director, head of the administration section and designers gave lectures and contributed many literatures to newspapers and magazine.

(2) PR activities by accepting inspection tours: efforts of a next-generation green hospital were introduced to more than 200 medical and welfare institutions.

(3) Visualization using digital signage: using display monitors set at the entrance, transmit eco information to the staff members and the patients.

### 6. Continuity and sustainability

(1) Briefing on eco-friendly hospital operation by the designer: held a briefing to explain the intention of the design and the operation methods to the hospital staff members.

(2) Performance verification by the designer: simulation of heat source operation using LCEM, and measurement of the interior environment and energy conservation.

(3) Eco patrol: Major members of the Eco Committee conducted eco patrols.

(4) Periodic reporting of energy usage by the Eco Committee: report energy consumption by division or level of the hospital.

### 7. Investment efficiency

-Initial cost of all facilities for energy conservation: Approx. 1.4 billion yen.

-Yearly running cost: Reduced by approx. 200 million yen .

-Simple investment recovery period: Approx. 7 years

### 8. Secondary results

(1) As a next-generation green hospital aiming to become a ZEB, the hospital was recognized in Japan, Asia and in the world.

(2) Won many environment-related awards. (Energy Conservation Grand Prize for excellent energy conservation equipment, the 1st Carbon Neutral Grand Prize, IFHE International Building Award 1st Prize etc.)

(3) Fostered medical staff members friendly to the environment and also to the patients. Human resources development through the environment.

(4) Fostered sustainable mind of the staff members by introducing a system ceiling, scratch-proof floor materials, wax-free floor materials, curved mirrors, visible piping, and eaves to prevent bird droppings from coming in, to extend the life of the hospital.

(5) Balanced energy-saving and disaster prevention initiatives. Maintained the functions as a disaster center hospital for full back-up in case of a disaster.

(6) CO<sub>2</sub> reduction: 3,930 t-CO<sub>2</sub>/year (average of FY2012 and 2013). ■

## BP3: University-wide Efforts to Build a Smart Campus

### 1.Details

In 2009,Mie University has established a medium-to-long-term plan on energy conservation,with the aim of becoming the most environmentally advanced university in the world. Meanwhile,the addition of new buildings in the campus has expanded the total floor space by 26.3% in 2013 from 2010,dramatically increasing energy demand. At the same time,peak power has also been on the rise. In order to meet an urgent need to reduce energy consumption and CO<sub>2</sub> emissions,to decrease peak power and to supply power for disaster prevention,president of the university,who supervises the university's environmental activities,led the university-wide program to create a smart campus in October 2011. Chief initiatives and responsible persons are described below:

(1)Energy conservation by introducing innovative energy-saving facilities (Smart Campus Program)

The objective of the Smart Campus Program is to reduce energy consumption and CO<sub>2</sub> emissions and to curtail peak power by introducing innovative energy-saving facilities combining the creation,storage and conservation of energy in an organic way. Reduction goal of CO<sub>2</sub> intensity from 2010 was set at 24%. In spring 2010,faculty members took the initiative and voluntarily made research on energy demand with the cooperation of the members at the Smart Campus Division. They also formulated a plan to introduce energy-saving facilities. The planning process took one and a half years. They explained the plan to the board,faculty meeting and department head meeting as necessary. They advanced the plan and successfully achieved the goal,obtaining consensus of all parties concerned in the university.

(2)Power saving efforts of all students and faculty members in the university

University students and faculty members voluntarily carried out environmental activities to reduce energy consumption and curtail power demand. At the beginning, the head of the Smart Campus Division (Professor) explained the objectives and intension, as well as detailed procedure of the activities to the board, faculty meeting, department head meeting and meeting at Center

for Environmental Management and Enhancement, in which students can also participate.

1) MIEU Point ('U' stands for University and 'yoU'):

In the MIEU Point system, each member of the university inputs his/her environmentally-friendly and energy-saving activities from a portable terminal, and the data instantly becomes visible to the person who made the

Efforts to become the most environmentally advanced university in the world

Build cooperative relationships with the stakeholders

Study sessions and seminars with Mie Prefecture, municipalities and the national government (METI Chubu)

Introduce innovative technologies for the next-generation energy society

Technology development expecting a large-scale introduction of renewable energy

- Use of locally-produced energy within the campus (wind power, solar power)
- Control the fluctuation of unstable power consumption and the maximum effect of lowering peak power using hybrid small capacity batteries
- Low-loss LED lighting without power conversion

High efficiency co-generation using electricity and exhaust heat to the full  
Energy conservation-oriented air conditioning suitable for marine climate (hot and humid)



Inspection tour of high efficiency co-generation system by elementary school students

University-wide energy-saving and power-saving activities

Energy-saving and power-saving activities using the MIEU Point\*  
Demand response with the university-wide participation  
Green walls created mainly by students  
Visualizing energy demand by department and power saving

\* MIEU Point: A unique initiative of Mie University. Students/faculty members input environmentally-friendly or energy-saving activities they performed instantly. The system then visualizes the achievement and gives points to the persons who implemented the activities.

Public relations of the demonstrations and expansion of the achievements to other universities

Educational activities for elementary, junior high, and university students (hands-on experience): 46 times in total  
Smart Community exhibition, introduction and presentation at university association: 32 times in total  
Planning and supporting smart campus projects to other universities in and outside Japan: 2 universities



Figure 1 Outline of the Smart Campus Concept



action. This motivated each member to make energy-saving efforts.

## 2) Demand Response (power saving activities)

Peak power demand of the university comes at the end of July each year, before the first semester's final examination. In the nine days at the end of July 2013, the university implemented university-wide power saving program. This university-wide program has been continuing for three years now (2015). The achievement is reported to all departments every year.

## 2. Diagrams, etc.

Refer to Figure 1, 2 & 3.

## 3. Energy conservation performance

Actual rate of reduction of energy and CO<sub>2</sub> emissions.

Figures show the comparison with the former facilities (2010); '%' is the comparison of floor area intensity (with 2010).

Refer to Table 1 and Figure 4.

## 4. Advanced nature and originality

(1) Maximize the use of exhaust heat from co-generation plant (2 patents filed)

Formulated a method to make a full use of exhaust heat from co-generation to (Patent filed in June 2014)

Cost-saving operation is being implemented. Effect of improving operation: Reduction of gas consumption (crude oil equivalent): 210 kl/year Reduction of gas cost: 19.7 million yen/year.

(2) Desiccant air conditioning to achieve both comfort

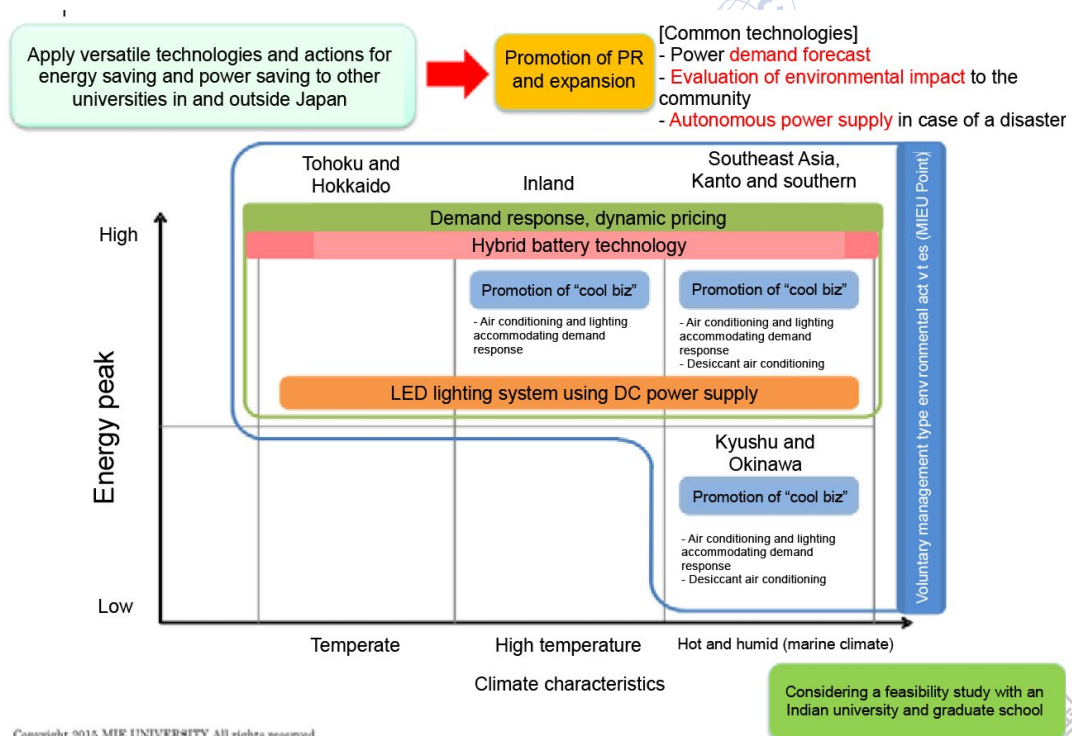


Figure 2 Generalization of the methods implemented in the Smart Campus Program and future expansion

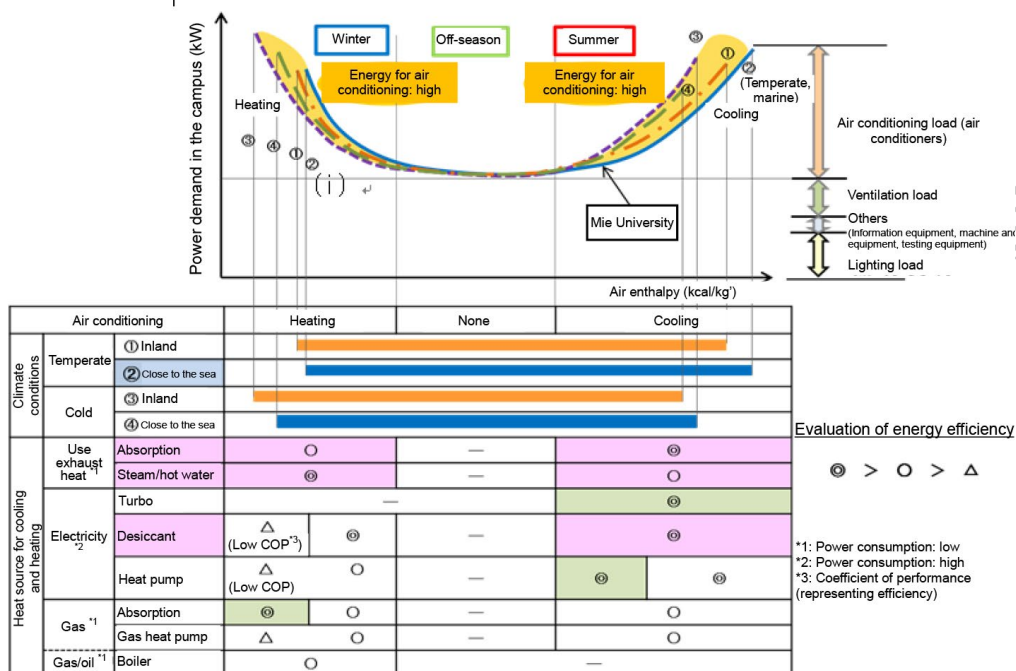


Figure 3 Selection of optimum heat source for air conditioning by region

Table 1

Item		Unit	2013 <sup>1</sup>	2014 <sup>2</sup>
Entire university	Energy (crude oil equivalent) <sup>3</sup>	kl/year (%)	▲1,855(▲20.4%) <sup>4</sup>	▲2,191(▲24.1%) <sup>4</sup>
	CO <sub>2</sub> <sup>4</sup>	t-CO <sub>2</sub> /year (%)	▲4,401(▲21.7%) <sup>4</sup>	▲5,354(▲26.4%) <sup>4</sup>

## Results of major initiatives

Major initiatives		Energy (crude oil equivalent) kl/year	CO <sub>2</sub> emissions t-CO <sub>2</sub> /year	Other achievements
(1) Introduce innovative energy conservation facilities and improve operation	- Renewable energy facilities	▲56	▲81	Prior evaluation of environmental impact
	- Co-generation using gas	▲68	▲99	
	- Conversion of fuel for heat source facilities (from heavy oil to gas)	▲1,183	▲1,725	
	- Small capacity battery to maximize the effect of curtaining peak power	▲466	▲2,322	
(2) Power saving with the participation of all students and faculty members of the university	- Battery to reduce fluctuation of renewable energy generation	—	—	Peak power ▲60 kW
	- Autonomous power supply in case of a disaster or an emergency (BCP)	—	—	Reducing instant fluctuation ±50 kW
	- Energy-saving desiccant air conditioning to create a comfortable interior environment	—	—	Power supply in case of a disaster
Energy conservation	- Use of DC generated by solar power generation (for lighting)	▲82	▲173	
		▲18.1% <sup>4</sup>	▲18.1% <sup>4</sup>	Comparison with A/C
(2) Power saving with the participation of all students and faculty members of the university		▲2,770 kWh <sup>4</sup>	▲1.03 <sup>4</sup>	
		—	—	Peak power: an average 4.5% reduction for nine days (430 kW)
		—	—	Solar insulation shielding effect ▲65 - ▲90%



and energy conservation during hot and humid summer. Generally, air conditioning in summer is controlled based on the room temperature. This time, we adopted a new air conditioning system to evaluate the comfort level (discomfort index) of the persons in the room, considering humidity as well. Energy conservation effect of the desiccant air conditioning has been demonstrated (a reduction of 36.6%). This is a unique and creative initiative that can be applied and expanded to other universities and office buildings.

(3) DC power supply to lighting equipment expecting a extensive introduction of PV

Intelligent DC (Direct Current) power supply is an energy-efficient system to sustainably supply power to important loads, such as lightings, POS terminals and ATMs in convenience stores using renewable energy in a time of disaster. In normal times it utilizes renewable energy efficiently, and at the time of disaster, this advanced system has an effective function for BCP.

(4) Power saving by demand response (DR) activity

Mie University implemented demand response initiative for nine days, which is effective to reduce electricity demand when it becomes tight in the daytime during mid-summer. The University has set two different pricing systems, the normal pricing system and the one for critical peak pricing. The latter charges higher unit price for power consumption during daytime to encourage people to reduce power consumption. People were allowed to choose the cheaper one. 41% of the entire university participated in the power saving activities, and the power saving

effect was 4.5% in 2013 and 5.9% in 2015. Mie University became the first university in Japan to implement university-wide power saving through DR. The efforts are still continuing.

(5) MIEU Point system to encourage students and faculty members to perform energy conservation activities

MIEU Point system is for encouraging people to perform environmentally-conscious and energy conservation activities, by visualizing the achievements and give points depending on the contents of the activities. Prizes are given or the points can be exchanged for gifts. This leading-edge initiative started in 2012 is still ongoing every year.

## 5. Versatility and expandability

(1) Details of versatile technologies

The following technologies realized by Mie University can widely be expanded to other universities and office buildings. (See Table 2)

(2) Introduction guideline of air conditioning facility plan (versatility)

When establishing a plan to optimize chilled and heat source equipments, it is important to consider the characteristics of the area where the equipment is located (ambient temperature and the distance from the sea). Figure 3 shows appropriate chilled and heat source systems for different weather conditions. This classification supports the planner to make an appropriate selection of heat source system for the area.



Table 2: Versatile technologies used in smart Campus

Technologies	Specific measures
Power demand forecast within the campus (temperature, humidity and insolation) (patent filed)	Methods of optimum operation of each equipment depending on power demand
Methods to evaluate environmental impact of the introduced facilities to the campus	Measures against noise, low frequency vibration and shadow flickers from windmills
(renewable energy, gas co-generation)	Noise of co-generation and odor from exhaust gas
Operation method of cold and heat source equipment (patent filed)	Methods to prioritize the operation of equipment
Minimize the capacity of power storage facility	Low operation cost, high-load operation of high efficiency equipment
Autonomous operation of power source in case of a disaster	Maximize investment effect of reducing peak power
	Autonomous and independent operation of gas co-generation system, wind power generation and solar power generation systems in case of a disaster

Table 3

Contents		Investment amount (million yen)	Recovery periods
Renewable energy	Solar power generation (consumed internally)	29	28
	Wind power generation (consumed internally)	150	29
Gas co-generation (advanced use of waste heat and large contract of city gas (medium pressure))		750	8
Desiccant air conditioning		117	18
Batteries		80	48
Replacing lighting fixtures with LED lightings and the use of DC from solar power generation			11
Environmentally-friendly and energy-conservation activities by students and faculty members	Environmental activities by MIEU	7	Within one year
	Demand response (DR) and dynamic pricing (DP) aiming at reducing power consumption (enhance the visualizing function)	8	2.6
	Green walls and roof gardening	0.5	Short-term
	ESD (education for sustainable development) and education on energy for elementary school students	-	Continuous education
	Expanding visualizing function to the entire university	8	2.6

(3) Planning an optimum method considering the amount of investment (versatility and expandability) Investment recovery period differs by respective energy-saving equipments, from short-term (3-8 years) to long-term

(10 years or longer). Mie University aptly combined these two types, aiming to increase the total amount of energy conservation. This method has versatility and expandability that can be applied to different

universities having different conditions.

## 6. Continuity and sustainability

(1) The final year of the medium-to-long-term energy conservation plan is 2020. In 2014, Mie University reorganized its environmental management system into a better organization (Mie Global Environmental Center for Education & Research), enhancing the division for energy conservation and the reduction of CO<sub>2</sub> emissions.

(2) 'Visualizing function' has been expanded to each department, so that all students and faculty members can monitor electricity demand of its department and also other departments. University-wide electricity

saving activities (demand response) is still continuing. In 2015, the third year of the activities, electricity demand at the peak time was reduced by 5.9%.

## 7. Investment efficiency

Contents and cost-effectiveness (Investment recovery periods)

Refer to Table 3.

## 8. Secondary results

Announcement, field survey, observation, exhibitions, release in magazines, academic meetings, theses, patents, awards. Refer to Table 4. ■

Table 4

① Announcement	62 times
② Announcement (newspapers)	46 media
③ Field survey and observation of Smart Campus	50 organizations
④ Exhibitions	9 exhibitions
⑤ Release in magazines	5 magazines
⑥ Academic meetings, theses	5 theses
⑦ Patents	2 patents filed
⑧ Awards (22nd Grand Prize for the Global Environment Award (Minister Prize of Education, Culture, Sports, Science and Technology), Minister Prize of Economy, Trade and Industries in the Energy Conservation Grand Prize for excellent energy conservation equipment, etc.)	4 awards

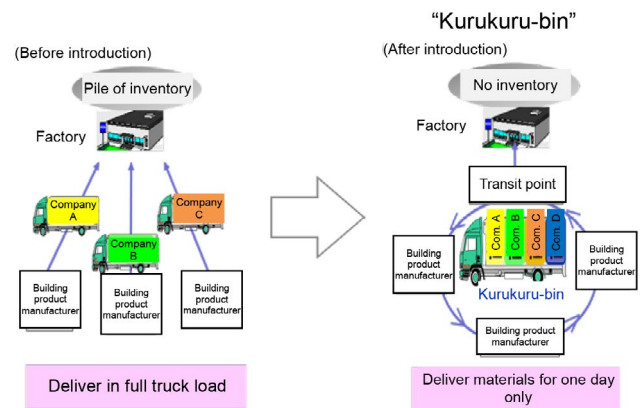
## BP4: Energy Conservation in the Distribution of Procured Building Products

### 1.Details

From early on, Misawa Homes has made great efforts to reduce CO<sub>2</sub> emissions in its distribution system by establishing a logistics subsidiary and creating its unique distribution system. 'Kurukuru-bin' (Daily circulating mixed loading pickup and delivery system) introduced in 1986 uses just one truck in one route that goes around building product manufacturers in an optimized route to gather building products, rather than receiving the materials separately to factories and depots. 'Module Palette' adopted in 1993 dramatically improved the loading efficiency of different building products of different sizes, by combining the combination of nine types of palettes. Then, in 2004, Misawa Homes established the 'a-net system' with which construction manufacturers can register the number of palettes they ship (minimum number for registration is one palette).

Building product manufacturers affix the slip output after the registration on the materials to be shipped, put them on the module palette and place it in the shipment yard. This saved trouble of ordering and transshipment.

### 2.Diagrams,etc.

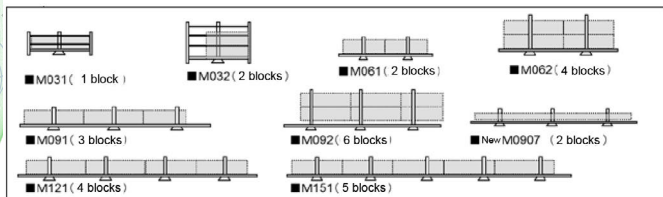


### 3. Energy conservation performance

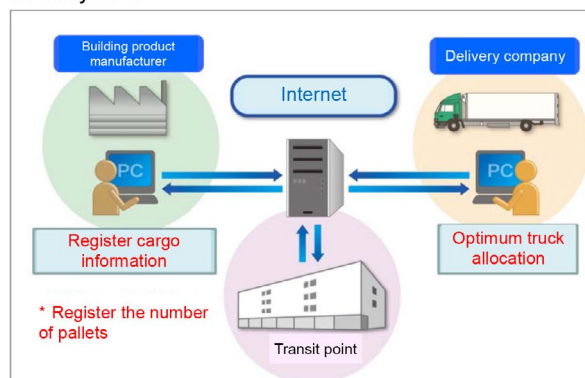
(1) Deliver necessary amount for the day in consolidated cargo of 'Kurukuru-bin'.



### Module Palette



### a-net system



(2)'Module Palette' can deliver long objects and products that are difficult to carry.

(3)Know the amount of cargo in advance using the 'a-net system'to allocate necessary number of truck.

These initiatives has led to a reduction of about 37% of energy usage per building for the delivery of purchased materials (GJ conversion) from FY2001.

### 4.Spirit of innovation and originality

An advanced model to manage the 'distribution of small quantities of various types of products',to delivery necessary amount of building products,facilities to the

factories and depots all around Japan from building products manufacturers. The system has been improved by developing the company's original pallets and systems. For the future,the company is planning to begin waste distribution.

### Distribution system of procured products

-Frequent delivery of consolidated cargo (nationwide,at the fixed time,amount not fixed)

-Integrated palletization of building products (9 types of original pallets)

-Web system to know the distribution amount (a-net system)

### Waste distribution system

-Recover waste at the construction sites after delivery of the products.

### 5.Versatility and spread effect

(1)The system was initially a closed system established internally. The company established a subsidiary and made the system open. Started external sales in 2010 to other companies and building product manufacturers. (joint distribution)

(2)The ratio of external sales stood at 35% (FY2014).

(3)The system can also be introduced by other distribution companies as a delivery service of building products. It can be expanded on a large scale.

### 6.Continuity and sustainability

(1)The company has made efforts for about 20 years to carry long objects and building products of special forms efficiently. It adopted various ideas such as establishing a nationwide distribution network,the development

and introduction of pallettes, and the development and introduction of a web system to know the amount of cargo.

(2) Going forward, the company will continue its efforts including the promotion of joint distribution and the development of new pallettes, in consideration of the market situation.

(3) The system will be expanded to the competitors in the industry.

## 7. Investment efficiency

(1) Investment amount: About 50 million yen (year)

(2) Recovery period: 1 year

## 8. Secondary results

Breakage of building products reduced by using Module Pallettes.

Addressed the problem of driver shortage by reducing the number of trucks to be allocated. ■

# Second Batch of Domestic TOP TENS List

## U.S. Building BAT List

Edited by Jing Sang

### BAT1: Condensing gas tankless water heaters

This type of water heaters provides end-users with instantaneous, on-demand hot water. To meet end-user demand in hot water, condensing gas tankless water heaters require larger burners. Compared to conventional, storage water heaters, this type of water heaters does not require water storage and thus eliminate standby losses (York, 2014).

In our modeling assumptions, tankless water heaters affect water heating demand in single and multi-family residential houses. Results show that on a national level, tankless water heaters can save about 34% of residential water heating demand. This accounts for about 0.4 Quads of both technical potential and maximum adoption scenarios, which is consistent with other sources (Navigant, 2017b reports technical potential for tankless water heaters as 0.459 Quads in 2030).

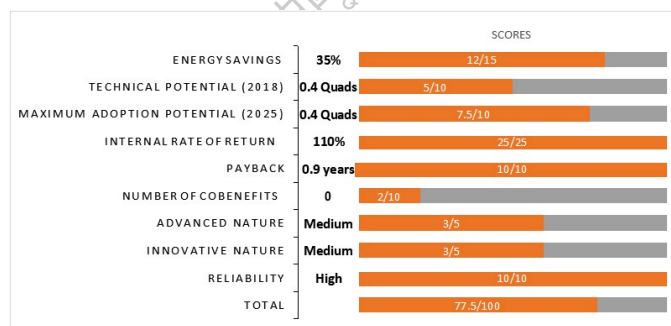


Figure: Results of evaluation of Condensing Tankless Water Heaters

### BAT2: Occupant responsive lighting

Responsive lighting systems improve the energy efficiency of office buildings. Using various sensors, management systems, and control components, these systems allow facility managers of commercial buildings to provide high-quality lighting services that meet individual preferences and



light needs while reducing energy demand and costs (GSA,2012a).

Occupant responsive lighting technologies affect lighting electricity consumption in commercial buildings. We estimate that under technical potential adoption scenario,occupant responsive lighting technologies can save 0.6 Quads. In case of Maximum adoption potential scenario,the savings potential is about 0.4 Quads in 2025. Overall,deployment of these technologies can reduce lighting consumption by 44% with a simple payback period of about 8.5 years. These results are consistent with those reported in our reference sources (for example,(DOE/EERE,2017a).

In addition,Occupant Responsive Lightning can improve occupant comfort,improve lifetime of other components,and provide demand response capabilities.

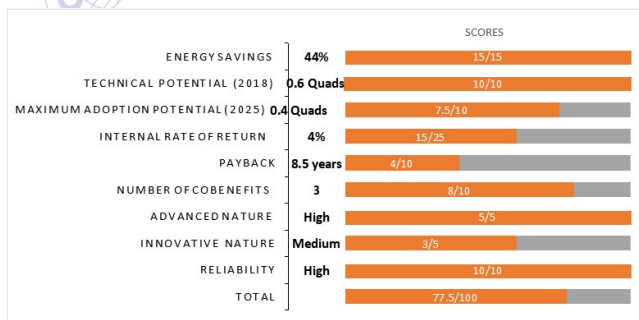


Figure: Results of evaluation of Occupant Responsive Lighting

### BAT3: Heat pump water heaters

Heat pump water heaters work as a refrigerator in reverse. Accumulating heat from surrounding environment,a heat pump moves this heat into a tank to heat water. Since heat pump water heaters move heat rather than generating it,they are 2-3 times more energy

efficient compared to traditional electric resistance water heaters (DOE,2018b). We consider only air-source heat pumps in this study.

Heat pump water heaters affect water heating electricity consumption in single and multi-family houses. We estimate that heat pump water heaters can reduce residential energy consumption for water heating by 59%. Under the technical potential adoption scenario,we estimate potential energy savings as 0.7 Quads in 2018 and 0.4 Quads in 2025 under maximum adoption scenario. Our estimated energy saving potential under the maximum adoption scenario is lower than reported in other sources ((Navigant,2017a) reports the annual saving potential for this technology as 0.8 Quads source energy in 2030). The difference in estimates can be due to different energy efficiency indicators used for modeling in our study and other sources.

However,our estimated simple payback period (4.1 years) is consistent with payback reported in other sources ((Navigant,2017a) reports a payback period of less than 5 years for heat pump water heaters). The literature does not mention co-benefits for this technology,which led to a low score for this component in scoring.

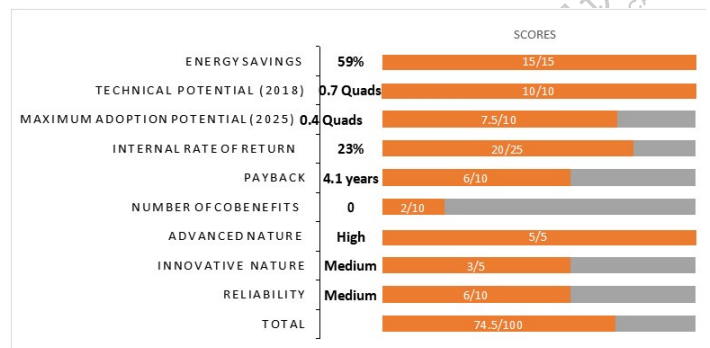


Figure : Results of evaluation of Heat Pump Water Heaters

#### BAT4: LED downlight luminaires

In our study, we assessed LED downlight luminaires as a replacement for incandescent and fluorescent technologies in the residential sector. Advanced LED technologies, readily available on the commercial market, can deliver significant energy and cost savings to end-users.

We estimate that LED downlight luminaires can reduce residential electricity consumption for lighting by 82%. This constitutes 0.18 Quads of savings in 2018 under the technical potential adoption scenario and 0.13 Quads in 2025 under maximum adoption scenario. Perrin and Davis (2015) reported that LED downlight luminaires adopted nationwide in both the commercial and residential sectors can save 0.278 Quads. Given that we only assessed the residential sector, which accounts for 46% of total lighting consumption in 2015 (EIA, 2017c), our savings estimates are similar to other studies. High savings and a short simple payback period led to an attractive internal rate of return (IRR) and hence high scores for these parameters. In addition to energy and cost savings, LED downlight luminaires improve occupant comfort.

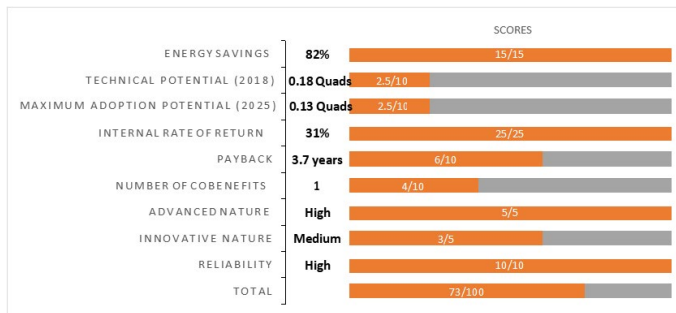


Figure: Results of evaluation of LED Downlight Luminaires

#### BAT5: Building energy management and information systems

During the literature review stage, we identified three similar and potentially overlapping technologies: 1) Cloud-based energy information systems, 2) Traditional building automation systems, and 3) Web-based lighting management systems. BTO staff suggested combining these specific technologies into one category.

Building energy management and information systems provide building facility managers with the ability to monitor and control the energy performance of various systems such as heating, ventilation, air conditioning, and lighting.

Among co-benefits for this technology, we identified the following: 1) Improved lifetime of other components; 2) Peak demand reduction; 3) Reduced maintenance needs. The modeling results show that simple payback period of this technology can be about 3.7 years, which in turn also lead to attractive IRR value.

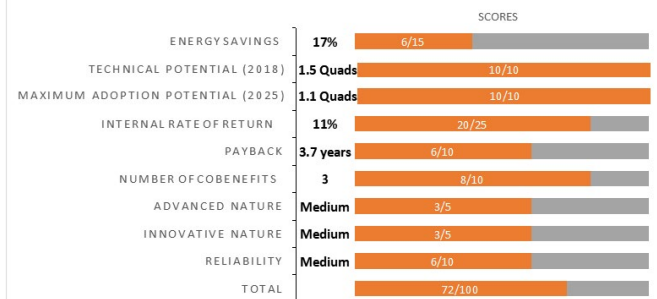


Figure: Results of evaluation of Building Energy Management and Information Systems

#### BAT6: Fixed window attachments

During the re-categorization stage, we merged three

separate technologies (Hi-R window panel<sup>[1]</sup>, Switchable film, and Window attachments<sup>[2]</sup>) into one category, "Fixed window attachments". Fixed window attachments affect the heating and cooling loads of buildings.

We estimate that this technology can reduce heating and cooling needs of buildings (both residential and commercial) by about 40%. The technical energy savings potential of this technology exceeds 1.78 Quads (1.22 Quads for residential and 0.56 Quads for commercial sectors).

We estimate that fixed window attachments are on average 40% more efficient than the baseline energy performance of building windows. The total technical savings potential is more than 1.7 Quads in 2018, and the maximum adoption potential is 0.77 Quads in 2025. The large share of heating and cooling energy use in total building energy demand can explain such relatively large savings potential. However, a long payback period and negative IRR resulted in low scores for these parameters.

We identified the following co-benefits of fixed

window attachments: 1) Improved occupant comfort 2) Improved lifetime of other components 3) Noise reduction, and 4) Peak demand reduction.

### BAT7: Advanced rooftop unit controls

Advanced rooftop unit (ARU) controls allow facility managers of commercial buildings to monitor, control and adjust heating, cooling and ventilation services provided by packaged rooftop HVAC systems. Specifically, using advanced control and monitoring strategies ARU controls allow building managers to improve occupant comfort while reducing operation and maintenance costs and delivering significant energy savings.

We estimate that ARU controls can save 56% the energy use compared with standard packaged HVAC systems with constant speed-supply fans. Our estimate is consistent with a savings rate of ARU controls provided by DOE/EERE (2017b). Our modeling also shows that when deployed, ARU controls can reduce HVAC energy use of commercial buildings by almost 0.5 Quads in 2018 under Technical potential adoption scenario and by 0.26 Quads in 2025 under Maximum adoption scenario. Co-benefits of ARU controls include improved comfort, indoor air quality, an improved lifetime of other components, and reduced peak demand.

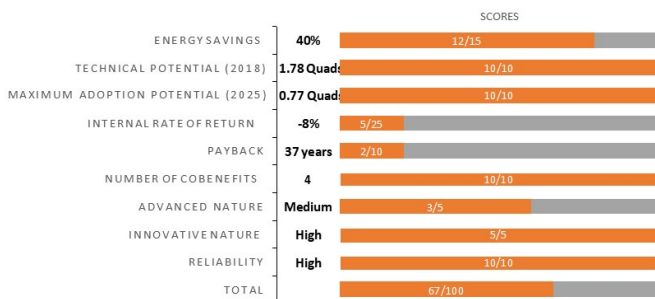


Figure : Results of evaluation of Fixed Window Attachment

Notes:

[1] These are often referred to as storm windows.

[2] These are window exterior and interior products that are designed to improve energy efficiency, daylighting quality, optical and thermal performance as well as overall occupancy comfort.





Figure: Results of evaluation of Advanced Rooftop Unit Controls

### BAT8: Plug load control devices

Plug load control devices help facility managers and building owners in managing the energy consumption of various devices and office appliances powered by the traditional plug. Limited information is available on the energy consumption of plug load control devices in the residential and commercial sectors (Metzger, 2012). In addition, Scout 0.2 does not include applicable baseline data. For that reason, we were not able to model this technology. Instead, we prepared our own estimates on potential energy savings, IRR and payback period in the residential and commercial sectors.

We used advanced power strips as a proxy here for plug load control devices to estimate the technology's energy savings potential. We estimated that plug load control can result in 0.75 Quads of savings under the technical potential scenario and 0.7 Quads in 2025 under the maximum adoption scenario. In addition to their relatively high energy savings, plug load control devices can reduce peak demand.

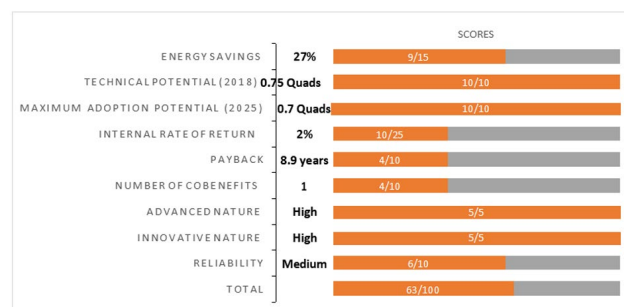


Figure: Results of evaluation of Plug Load Control Devices

### BAT9: Comprehensive attic update

Attic insulation and other attic weatherization measures can significantly reduce the heating and cooling load of residential buildings. In our modeling, we assumed that existing residential houses upgrade their attic to meet the requirements of 2012 International Energy Conservation Code. Specifically, when attic insulation is completed, the attic should achieve following R-values:

- Climate Zone 1: R-30.
- Climate Zone 2-3: R-38
- Climate Zone 4-8: R-49 (ENERGY STAR, 2014).

We estimate that roof insulation of existing residential houses will deliver 15% of energy savings and decrease energy use by almost 0.2 Quads under Technical Potential scenario and by 0.08 Quads in 2025 under Maximum adoption scenario. These estimates are lower than reported in the literature. For example, Navigant (2017b) reports technical potential savings of attic insulation and sealing as 0.7-1.1 Quads per year. The difference can be due to different baseline assumption in Scout modeling tool and methods to estimate savings potential by other sources.

Apart from energy and cost savings, comprehensive attic update measures improve occupant comfort, extends the lifetime of other components and reduces noise.

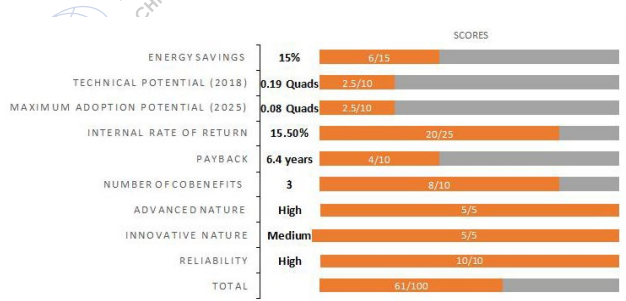


Figure: Results of evaluation of Comprehensive attic update

### BAT10: Dynamic solar control systems

Dynamic solar control systems in residential and commercial buildings provide occupants with multiple benefits. These systems adjust lighting, prevent overheating of surface area inside premises while improving comfort and delivering cost and energy savings. Dynamic solar control systems include automated shades, as well emerging technologies such as dynamic glass glazing. As noted before, this report focuses only on commercially available technologies, even though we

recognize the potential future market for emerging technologies.

Deployment of dynamic solar control systems primarily affects heating and cooling load of buildings. We estimate that dynamic solar control systems on average can save almost 20% of the energy used in both commercial and residential buildings. Our modeling shows that the technical potential for the residential sector is 1.2 Quads and 0.8 Quads for commercial. The maximum adoption potential in 2025 is 1.1 Quads. However, the long payback period and negative IRR resulted in lower scores for these evaluation categories. Regarding co-benefits, dynamic solar control systems can improve the lifetime of other components, reduce peak demand and improve occupant comfort. ■

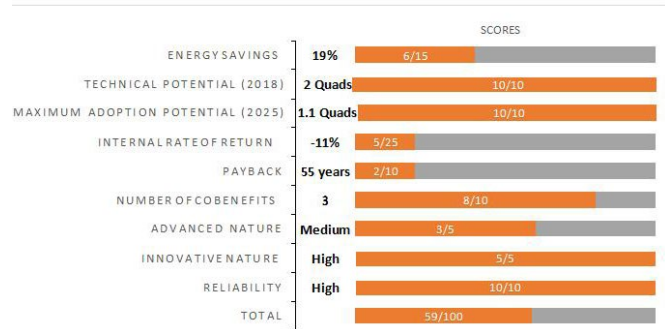


Figure: Results of evaluation of Dynamic solar control systems

# Second Batch of Domestic TOP TENS List

## France Industrial BAT List

Edited by Jing Sang

### BAT1: Infrared Technologies for Drying and Baking Thin Products or Coating

#### 1. Technology description

##### (1) Infrared tunnels:

Infrared tunnels are facilities for baking powder coatings, drying of liquid paint or items warm-up. Final hardening of the powders is achieved by baking in a conventional oven.

Infrared radiation: Infrared is electromagnetic radiation like light or UV rays, radio waves etc. Any bodies brought to temperature emit radiations that carry energy in the form of vibrational waves. Conversely, the receiver absorbs some of this energy and transforms it

into heat.

The emitted radiations are spread over a wide spectrum of wavelengths. Infrareds for industrial applications range from 0.76 to 10  $\mu\text{m}$  (short infrareds from 0.76 to 2  $\mu\text{m}$ , medium infrareds from 2 to 4  $\mu\text{m}$  and long infrareds from 4 to 10  $\mu\text{m}$ ). Two factors can limit the energy received by the item: the shape factor (related to the geometry of the emitter and of the item) and the capacity of absorption of the material to be treated.

##### (2) Technologies used:

- Electrical infrareds emitters



An electrical infrared emitter is a body brought to high temperature (1500 °C to 2500 °C for the short infrareds. 500 °C to 1200 °C for medium and long infrareds) by an electric current through a resistive element. These transmitters enable an accurate regulation as long as the exact room temperature is known.

### (3) Gas infrared emitters:

The combustion is stabilized in a porous or perforated surface. The radiation is produced by this surface, brought at a certain temperature range (500 °C to 1200 °C, medium and long infrared) and not by the radiation of a flame.

## 2. Level of Energy Savings

Energy saving: 20% to 80% depending on the application.

## 3. Market prospect

- Liquid paint drying;
- Gelling and baking powder coatings;
- Pre-drying and textile powdering.
- Coatings polymerization technology like PTFE coatings (Polytetrafluoroethylene), chrome or aluminium for the aerospace industry;
- PVC (Polyvinyl chloride) and latex gel induction;
- Flame treatment effect (pizza, biscuits, burned creams etc.)

## 4. Reliability

The choice of an infrared tunnel depends on many parameters:

- The material of the items;
- The shape of the items;
- The type of interlocking parts;
- The number of parts and the speed of the conveyor

## 5. Economic Characteristics

Payback time: 2 to 3 years

## 6. Social Characteristics and cobenefits

### (1) Speeds the parts temperature rise

Infrared radiation provides a direct transfer of energy between the heat source and the receiving parts without using air movement. Thus the pieces rise in temperature quickly which improves the final quality of the coating (tense, shine ...).

### (2) Reduce the use of space

By rising the temperature faster, the product obtains the required temperature in a shorter time. The cooking tunnel uses less space.

### (3) Improves layer quality

In the case of powder coatings, the use of infrared pre-gelling avoids a blend of powders in the convection zone and improves the tense (quality) of the paint layer.

- Space saving
- Energy saving: 20% to 80% depending on the application
- Transition to solvent-free products
- Reduced cycle time
- Productivity gain. ■

## BAT 1 Application Examples

### Application 1: Car painting touch-up using infrared

#### 1. Technical Principle

##### Conventional process:

- Forced convection hot air oven
- Blowing oil burner
- Cycle time: about 45 minute
- Annual consumption: 210,000 kWh

##### Short wave infrared solution:

- IRT Installation
- Infrared power of 54kW
- Dimensions: 2.5 x 2.0 x 0.5 m<sup>3</sup>
- Cycle time: 13 min

#### 2. Technical Schematic

Refer to Figure 1 to 4.

#### 3. Main Specifications

##### Conventional process:

- Specific consumption of about 126 kWh of fuel / touch-up.

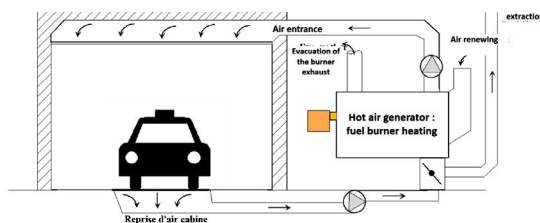


Figure 1 : Conventional process

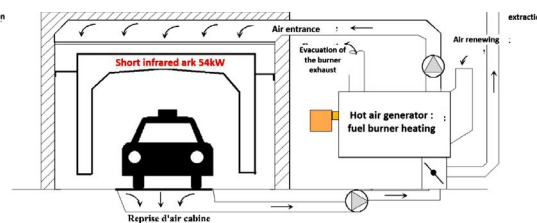


Figure 2 : infrared process

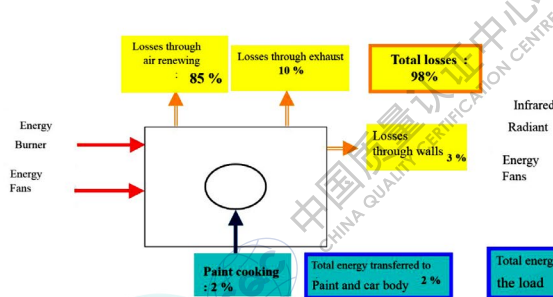


Figure 3 : Conventional process heat balance

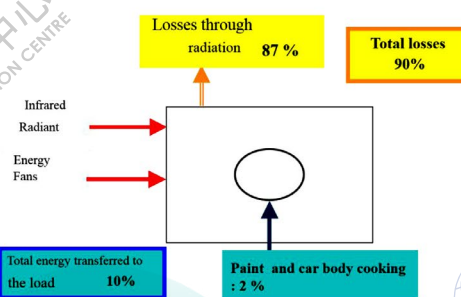


Figure 4 : infrared process heat balance

##### Infrared solution:

- Specific consumption of about 18 electrical kWh / touch up.
- Gain with IR process: 30000 kWh / year. corresponding to more than 80% of the conventional method.
- Cycle time reduced by 3.

#### 4. Scope of Application

Cars paint touch-ups

#### 5. Cost-effectiveness Analysis Investment

- € 30 000 for 50 kW.
- Approximately 300 to 600 € / kW.
- Payback time 2 to 3 years

#### 6. Benefits

Other benefits of the IR solution:

- Energy saving: 80% (selective heating)
- Reduction of cycle times and waiting time
- Increased production
- Shift to solvent free products
- Space saving (storage of vehicles) ■

## Application 2: Pre drying of textiles

### 1. Technical Principle

#### Conventional process:

- Hot air drying tunnel KRANTZ
- 9 blowing natural gas burners Valupak
- cycle time: 40 seconds
- Annual consumption: 5,000,000 kWh

#### Gas Infrared solution:

- Installation MATHERM
- IR power of 320 kW
- Heating zone dimensions : 1.0 x 1.5 m<sup>2</sup>
- Cycle time: 2.5 seconds

### 2. Technical Schematic

Refer Figures 1 to 4.

### 3. Main Energy Specifications

#### Conventional process:

- Specific consumption of about 4.1 kWh of gas / kg of evaporated water

#### IR process:

- Specific consumption of about 3.4 kWh of gas / kg of evaporated water.

### 4. Scope of Application

Textile

### 5. Cost- effectiveness Analysis

#### Investment:

- Energy savings with IR process on drying operation: 300 000 kWh / year being 20% of the conventional method
- Investment of approximately 150 to 200 €/kW
- Payback time 2 to 3 years

### 6. Benefits

- Energy saving: 20%
- Limit the number of train passages
- Increased production of 20% to 40%
- Space Saving
- Cost ■

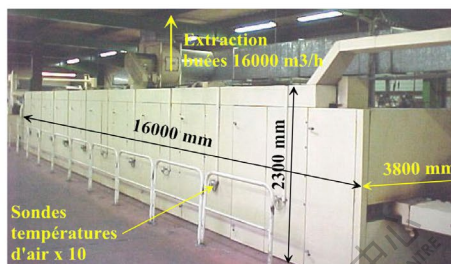


Figure 1 : Conventional process - drying paddle

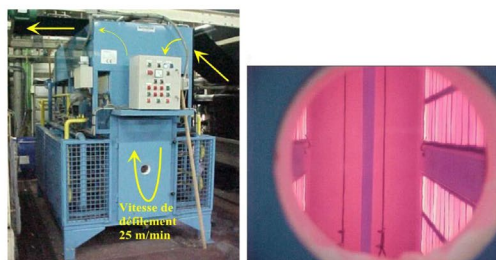


Figure 2 : infrared process - IR pre dryer

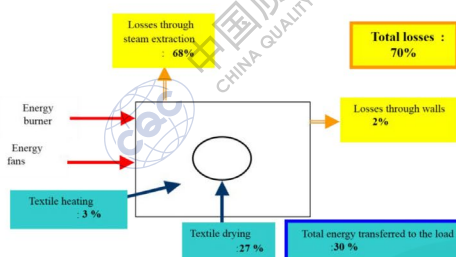


Figure 3 : Conventional process heat balance (textile paddle)

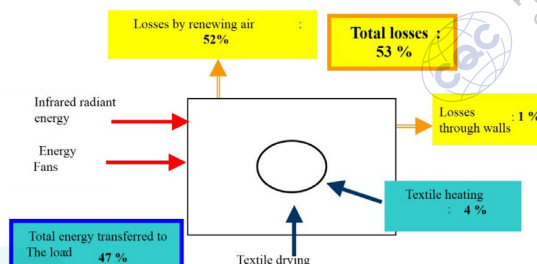


Figure 4 : infrared process heat balance (IR predryer)



### Application 3: Powder paint baking

#### 1. Technical Principle

##### Conventional process:

- Hot air tunnel SUNKISS
- Blowing natural gas burner
- Cycle time: about 15 minutes
- Annual consumption: 1,540,000 kWh

##### Gas Infrared solution:

- SUNKISS Installation
- IR power of 288 kW
- Heating zone dimensions : 4.0 x 1.0 m<sup>2</sup>
- Cycle time: 5 min 30 seconds

#### 2. Technical Schematic

Refer to Figure 1 to 4.

#### 3. Main Energy Specifications

##### Classical solution:

- Specific consumption of 6.4 kWh gas per painted item

##### Infrared solution:

- Specific consumption of 4.2 kWh gas per painted item.

#### 4. Scope of Application

Powder coating and baking

#### 5. Cost- effectiveness Analysis

##### Investment:

- Gain with IR process: 540 000 kWh / year, or 30% of the conventional method
- Reduction of the cycle time by 3
- Saving of approximately € 15,000 / year
- Additional cost of 20%
- Payback time of 2 to 3 years

#### 6. Benefits

##### Benefits of IR solution:

- Better tense
- Flexibility in the regulation
- Heating kinetics
- Energy saving (20%-40%)
- Limited over cost compared to the conventional technique (20%-30%) ■

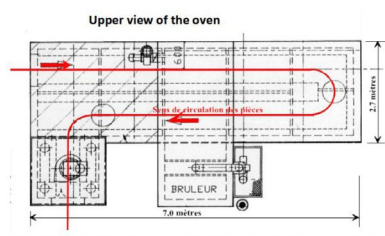


Figure 1 : Conventional process

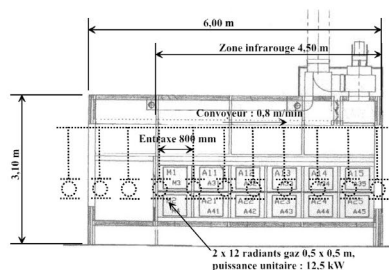


Figure 2 : Infrared process -

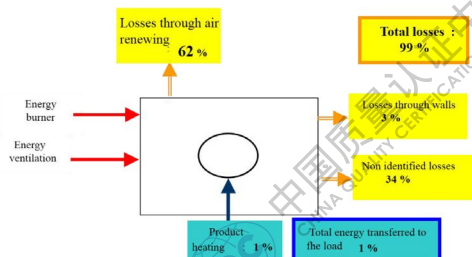


Figure 3 : Conventional process heat balance (hot air oven)

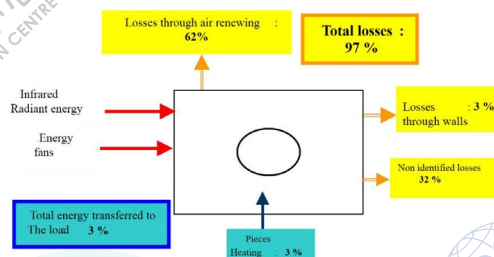


Figure 4 : infrared process heat balance (IR oven)

## BAT2: Variable Speed Drives(VSD) Applied to Centrifugal and Dynamic Machines (Pumps, Fans, Compressors)

### 1. Technology description

**Centrifugal pumps with Variable Speed Drives (VSDs):**  
VSDs installed on pumping systems allow the optimization of the electric consumption.

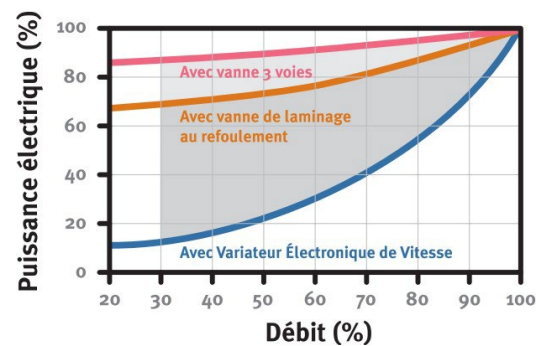
Most centrifugal pumps operate flow regulation using adjusting devices installed on the hydraulic circuits, like valves. These installations use the energy in a non-optimized and non-efficient way. The energy consumption of the circuit can be optimized by reducing the pump rotational speed by adapting the speed of its electrical motor.

VSD is the most appropriate technical solution to adjust the exact energy to the real need.

### 2. Technology schematics

Refer to Figure 1&2.

### 3. Level of Energy Savings



Example: Energy Gain on pumping facility with a VSD

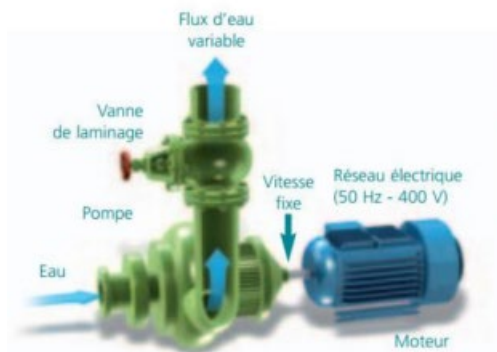


Figure 1 Adjustement through throttle



Figure 2 Adjustement through VSD valve



#### 4. Market prospect

All industrial processes using pumps, compressors, fans etc. with electric motors.

#### 5. Reliability

- The dimensioning parameter for the VSD is the power of the engine.
- The installation location must be chosen before supplying the VSD: existing electrical panels, electrical room or the pump warehouse. The VSDs must be located and protected in a dedicated cabinet.

#### 6. Economic Characteristic

Financial savings are achieved by reduction of electricity consumption.

#### 7. Social Characteristics and co- benefits

Benefits of VSD:

- Reducing the electricity consumption especially when flow variations are important
- Flexibility and precision in operation (smooth start/stop/ regime changing, speed control).
- Presence of automation loops and easier automation of the pumping process.
- Reduced mechanical stress on the pump and pipes
- Pumps noise reduction.
- Smoother start of the motors
- Reduction of reactive power consumption.
- Reduction of CO<sub>2</sub> emissions. ■



## BAT 2 Application Examples

### Application1: Replacement of a classic compressor by a Variable Speed Drive Compressor

#### 1. Technical Principle

##### Context & Issues:

Eternit is a company specialized in the manufacture of roofing, facade and construction materials. After a set of measures carried out on the site of Terssac, a great potential of energy savings has been identified on compressed air production. The introduction of VSD compressors replacing the classical fixed speed compressors brought about 15% of energy savings.

The VSD is the only type of regulation that allows to make energy saving almost proportional (not centrifugal) to the flow rate (on a range from 15% to 100% of the nominal output). Moreover, this technic allows a better precision in maintaining set pressure.

#### 2. Picture



New screw VSD compressor

#### 3. Main Specifications

Fixed-speed air compressors are the most commonly used type of compressors, but VSD compressors today are quite well known in industries and enterprises but not mostly used. They are about 25% more expensive at purchase than a fixed speed compressor, depending on power, but they bring high economies on the life cycle of the product.

#### 4. Cost-effectiveness Analysis

- Financial gains: 3 528€ per month
- Payback time: 11.5 years . 2.5 years on over cost

#### 5. Benefits

- Reduction of polluting emissions, reduction of the consumption of drinkable water for cooling the process.
- No more use of water for compressed air cooling.
- 72 MWh / year, being 9% saving on compressed air production.

Energy balance:

Before: 817 MWh of electricity for compressed air production

After: 7745 MWh per year for production compressed air

- Energy saving: 72 MWh/ year being 9% saving on compressed air production
- Financial gain: 3 528 euros per year ■

## BAT3: Selective and Mass Heating by Microwaves

### 1. Technology description

Two types of electromagnetic radiation are used for industrial applications: high frequency radiation, whose usual frequencies are between 10 MHz and 30 MHz. and the microwave radiation whose frequencies are between 800 MHz and 3000 MHz.

Although the heating processes by high frequency or microwave are based on the same principle, the effect on the product to be heated is different:

- With high-frequency, the wavelengths are bigger than the dimension of the equipment. thus, the laws of electricity at low frequency are still applicable. The generators are oscillators. Voltage and current are carried out through isolated conductors and electrodes distribute the energy to the to-be-heated-products.

- In contrast, with microwave, the wavelengths are smaller than the dimensions of the equipment, the technology is based on the propagation of electromagnetic waves and its properties.

#### Features of the use of heating by microwaves:

- The electromagnetic energy is dispersed inside the product as a function of the electric beam distribution; it is a distant heating.
- The heating system is said « selective » because it directly depends on the permittivity of each product.

- The heating is heterogeneous in the case of a mix of different materials with different permittivity.

- This system is very effective, because it is possible to generate intense field distributions and to apply high power densities (10 kW per litre of product). It is also possible to heat rapidly because the setting of the generators is instantaneous.

- Non-polluting, this system allows a gain of time compared to conventional techniques. Heating by microwaves is often used in complement to traditional techniques such as hot air, infrared radiation

### 2. Technical Scheme

#### Principle of a microwaves heating installation:

Microwave facilities at 915 MHz and 2450 MHz are used mainly in industry. They are constituted of a generator, an applicator, and connecting and measuring circuits.

For these frequencies, the industrial generators are

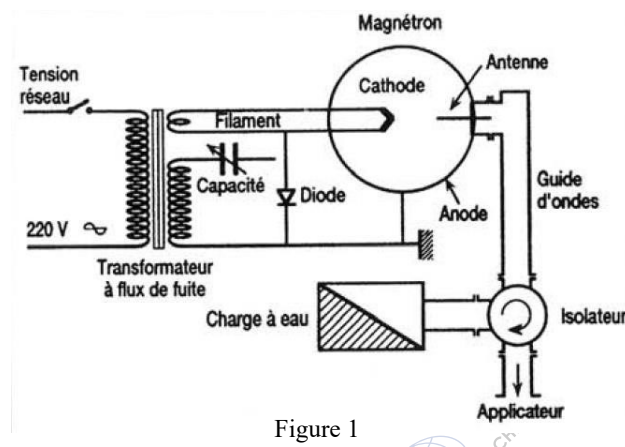


Figure 1

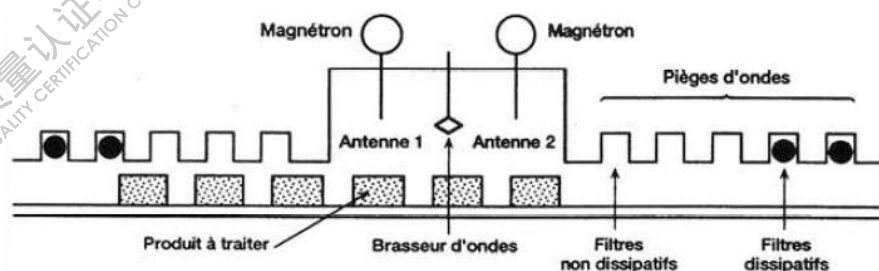


Figure 2

magnetrons, their rated power is between 1.5 kilowatts and 70 kilowatts.

Refer to Figure 1.

#### Multimode tunnel for continuous processes:

Industrial cavities (such as domestic microwave oven) are used for discontinuous processes. For continuous processes, tunnels are used. They are actually a succession of several multimode cavities. Sealed airlocks, hermetic to microwaves leakage ensure the introduction and exit of products.

Refer to Figure 2.

### 3.Level of Energy Savings

The energy saving potential is of course closely linked to the application, but the use of Microwaves and High Frequencies only makes sense when this solution brings significant advantages compared to conventional solutions. In most cases, this heating method generates energy savings of more than 50% of the initial consumption of a process. It can achieve 80% for some applications.

### 4.Market prospect

The industrial applications of high power microwaves are

numerous: drying, baking, pasteurization, vulcanization, waste treatment. In the food industry: cooking, pasteurization, sterilization, drying, defrosting, flavour extraction

### 5.Reliability

This technology has a good maturity, but each application requires a specific design study because the effect of MW and HF depends directly on the product they are used on. The sizing of the applicator must be made case-by-case.

### 6.Economic Characteristics

To be seen case-by-case.

For MW generation, as a general average, pricing is such that 1kW power is 1k€ cost.

### 7.Social Characteristics and co-benefits

The microwaves used for heating purposes bring benefits, often decisive, in the industrial processes they are used in: fast heating, improving the quality of treated products, energy savings, flexibility of use and control, absence of pollution. ■



## BAT 3 Application Examples

### Application 1: Pre-vulcanization of rubber pieces

#### 1. Technical Principle

Heating by microwaves is mainly used for preheating operation before pressurized moulding, and for heating operations of the extruded pieces until they reach the vulcanization temperature (rubber is stiffened with sulphur-based additives). The temperature is then maintained using an electric resistance furnace.

On the rubber pieces' industrial line, the successive operations are:

- Plasticizing: aims to soften the rubber through mechanical working. The temperature reached varies between 75 ° C and 110 ° C;
- Extrusion: the rubber pieces are shaped by passing the rubber through a profile;
- The vulcanization itself comprises two phases:
  - The heating of the material up to its vulcanization temperature in a microwaves oven;
  - The preservation at temperature in a resistance furnace until the end of the vulcanization process;
- Cooling: brings the temperature down to 80 ° C. It is followed by the packaging of the products;

#### 2. Technical Scheme

Refer to Figure 1.

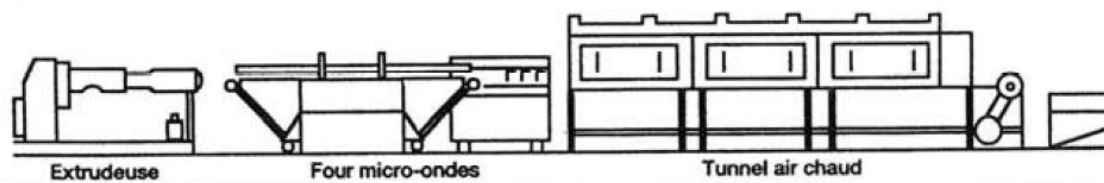


Figure1: Drawings of a rubber pieces extrusion line using microwaves heating.

#### 3. Main Specifications

The microwaves applicators used are generally some sort of resonant cavity at 2450 MHz, or waveguide. A line of 5 kW power microwaves and 20 kW power for the resistance furnace can treat around 100 kg /hour of rubber. Microwaves line of 25 kW power and 45 kW power for the resistance furnace are the most commonly constructed. They can process around 500 kg /hour of rubber pieces with a total consumption of 0.15 kWh / kg to 0.17 kWh / kg, which corresponds to a significant energy saving compared to more conventional systems.

#### 4. Scope of Application

Preheating before moulding operation

#### 5. Cost- effectiveness Analysis

Significant energy savings compared with more conventional systems.

#### 6. Benefits

The advantage of microwaves heating is its ability to quickly raise the rubber's temperature throughout all its mass (for traditional techniques, the complete warming is very slow because the rubber is a poor heat conductor). moreover, the state transition is rapid, which is a guarantee of the good dimensional stability of the products.

## Application 2: Paint drying on foundry moulds

### 1. Technical Principle

#### Conventional process:

- Hot air oven
- Propane gas atmospheric burner
- Cycle time: around 110 minutes
- Annual consumption: 750 MWh (750 000 kWh)

#### Micro-waves process:

- KUTTNER installation
- Micro-waves power potential: 30kW –frequency: 2450Mhz
- Dimensions: 1.6 x 1.6 x 1.5 m<sup>3</sup>
- Financial investment: 115 k€

### 2. Technical Schematic

Refer to Figure 1 to 4.

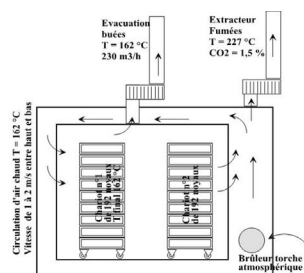


Figure 1 : Conventional process

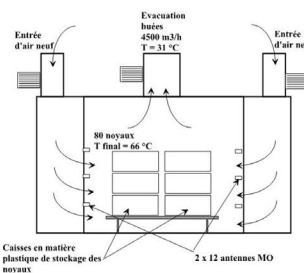


Figure 2 : Microwave process

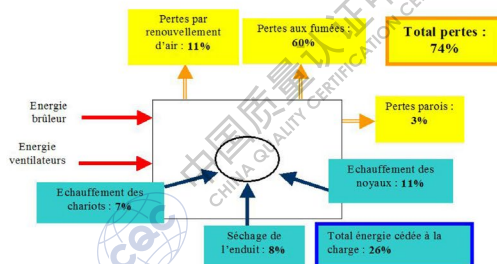


Figure 3 : Conventional process heat balance

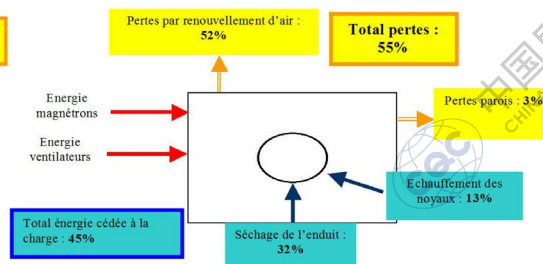


Figure 4 : Microwave process heat balance

### 3. Main Specifications

Conventional Solution:

Specific consumption of 250 kWh gas / tons of moulds

Micro-Waves solution:

Specific consumption: 63 kWh electric / ton of moulds

### 4. Cost- effectiveness Analysis

Investment:

- Overcost compared with classical solution: 40%
- Estimated payback time: 2 years

### 5. Benefits

Advantage of MW solution:

Gain with MW process: 561 000 kWh / year, being 75% of conventional process

Reduction of treatment time by 15. ■



# BAT4: Heat, Cold and Electricity Generation by Tri-generation

## 1. Technology description

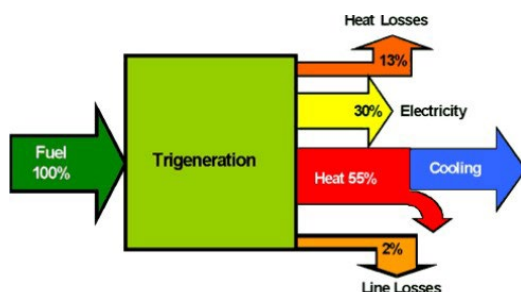
Power generation method (combined cycle) with a very high energy efficiency, generally exceeding 80% to 95%.

It is about producing, from a primary energy (natural gas mostly) 3 different kinds of usable secondary energy:

- A thermal energy, which is used for heating, drying, greenhouse heating, swimming pools, hot water, industrial processes...
- A cold production (produced mechanically or indirectly through absorption refrigeration plant) .
- An electric power. produced with a turbine + dynamo system (direct current) or an alternator (AC), with a transformer to adapt the tension.

The most commonly used primary energy is natural gas, but in theory any kind of energy can be used like gasoline, oil, gas, biogas, waste gases produced by some industries (gases from industrial processes and often wasted), etc.

## 2. Technical scheme



Principe de la trigénération

## 3. Level of Energy Savings

Trigeneration is particularly interesting on an energy level because it allows to use the waste heat from cogeneration outside of the heating periods and to produce cold plus heat for additional uses (domestic water). In the best cases the overall efficiency of the plant is around 85%.

## 4. Market prospect

This system is to be used in industrial processes in need of simultaneously these three kind of energy: heat, cold and electricity.

## 5. Social Characteristics and co- benefits

Reduction of CO<sub>2</sub> emissions:

Optimization of energy consumption.

Trigeneration technology generates an energy saving and an environmental gain while being economically profitable. ■



## BAT 4 Application Examples

### Application1: TRIGENERATION with « double effect » absorption – space centre in Toulouse

#### 1. Technology Principle

In general, a trigeneration plant consumes natural gas in order to produce simultaneously electricity, heat and cold. Compared with the cogeneration solution (which is a simple recovery of lost heat during electricity generation process) or 'simple effect' trigeneration (which consists in transforming into cold a part of the recovered heat), the 'double effect' trigeneration solution chosen by the Toulouse's site presents a better energy performance and a better payback time for a reasonable investment cost.

#### 2. Technical Scheme

Refer to Figure 1.

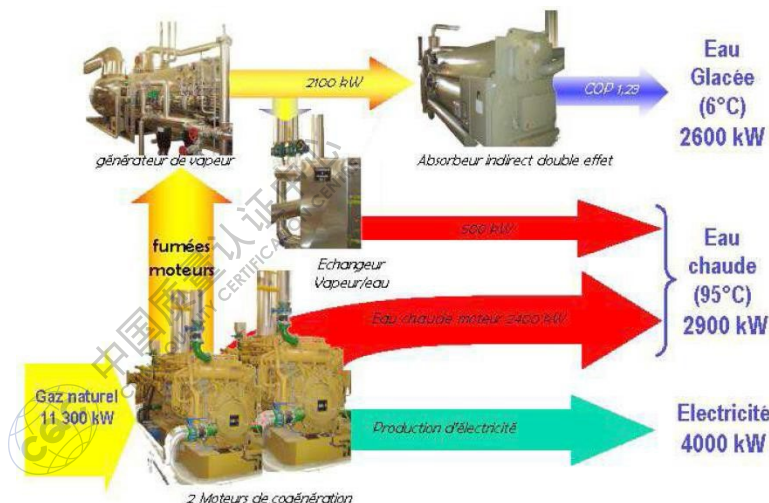


Figure1

## 3. Technical Specifications

The trigeneration in the Space Center relies on the use of two 'Caterpillar CAT 3532 HR SITA' motors that develop an engine nominal power of 2140 kW for a unit consumption of 5 690 kilowatts LHV (lower heating value) of natural gas. Each of these motors drive a SR 4828 type Caterpillar generator of a 2080 kW electric power for a total net electricity generation of 4000 kWe.

#### 4. Main energy specifications

##### Annual energy needs of the site (initial):

- Electricity: 8900 toe \*
- Natural gas: 2233 toe \*

##### Energy Balance of the 'double effect' trigeneration (period: from November 1 to March 31):

- Production of 14 GWh of electricity, 10 GWh of heat and 9 GWh of cold, which represents a saving of around 2 000 toe.
- The heat losses generated by the electricity production are recovered and exploited (in the form of heat or cold) to 80%.

-82% of hot water needs and 85% of cold water needs are covered by this 'double effect' trigeneration

\* Toe: ton oil equivalent

## 5. Market prospect

The operation carried out in the Toulouse Space Center is an exemplary environmental approach and it also constitutes an important step for advanced technology and sustainable development. Indeed, with a reasonable over-cost investment, the "double effect" absorption trigeneration system is now clearly identified as the most efficient solution compared to cogeneration or "single action" trigeneration.

## 6. Cost- effectiveness Analysis

Investment: € 3.85 million

- ADEME Grants: € 457,000 and the

Region's grants: € 152,000

- Over the regulatory period of operation (November 1-March 31)

- Before trigeneration:

€ 425,000 annual expenditures (value 2001)

- With trigeneration: € 243,000 of income (2003- 2004 season) an annual operating profit of €668,000

- Payback period: 5 years (with subsidies)

## 7. Benefits

The use of 6000 Tons Oil Equivalent and the emission of 19,000 tons of CO<sub>2</sub> were avoided. (over the 12-years power resale contract) ■

## BAT5: Mechanical Steam Compressor

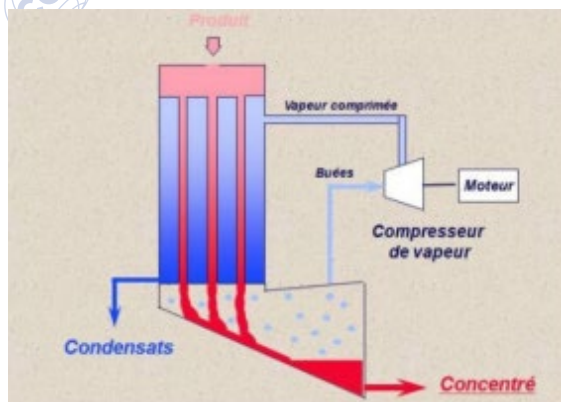
### 1. Technology description

Mechanical steam compression allows the recovery of waste heat contained in the steam derived from a process of concentration, drying etc.

The steam is compressed by a centrifugal compressor.

The resulting product is used on the same process to provide the heat required for the vaporization of a new quantity of steam. Once the process started, it maintains itself without any additional heat energy.

### 2. Technical scheme



Principle of mechanical steam compressor

### 3. Level of Energy Savings

The electricity consumption associated with the compressor operation is usually very low compared to the amount of energy recovered by the system.

It mainly depends on the compressor's compression

ratio, which is the difference between the inlet and outlet vapour temperature.

Coefficients of performance (COP) are variable and can reach very high levels, ranging from 5 to 30.

Depending on the application the mechanical steam compression system allows the use of 7 to 50 times less energy than heating from boilers and 4 to 5 times less energy than a multi-effect technology.

### 4. Market prospect

This technique has many applications like in the industrial effluent concentration (e.g.: black liquor from paper mills) or food products (grape juice, tomatoes, etc.), crystallization, surface treatment, desalination of sea water, agro food industry, paper, chemistry etc.

### 5. Social Characteristics and co-benefits

This technique consumes little electricity: 10 kWh / tones to 20 kWh / tones of evaporated water (which corresponds to the motor power supply).

#### Advantages:

- Reduced primary steam needs
- Space saving
- Reduction of the effluents volume

#### Disadvantages:

- Compressor's maintenance and control
- Risk of corrosion (quality of inlet steam)
- Decreased performance with the product concentration ■



## BAT5 Application Examples

### Application1: Mechanical steam recompression in a dairy company: steam recompression, reused and re-introduced into the industrial process

#### 1. Technical Principle

##### Original process:

- Steam is injected into an evaporator in order to heat the milk. Use of an -- 6 effects -- evaporator (3 tons of steam / hour).
- Required steam: 15 bars-110 gr steam for 1kg of water
- The steam is condensed and discharged into the natural environment (T 57 °C - < too low to be reused in the process).

##### MVR process:

- A MVR is installed on the evaporator
- The MVR recover the steam and recompress then
- The steam thus produced is reintroduced in the

evaporator

#### 2. Technical Scheme

Refer to Figure 1.

#### 3. Benefits

Allows to reduce the steam need by:

- Modification of the buildings and construction of a concrete foundation to support the compressor.
- Adaptation of piping: modification of evaporation inputs and outputs (to allow an exchange between the incoming milk and the outgoing condensates, in order to cool the condensates before their storage and to recover calories for milk heating), modification of condensates and washing piping.
- Implementation of measuring devices in order to permit the automation of the compression system
- Implementation of sheaths to recover steam milk. ■

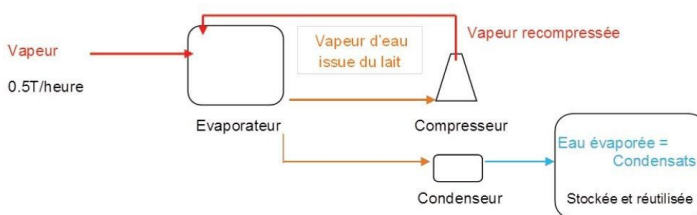
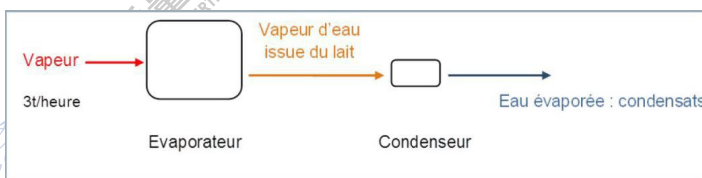


Figure 1

## BAT6: Gas Absorption Heat Pumps

### 1. Technology description

The system functions in a closed cycle:

- Absorption of the ammonia ( $\text{NH}_3$ ) gas in the presence of water to form a concentrated ammonia solution ( $\text{NH}_4\text{OH}$ ).

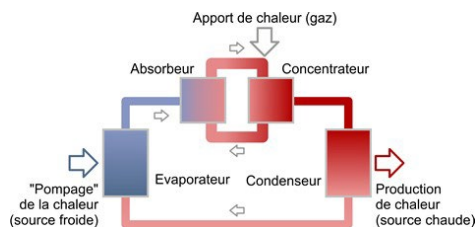
This action releases a large amount of high temperature heat.

- This ammonia solution ( $\text{NH}_4\text{OH}$ ) is desorbed, which allows the release of ammonia ( $\text{NH}_3$ ) gas. This desorption action needs heat.

The principle is the use of ammonia ( $\text{NH}_3$ ) in a secondary cooling cycle that will 'pump' the heat from a cold source (in the evaporator) and return it to the hot source (the condenser): this heat is free.

By combining the release and the absorption of heat along the whole process, the energy balance is clearly positive.

### 2. Technical Schematic



### 3. Level of Energy Savings

Some manufacturer claims performance (Coefficient of Performance) of about 150%. The performance gas absorption heat pump is influenced by the parameters shown in the table below:

Influent parameters	Level of Influence
Cold source temperature	low
Hot source temperature	average
Charge rate	high

### 4. Market prospect

An innovative solution to meet the thermal requirements of collective housing and tertiary buildings, for construction as for rehabilitation.

### 5. Economic Characteristics

An economical solution:

- Significant operating gains thanks to very high returns on primary energy.
- The geothermal version is immediately profitable thanks to heat recovery from the absorption reaction: the required probes size is reduced to 70% compared to an equivalent electric heat pump.

The net price for the installation of a geothermal heat pump absorption gas is about €14,000 VAT (source: CEGIBAT-GRDF).

### 6. Social Characteristics and co-benefits

- Respect of the environment
- Use of eco-friendly refrigerants fluids that respect the ozone layer (without HFCs or HCFCs).
- Qualities of natural gas: cleanliness, flexibility, and use of combustion products with low levels of  $\text{CO}_2$  and  $\text{NO}_x$ .
- Contribute to sustainable development by minimizing the greenhouse effect.

Source: Energie plus / ATEE ■



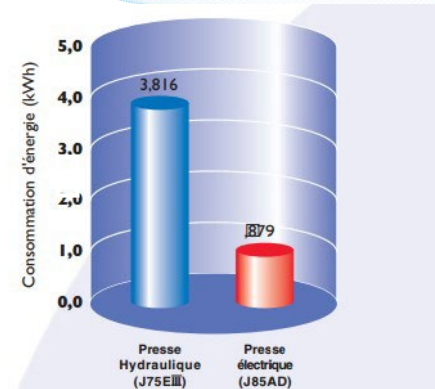
## BAT7: Electrical Injection Moulding Press

### 1. Technology description

An electric press uses electric motors instead of the hydraulic activation system of the cylinders.

Therefore, all losses linked with the hydraulic system are eliminated.

The electrical power of the machine is the power rating indicated on the press.



### 2. Technical Scheme

All electric injection press (source FARDI).



### 3. Level of Energy Savings

Electricity consumption reduced by 50% to 70%.

Energy savings from hydraulic to electric press (source FARPI).

Automotive, medical, electronics (mobile phones ...), packaging, technical mouldings (household appliances, furniture gardens, toys.)

### 4. Market prospect

### 5. Economic Characteristics

In terms of profitability, the fully electrical press has



a decisive advantage on the conventional hydraulic press which is his very low operating cost: electricity consumption up to 60% lower,very low cooling water consumption,no waste oil treatment,little maintenance.

The electrical press also brings an increase in productivity (shorter cycle times),an improved production quality,decrease number of pieces which contribute to a significant improvement in the profitability of electric presses.

#### 6.Social Characteristics and co- benefits

- Electricity consumption reduced by 50% to 70%
- Accuracy and repeatability starting from the early cycles
- More oil
- Low water consumption
- Low noise level <65dB

- High measurement accuracy for positions and speeds:

-Positioning accuracy to 0.01 mm

-Accuracy 10 times higher than for a hydraulic press

-No set point overshoot risk

-Accuracy and repeatability on all machine movements

- Direct impacts on the quality of the moulded parts:

-Accuracy and consistency of the injected volumes

-Reduction of waste (due to the reduction of non-compliant pieces) decrease of material cost...)

- Facilitates automation (robotics,gripper,...)

- Accuracy and repeatability of the opening movement and ejection

(Source BILLION 2011) ■

## BAT8: Regenerative Self-recuperative Burners

### 1. Technology description

Recuperative and self-regenerative burners have been developed to allow the direct recovery of waste heat by preheating the combustive air.

A recuperator is a heat exchanger that extracts the heat from furnace outgoing flue gases to preheat the combustive inlet air. Compared with ambient air combustion systems, energy savings can reach 30%. They usually preheat the air to a maximum temperature of 550°C to 600°C. It is then possible to use recuperative burners in high temperature processes (700°C~1 100°C)

Regenerative burners work by pairs and on the principle of short-term heat storage using ceramic heat regenerators (see drawing). They recover between 85% and 90% of the waste gas heat, therefore the incoming combustion air can be preheated to very high temperatures of up to 100°C to 150°C below the operating temperature. It can be applied to temperatures ranging from 800°C to 1500°C. The decrease in fuel consumption can reach 60%.

### 2. Technical Scheme

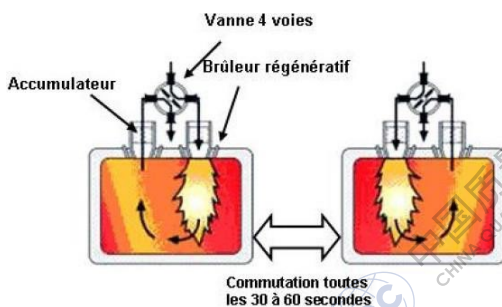


Figure: Operating principle of the regenerative burners.

### 3. Level of Energy Savings

In industrial furnaces, combustive air can reach temperatures of between 800° C and 1350 ° C, through a high performing heat exchanger. For example, a modern regenerative heat exchanger switched on a high cycle can recover of about 90% of the waste heat, which generates large energy savings.

### 4. Market prospect

Widely Applied.

### 5. Reliability

The main technological constraint for recuperative/regenerative burners is the conflict between technologies designed to reduce emissions and those focused on energy efficiency.

The formation of NO<sub>x</sub>, for nitrogen-free fuels, usually depends on the temperature, the oxygen concentration and the residence time. Due to the high temperatures of the preheated air and to the residence time, the flames have a peak of temperature that lead to an increase in NO<sub>x</sub> emissions.

### 6. Economic Characteristics

These burners have the disadvantage of their investment cost. Reducing energy costs alone rarely permits to compensate the initial additional investment. This is why the increase in productivity within the furnace and the reduction of emissions of nitrogen oxides are important factors to include in the cost / benefit analysis. ■

## BAT 8 Application Examples

### Application 1: Heat recovery on an industrial furnace burner

This sheet concerns the implementation of a regenerative or a self-recuperative burner (self-regenerative or pair of regenerative burners), or the implementation of a centralized heat recovery of fumes to preheat the combusive air of an industrial natural gas furnace, at a temperature over 600°C.

A gas burner is a mechanical element which ensures the production of heat by mixing a fuel gas with air containing oxygen. This mixture produces combustion.

Except in the few cases for which it is possible to consume most of their heat, the fumes leave the furnace at a temperature which may still be high, often close to the operating temperature. It is therefore interesting, to limit energy consumption, to recover the thermal energy contained in the fumes before they are released to the atmosphere to preheat the combustion air. Thus, the inlet air is already preheated and allows a reduction of as much as the spared gas consumption.

#### 1. Technical Principle

The devices to implement the recovery are described below.

##### **(1) The hot air burners: heat recovery on exhaust or centralized recovery system**

The system works with a gas heat exchanger placed at the furnace outlet to preheat the intake air. The heat recovery is called 'centralized' because all the exhaust leaving the furnace as well as all the air injected into the furnace pass through this exchanger.

The efficiency of the recovery is related to the system ability for preheating the combusive air. The recovery efficiency of this type of burner is between 40% and 50%.

In some cases, the furnace fumes are diluted with some fresh air before entering the heat exchanger in order to avoid damaging it.

##### **(2) The self-recuperative burners**

The combustion chamber is a metal or a ceramic tube open at its end. The entering air passes near the return of hot fumes. The burner possesses fumes recirculation system (fins, asperities on the burner tube) to increase the exchange surface with the incoming combustion air. It is used 'alone' for direct heating or encapsulated in a radiant tube. These burners are used for two types of temperature ranges: 600°C~1000°C and 1000°C to 1300°C.

The areas of application are first heat treatment batch furnaces or other furnaces with long treatment duration.

The recovery efficiency of this type of burner is between 50% and 70%.

##### **(3) Self-regenerative burners and pairs of regenerative burners**

These burners are associated in pairs: the first one works while the other, stopped, 'vacuums' the fumes of the first one and heats a thermal mass ceramic (the regenerator). Then the air of the second warms passing through the regenerator. They alternate the operations each minute.

If installed with well-sealed valves and complete control systems, the burner can be self-regenerative and vacuum its own fumes through a set of heat loads disposed locally around the burner nose.

These burners used at high temperatures (700°C



~1400°C) are very economical in operation but still require a big initial investment and should operate in a clean environment (absence of clogging or pollution of evaporated metal).

These systems allow preheating the air up to 50°C below the process temperature.

The main application areas are those where the temperature is high enough for the investment to be relevant. Today it mainly concerns glass melting furnaces, aluminium reflow ovens, steel reheating furnaces and heat treatment furnaces.

Burners of this type have a recovery efficiency of 70% to 90%.

## 2. Technical Scheme

Refer to Figure 1 to 4.

## 3. Scope of Application

The data from the literature and from manufacturers demonstrate that these burners only bring significant energy gain for the furnaces of over 600°C. Thus, the considered park concerns industrial furnaces whose temperature is higher than 600°C.

The available statistical data are based on the CEREN Study No. 0305 'extrapolation of equipment in 2008 in the industry' in September 2011.

Refer to Table1.

## 4. Energy Saving Capacity

The energy savings brought by replacing classical burner by heat recovery burner only come from the preheating of the air in the burner. They depend on the following criteria:

Criterion 1: Nominal power of the burner. It represents the furnace gas power need.

Criterion 2: Annual average load factor of the burner. This is the ratio between the energy supplied during a determined time interval, and the nominal power in continuous operation multiplied by this time interval.

Criterion 3: Annual operating time.

Criterion 4: Gains related to the combustion air heating. This is the function of the outlet fumes temperature and the temperature of the preheated air.

The values of recovery efficiency (noted  $\epsilon$ ) for different types of recuperators are as follows:

-40% to 50% for centralized heat recovery systems, which

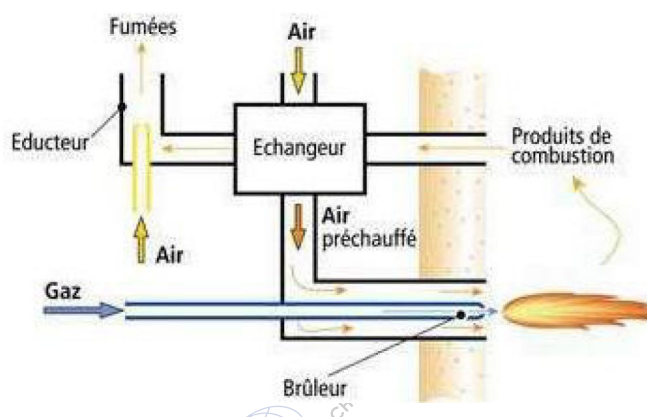


Figure 1: centralized recovery

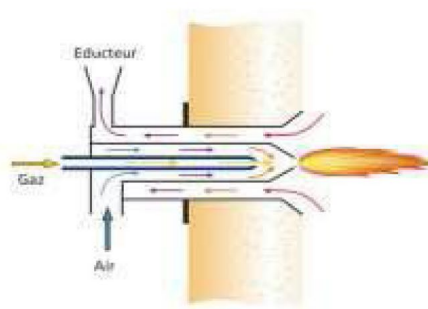


Figure 2: self-recovery system

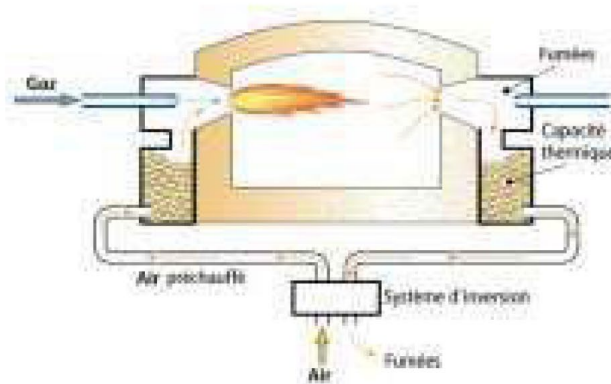


Figure 3: pair of regenerative burners

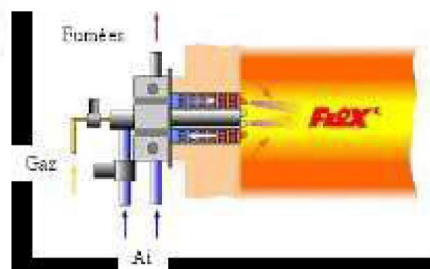


Figure 4: self-regenerative system

Table 1

Application	600-750°C	750-1000°C	1000-1250°C	> 1250°C
Fusion de ferreux				X
Fusion d'alliages légers (aluminium...)		X		
Fusion d'autres non ferreux (cuivre, bronze...)		X	X	
Traitement thermique de ferreux	X	X	X	
Traitement thermique de non ferreux	X			
Chauffage avant formage de ferreux (forge)			X	
Chauffage avant formage de non ferreux (forge)	X			

preheats the air for a hot air burner.

-50% to 70% for self-recovery burners.

-70% to 90% for (self) regenerative burners.

## 5. Implement Cases

Increase of the capacity of a rotary hearth furnace for heating steel billets by continuous regenerative heat exchanger (Valti): 20% in specific fuel consumption, +33% at max production.

Construction of a new forging mobile hearth furnace equipped with self-regenerative burners (Forecast): -50% of CO<sub>2</sub> emissions, NO<sub>x</sub> < 250 mg/ Nm<sup>3</sup> to 3% O<sub>2</sub>.



## BAT9: Very High Efficiency Electric Motors

### 1. Technology description

The operating principle of electrical motors is very simple. In physics, we know that the application of an electric current in a magnetic field generates a mechanical force.

An electric motor contains coils of wire (same wire as the one used to carry the current). This coil winding is perpendicular to the magnetic field of the electric motor. As a magnetic field has always two poles, the ends of the wires are placed in opposite directions. This configuration creates a rotary motion.

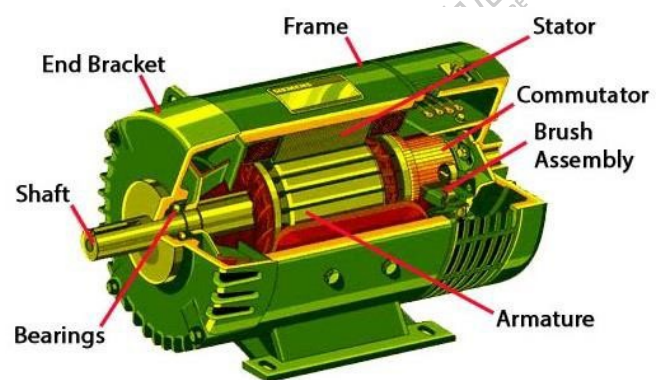
The torque is controlled by increasing the wire windings on the armatures. The magnetic field is generated by an electromagnet. This design allows the rotor to pivot under the influence of the electromechanical force. Very few parts are exposed to wear. With these two factors combined, the electric motors can operate for extremely long periods of time, almost without wearing.

The efficiency of an electric motor is given by the ratio between the delivered mechanical power and the electrical power consumption. The increase in efficiency allows for the same delivered mechanical power, to consume less electricity. For the manufacturers, the search of electrical efficiency is driven by the environmental objective, but also by looking for economy and performance.

The purpose of using efficient engines is to achieve the

same work than with a traditional engine while consuming less energy. It is therefore very important to choose the right motor for the job. For optimal performance, it is recommended that the engine load level corresponds to about 75% to 90% of the nominal motor power.

### 2. Technical scheme



- The frame: it contains all the components of the electric motor.
- The shaft: It receives the energy generated by the motor rotation. It transmits it to an external system via a mechanical connection. A metal part extends outwardly of the frame.

The stator: it is stationary and it is usually the magnet of the electric motor. It can be a permanent magnet or an electromagnet. An electromagnet includes windings usually made of copper wire.

The commutator: located near the stator, it reverses the direction of the current in the device. It is one of the only moving parts of the electric motor.



**Brushes:** The brushes are in contact with the commutator and complete the electrical circuit required for the passage of the current to the windings.

**Bearings:** They carry the motor shaft and are mounted in the frame walls. They allow a free rotation of the shaft with a minimal friction and eliminate interfering movements.

**Armature:** This conductive component is located. Through the combined effect of the magnetic field and the winding, it generates the mechanical torque which triggers the rotation of the shaft.

### 3. Level of Energy Savings

A motor rated IE2 reduces the energy loss by 40% on average. It is recommended to install from now on an IE3 high-efficiency motor. Although the cost of buying a high-efficiency motor is higher, the energy savings will quickly offset the initial investment as energy represents more than 80% of the full cost of an engine.

It is estimated that a high-efficiency motor (IE2 or IE3) is paid back in between 24 and 36 months, for a lifetime of about 15 years. For example, for a 15 kW motor, working

during 6000 hours/year, the economy will be of about 4MWh/year (being 200 € / year, with a kWh costing 0.05 €)

### 4. Market prospect

In the industry and the tertiary buildings, the motors are everywhere. Conveying, cooling, ventilation, pumping, compressed air... It is estimated that 70% of electricity consumption in the industry is due to the motors.

### 5. Reliability

New standards:

- IE1: Standard efficiency, level equivalent to Eff2
- IE2: High efficiency, equivalent to Eff1 or 'Energy Efficiency' in the US (EPA Act '92), applicable from June 2011
- IE3: Premium efficiency, new in Europe or 'Nema Premium' in the US (EISA) applicable starting January 2015 (or 2017 depending on the powers)
- A fourth class is under consideration: IE4: super premium performance.

For high-efficiency motors as for their conventional counterparts, power, speed, and the environment are the main criteria of choice, as well as the targeted application.

### 6. Economic Characteristics

High performance requirements certainly lead to an increase of the engine cost at purchase. But this increase is offset by the energy savings made throughout the whole life of the engine. In the end, the life cycle cost of high-efficiency motors (IE2 or IE3) would be much lower and made profitable on average between 24 to 36 months.

### 7. Social Characteristics and co-benefits

Engines consume less energy efficiently and heat up less, extending the life of the bearings and windings. ■

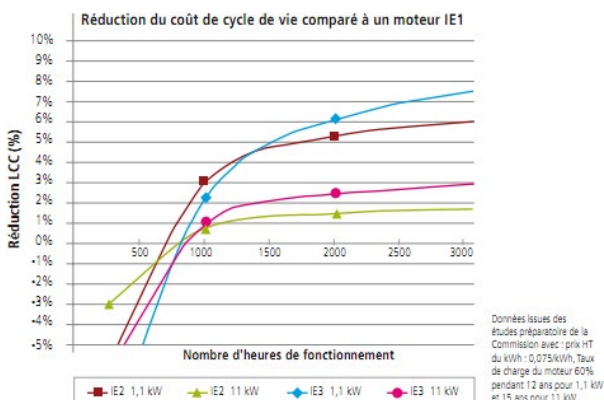


Figure: Comparison of the life-cycle cost between high-efficiency motor IE2 and IE3

## BAT10: Industrial Heating Baths Using Immersed Compact Tubes (ICT)

### 1. Technology description

In the fabrication of the tubes, the stripping/ pickling step requires heating baths (acids baths, rinsing baths, etc ...).

The heating of the bath was previously provided by a boiler:

- The acid baths were heated by circulation on a graphite exchanger heated by the vapor coming from the boiler.
- The rinsing baths were heated by immersed coils with condensate recovery.

In 1999, the company was confronted to the problem of compliance of its boiler with the standard for monitoring steam generators. Given the age of the existing boiler, it was decided to replace it: two options were available:

- Purchasing a new boiler
- Investing in a solution with immersed compact tubes.

Despite the higher initial investment, the company decided to choose the immersed compact tubes solution, that reduce by almost half the running costs, especially through the energy savings generated. To ensure a better exchange, some basins had to be modified. In other cases, the tubes have been placed in auxiliary tanks.

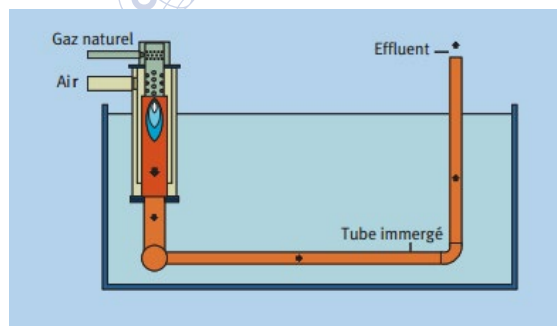
During the immersed combustion process, the products of gas combustion indirectly heat the liquid. The heat transfer takes place through the tube immersed in the bath and in which the hot gases are pushed from their source.

The gases emerge at the end of the tube located outside the basin.

### 2. Technical scheme



Immersed Compact Tubes



Heating Process

### 3. Level of Energy Savings

By modifying its process, the company achieved a 40% energy saving on heating baths.

### 4. Market prospect

Surface treatment basins, every kind of industrial baths.

## 5. Reliability

Mature technology.

## 6. Economic Characteristics

Refer to Table 1.

## 7. Social Characteristics and co-benefits

Beyond the achieved energy savings, the elimination of the steam in the pickling/stripping workshop has simplified the piping system, it has reduced the consumption of

drinking water and the condensates generated and it reduces the risks associated with the generation of steam.

**In a more general manner, the technology of immersed compact tubes allows:**

- An efficiency that can reach 77% to 81%
- Reduced dimensions compared to conventional systems, allowing thus the installation of the in baths of binding forms, narrow or shallow.
- An excellent profitability ■

Table 1

Bilans	ANCIEN PROCÉDÉ	NOUVEAU PROCÉDÉ
<b>Bilan des matières</b>		
Consommation d'énergie pour le chauffage des bains (MWh/an)	10 867	6 520
<b>Économie (MWh/an)</b>		4 347
<b>Bilan économique</b>		
Economie d'énergie (€/an)		58 500
Economie de frais de maintenance et de traitement des eaux résiduaires (€/an)		21 000
<b>Économie annuelle (€/an)</b>		79 500
<b>Investissement (€)</b>		75 000
<b>Amortissement de l'investissement</b>		11 mois



# Second Batch of Domestic TOP TENS List

## France Industrial BP List

Edited by Wei Han

### BP1: Cooking of Food Products Using Micro-waves

#### 1. Technology description

##### Conventional process:

- Steam Autoclave
- Cycle time: about 60 minutes
- Cooking temperature: 95°C ~
- Specific consumption: 0.65 kWh/kg product

##### New microwave solution:

- SAIREM Installation
- Tunnel with a conveyor belt
- Microwave of 24 kW power and hot-air battery of 12 kW
- Tunnel dimensions: 9x1m<sup>2</sup>
- Cycle time: 20 minutes
- Cooking temperature: 95°C

#### 2. Technical scheme

Refer to Figure 1&2.

#### 3. Level of Energy Savings

Classical solution: specific consumption of 0.65 kWh gas / kg of treated product.

MW solution: 0.20 kWh electric / kg of treated product.

Energy gain with MW solution: 7% of the process.

#### 4. Market prospect

Food Industry.

#### 5. Economic Characteristics

- Additional cost compared to conventional solution: 40%



Figure1: Microwaves Tunnel

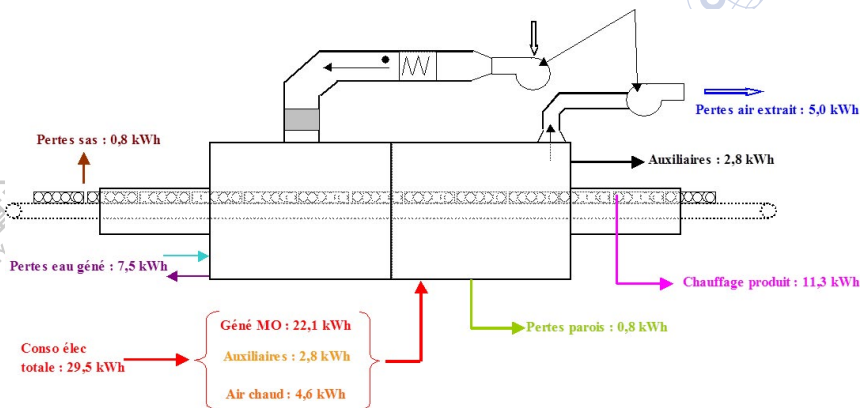


Figure2: Microwaves Tunnel-Process heat balance

- Estimated payback time: 2 years

## 6.Social Characteristics and co- benefits

### Advantages of the MW solution:

- ~ 70% energy saving.
- Continuous and rapid treatment (20 minutes against 60

minutes in autoclave).

- Increased productivity by 30%.
- Space saving: a tunnel replaces 3 MW autoclaves.
- Improved quality of finished products.■

## BP2: High Frequencies for Gelation of PVC Coverings

### 1. Technology description

#### Conventional process:

- Furnace forced air
- Heat exchanger associated with a gas burner
- Cycle time: about 2 minutes
- Annual consumption: 6,300,000 kWh

#### 27.12 MHz High frequency solution:

- HF power of 270 kilowatts
- Length: 3 m
- Production rate 900 kg/h
- Cycle time: 10 seconds

### 2. Technical scheme

Refer to Figure 1 to 4.

### 3. Level of Energy Savings

Energy saving: 78%

### 4. Market prospect

- Thermal gelation of rubbers and plastics
- PVC coating manufacturing and linoleum

### 5. Economic Characteristics

Reduction of cycle time by 12.

Gains with the MW process:

4900 000 kWh/year, representing 78% of the hot air process.

### 6. Social Characteristics and co-benefits

#### Classical solution:

Specific consumption of 1.87 kWh/kg of plastisol.

#### HF solution:

Specific consumption of 0.4 kWh/kg of plastisol.

Gains with the HF process: 4,900,000 kWh/year, representing 78% of the hot air process.

#### HF solution advantages:

Energy saving: 78% (selective heating) .

Reduction of gelling time by 10.

Product quality improvement .

50% reduction of gas emissions. ■

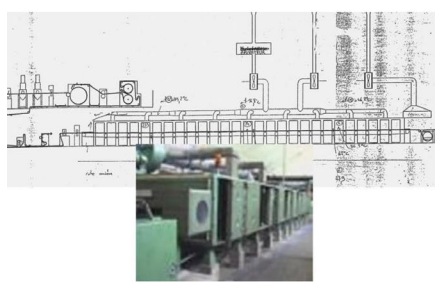


Figure 1 : Conventional process

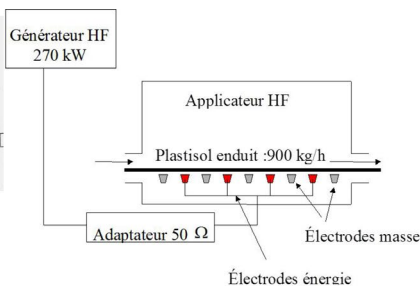


Figure 2 : PVC Gelling by High Frequency process

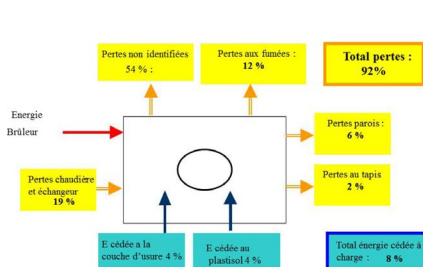


Figure 3 : Conventional process heat balance

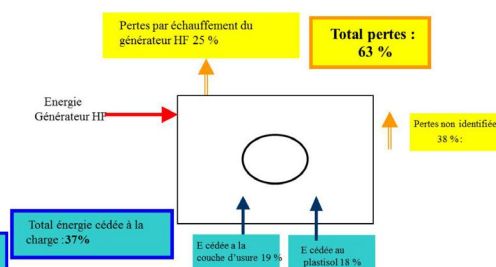


Figure 4 : PVC Gelling by High Frequency process heat balance



## BP3: High Frequency Sticking of Composite Products

### 1. Technology description

#### Conventional process:

- Heated Veneer Press (circulation of hot water - conduction heating)
- Natural gas boiler
- Cycle time: about 10 minutes
- Annual consumption: 72.7 MWh

#### High frequency solution:

- EURO HERTZ Installation
- HF installed power of 24 kW - frequency of 27.12 MHz
- Dimensions: 2.0 x 1.0 x 0023 m<sup>3</sup>
- Cycle time: 70 s

### 2. Technical Scheme

Refer to Figure 1 to 4.



Figure 1 : Conventional process



Figure 2 : sticking composite parts by High Frequency process

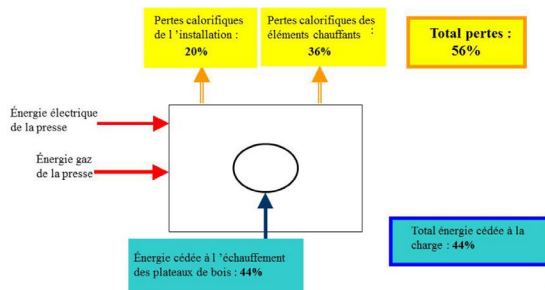


Figure 3 : Conventional process heat balance

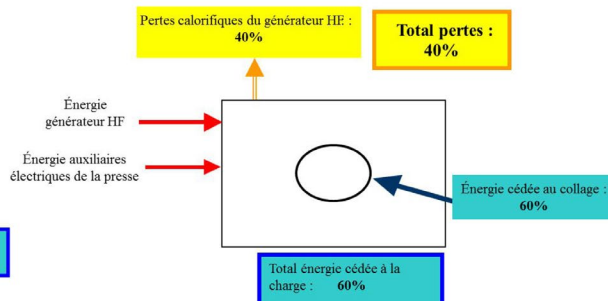


Figure 4 : by High Frequency process heat balance

## BP4: Recovery of Animal Fats and Transformation into Biofuel

### 1. Technology description

The technology implemented involves two different phase:

The first one concerns the recovery of waste animal fat and its transformation into animal oil. Creation and implementation of a special static lamella clarifier that is used to separate (i) oil (ii) solids parts (iii) water.

The second phase concerns the transformation this animal oil into bio-fuel and its combustion in the boiler. For burning the bio-fuel in the boiler, an alternative gas/fuel burner has been adapted into an alternative gas /bio-fuel burner.

The Argoat workshop company annually produces about 500 tons of sausages, of which 90% is hand processed.

However, the finished products represent only 30% of the initial raw materials purchased. The remaining 70% are mainly composed of fat and water polluting discharges.

The company has implemented a comprehensive and systemic solution of waste recovery and their transformation into biofuels and marketable co-product. For this, the animal fats are trapped at the working table, melted out, and decanted in order to separate, water solids and animal oil.

### 2. Technical Scheme



Figure 1: Retention basin and storage tank



Figure 2: Hot water tank



Figure 3 : Lamella clarifier



Figure 4: New boiler



Figure 5: 'Biothermie' reactor

### 3. Level of Energy Savings

Decrease of 20% in the electricity bill and 60% in the gas bill.

### 4. Market prospect

Any kind of animal fats.

## 5. Reliability

Emerging technology, which requires a comprehensive approach of process management and adaptation of technologies for optimization of co-products.

## 6. Economic Characteristics

**The installation has cost € 380,000:**

- Recovery of fats and oil processing: € 197,000
- Oil processing into bio-fuel and combustion in the boiler: € 183,000.

**Gains generated:**

- Decrease of the volume of waste: gain € 16,000 per year
- Decrease of of pollution generated: gain € 8,000 per year
- Decrease of of gas consumption: gain € 45,000 per year
- Decrease of power consumption: gain € 7,000 per year
- Sale of the marketable co-product: gain € 15,000 per year

Nevertheless, it must be assigned to all these gains the costs of the implementation of the process, monitoring and maintenance tools for about € 20,000 per year.

## 7. Social Characteristics and co-benefits

**Significant reduction of environmental impacts:**

- The pollutant loadings were reduced by 23%

-The water recovery at the end of the process is increased by 10%

-The fossil fuel consumption has decreased by 60% due to the use of new bio-fuel from animal fat.

**In addition, installation generates significant induced savings:**

-On the sanitation bill.

-By the sale of animal oil surplus.

-By the diminution of about 50% of the waste removal bill.

Moreover, there was a significant drop in the number of workplace accidents due to improved cleanliness of the working areas, less greasy and thus less slippery.

**Figures of the energy gains and environmental impacts are the followings:**

-Reduction of waste volume: 180 tons

-Decrease of the pollution generated by the company:

BOD5: - 23%

COD: - 28%

-Decrease in the consumption of fossil fuels (gas): currently 60% being 70 tons over a full year.

-Reduction of the electricity consumption: about 20% being 110 MW.

-Creation of a co-product instead of waste: 50 tons.

-Creating a renewable energy: about 80 tons. ■



## BP5: Waste Heat Recovery (Exhaust Gases, Compressor Cooling Systems, Data Centers...)

### 1. Technology description

Depending on the temperature at which the heat sources are available on the industrial site and the nature of needs (local and / or external), heat can be recovered:

By means of a heat exchanger, the heat is transferred to other fluids / processes / storages: for example, the heating of premises, the heating of other fluids/processes onsite, etc.

The temperature of the process determines the recovery method to be implemented. In all cases, the energy can be recovered under the form of heat or mechanical work (which can be converted into electricity or used to raise the temperature of another heat source).

### 2. Level of Energy Savings

The lost heat (called waste heat) represents in the french industry a potential of more than 100 TWh of which 60% to over 100°C.

### 3. Market prospect

Chemicals, plastics, paper, metals, agro-food industry.

### 4. Reliability

Mature technology.

### BP5-application: Heat recovery from a boiler exhaust in an equipment manufacturer

#### 1. Technical Principle

An energy audit showed that 7%-8% of the boiler output was going up in fumes. The company thus installed a heat recovery on the chimney flue, which recovers the heat to preheat the water of chemistry process.

This water is pre-heated from 15°C to 46°C. It resulted a 7.2% saving on gas consumption. A buffer tank was also installed in order to store the hot water and maintain the temperature, because the process water is not consumed continuously by the chemistry process unit.

Finally, monitoring is performed through a flow meter and two temperature sensors (input and output of process water), which allows to calculate the energy saved.

#### 2. Co-benefits

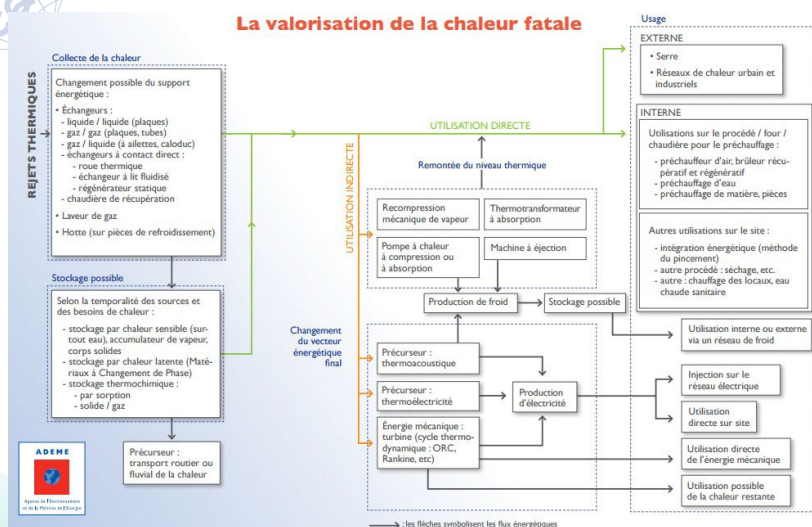
145.8 tons of CO<sub>2</sub> avoided

#### 3. Cost-effectiveness Analysis

Investment costs: € 150,000

Financial gain: € 70,000 / year

Payback time: 2.1 years.



## BP6: Optimization of Refrigeration Facilities with the Use of Floating High Pressure and Floating Low Pressure Controls; VSD on Fans and Compressors

### 1. Technology description

#### **Floating high pressure:**

The floating high pressure control is a method of regulation that consists in adjusting the condensing pressure to the outside temperature and allow the lowest consumption possible of the whole system (compressor, condenser and auxiliaries). A difference of 10°C between the pressurized condensate and the exterior temperatures is enough for the system to work efficiently. The Floating Head pressure control is an electronic system that will regulate the condensing temperature in relation with the ambient air temperature. This system is made to avoid over pressurization and overworking of the compressor which would require more energy from the compressor for no reasons.

Reducing the high pressure is interesting in terms of energy: when the high pressure decreases, the compressors coefficient of performance increases and inversely. By reducing the high pressure, we adapt the condensation temperature. As the condensation temperature is closely linked to the coefficient of performance, it results a better efficiency of the compressors.

In terms of financial gains, 1°C decrease on the

condensation temperature allow an economy of about 2,5% on the consumption, and this gain can go up until 35% depending on the variation of the outside air. The payback back time is usually between 2 and 4 years.

#### **Floating Low Pressure:**

The floating low pressure functions on the same model as the Floating Head Pressure. This time, the control system can rise the evaporation temperature to reduce the compression ratio and improve the coefficient of performance of the installation.

The floating low pressure consists in regulating and adapting the evaporating pressure to the value that will lead to the lowest consumption of the couple compressor / evaporator (and auxiliary).

An increase of 1°C in the evaporation temperature set point enables reductions in consumption of 2.5% to 4%. However, the temperature variation amount is limited to 2°C to 4°C maximum.

#### **Variable Speed Drive:**

The technology called electronic speed variation is a very promising technology. It can be used for compressors, fans, pumps... These installations operate at a fixed rotational speed. thus the flow control is obtained by energy dissipation. Electronic speed variation permits to regulate the flow of the fluid by reducing the engine rotation speed (compressor, pump or fan) thanks to an



electronic frequency converter.

This technology has a wide range of advantages: reduction of consumed electric power, precision and flexibility of operation, high control flexibility, reducing the number of starts. For many machines, the system is particularly efficient for the engine that regularly do not function at full load. For a cost of about € 200 per kW, the energy gain between 10% and 25%.

### 3. Level of Energy Savings

Generally, in temperate regions, the energy savings are in a range of 15% to 35%.

### 4. Market prospect

Industrial refrigeration plants with air condensers

### 5. Reliability

Good

### 6. Economic Characteristics

Payback time less than 2 years in temper countries.

### 7. Implement Cases

Refer to Table 1&2.

In a cold store, a fixed high pressure at 40°C is compared to a floating HP. The comparison is made for 2 external temperatures: 30°C and 15°C. ■

Table 1: – HP flottante : exemple de gain

	Centrale positive (R 404A)	Centrale négative (R 404A)
Régime de fonctionnement	- 15 °C/+ 40 °C	- 38 °C/+ 40 °C
Durée fonctionnement/an	4 380 h	6 000 h
COP*	2 soit 0,5 kW(e)/kW(f)	1 soit 1 kW(e)/kW(f)
Gain moyen avec la HP flottante	0,137 kW(e)/kW(f)	0,275 kW(e)/kW(f)
Gain annuel	600 kWh/kW(f)	1 650 kWh/kW(f)

\* coefficient de performance (EER) = kW de froid produit par kW électrique absorbé.

Table 2: - HP flottante : autre exemple de gain

	HP à 40 °C	HP flottante	Économie
Pour une température extérieure de 30 °C			
Besoin frigorifique	300 kW	300 kW	
Valeur de la HP	40 °C	40 °C	
Puissance électrique des compresseurs	129 kW	129 kW	
Puissance électrique des condenseurs	22 kW	22 kW	
Puissance totale	151 kW	151 kW	0 %
Pour une température extérieure de 15 °C			
Besoin frigorifique	240 kW	240 kW	
Valeur de la HP	40 °C	25 °C	
Puissance électrique des compresseurs	103 kW	62 kW	
Puissance électrique des condenseurs	7 kW	15 kW	
Puissance totale	110 kW	77 kW	30 %



## BP7: Uranium Enrichment by Centrifugation

### 1. Technology description

Two different industrial processes for uranium enrichment are exploited worldwide: gaseous diffusion and centrifugation. The centrifugation technology is considered the best technology in the field of uranium enrichment.

The differences in chemical properties are very small between the isotopes of uranium. One way to separate them from one another is to use the difference of mass between the two isotopes (uranium 238 and uranium 235). (The isotope uranium 235 is lighter than uranium 238 isotope)

#### **Gaseous diffusion (developed by French CEA)**

- All gas molecules are in movement. they strike the wall of the chamber in which they are confined.
- The lightest molecules being the fastest, they statistically hit the wall more often.
- If the wall is porous, the lightest molecules pass through the wall more often than the heaviest molecules.
- The isotopes are then separated and this separation produces the enrichment.
- Enrichment is here accomplished by successive steps: the UF<sub>6</sub> gas is pushed by a compressor through a set of diffusers containing porous diffusion barriers. The gas is enriched with uranium hexafluoride 235 at each passage (1400 in total).

#### **Centrifugation: (developed by ETC in Germany and the Netherlands):**

- The UF<sub>6</sub> gas is introduced into a rotating cylinder, at

high speed, under vacuum and in a sealed housing.

- The heaviest molecules, under the centrifugal force effect, are sent to the periphery of the tube while the lightest (U-235) migrate toward the centre.
- The gas enriched with light isotopes (U-235), in the centre of the tube rises. The gas enriched in uranium-238, heavier, goes down.
- The enriched and depleted products are recovered at the upper and lower ends of the tube.

This basic step of separating molecules is repeated in a set of centrifuges connected in series, called a cascade. The progress achieved in the late 1980s in the field of resistance to carbon fibre materials, allowed the centrifugation method to be regarded now as the reference technology relating to uranium enrichment.

### 2. Technical Scheme

Refer to Figure 1 to 4.

### 3. Level of Energy Savings

Centrifugation consumes 50 times less electricity than the gaseous diffusion and does not require to take off water from the near river, being 98% of energy saving -5% of French electricity consumption.

### 4. Market prospect

Technology of nuclear power generation from uranium

### 5. Reliability

This technology is industrially proven and tested since 1992 in Germany, the Netherlands and the UK.

The technology developed by ETC, and its model of centrifugal 'TC12' which equips the Georges Besse II site, offers the best guarantees in terms of competitiveness, energy savings, technical reliability and environmental impacts.

## 6. Economic Characteristics

The overall cost of the project 'Georges Besse 2' is 3 billion euros of which over 50% is the provision of centrifuges.

## 7. Social Characteristics and co-benefits

The Georges Besse II plant was originally designed to have an environmental impact even lower than that of the Georges Besse EURODIF:

- The centrifugation consumes fifty times less electricity than the gaseous diffusion.
- The process does not require to take off water from the near river for its cooling needs.
- Due to a building height two times lower than that of the current plant and the absence of noise, the Georges Besse II plant has an easy integration into the landscape and its immediate environment.

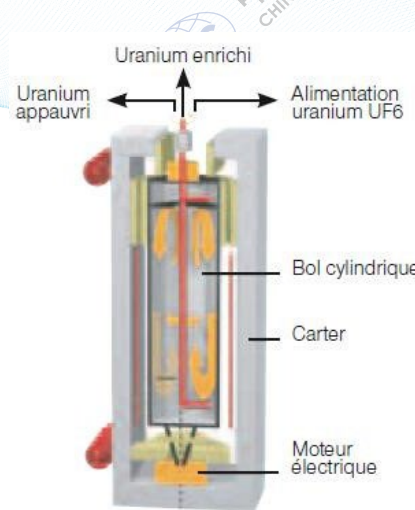


Figure 2 : Centrifuge drawing

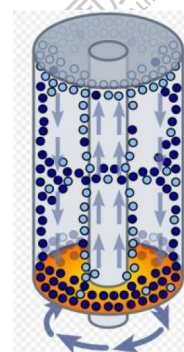


Figure 3 : Ultracentrifugation

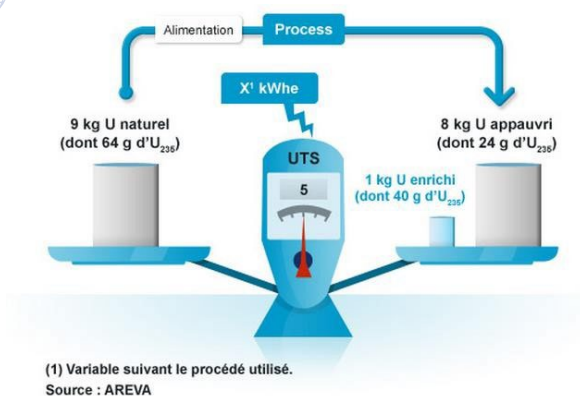


Figure1 : Enrichment of uranium process



Figure 4 : Set of centrifuges

## BP8: Energy Management and Control System

### 1. Technology description

The implementation of a Centralized Technical Management system for the entire site, production offices and workshops, proved to be the right solution adapted to the steady energy cost rise.

This centralized management system aims to reduce natural gas and electricity consumption and thus CO<sub>2</sub> emissions. It integrates with an ancient and heterogeneous installation.

It includes heating equipment, ventilation, extraction, air conditioning and compressors.

#### **The technical objectives were:**

- The creation of a data collection network for the Centralized Technical Management system;
- The setting up of automatic actuators and sensors, equipment command and control;
- Field data acquisition and management by an IT supervisor;
- Archiving and processing of data (for reporting, creation of indicators ...).

Heating devices had obsolete control systems, disparate or non-existent. The open and flexible management system covers 40000m<sup>2</sup> of workshops and 2500m<sup>2</sup> of offices.

The Centralized Technical Management system has selected:

#### **For equipment:**

- 2 automatons;
- A field network for the acquisition and control of various equipment;
- An optical fibre network dedicated to the centralized management system for communication between the automatons and the remote modules;
- Two servers for supervisor applications.

#### **For IT:**

- A Panorama E2 supervisor for management and maintenance;
- A server for storing data;
- A system that can manage about 800 data from the field (digital or analogical inputs and outputs).

The centralized management system allows both a management and an optimization of the energy consumptions.

#### **It provides:**

- The control of process gas and compressed air networks (counting, pressure measurements, leakage rate measuring);
- The management of buildings air extraction;
- The management of air extraction at the weld processes.
- The management of air introductions.

A monitoring is now done from SQL databases and from specific tools for processing and formatting of the



information collected.

## 2.Level of Energy Savings

- Natural gas: 1 MWh/year being about 20% of consumption
- Electricity: 0.5 MWh/year being about 20% of consumption

## 3.Market prospect

This kind of operation is completely reproducible in all kind of industrial facilities because this concept centralized management is applicable to any kind of activity areas. The system is a management and control tool for the facilities as well as for consumption monitoring. Before engaging in this type of project a cost-effectiveness analysis should be performed with respect to the energy challenges of the company.

## 4.Reliability

Mature technology

## 5.Economic Characteristics

- Investment costs: € 325,000
- Financial gain: About 100 k€ per year
- Return on Investment: 3 years

## 6.Social Characteristics and co-benefits

- Tons of CO<sub>2</sub> avoided: 450t to 500t CO<sub>2</sub> per year (all fuels included)
- Reduce of air polluting emissions (leakage control on the process gas networks)
- Improved working conditions through better control of the premises atmosphere (heating,ventilation,air conditioning,...) workshops and offices. ■

## BP9: Optimization of Ambient Conditioning Systems in the Industry (Clean Rooms, Food Industries ...)



### 1. Technology description

**A controlled contamination zone may be defined using three criteria:**

- A delimited space (enclosed with a specific envelope)
- Access to this space by a procedure system and airlock for people, materials and equipment
- Existence of an air treatment system with filtration and maintenance of pressure or depression.

**Definition given the ISO 14644-1 norm:**

"Room in which the concentration of airborne particles is controlled, and which is constructed and used in a manner to minimize the introduction, generation and retention of particles inside the room, and in which other relevant parameters, e.g. temperature, humidity and pressure, are controlled as necessary".

The aeraulic system has the function of keeping the air inside the cleanrooms under the conditions defined by the requirements:

- of the process
- of the product
- of the staff
- of the environment (discharge of waste gases)

**The 5 key criteria are:**

- The air filtration
- The air distribution
- The continued positive or negative pressure

- The mixing rate (recycling and / or extraction)
- The control of physical air conditions

The technique of cleanrooms entails the implementation of a certain number of components that need to be optimized from the beginning if you do not want them to become great energy consumers.

These provisions begin at the conception phase:

**Energy Consumers in the study:**

Temperature, Humidity

Dust analysis

Mixing rate

Quality of filtration

Renewed air

Free-cooling

Process

- Collection of the calories in the room

- Input/output air exchanger

Air treatment

**Energy Consumers in the material:**

T° Regulation (control of the dew point replaced by other systems)

Moto-ventilation

Filter box

Aeraulic network

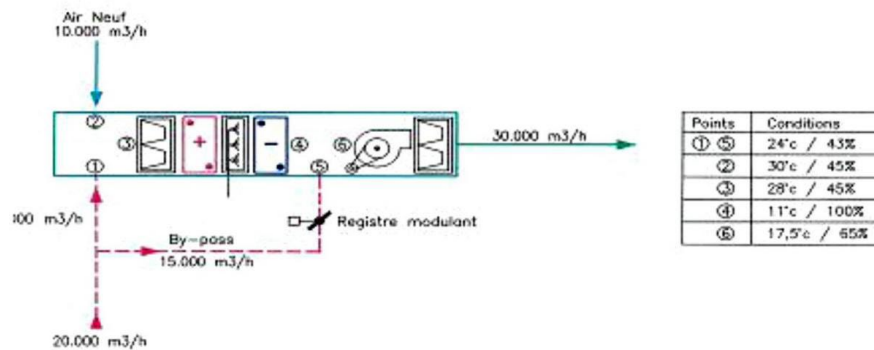
Water resistance of ducts

Insulation of ducts

The BYPASS central allows under certain conditions to maintain a controlled humidity by by-passing the treated air to obtain a final mixture adapting to the supply air temperature thus avoiding successive dehumidification and reheating. The bypass is regulated according to internal loads.

## 2. Technical Scheme

### CENTRALE BY-PASS / MELANGE



## 3. Level of Energy Savings

- Exemple : Débit soufflé 30.000 m³/h à 17,5°C (ambiance : 22°C / 50%)  
 Débit repris : 5.000 m³/h  
 Débit by-pass : 15.000 m³/h  
 Air neuf : 10.000 m³/h

Soit puissance BF : 123 kW

- Une installation classique avec centrale de mélange air neuf / air repris aurait nécessité pour les mêmes conditions :

Puissance BF : 192 kW  
 Puissance BC : 73 kW



#### 4. Market prospect

Classe 1	Classe 10	Classe 100	Classe 1 000	Classe 10000	Classe 100 000
<b>Microelectronics</b> : Fabrication de semi-conducteurs circuits Intégrés avec des géométries submicroniques.					
		<b>Chimie Fine Pharmaceutique</b> : Médicaments injectables, Production d'implants prothèses chirurgicales, Conditionnements buvables, Gélules.			
		<b>Supports D'information</b> : Fabrication de films plastiques, Cassettes video, CD, Disques durs microphotographies.			
			<b>Electronique / Opto-electronique</b> Matériel optique de haute précision. Assemblage de micro supports.		
			<b>Micro-Mécanique</b> : Appareillage de mesure, Roulement Optique, Robinetterie, Instrumentation de bord.		
			<b>Industries Agro-Alimentaires</b> : Plats cuisinés, Boisson, Industrie de la viande, Conditionnement.		
				<b>Spatial</b> : Assemblage et intégration de satellites, Fabrication de miroirs.	
				<b>Automobile</b> : Cabines de peinture, Equipements électriques.	
					<b>Hydraulique et Pneumatique</b> : Assemblage de composants.

#### 5. Reliability

Known good practices. The challenge is to maintain the level of the clean room while minimizing energy consumption.

#### 6. Economic Characteristics

Economic gain due to a decrease in energy consumption. ■

# First Batch of International TOP TENs List

## List of Top Ten Energy Efficiency Best Available Technologies (BATs)

Edited by Yunpeng Zhang Kan Wang

No.	BAT Title		Nominator
1	Combined heat and power (Cogeneration)	Co-generation projects	Japan
			Australia
			United States
2	Drying optimisation	Pre-drying technologies	Australia
3	Heat pump Technology	Two-stage heat pump technology	China
		Heat pump for high-temperatures: Steam condensation type vacuum degreaser	Japan
		Heat pump for low-temperatures: Heat pump system for high-efficiency steam supply	Japan
		The simultaneous heating and cooling heat pump	Japan
4	High-efficiency light emitting diodes (LED) lighting		Japan
5	Low-emission boiler	Boiler economiser	Australia
		Flue gas heat recovery system	United States
		Low NOx regenerative burners: High-performance industrial furnace (regenerative burner)	Japan
		High-efficiency industrial pulverised coal Boiler	China
		Small once-through boilers	Japan
6	Premium light dimming technology		Japan
7	Pumping System Optimisation	Reduce throttling losses	Australia
8	Recovery of industrial waste heat	Slag water waste heat recovery blast furnace	China
		Heat recovery and conversion to electricity	Australia

Top Ten Energy Efficiency Best Available Technologies (BATs)  
and Best Practices (BPs)

No.	BAT Title		Nominator
8	Recovery of industrial waste heat	Low-temperature waste heat recovery for power generation using organic rankine cycles	United States
		Thermoelectric coordinated central heating technology	China
		Low-grade waste heat to power absorption chillers	United States
		Waste energy recovery technology in the metallurgical industry using a coaxial drive turbine unit	China
9	Foundry metal stress relief technology		China
10	Variable frequency drives		United States

Note: the list is alphabetically ordered.



# First Batch of International TOP TENS List

## List of Top Ten Energy Efficiency Best Practices (BPs)

Edited by Xiaoliang Sun

No.	BP Title	Nominator
1	Energy conservation in the refining and chemical industries	China
2	Energy Just In Time (JIT) activities	Japan
3	Energy saving in a gigawatt-scale coal-fired generation unit	China
4	Zero-energy office building practices	China
5	Flight planning	Australia
6	Optimising generator controls	Australia
7	Promoting energy conservation and peak load control for factories	Japan
8	Integrating LNG cold energy into an ethylene plant	Japan
9	Reducing idle running in manufacturing	Australia
10	Using low-temperature industrial waste heat for district heating	China

Note: the list is alphabetically ordered.

## Second Batch of International TOP TENS List

### List of Top Ten Energy Efficiency Best Available Technologies(BATs)

#### Industrial Sector

Edited by Ying Zhang

No.	BAT Title	Nominator
1	Energy-saving control chip technology on body voltage sensor	China
2	Energy saving technology based on three-phase sampling and fast response	China
3	Heat, cold and electricity generation by tri-generation	France
4	High-strength and low thermal conductivity heat insulating materials "ROSLIM™ Board GH"	Japan
5	Infrared technologies for drying and baking thin products or coating	France
6	Matrix Converter U1000	Japan
7	Optimum control of high efficiency inverter centrifugal chillers using a heat source integrated control system	Japan
8	Selective and mass heating by microwaves	France
9	The high-effective energy-conservation recovery technology of the excavator's potential energy	China
10	Variable speed drives (VSD) applied to centrifugal and other dynamic machine (pumps,fans, compressors)	France

Note: the list is alphabetically ordered.

# List of Top Ten Energy Efficiency Best Practices (BPs)

## Industrial Sector

Edited by Wei Han

No.	BP Title	Nominator
1	Cooking of food products using Micro-waves	France
2	ECO activities to actualize "Visualization(energy audit)"and "Optimization" using EQS-AD10 (Environmental Andon System)	Japan
3	Energy Management System Construction Case	China
4	Energy-saving practical case through centralized management and control by Yanggu Xiangguang Copper	China
5	High frequencies for gelation of PVC coverings	France
6	High frequency sticking of composite products	France
7	Promotion of energy conservation by circle activities at a paperboard manufacturing plant	Japan
8	Reducing CO <sub>2</sub> emissions in the supply chain	Japan
9	Reduction of base-load energy usage	Japan
10	Shagang Group 2500kW dust exhausting fan energy-saving reconstruction project	China

Note: the list is alphabetically ordered.



## List of Top Ten Energy Efficiency Best Available Technologies(BATs)

### Building Sector

Edited by Bin Hao

No.	BAT Title	Nominator
1	Building energy management and information systems	United States
2	Carbon dioxide (CO <sub>2</sub> ) heat pump water heaters for home use ecoCute "ESTIA Premium Model"	Japan
3	Condensing gas tankless water heaters	United States
4	Heat pump water heaters	United States
5	Intelligent district heating platform with monitoring and operation optimization technology in heating system	China
6	Key technologies of centrifugal units based on temperature and humidity independent control system	China
7	Light-weight, small-sized, low-cost high efficiency LED high-bay lighting fixtures	Japan
8	Occupant responsive lighting	United States
9	Split-type air conditioner "Kirigamine FZ Series"	Japan
10	Treatment process of the prefabricated directly buried thermal insulating pipes	China

Note: the list is alphabetically ordered.

# List of Top Ten Energy Efficiency Best Practices (BPs)

## Building Sector

Edited by Qingpeng Wei, Lanqin Zhang

No.	BP Title	Nominator
1	Application case of the whole-process management of near-zero energy of No. 9 building of Shanghai Hongqiao State Guest Hotel	China
2	Case of Guangzhou White Swan Hotel energy saving reconstruction	China
3	China Academy of Building Research nearly zero energy building	China
4	Energy conservation activities at a next-generation green hospital	Japan
5	Energy conservation in the distribution of procured building products	Japan
6	Passive house technology center of Sino-German Ecopark	China
7	Promotion of super energy-saving construction by achieving "Japan's first urban-style Zero Energy Building (ZEB)"	Japan
8	Life-cycle management of energy efficiency target-"Joy City"project in Chengdu	China
9	University-wide efforts to build a smart campus	Japan
10	Zhuhai Singyes renewable energy R&D building	China

Note: the list is alphabetically ordered.

## Enterprise Interviews

### Transform Corporate Social Responsibility into the Driving Force for Energy Conservation: Pacific Textiles Strives to be an Industrial Pioneer

Reprinted from China Economic Herald

Instead of seeing large chimneys giving off black waste gas or smelling pungent chemical odors, the reporter was impressed by the green football field behind the plant gate, the green corridor surrounding the plant area, the flowers on two sides of the corridor, the flowing water and rockery nearby the dyeing room. The industrial waste water after being processed became the artificial pond of the water source. In the pond were dozens of carps... When stepping into Pacific (Panyu) Textiles Ltd (hereinafter referred to as 'Pacific Textiles'), the reporter felt as if entering a residential community.

'The road that we are walking on is our plant's 'environmentally-friendly road' and we named other roads as 'energy saving road', 'efficiency increase road', 'emission reduction

road' in the hope of planting the philosophy of energy saving and environmental protection into the mind of every employee of the plant.' While showing the reporter around the park, Ma Jianhua, director of ISO Office of Pacific Textiles said that "we have been taking the energy saving, emission reduction and environmental protection as the most basic requirements of plant building and development and plant operation since the establishment."

Overfulfilling energy saving indexes, strictly formulating energy saving standards of the enterprise

Established in 1997, with its plant located in Nansha Development Zone, Guangzhou, Pacific Textiles is a Hong Kong-invested high-tech enterprise dedicated to





professional research and development, production and operation of medium and high-grade knitted products. In 2010, it was one of the pilot units that promoted Energy Management System in top 10 industries nationwide. In March 2011, it passed certification as the first enterprise in the dyeing industry nationwide. In March 2013, it passed the ISO50001 energy management system certification as the first enterprise in textile industry nationwide. Since the establishment of plant, for 21 years, Pacific Textiles has been taking energy saving and environmental protection as its social responsibilities and innovating energy-saving technologies.

According to the Comprehensive Work Plan for Energy Conservation and Emission Reduction during the 12th Five-Year Plan, Guangdong Province set the goal of cutting the coal consumption by 47,694 tons of coal equivalent for Pacific Textiles. After five years of efforts, Pacific Textiles has cut the coal consumption by 50,642.82 tons of coal equivalent from 2011 to 2015 in total, thus overfulfilling the energy-saving task set by the

Guangdong Province.

As one of the 20 enterprises whose energy-saving and emission reduction effect are under direct assessment of the Guangdong Province, Pacific Textiles has an assessment expert team which is responsible for field survey in plants. In order to effectively implement the energy-saving and emission-reducing goal in every link of the plant production, Pacific Textiles has been following a strict set of standards, which divides the energy-saving indexes by different workshop departments and products. Though the Guangdong Province has not yet set the energy-saving indexes for Pacific Textiles by the Comprehensive Work Plan for Energy Conservation and Emission Reduction during the 13th Five-Year Plan, Pacific Textiles will set the energy-saving goal for itself annually, attempting to reducing the energy consumption by 10% by 2020.

'Apart from referring to the energy-saving indexes set by the Guangdong Province', Pacific Textiles also formulates the energy-saving indexes annually, from

5%,3% and 2% to 1% in the recent two years. The company has developed a detailed index planning. Energy conservation and emission reduction are like the squeezing of a sponge. The more the sponge is squeezed,the less the water is left in the sponge. Then,the less the room is for further energy conservation and emission reduction,and the more difficult it will be. Therefore,we have gradually lowered the energy-saving indexes,' says Ma Jianhua.

### Paying equal attention to social responsibilities and interests,and strengthening the market competitiveness in an 'environmentally-friendly'way

'We have been fighting hard for energy conservation and emission reduction for 21 years. For years,we have stuck to energy conservation and emission reduction. Not only have we achieved satisfactory social efficacy,but also we have created favorable economic efficacy,' says Zhao Qizhi,General Manager of the Public Works Department of Pacific Textiles. 'Energy-saving and emission-reducing projects can actually create economic efficacy. Many projects can recover its costs in one to two years. Without benefits,enterprises' enthusiasm for investing in energy-saving projects will be dampened,' adds Ma Jianhua,"Energy conservation and emission reduction are actually a reflection of corporate social responsibility and we have long regarded corporate social responsibility as the driving force for our energy-saving and emission-reducing projects.'

Energy conservation and emission reduction can,in

addition to creating social and economic efficacy,more importantly strengthen enterprises' competitiveness on the market. For example,foreign brands not only review product quality and safety,but also include the energy-saving and environmental protection effects of the suppliers into the scope of assessment. The medium-and high-end foreign brands in particular do not hope that suppliers provide goods at the sacrifice of the ecological environment. "If we do a good job in environmental protection,clients will come to us. Then,we will become more competitive on the market,' says Ma Jianhua.

The production capacity of Pacific Textiles has reached 90,000 tons,more than 95% of which are sold to high-end markets in Japan,European and North American countries. The service brands cover multiple fields,such as the underwear,swimming suits,full dress,sports,and recreation. Among them,there are many famous brands,such as H & M,Calvin Klein,GAP,Polo,and Adidas. According to statistics of the General Administration of Customs,P. R. China and Statistical Society for Foreign Economic Relations and Trade of China,Pacific Textiles has been listed among the Top 500 Chinese Foreign Trade Enterprises,and the Top 10 Export Enterprises in China's textile and apparel industry since 2004,and has maintained the ranking to this date.

### Vigorous investments in energy-saving projects and striving to be energy-saving leaders in the industry

"New-type Airflow Dyeing Machine Upgrade and Transformation Project','Secondary Waste



Heat Recycling Project for Cooling Gas and Hot Water in Compressor','Green Lighting Upgrade and Transformation Project (LED Energy-saving Lights)'... Ma Jianhua and Zhao Qizhi demonstrated major energy conservation and emission reduction projects launched by Pacific Textiles in recent years to the reporter of China Economic Herald. There have been 32 energy-saving projects,whose investments totaled at around RMB 300 million,taking up 1% of the total enterprise assets.

Annually,the China National Textile and Apparel Council (CNTAC) organizes industrial experts to visit enterprises doing a good job in energy conservation and emission reduction in China,and provide voluntary diagnosis for the enterprise on energy conservation and emission reduction. "Before the visit of experts,the enterprise leaders thought that they had been doing a good job in energy conservation and emission reduction. 'Our outlook is limited,' say the company leaders after listening to experts' energy-saving suggestions,' recalls Ma Jianhua. "It has never occurred to us that there is still such huge room for our energy conservation and emission reduction.' After receive the voluntary diagnosis report from the expert team of the CNTAC,Pacific Textiles will invite the third party professional institution for a comprehensive and strict assessment at its own expenses. If the assessment results provided by the third party institution realize the energy-saving and emission-reducing goal set by the enterprise,Pacific Textiles will invest again in launching projects.

Many energy-saving projects of Pacific Textiles have been promoted within the industry. For example,its dye

vat coating heat insulation technology has been widely adopted by the industrial colleagues. Inspired by the heat-insulating coatings used by ships and airplanes,the company had the idea of spraying the heat-insulating coatings on dye vat for heat preservation. The internal temperature of the dye vat,when working,will reach 140°C. If the surface cannot preserve the heat,the surface temperature of the dye vat can reach around 90°C at most. The high surface temperature will cause loss of large amounts of heat. The lost heat takes up around 25% to 35% of the heat consumed by the dye vat. Apart from the heat loss,the working environment is worsening,and the ambient temperature will be high. The dye vat wall can easily scald workers. Generally,the dye workshops use the heat-insulating cottons to wrap the dye vat. But this approach has some defects,including poor attachment,poor heat-insulating effects,and vulnerability to damage,which can impair the heat-insulating effect. Pacific Textiles purchased coatings from the United States,Japan and China for a spraying experiment on the dye vat,respectively. The effects and economical effects were compared. At last,coatings from the Chinese market that achieved the best effects and were proved to be the most economical were chosen. Following that,all dye cylinders were sprayed with the heat-insulating coatings.

"The dye vat coating heat-insulating technology is an original technology developed by Pacific Textiles. The Hong Kong Productivity Council once visited our plant. After verifying the heat-insulating effects,it recommended the technology to the Hong Kong-invested printing and dyeing plants based in the Pearl River Delta Port,and



demonstrated it as a clean production achievement of Hong Kong in the Shanghai World Expo. This technology has now found wide application among textile printing and dyeing plants. In addition, our dye vat heat-insulating technology was once adopted by the NRDC as the material for making the energy-saving and environmental protection film to be known worldwide,' says Ma Jianhua proudly.

Additionally, Pacific Textiles has been actively making use of the Internet technology in recent years, having established the intelligent sewage treatment plant central control room, which can monitor the operation status of devices, including the draught fans and water pumps, and realize the remote control of some valves. At the same time, the control center also collects the operation parameters of the water plant, including the water volume, dissolved oxygen, effluent quality indexes, etc. These parameters can facilitate maintenance personnel's

immediate adjustment of the operation of sewage treatment facilities, ensure the discharge of waste water to be up to standards, and realize the real-time transmission of the sewage discharge indexes. At the same time, there are designated personnel who can immediately check relevant data via the mobile app.

'We hope that more and more textile printing and dyeing enterprises can emphasize on energy conservation and emission reduction. In this way, enterprises can not only contribute to the environmental protection of China, but also create economic benefits for enterprises,' says Zhao Qizhi. Pacific Textiles has kept on exploring and innovating energy-saving and emission-reducing projects, and actively embraced the new-type energy-saving technologies, striving to be an energy-saving pioneer in the industry. ■

(Pi Zehong & Ma Siyong, reporters from China Economic Herald).

# S Zorb Low-temperature Waste Heat Power Generation: 'New Pacemaker' of Energy Conservation Technologies of Chemical Industry

Reprinted from Economic Guide

'By calibration,the net generating capacity of the ORC unit is about 535 kilowatts,which can satisfy the total electric load of the unit by around 50% and meet the elastic requirement of the load operation of the unit by around 60% to 100%,equivalent to energy saving of around 1.68 million kg of coal equivalent per year and reduced energy consumption of around 1 kg of oil equivalent per ton. The energy-saving effects and economic efficacy are obvious,' says the technical director in relevant fields of Sinopec,full of confidence in the operation effect of the 2#S Zorb low-temperature waste heat power generation project of Yanshan Petrochemical Company,the first set of units set up by China Petroleum and Chemical Corporation (hereinafter referred to as 'Sinopec') for recycling and power generation of low-temperature heat of gasoline products.

Though being 'the first mover',the 2# S Zorb low-

temperature waste heat power generation project of Yanshan Petrochemical Company went smoothly from its design to its use for production. 'The designed capacity of the waste heat comprehensive utilization system is 1.05 million tons a year and the designed annual operating hours are 8,400 hours. On September 18,2015,the evaporator started oil citation and realized start-up and grid connection successfully,' the director told the reporter from China Economic Herald. The project has not yet been found with problems,such as unit alteration,overall unit problems,etc. Its operation status has been quite steady. Besides,it can work uninterruptedly during the unit maintenance period and under the prerequisite of reserved interface.

Low-temperature heat is converted into high-quality electricity

It is known that,among various channels of low-

temperature heat utilization, low-temperature waste heat power generation is an important form of energy recycling, which can directly convert the low-temperature heat energy into the high-quality electricity. When it is hard to find a suitable channel to recycle the low-temperature waste heat, low-temperature heat power generation is an effective approach.

The reporter from China Economic Herald learned that the industrial application project of S Zorb low-temperature waste heat power generation has been listed in the technology development project of the Department of Technology of Sinopec. While forming technical standards, ORC waste heat power generation technology is proposed to be comprehensively promoted and applied in other S Zorb units in petrochemical system. The energy saving amount is estimated to reach 55 million kg of coal equivalent per year.

ORC power generators of S Zorb unit of Sinopec Changling Refining & Chemical Company are being debugged and operated. the detailed design of S Zorb unit and ORC power generators of diesel hydrogenation unit of Sinopec Anqing Petrochemical Company has been completed. ORC power generators of diesel hydrogenation unit of Sinopec Maoming Petrochemical Company are being debugged and operated. SEI (Sinopec Engineering Incorporation) has realized 3 sets of S Zorb low-temperature waste heat industrial operation projects and over 10 sets of planning and design projects. The low-temperature waste heat power generation technology has been promoted by leaps and bounds. Meanwhile, the reporter from China Economic Herald also learned that SEI undertook the Packaged Technology Development

and Industrial Application of Low Temperature Waste Heat Power Generation, the 2015 technology development project developed on the basis of Yanshan Petrochemical Company project and further promoted reformers with similar low-temperature waste heat resources, diesel hydrogenation unit and various types of process units and system units in petrochemical industry with energy saving amount reaching 40\*1.04 million kilograms of coal equivalent per year.

### Challenges facing the industry are tackled by technical reform

Then, people may wonder what challenges in the industry are tackled by low-temperature waste heat power generation, where the important technical value lies and why the promotion is pushed at such a high speed. It's known to all that the energy consumption of petrochemical industry occupies 16% of the total industrial energy consumption. The fuel consumption of Sinopec is around 40 million tons of oil equivalent per year, the majority of which is dissipated as waste heat.

It's known that low-temperature waste heat refers to waste heat resources at the temperature of 90°C-150°C, including water for heat transfer, exhaust gas, low-pressure diffused steam, to-be-cooled process logistics, etc. Industries such as chemical engineering, cement and metallurgy are abundant with low-temperature waste heat resources. However, in the absence of corresponding technologies, for a long time, a large amount of low-temperature waste heat has been wasted except for the application in cooling and heating with a small amount. In some processes, low-temperature heat is treated by energy-consuming means



such as air cooling and water cooling,during which,instead of energy saving,a large amount of other energies are consumed.

'The recycling of such part of waste heat is of strategic importance for the realization of energy saving and emission reduction, costs decrease, benefits increase and corporate competitiveness enhancement,' says the director. How does S Zorb unit carry out low-temperature waste heat power generation? For example, for a set of S Zorb units with a capacity of 1.2 million tons per year, the load of low-temperature waste heat (135°C~70°C) of bottoms is designed to be 7 megawatts and the heat load under normal operation is 5~6 megawatts. By adopting ORC for power generation, the gross generating capacity is 600~700 kilowatts, the system cycle power generation efficiency is 8%~10% and net electric generation is around 500-600 kilowatts.

'ORC power generators have been provided for low-temperature waste heat of bottoms of 2# S Zorb unit (130-140/70°C). In design conditions, the net generating capacity of ORC unit is around 540 kilowatts, which can satisfy 50% of the total electric load of the unit,' the director told the reporter from China Economic Herald.

### The restricted application condition has no impact on technology promotion

As a matter of fact, the S Zorb low-temperature waste heat power generation project features outstanding advantages in technology promotion: firstly, when direct utilization is not possible, low-temperature waste heat

(> 100°C) of most processes can be used for power generation. secondly, while utilizing waste heat for power generation, the air cooler and water cooler for original logistic cooling can be suspended to save electricity and water. thirdly, the biggest advantage of waste heat power generation is the unrestricted utilization of power generated and the unit can function normally without being subject to changes in heat trap conditions. fourthly, the emergency shutdown of waste heat power generators exerts no impact on the safe and stable operation of the unit and other units.

However, some problems may occur in actual case application of the technology. For example, as the requirement on gasoline vapor pressure in summer and winter varies, operation parameters of stabilizers may vary, which affects the power generation power. It's said that the gross power generation power and self-used power are slightly higher than design value even though waste heat comprehensive utilization system satisfies designed generating capacity.

Meanwhile, the waste heat power generation technology has its fixed application conditions - the temperature of waste heat for power generation should be high and preferably higher than 100°C with heat basically ranging from 1 to 5 megawatts. For waste heat resources with a temperature lower than 100°C, the director said that it's not suggested to recycle waste heat for power generation but we may consider other utilization measures such as water desalted by waste heat, cooling by waste heat, temperature maintaining of tank field and heat tracing. 'The temperature of the water for heat transfer

of hot water power generation project of a refinery enterprise is 70/95°C and the cycle efficiency of waste heat power generators is only 5%. Therefore, only when the application conditions are met can the maximum efficiency and value of technologies be realized. However, the fixed conditions will not influence the further promotion of technologies.'

Without doubt, the design of waste heat power generation system is subject to some requirements such as the in-depth understanding of process unit design and operation, mastery of advantages and disadvantages of all kinds of waste heat power generation technologies, safe design of heat removal system, safe and reliable heat-exchange device, well-prepared precautionary measures, no influence on work safety of the unit (such as the harm of the leakage of heat removal system of aromatic hydrocarbon unit on adsorbent) and no influence of low-temperature power generation system on production load, stable operation, work safety, product quality of

process units under all situations.

According to relevant statistics, currently, our recycling efficiency of industrial waste heat is only 80% of that of developed countries. Therefore, to enhance the energy utilization efficiency is our top priority in energy saving and emission reduction. For refinery enterprises having a huge amount of waste heat resources, the large-scale industrial application of S Zorb low-temperature waste heat power generation technology enables these enterprises to fully realize gradient utilization of energy and form energy saving products with independent intellectual property right and core competitiveness. In this context, the 2# S Zorb low-temperature waste heat power generation project of Yanshan Petrochemical Company will undoubtedly set an example for the recycling of low-temperature heat resources, carbon emission reduction, energy saving and consumption reduction of refinery enterprises. ■

(Gong Xin, reporter from China Economic Herald).



# Energy Passed in the Air-Permanent Magnetic Transmission Energy Saving Device of Xinyu Iron & Steel

## The Energy Saving Practice with the Maximum Power in the World

Reprinted from Economic Guide

### Primary dedusting fan of blast furnace of Xinyu Iron & Steel after renovation

'Our company launched the world-leading permanent magnetic eddy flexible transmission energy saving technology that is safe, green and energy saving. Based on modern theory of magnetism, it's a new energy saving technology that applies the magnetic action produced by permanent magnetic materials to complete non-contact transfer of force or moment and realize air transfer of energy. The core value is to make transmission safer, more convenient, efficient and environmentally friendly. It's another epoch-making innovative technology following fluid coupling technology and power variable frequency drive technology,' Huang Jihua, head of Technical Support Department of MagnaDrive told the reporter from China Economic Herald during an interview, 'our technology usually saves energy of 10% to 60%. After Xinyu Iron &

Steel applied our technology, they saved power of 7.2482 million kWh every year, equivalent to saving 19,800 kWh every day and saving energy of 2,261 tons of coal equivalent every year.

This technology is an emerging technology that can reach the dual indexes of safety, reliability and energy saving, consumption reduction and an ideal alternative green product. It's an important reform in power transmission technology.

### Dual guarantee of energy saving and safety

Currently, 70% power generated in the whole society is consumed in industry and 70% power in the industry is consumed by motor. Therefore, to find a way to save energy in motor system is the top priority in energy cost reduction in industrial development process and a key link in deepening energy saving, consumption reduction





and promoting industrial structure adjustment. As a new energy saving technology, permanent magnetic transmission technology plays an increasingly important role in guaranteeing safety of motor system, enhancing energy saving of motor system despite its short entry into Chinese market. It has become the most effective clean technology to accelerate industry structure restructuring and energy efficiency upgrade in China.

Established in 2012 in Anshan, the steel city in Northeast China, MagnaDrive made its way to NEEQ. Mainly engaged in R&D, production, service and sales of permanent magnetic eddy flexible transmission technology (permanent magnetic transmission technology), the company is dedicated to the promotion of permanent magnetic transmission technology in work safety, energy saving and environmental protection.

MagnaDrive's listing in NEEQ effectively raised the awareness of permanent magnetic transmission technology, enhanced the application of permanent magnetic transmission technology and promoted the popularity of it. The self-developed permanent magnetic

eddy flexible transmission energy saving technology is a new technology that applies the magnetic action produced by permanent magnetic materials to complete non-contact transfer of force or moment and realize air transfer of energy. The core value is to make transmission safer, more convenient, efficient and environmentally friendly.

'Located in the medium-sized city of Anshan, we are most challenged by talents problem during technology innovation and development. The solution is 'two external supports'. Firstly, we rely on external best minds. In recent years, we established two academician workstations based on the technical support from two academicians of CAE and two institutes of CAS and obtained good effects. We made major breakthrough in innovation and development of product technology. Secondly, we rely on non-local areas. We established technical R&D center in Beijing and enhanced our R&D level through big platform.' Ma Zhongwei, president of MagnaDrive said that 'now we have two technical centers. Anshan Center focuses on current issues and Beijing Center focuses on future

issues. In this way, we have more choices, more reserves and more competitive edges.'

During technical exchange with Xinyu Iron & Steel, Huang Jihua learned that the speed-regulating fluid coupling adopted by them is subject to the following shortcomings in actual application: complex structure, large work load in daily maintenance, difficulty in installation and dismantling, poor accuracy of fluid coupling operation and different rotating speed for the same open value, high fault rate, poor reliability, frequently stuck connecting rod, especially failure to normally speed up during 560r/min-580r/min, frequent oil leakage to pollute operation environment and bury hidden risks for overhaul, long adjustment time of 4 minutes from low speed to high speed (500r/min~1,000r/min), high maintenance fees as 200 liters of oil are added to each liquid coupling every month.

'Liquid coupling features low efficiency, high fault rate. Most deadly, it's easy to cause blast of converter when it's shut down. Therefore, Xinyu Iron & Steel is concerned about the transmission device. After learning about our permanent magnetic technology, the cooperation of both parties was reached,' says Huang Jihua.

### Daily saving of 19,800 kWh

China Economic Herald learned from CECEP Consulting Co., Ltd. that their energy saving audit report showed that the primary dedusting fan (3,500 KW, 1,500RPM) of blast furnace of the No. 2 Steelmaking Plant of Xinyu Iron & Steel used fluid coupling for speed adjustment before and the minimum rotating speed can be only adjusted to 600rpm. In January 2016, they conducted energy saving

transformation with the permanent magnetic eddy flexible transmission energy saving device WH-4000 developed by MagnaDrive and the minimum rotating speed can be adjusted to 300rpm. 45% energy saving rate is added on the basis of energy saving of fluid coupling. After third party testing of CECEP Consulting Co., Ltd., the annual energy saved can reach 2,261 tons of coal equivalent. Meanwhile, the project is the first application of permanent magnetic eddy flexible transmission energy saving device in the maximum power (3,500 KW).

Huang Jihua explained the permanent magnetic eddy flexible transmission energy saving technology to the reporter that it is a new technology that applies the magnetic action produced by permanent magnetic materials to complete non-contact transfer of force or moment based on the basic theory of modern magnetism. By the principle of 'like charges repel, but opposite ones attract' of magnetic materials, it turns magnetic power into mechanical power. The basic principle of the technology is to follow the basic principle of magnetic induction, namely 'Lenz's law'. When motor drives conductor disc to rotate, the disc and the permanent magnetic disc installed at load end started to cut magnetic line of force, thereby forming eddy in conductor disc. The eddy generates repulsive magnetic field surrounding conductor disc, thereby driving the rotating of permanent disc, thereby achieving air transfer of energy.

'It's the medium-free transmission system that achieves higher energy saving effect,' explains Huang Jihua. The permanent magnetic eddy flexible transmission device is developed based on these principles in combination with the application of rare earth permanent magnetic

technology,transmission new technology and high-precision equipment manufacturing technology.

The energy saving audit report of CECEP Consulting Co.,Ltd. shows that Xinyu Iron & Steel after adopting the permanent magnetic speed-regulating fan project transformation of MagnaDrive,has lower daily maintenance amount,saves around RMB 60,000 in fluid coupling oil injection fees annually. enjoys higher operation accuracy and adjusts fan flow rate and pressure according to production process needs in strict accordance with process needs. enjoyed high operation stability. Permanent magnetic speed-regulating device,through air transfer of torque,enjoys higher reliability and more stable equipment operation without stuck fluid coupling scoop tube compared with fluid coupling with oil as working medium. Meanwhile,the device life cycle is longer. The service life of main body parts of permanent magnetic speed-regulating device can reach 25 years under normal usage and maintenance. Compared with fluid coupling,the

overall service life of fan system is greatly enhance. Moreover,the production environment will not be polluted due to oil leakage of fluid coupling and the energy saving efficiency is outstanding. Meanwhile,the transfer of torque via air can effectively avoid vibration damage caused by physical connection.

Huang Jihua mentioned that this new technology is widely applied. Due to continuously innovated and upgraded technology,the product series continue to improve and sales market has covered many fields such as aerospace,military industry,maritime,metallurgy,oil,petrochemical,coal,electricity,mine and many transmission devices such as pump,fan,oil extractor,air blower,bucket wheel machine,compressor,pulper,rusher and belt conveyor. CNPC,Sinopec,CNOOC,China Guodian,CPI,China Huadian,CSIC,Ansteel,Shougang Group,Baosteel,CHALCO are users of the company. ■

(Cheng Hui,reporter from China Economic Herald).





# Energy Consumption Waste of Compressed Air? Leave It to Smart Collocation Air Compression Station

Reprinted from Economic Guide

## Air Compressor Station

As one of the three major power sources, compressed air is widely applied. The energy consumption ratio of air compressor in the industry is 8.7% while the annual power consumption of air compressors reaches as high as 300 billion kWh, among which, over 40% of energy consumption was wasted due to unmatched power device loads, irrational configuration of gas supply network and extensive gas consumption of end device. Some electronic enterprise customers with high demand on compressed air can save electricity fees of over RMB 1

million annually only by improving the air compressor system efficiency by 1%.

As industrial enterprises fail to fully recognize the energy consumption waste of compressed air system, the energy saving of compressed air system is becoming an important and pressing issue in China. During the 'the 11th Five-Year Plan' and 'the 12th Five-year Plan' periods, many enterprises carried out energy saving transformation on fans and water pumps without involving energy saving of air compressors. With the implementation of energy-saving plan of 'the 13th Five-year Plan', currently, many



enterprises have started to improve energy saving of compressed air system.

Then how is air compression system transformed to be energy-saving? Beijing Ecoso Co.,Ltd. (hereinafter referred to as 'Ecoso') has been specialized in compressed air system energy saving for nearly 10 years and provided an effective solution to it. The smart air compression station developed by Ecoso manages energy saving system,air compression pipe network energy saving control system,terminal dedicated energy saving and control system based on the gas consumption characteristics of production devices of factory to enhance the usage efficiency of air compressors,reduce electricity consumption and increase energy saving rate to 30%. Meanwhile,it enhances the automated management level of enterprises and produces energy saving benefits far higher than that of common devices.

### Compressed air is 10 times more expensive than electricity

According to tests run by authoritative institutions,only 10% of the electricity consumed by air compressors can be converted into compressed air,and the remaining 90% is converted into heat. So it is apparent but also often ignored that compressed air is 10 times more expensive than electricity. The sound of air leakage can be heard everywhere in most factories,but very few people seem to care. If the leakage problem is solved,a huge amount of energy can be saved. Therefore,controlling air compressor clusters comprising multiple air compressors in a centralized

manner is an effective way to save energy.

Li Jing,president & general manager of Ecoso told the reporter from China Economic Herald that 'Ecoso conducts energy saving transformation on air compression system widely applied in industrial manufacturing field and provides overall energy saving solution from power source to end gas consumption device. Specifically,the comprehensive energy saving of compressed air system is a system energy saving from power source to energy consumption end,from single device to the whole system,from extensive management to intensive process.

Li Jing explained that 'the main body subject to transformation includes air compressor station,compressed air transmission pipe network,gas appliances. The transformation aims to improve the load and air compressor matching efficiency,enhance compressed air utilization efficiency,realize overall energy saving solution from power source to end gas supply device of air compressor system,achieve energy saving efficiency of compressed air system in the field of manufacturing industry and realize information-based,automated,intelligent management of compressed air system of industrial enterprises.'

According to Li Jing,in the implemented energy saving transformation project,the current energy saving rate is 20% to 30%,which brings favorable economic benefits and social benefits to enterprises.

'As the conditions of industrial enterprises in China are complicated and the devices purchased in different period may vary,air compressor system can jointly control several air compressors of different brands and ages and auxiliary



devices of air compressor, etc.,' Li Jing told the reporter from China Economic Herald. Therefore, the system features strong compatibility. Based on the gas production of air compressors, the system matches dryers and monitors and controls cooling towers, water pumps, cooling water valves, air compressor energy saving auxiliary control cabinet, pipeline gas supply energy saving management units. Meanwhile, it calculates power for relevant devices, monitors pressure, flow, temperature and dew points of compressed air and pressure, temperature and flow of cooling water.

After one decade of development, the technology of Ecoso won second prize of National Science and Technology Progress Award. Experts from China Machinery Industry Federation gave authoritative evaluation: the research results made several innovations in theory and technology and solved some key technical difficulties in our compressed air system energy saving. The formed technical system has been applied in energy saving transformation in many manufacturing enterprises in China with energy saving rate reaching 30%.

### Brand new collocation business mode

Since it's called smart collocation air compression station, in addition to energy saving, 'smart' is a must-mentioned part. It's known that smart collocation air compression station is a brand new collocation business mode and sharing economy. What does it mean?

Targeting this set of brand new business

mode, Li Jing explained that 'smart collocation air compression station adopts BOO mode invested, constructed, operated and maintained by Ecoso, which changed the EPC mode of traditional air compressor energy saving technical transformation and EMC mode of contract energy management. Customers are free from investment, operation and have lower gas consumption cost. All equipment of smart collocation air compression station is owned by Ecoso and can be shared by different customers'.

Additionally, Li Jing said that 'we specially developed data collection device dedicated for air compression station and smart sharing integrated intelligent air compressor. We also built intelligent data monitoring platform.'

The data collection device dedicated for air compression station builds sensor network by IoT technology to collect relevant device operation information, process parameters in real time through imbedded system technology. Combined with Internet, it provides data basis for smart energy air compression station and provides underlying support for 'the integration of IT application with industrialization'.

Smart sharing air compression device integrates sensors and intelligent devices of intelligent control system, integrates advanced manufacturing technology, information technology and intelligent control technology. It focuses on operation efficiency of air compressor and maximizes gas and electricity ratio. The container-type standard structure and



its adaptation to massive manufacturing, shortened construction period and easy movement make it applicable to sharing air compression station.

Centering on whole life cycle of 'access, management, computing, usage, maintenance', intelligent data monitoring platform provides access, integration, treatment of relevant cloud service of flow-type real-time data and structured data and realizes fast gathering, comprehensive management, efficient computing, dynamic association of big data. By means of big data technology, cloud computing, relevance analysis, intelligent service, through analysis of operation data of air compressors, device fault can be early warned accurately so as to greatly enhance operation efficiency of factory. Especially through optimized scheduling and precise control, the operation efficiency of air compressor is enhanced and energy consumption is reduced to the greatest degree.

### 'Thousand-station plan' has been implemented for two years and users already had a preliminary understanding

As a matter of fact, as early as 2016, Ecoso launched 'thousand-station plan' for commonly existed problems such as low equipment efficiency, excessive gas supply under high pressure, loss of regular maintenance, inadequate purification treatment and poor working environment. It planned to build 1,000 smart collocation air compression stations nationwide within 10 to 15 years. Through designing efficient, intelligent, normalized and standard configuration, Ecoso

optimized station layout, replaced low-efficiency equipment, stabilized output pressure, improved purification quality, promoted green and low-carbon development and lowered operation cost to realize new air compression station where energy can be smartly utilized. The plan adopts BOO operation mode to completely eliminate the investment pressure of users in the early stage.

Currently, the 'thousand-station plan' has been implemented for over 2 years and some problems occurred in the process. Li Jing told the reporter from China Economic Herald that 'the biggest problem is the model transformation to be accepted by customers.' For this, she said that it's required to step up publicity efforts, promote the kind of business mode through network, exhibition, training session, and customer reception meeting. Currently, users of air compressors in China already had a preliminary understanding of 'thousand-station plan' and showed interest in this mode.

According to Lu Huapeng, general manager assistant of Shandong Binzhou Mengwei Daika Hub Co., Ltd., the first user unit of smart energy air compression station of 'thousand-station plan', 'the smart energy air compression station of Ecoso provided an effective solution to three problems of factories: firstly, the air compression station collocation mode alleviated new compressor investment pressure for gas consumption of newly added production capacity. secondly, the energy saving and upgrade of original air compression station lowered energy consumption and finally

out the comprehensive gas consumption costs of factories. thirdly,the standard,intelligent,professional smart energy air compression station guaranteed

gas consumption safety and greatly lightened the management burden of factories.' ■  
(Bai Xue,reporter from China Economic Herald).

## Yungang Thermal Power's Way to Achieve Energy Conservation Serves Three Purposes

Reprinted from Economic Guide

### Full view of Dead Steam Renovation System

Is there really a technology that can save energy while increasing heating capacity, reducing emission and consuming the same amount of energy? Yes, this is the surprise brought by the turbine dead steam waste heat utilization project based on high-temperature-difference by Shanxi Datang Yungang Thermal Power Co., Ltd (hereafter referred to as 'Yungang Thermal Power').

'Absorption heat exchanger unit installed on user side is connected in series with traditional plate-type heat exchanger. Without changing secondary network supply and return water temperature, the primary heat-supply network return water temperature can be greatly reduced. The dead steam waste heat supply of turbines of power plant (note: dead steam refers to the dead steamed from dead steam port and thermal potential energy) enables





the thermal power plants to enhance its the existing heating capacity of heating units by over 30% and reduce system heating energy consumption by over 40%. In this way,it made high-temperature-difference convey of pipe network possible,enhanced conveying capacity of heat-supply network by around 80% and reduced investment and conveying energy consumption of new pipe network by over 30%,' the relevant technical director of Yungang Thermal Power told the reporter from China Economic Herald.

In 2012,as required by Datong Municipal Government,Yungang Thermal Power implemented dead steam waste heat utilization renovation project to enhance heat supply ability. Up to now,the project has been running for over 6 years. 'The system equipment operation is stable and the comparative advantages of the project technology are evident. In particular,in terms of return water temperature difference of enlarged heat-supply network,the well-matched technologies can be hardly found in China,' the director told the reporter. By combining the characteristics of existing heating system and absorption heat pump technology,many technical innovations have been achieved in project research and application. The successful operation of the project played a positive demonstration role for the further promotion and development of the technology. It's the future development direction for our CHP centralized heating mode.

### Born at the right moment with evident technical strength

For a long time,the cold-side loss of thermal power plant

is the biggest losses of thermodynamic system. 'Taking Yungang power plant as an example,subject to the rated heating operating conditions in winter,the exhaust steam loss of turbines occupies around 17% of the total calorific value of fuels. The exhaust steam of turbines is waste heat emission for thermal power plant. However,for low-grade building heating,huge energy waste will be caused if it's not utilized,' says the technical director.

For Datong City,with the fast development of the city,the tension in heat supply and demand has long existed. For example in 2015,based on overall planning of Datong,the centralized heating area of urban area reached 67.8 million square meters,including 23.8 million square meters of heating area of Yungang Thermal Power. Back then,the actual heating capacity of centralized heating source of Datong urban area was only 2,610 megawatts which could only meet the heating demand of 50.19 million square meters when it's severely cold upon the calculation according to 52 watt/square meter of mixed heating thermal load of new and old buildings. The gap reached 17.61 million square meters.

The development of CHP technology is expected improve the shortage in heating. Currently,CHP centralized heating features the highest efficiency in all kinds of heat sources in towns in North China. In recent years,we have gradually formed the basic heating pattern of CHP-centered,regional boiler-supplemented and other advanced efficient heat source methods as supplement.

As to the way to improve heating capacity and energy utilization efficiency of CHP by extracting dead steam heat and enhance the heat-supply network conveying power by increasing temperature difference of heat-

supply network supply/return water, Tsinghua University proposed the 'absorption heat exchange concept' and 'CHP centralized heating system based on absorption heat exchange (hereinafter referred to as Co-ah system)' in 2007, thus starting the new phase of efficient utilization of dead steam waste heat of turbines.

In 2011, Yungang Thermal Power obtained approval for dead steam waste heat utilization transformation project and started transformation in 2012. After transformation, the heating capacity was improved by 480 megawatts and the heating area was increased by 8.89 million square meters, equivalent to the reduction of two 300-megawatts centralized heating units or ten 80t/h (note: t/h is boiler capacity unit) heating boilers. In this way, it effectively alleviated the critical issue facing CHP centralized heating and directly promoted the acceleration of municipal infrastructure construction, guaranteeing of thermal supply and improvement of urban environment. The reporter of China Economic Herald learned that the implementation of the heating project greatly improved the economy of CHP, enhanced profitability of power plant on the premise of caloric value loss and effectively reduced emission. Due to the implementation of Yungang Thermal Power waste heat utilization project, in 2013, Datong completed emission reduction tasks.

It's reported that the project set low-temperature heat exchanger within waste heat recycling units, adopted three-section gradient heating network circulating water of direct heating of condenser, absorption heat pump heating, bleed heating based on energy gradient utilization principle. In this way, the low-temperature heat exchanger of waste heat recycling units only undertook

basic load during the whole heating season and the heat-supply network only provided peak heating when it's severely cold, so as to greatly save heating steam extracting, increase the power generation and heating capacity of thermal power plant.

In addition, the technology has a striking advantage compared with other condensed steam waste heat recovery technologies. For example, the condensed steam extraction ratio is matched with that of units to make the capacity selection of heat pump more reasonable. Through the provision of low-temperature heat exchanger and system series-parallel connection in the origin station, the energy level matching of low-temperature dead steam waste heat of heat-supply network water and power plant was achieved and the water temperature rise in heat-supply network was significant. In this way, the dead steam recovery and utilization amount was enhanced to occupy 30% of total heating capacity and significant energy saving effect was shown.

As a matter of fact, regular absorption heat pump centralized heating technology adopts parallel connection in system layout. When heating loads are reduced, low-grade dead steam waste heat cannot be fully utilized and heating load is increased. When it's severely cold, the recycling amount reduces due to insufficient waste heat. The project adopts the way that combines series and parallel connection to arrange the low-temperature heat-exchange section in series and arrange them to heat in medium-temperature heating section of waste heat recycling units in parallel, that is, primary heat-supply network return water passes through the low-temperature heat exchanger of a unit to directly absorb dead steam



waste heat and passes through low-temperature heat exchanger of another unit for secondary heat absorption.

The heated primary heat-supply network water is heated in medium-temperature heating section of their respective waste heat recycling units in parallel before peak heating in heater of origin station of heat-supply network.

### Stable operation and increased economic effect and social environmental protection effect

However,as the transformation is carried out based on original system,the transformation process is subject to unfavorable factors such as construction sites,work period,drawings,which brought high degree of difficulty in technical modification. However,the implementer overcame all difficulties and successfully put the project into operation. Relevant director told the reporter that the production system functioned stably and waste heat recovery effect was evident and energy saving effect was also evident after the project was put into operation. Precious experience in engineering construction and operation optimization was also obtained during project implementation and operation.

On one hand,the project fully realized gradient utilization of energy,reduced irreversible loss and fully utilized low-grade dead steam waste heat compared with traditional CHP heating,heat pump centralized heating modes and high back pressure heating mode,thus realizing energy level matching of heat exchange process. On the other hand,it greatly reduced irreversible loss and enhanced economic benefits of thermal power plant in heat

exchange process.

'The rated heating capacity of single unit before transformation was 377 megawatts. After transformation,it increased to 422 megawatts after transformation and the hourly income under rated heating working condition increased by RMB 500. If the thermal load variation is not high and the operation is conducted according to 380 megawatts of heating load under the condition of all-open low-adjusted valves that satisfy high steam extraction amount,the hourly income increases by RMB 12,000.' says the director of Yungang Thermal Power when speaking of the income changes after project transformation.

Certainly,economic benefit is only one thing. Analyzed according to the alternative large-area coal-fired heating boiler,the recovered dead steam heating load is equivalent to 254,000 tons of coal equivalent saved,656,100 tons of carbon dioxide emission reduced,8,900 tons of sulfur dioxide emission reduced,38,000 tons of smoke emission reduced,15,000 tons of ashes emission reduced every year. Compared with conventional heating plan,the project,while saving energy and reducing consumption,not only reduced the impact of coal,ashes on the environment,traffic and land occupation during handling,transportation and storage process but avoided the disturbance of noise and dust on residential life during operation of centralized coal-fired boilers. Thus,after the implementation of the project,with the increased heating capacity of power plant,the energy saving,environmental protection and social benefits achieved are outstanding. ■

(Gong Xin,reporter from China Economic Herald)



## Beautiful but Not 'Wasteful'

### White Swan Hotel's Development Fueled by Energy Saving Measures

Reprinted from Economic Guide

#### 'Hometown Water' Water-curtain Air Conditioner System of White Swan Hotel

Alongside the glistening Pearl River, a 'swan' has been 'guarding' the Shameen Baietan of Guangzhou. It has survived the trials and hardships during the past 35 years, and still lingered in the minds of Guangzhou citizens after over 3 years of suspension for renovation. years of energy saving and emission reduction efforts equipped her with the wings of energy saving for her to 'fly' further in the 'green' sky.

At the end of 1970s, the construction of Guangzhou White Swan Hotel officially began. On February 6, 1983, it was open to citizens in Guangzhou. With the booming of hotel industry in Guangzhou, a large number of upscale hotel buildings were built. International brand and high star-level new hotels greatly challenged White Swan Hotel in its 'aged period' in terms of



brand influence and hardware configuration. In 2012,to strengthen brand,enhance market competitiveness,enhance customer experience and reach comfortable,targeted,personalized,low-consumption,high-efficiency standard,White Swan Hotel officially launched comprehensive renovation project and launched energy saving projects at this time. After over 3 years of comprehensive upgrade,White Swan Hotel equipped with energy-saving wings was reopen to citizens in Guangzhou in July 2015.

### Joining hands with professional institutions to achieve significant effect in energy saving and emission reduction

To make the energy saving project more targeted and professional,White Swan Hotel entrusted Guangzhou Design Institute as the 'main designer' of the energy saving renovation project and made it responsible for planning,drawing design,core technology R&D. Guangzhou Design Institute 'tailored' over 11 energy-saving plans according to the actual needs of White Swan Hotel and applied for over 10 inventions and utility model patents,and published 8 relevant papers. The reporter was impressed by one after another energy saving 'black technologies' including atrium 'hometown water' water curtain air conditioner system','rainwater recovery technology','energy monitoring and management system application'.

You may find the overall style of the building kept as a whole when you enter White Swan Hotel that welcomes guest with brand new image. The 'hometown water'cherished by numerous visitors is still flowing. 'Actually,the 'hometown water' has some secrets. The

'hometown water' was transformed from the man-made waterfall to a water-curtain air conditioner,' says Deng Wenyue,deputy general manager of Guangzhou White Swan Hotel excitingly,'the flowing water of 'hometown water' cools down the landscape water of fish pond by virtue of redundant air conditioner cooling capacity at night so as to transform and store excessive cooling capacity. In the daytime,natural thermal radiation principle is utilized to release the cooling capacity in the pond and create a cool environment in the open atrium so as to greatly reduce the energy consumption of air conditioner of atrium with large areas of light tent. The heat exchanger of cooling 'hometown water' is buried in the underground equipment room and will not affect landscape.'

Data shows that after transformation,White Swan Hotel lowered its whole-year comprehensive energy consumption (coal equivalent) in 2016 by 30% compared with the year 2010 with the actual energy consumption fees lowered by 49% compared with the year 2010 and the energy consumption fees saved exceeding RMB 17 million. In 2017,while the business volume was greatly increased,the whole-year actual energy consumption fee evened out with that of 2016,only occupying 5.5% of total revenue of the year,outperforming the energy saving indexes placed by competent departments of Guangdong,Guangzhou Governments on White Swan Hotel.

### White Swan Hotel faced up to challenges along the road of energy saving

When approving the renovation project of White Swan

Hotel, relevant authorities of Guangzhou Municipal Government clarified that White Swan Hotel is located within the scope of Baietan Economic Cycle and all newly built and renovated projects within the region must research green building standards. Relevant authorities of Guangzhou Municipal Government demanded White Swan Hotel to lower its comprehensive energy consumption by 23.82% from 2010, the complete operation year before renovation.

'While the structure, layout, equipment and pipeline space are limited, the renovation of an existing building under historic preservation and strict restriction of all kinds of professional standards is required to satisfy future operation needs, increase energy consumption systems such as controlled air conditioners, outdoor constant-temperature swimming pools. White Swan Hotel faced great challenges in reaching the energy saving and consumption reduction objective set by Guangzhou Municipal Government,' recalls Deng Wenyue, 'at that time, after careful study of White Swan Hotel Group, White Swan Hotel leaders and project management team, they decided to face up to challenge to not only meet the energy saving objective proposed by superior competent department but also scale new height.'

After setting the objective, the project management team and Guangzhou Design Institute that undertook electromechanical system design organized technical breakthrough team. They made full use of resources of consultant teams and had systematic research on operation demands, restriction conditions and energy saving objectives. After making comprehensive analysis

of all non-traditional energy technology maturity and investment cost performance, it decided to make 'targeted monitoring of traditional energy and comprehensive utilization of waste energy' as main modes of energy saving and consumption reduction. Backed by architecture energy saving, assisted by rainwater collection and utilization, the team focused on system and controlled details to ensure that energy-saving investment was put in the right place so as to satisfy the renovation objectives of historic preservation, operation demand, professional norms, essence heritage while achieving energy saving and consumption reduction.

### Making down-to-earth analysis and choice during energy-saving endeavor

Deng Wenyue was the general manager of a real estate group. He was the witness of the development of White Swan Hotel as he lived in Xiguan, Guangzhou at a young age and often played around in Shameen with adults. Therefore, he had a deep feeling for the legendary hotel that witnessed the reform and opening up of China.

When asked about the sentiment about leading energy saving project of White Swan Hotel, Deng Wenyue said that 'it's not advisable to save energy for energy saving only. Instead of taking energy saving as a stunt, being immersed in immature new energy technologies, we need to stay down to earth and make analysis and wise choice and create energy saving system with investment feasibility and operation applicability'. 'Energy saving renovation must be combined with and adapted to operation. Energy saving renovation on the sacrifice of operation quality is not advisable. Energy saving renovation is not simple



packing of energy saving equipment. To achieve good overall energy saving effect, it's a must to value systematicness, implement by steps instead of taking random steps.

It's required to value energy consumption measurement and monitoring, value cross-system energy conversion and repetitive utilization of waste energy. It's tough to have energy saving renovation on old buildings. The restrictions are high and a lot of choices are made during the promotion process. However, the leaders and project team of White Swan Hotel made it through.

Energy saving and emission reduction project brought benefits to White Swan Hotel. The energy consumption costs saved after renovation reached over RMB 17 million. The ratio of energy consumption cost in

business volume reduced from over 11% to less than 6%. Additionally, energy saving project expanded the brand influence of White Swan Hotel and provided models and demonstrations for traditional hotel energy saving renovation.

Relevant directors of White Swan Hotel told the reporter that they will continue to push forward the establishment of energy saving and intelligence standards and design business modes suitable for old-fashioned building energy saving renovation to explore a new path for future group brand development, diversified development of businesses and new profit growth path. ■

(Pi Zehong, Ma Siyong, reporters from China Economic Herald).

## CECEP Green Building Museum: Building A Glamorous Energy Conservation Visiting Card for Hangzhou

Reprinted from Economic Guide

### China's Energy Conservation Green Architecture CECEP Green Building Museum

In Hangzhou, as the benchmarking and demonstration in domestic architecture energy conservation field, CECEP Green Building Museum firmly grabbed the attention of all walks of life by the excellent advance of National Energy Conservation Publicity Week. In the past few days, reporters from China Economic Herald entered CECEP Green Building Museum and appreciated the special elegant demeanor of the 'Glamorous Energy

Conservation Visiting Card' for Hangzhou on the spot.

### Build 'Hangzhou Model' for energy conservation, promote 'Hangzhou Experience' of energy conservation

CECEP Green Building Museum is the demonstration project of national architecture energy conservation and renewable energy source use, the demonstration project of the first batch of renewable energy source of all provincial and municipal levels of Zhejiang, the key project of Hangzhou Municipal 'Ten Major Projects', and has passed the three-star rating of national green architecture





design, the three-star rating of national green architecture operation, therefore, it is the benchmarking of domestic advanced green architecture.

CECEP Green Building Museum covers an area of 1,348 square meters, with the overall floorage of 4,679 square meters and the building height of 18.5 meters, integrating research and development, exhibition and technical exchange in one. The main functions of the Museum are scientific research office, green architecture energy conservation and environmental protection technology and industry publicity and exhibition.

Just at the arrival of reporters from China Economic Herald at the gate of CECEP Green Building Museum, a distinguishing feature is found - the architecture leans an angle of 15 degrees southward in whole, building a self-shading system.

Such design is regarded as with unique ingenuity: the solar altitude in summer is relatively higher, and the envelop enclosure southward can obstruct excessive solar radiation; the solar altitude in winter is relatively lower, thus heat can come indoors, and more natural light may be brought in from the north.

Reduce adverse impact of solar radiation, and improve comfortable environment indoors. On the whole, Hangzhou is located in the zone of subtropical monsoon climate, with rainy climate in spring, damp and hot climate in summer, invigorating autumn and dry and cold climate in winter. According to such climatic characteristics, CECEP Green Building Museum adopts ten major systems including 'Architecture Self-shading System' so as to achieve the goal of ultralow-energy conservation architecture, such as intelligentized out-

sunshade ventilation jalousie system, energy regeneration elevator system, rainwater collection, reclaimed water reuse system, intelligent control, subentry measuring system and others. The integrating and simultaneous use of these systems makes the energy consumption per square meter of CECEP Green Building Museum only 1/4 of that of ordinary architectures.

It now appears that the useful exploring and practice of CECEP Green Building Museum not only makes important periodical advances for their own sustainable development, but also bears preliminary fruit with breakthrough and model significance in multiple fields and links.

For example, principle of the passive ventilation system is to open the passive ventilation system in cool summer nights and transition seasons, and fresh air is brought in through semi-underground air flue into the room by vertical air flue, while air taking away heat indoors enters the atrium which is then discharged to the outdoors by the draft effect of the rooftop chimney. Thus will effectively reduce air conditioning load indoors, shorten the run time of air conditioning unit so as to achieve energy conservation. And shut down the passive ventilation system when the temperature or humidity outdoors is relatively higher, which can keep it cool indoors by the heat-shielding performance of the architecture.

For another example, environmental protection, rational external envelope system. The north and south facade, roof of CECEP Green Building Museum use titanium-zinc panels, and the east and west facade use terracotta panels, both being self-clean, recyclable and reusable. Architecture doors and windows adopt bridge-cutoff



heat insulation metal section multi-cavity hermetic window frame and high-transmittance low-e hollow glass, which greatly reduce the window heat in summer but with little influence on heating load in winter. The window-wall ratio is 0.29 in the south facade, 0.38 in the north facade, 0.07 in the east facade and 0.1 in the west facade of the architecture, and rational window-wall ratio not only satisfies the lighting requirements inside the architecture, avoids adverse effect on people indoors by dazzle light brought by perpendicular incidence, but also avoids greater air conditioning load.

Also for another example, humidity independent control air conditioning system can meet personalized requirements on heat humidity ratio in different rooms, which solves the problem that ordinary air conditioning system is difficult to satisfy humidity parameter simultaneously and avoids too high or too low humidity indoors.

During the interview, reporters from China Economic Herald felt that, the pleasantly cool sense in CECEP Green Building Museum was not totally the sense brought by traditional air conditioning refrigeration. The air conditioning in CECEP Green Building Museum is different from that at home - it neither consumes electricity, nor blows wind. Visitors can see the suspended ceiling rank like heating radiators and sinuous water pipes in the roof when looking up. Such is a series of ground-source heat pump system, and at the beginning of design, there are pipeline at the periphery of the architecture deep into 60 meters underground to draw water at the temperature of about 18°C to form a water circulation system so as to lower the temperature indoors by the way of heat transfer. This system adopts high

temperature cooling source and air conditioning terminal to remove sensible heat load indoors, and takes water as the transport medium, with the transmission energy consumption only 1/10-1/5 of air transmission energy consumption.

### Form all-circle energy conservation resultant force, deepen persistent energy conservation power

The perfectness of system integration and the advancement of technological means in CECEP Green Building Museum endow it with important and extensive demonstration in the energy conservation building field. The completion and opening of CECEP Green Building Museum bring it to the forefront of government sectors, specialists and scholars as well as the industry, who come to visit, investigate and survey in succession. According to incomplete statistics, the Museum has received over 3,000 batches of investigation groups accumulatively now, with nearly 100 thousand people.

During Shanghai World Expo in 2010, CCTV International specially entered China's Energy Conservation Green Architecture CECEP Green Building Museum to make a special report on advanced energy conservation and environmental protection technology of the Museum to the world. Reuters and other international mainstream media have also made a mass of positive coverage on CECEP Green Building Museum.

CECEP Green Building Museum is also a display platform and educational base for energy conservation and environment protection, which enjoys popularity among relevant enterprises as well as colleges and

universities and scientific research institutions. Chambers of commerce at home and abroad have organized entrepreneurs to investigate and study over and over again to have learning exchange on energy conservation building technology, including American Chamber of Commerce, Singapore Chamber of Commerce, Japanese Chamber of Commerce and representatives from the world's top five hundred enterprises. Moreover, visiting groups from colleges and universities and scientific research institutions come to investigate and study in an endless stream, including Tsinghua University, Zhejiang University, Zhejiang University of Technology, Shanghai Research Institute of Building Sciences, Research Center for Eco-Environmental Sciences, China Academy of Sciences and others.

As an important domestic platform for energy conservation building technology demonstration and education, CECEP Green Building Museum plays the special demonstration and leading role in energy conservation building development.

It is mentionable that Program Group of Everyone Have Something to Say of Hangzhou TV has entered Energy and Environment Industrial Park where CECEP Green Building Museum is located, and taken CECEP Green Building Museum as one of its experience stations for Hangzhou low-carbon lifestyle experiencing programs organized by it to demonstrate the advanced green energy conservation building to Hangzhou citizens. Citizens going to visit have all been marveled by the advanced energy conservation technology in CECEP Green Building Museum with pride.

CECEP Green Building Museum has become a gorgeous visiting card of Hangzhou and even Zhejiang, which will continuously give great impetus to ecological civilization construction and make new contribution in providing more superior ecological products to constantly meet people's ever-increasing demands in beautiful ecological environment.

### Show energy conservation undertaking of central enterprises, make contribution in energy conservation by central enterprises

CECEP Green Building Museum is the demonstrative green architecture built by China Energy Conservation Investment Corporation (hereinafter referred to as 'China Energy Conservation Group') in promoting China's architecture energy conservation work and emphasizing harmonious co-existence between human and nature, which is developed and operated by CECEP Industry Development Co., Ltd.

China Energy Conservation Group is the only central enterprise with its main business in energy conservation and environment protection. As China's largest energy conservation and environment protection industrial group with the most complete and professional system, the most extensive professional coverage, the most powerful comprehensive strength, influence and driving force in the energy conservation and environment protection field, China Energy Conservation Group has formed '4+1' main business pattern with energy conservation, environment protection, clean energy, health and comprehensive energy conservation

and environment protection service as the main contents, and is equipped with the comprehensive energy conservation and environment protection service capabilities, integrating planning consultation, R&D and design, investment and development, equipment manufacturing, engineering construction and operations management in one, which is the only large-scale energy conservation and environment protection enterprise group capable of implementing comprehensive treatment, providing comprehensive environment service for a drainage basin, a region, a city in China.

Now, China Energy Conservation Group's scale and strength is leading domestic industrial energy conservation, architecture energy conservation, solid waste treatment, flue gas treatment, heavy metal governance, soil remediation, water treatment, photovoltaic power generation, new energy conservation and environment protection material and other fields. ■

(Fu Qingxi, Reporters from China Economic Herald)



# Sino-German Ecopark 'Passive House' Project Goes in the Forefront of Sustainable Energy Conservation

Reprinted from Economic Guide

## External View of Passive House Technique Center

Energy conservation enterprises are the most important main bodies in practicing energy conservation and emission reduction, circular using of resource. In recent years, Sino-German Ecopark sticks to the exploration in energy conservation building all along, takes energy conservation and emission reduction, comprehensive utilization of resources as the important means in adjusting the economic structure, and has adopted a series of measures including intensifying target-oriented responsibility, readjusting industrial structure, implementing priority projects, promoting advanced technical products and others to positively carry out energy conservation and emission reduction, which further strengthen its competitiveness and sustainable development capacity. On July 7, 2014, Sino-German Ecopark Passive House project contract was signed in the Great Hall of the People in Beijing as witnessed by Prime

Ministers of China and Germany, which opened a new era of passive house development in China.

## Preemptive Research High Spot Launch

Passive ultralow energy conservation green architecture originated from Germany is also known as the passive house, which is an energy conservation architecture technology integrating high comfort level, ultralow energy conservation, economical efficiency in one as recognized by the world. It applies excellent thermal insulation properties, air impermeability and high-efficiency fresh air heat recovery and other technologies, with the energy conservation rate up to over 90% as calculated according to current architecture energy conservation standard, which realizes the living dream of more comfortable bodily sensations and fresher air while achieving energy conservation and environment protection.

As the forerunner in China's passive house

development, Sino-German Ecopark Passive House Company completed the Technique Center project in August, 2016 after great efforts for two years, which became the firstly completed project among the 6 projects signed in 2014 as witnessed by Prime Ministers of China and Germany. After the commissioning of the project, experts from China and Germany conducted strict detection and analysis on energy use condition, and made targeted debugging according to the service condition of fresh air system so as to gradually reduce architecture energy consumption. For example, the data comparison on 2016~2017 heating season against 2017~2018 heating season of Passive House Technique Center shows that: the total energy consumption of the latter is 88,736.78 kWh less than the former, reducing carbon emission of 30,170.44 kg. The project totally meets the design objective as measured, with its heating and refrigeration energy consumption only 20% of that of similar ordinary buildings. Consumption of primary energy will be saved for 1.3 million kWh every year, reducing carbon emission of 664 tons. In June, 2017, China's largest passive house demonstrative residence community - Sino-German Green Era started construction, with its overall floorage over 130 thousand square meters, and consumption of primary energy will be saved for about 10.43 million kWh every year after establishment as measured, reducing carbon emission of 3,200 tons.

On the basis of demonstration practice, Ecopark devotes greater effort in research and development, and now, Sino-German Ecopark Passive House Company has undertaken the two national 13th Five-year Plans tasks of 'Public

Building Technology Integration and Demonstrative Project Research' and 'New Urban District Planning and Design Optimization Technique', and has been elected as the council member unit of Zero Energy Consumption Architecture Academic Committee of the Architectural Society of China and the vice chairman member unit of Green Architecture and Near Zero Energy Consumption Architecture Specialized Committee of Shandong Architecture and Civil Engineering Society.

### Set Standards Lead Asia

Ecopark positively promotes the setting of China's passive house standards: the passive architecture technical standard drafting working team of National Architecture Energy Conservation Standardization Technical Committee settled in the Park in 2017. Ministry of Housing and Urban-Rural Development Passive Ultralow Energy Consumption Green Architecture (Residence Part) Technical Guide Rule, Shandong Province Engineering Construction Standard of Passive Ultralow Energy Consumption Residential Architecture Technical Standard compiled by Sino-German Ecopark Passive House Company have been issued and implemented. now National Near Zero Energy Consumption Architecture Technical Standard and Shandong Passive Ultralow Energy Consumption Green Architecture Technical Guide (Public Building), Shandong Province Passive Ultralow Energy Consumption Architecture Energy Conservation Structure Map Collection, Shandong Province Ultralow Energy Consumption Building Construction Technical Guide Rule and other standards are under compilation.

seven passive house patents by independent research and development have been approved. high-powered passive house household fresh air handling units with proprietary intellectual property rights have been put into production in commission in the Park, which fill in gaps in this field in China.

In September, 2016, Sino-German Ecopark initiated and launched the 1st Session Asian Passive House Conference, with over 200 authoritative experts in the passive house field from China, Japan, South Korea, Germany, Austria, Italy, Finland and other countries all together to discuss the latest scientific payoffs and development directions in the passive house field at home and abroad.

In August, 2017, the 2nd Session Asian Passive House Conference was held in Japan, and Sino-German Ecopark made the keynote speech as the initiator. The 3rd Session Asian Passive House Conference will be held in South Korea in 2018, and Ecopark will make a speech as the special guest again, continuing its leading position in Asia.

### Promote Comprehensively Contribute to the Future

Sino-German Ecopark will set up an energy consumption data collection and analysis center to promote the integrated innovation development of 'Four Energies' technologies of architecture energy conservation, energy

use, energy production and energy storage, construct passive house scientific research innovation basis, build passive house whole industry system, and explore the new pattern of the development of passive architecture in China.

Now, Ecopark has practiced multiple types of passive technology solutions by technology research and development, including school, office, residence, hotel, library and other buildings. In the future, Sino-German Ecopark will also intensively develop a passive building with the overall floorage of about 1.6 million square meters in the Park, devoting to building China's largest passive building cluster.

There are newly-erected buildings of about 2 billion square meters in China every year, and the carbon dioxide emissions will reduce about 12 million tons every year if 20% of them are constructed by the standard of passive house as compared to China's existing energy-saving standard of 65%.

It is foreseeable that passive house will make proactive contribution to more comfortable life and more azure blue for people.

(An Ran, Reporters from China Economic Herald). ■



## 'Green Joy City' Implemented Objectives Oriented "Whole Process Energy Efficiency Management"

— Documentary of practice in innovating green development mode in commercial complex construction by COFCO Real Estate

Reprinted from Economic Guide

### Exterior of Chengdu Joy City

The yearly energy conservation rate is above 30%. it saves energy cost for RMB 5 million/year as compared to projects of the same scale. Meanwhile,owing to the implementation of such green development mode,the project not only insures the comfort level of indoor environment and great improvement in customer

satisfaction,but also directly saves about RMB 12 million of investment cost at the design stage.

The energy-saving effect of Joy City in Chengdu Municipality,Sichuan Province mentioned above benefits from the innovative green development mode of 'whole process energy efficiency management by objectives' by such project's developer- COFCO Real Estate business.



## Energy Conservation is Embodied Everywhere

Reporters from China Economic Herald has found that there is a dedicated through channel for cars to Joy City parking lot as detached from the main street line to Joy City Shopping Mall when driving to Chengdu Joy City, and the parking lot with 2 thousand stalls is equipped with charging facilities for new energy electric vehicles. When reporters entering the shopping center, its grand and spotless shopping environment makes people feel comfortable. There are over 4 hundred shops in the shopping mall, covering delicious food, cinema, clothing and shoes, leisure and entertainment, mother and baby products, beauty makeup, accessories and household supplies.

When reporters going up to the spacious roof of Joy City, the landscaping design style here leaps to the eyes, with the green plants on the roof greatly reducing energy consumption, and the meticulous and scientific design brings best energy conservation experience.

Chengdu Joy City covers a floor area of 308 thousand square meters, and air conditioning area of 113 thousand square meters (including Joy Street), and as to the whole design concept, it adopts scientific energy conservation and environment protection automatic system. To be specific, in terms of electromechanical equipment energy conservation, Joy City adopts teletransmission to collect terminal utilities data, achieving real time monitoring on energy conservation. adopts full-automatic air conditioning system air handler frequency conversion mode, achieving intelligent adjustment. adopts real time data monitoring on energy management system and

provides timely information feedback and energy data analysis, achieving planned use of energy.

## Success owing to sustainable exploratory development

Commercial architecture is a high-density energy consumption field, and according to investigation, energy waste in commercial architecture is still in a severe situation in China, with more energy-saving potential left.

COFCO pays constant attention to energy-saving operation and green property management, continually explores and studies the solution to 'too high energy consumption, too low energy efficiency' of commercial architecture, accumulates and gropes the innovative green development mode of 'whole process energy efficiency management by objectives' through development and operation management experience of multiple projects since it entered the development and operation field of commercial complex in 2007.

'Whole process energy efficiency management by objectives' is an innovative green development mode comprehensively taking the project's initial cost, integral development progress, actual operation energy consumption and energy efficiency into consideration. In 2013, COFCO Real Estate identified Chengdu Joy City as the demonstration project of public-building 'whole process energy efficiency management by objectives', set clear energy efficiency objectives during the first three years since opening. afterwards, energy conservation control objectives and corresponding measures form effective delivery among different links by management technology measures throughout all phases of design, construction and operation. Since its opening

in December, 2015, the project has achieved the energy efficiency objectives: during the first three years since opening that 'yearly energy efficiency ranking top 10% in the industry', 'yearly power saving rate reaching above 30%' a year in advance as evaluated by Building Energy Conservation Research Center, Tsinghua University, with the energy cost saved for RMB 5 million every year as compared to projects of the same scale. Meanwhile, owing to the implementation of such green development mode, the project not only insures the comfort level of indoor environment and great improvement in customer satisfaction, but also directly saves about RMB 12 million of initial investment cost at the design stage. It provides a new exercisable mode for green construction and operation of China's commercial complex.

### Innovative practice of 'three transformations'

Chengdu Joy City Project has achieved design in advance of project development in the transformation from 'calculating how much energy consumption will cost after project completion' to 'setting energy conservation target first and then constructing the project according to the target', and during the project design phase, the project team constructed DeST (a software platform simulated by architecture environment and HVAC system) architecture energy consumption model to simulate hour-by-hour energy consumption of 8,760 hours a year, and continually improved design scheme by simulation analysis means to explore the best energy efficiency and the lowest energy-consumption index as achievable which was then identified as the ultimate energy conservation goal. meanwhile, the energy conservation goal was split into

3 categories and 15 subgoals, which were thus taken as effective management means to make the construction goals of each subsystem in the energy system more explicit. This innovative measure has successfully solved the problem under traditional development mode that 'there is no explicit energy-conservation control goal, and no actual focus on reduction of energy consumption, but only focus on the simple gathering of energy-conservation technology during the design phase'.

The work pattern transforms from 'each railway policeman is responsible for only one section, with nobody responsible for energy efficiency quality' to 'product manager responsibility system. The project mainly experiences planning and design phase, site operation phase, estate operation phase from project approval to service. Under traditional development mode, design, construction, operation and other links are conducted independently and separately, leading to the failure of the effective delivery of energy conservation goal to the next phase, with the energy conservation work only staying on the blueprint. However, this project modifies organizational structure, and introduces 'product manager' thought of internet enterprises into real estate development for the first time: Design Department takes the role of energy system 'product manager' to coordinate the work of design, construction, operation and other links and is responsible for its ultimate energy conservation goal while completing planning and design work in hand. According to the on-spot record, 91 big questions have been found and solved just in the sublink of 'construction quality inspection' only, which has greatly reduced the risk of too high energy conservation due to construction



deficiency and has laid good basis for energy conservation operation.

Transform from 'ensuring the usability of the energy system only based on previous technical measures' to 'ensuring the efficiency of energy system by researching and developing a set of complete technical measures to conduct multilayer protection'. It is inevitable that high-standard energy conservation goal calls for the support of high-level technical support measures, which also puts forward higher requirements to the technical capacities of COFCO team as well as design consultants, construction organizations, manufacturers and various other partners. Reporters from China Economic Herald have learned in the interview that, in this project, the team has completed the research and development of a set of technical measures of whole process energy efficiency management by objectives throughout design, construction, operation and various other phases, including 'typical working condition comprehensive COP (Coefficient of Performance) energy system argumentation method' in the design phase, '3 important items, 47 digitized quality inspection and debugging technical standards' in the construction phase, 'high-efficiency energy system platform and technical standards' in the operation phase and other contents to guide project construction, which solves

'the problem that the development team wants to achieve energy conservation by technological means, but key technical matters in design, construction and operation are muddleheaded and technological difficulties have no basis' under traditional mode to a great extent.

During the interview, the relevant person in charge of COFCO Real Estate said that, reports of the 19th National Congress of the Communist Party of China clearly proposes to accelerate structural reform in ecological civilization, construct Beautiful China, which has pointed out the direction and provided basic abundance for China's energy conservation work. In the future, COFCO Real Estate will continue implementing five concepts for development, take energy conservation and emission reduction, green and environmental protection, comprehensive utilization of resources as important measures to improve quality and efficiency, continually innovate technological means, deepen the implementation of 'whole process energy efficiency management by objectives' mode, promote the coordinated development of urban construction and environmental protection as always to achieve mutualistic symbiosis and win-win results in enterprise competitiveness and sustainable development capacity. ■

(Li Pinggui, Reporters from China Economic Herald)

## Green Parks Can Realize the Energy Saving Effect by Following Certain Mode

Reprinted from Economic Guide

According to statistics, the public building areas cover less than 30% of that of gross floor areas but consume around 60% of total energy consumption of buildings. Having effective energy-saving management on public building areas is an important way to control the growth in building energy consumption.

With gross floor area of over 72,000 square meters, the park, namely, China Key System Co., Ltd. Lihu Park, a subsidiary of CETC (hereinafter referred to as 'CKS Lihu Park') is situated inside of National Integrated Circuit Design Center located in No. 777, Jianzao West Road, Binhu District, Wuxi, Jiangsu. To reduce energy consumption, the park built projects such as rooftop distributed photovoltaic power station and put them into operation. By doing so, it saved around 1.1 million kwh of electricity with comprehensive energy saving rate reaching 20%.

The reporter from China Economic Herald learned from the interview that China has many similar parks with

similar energy types and usage modes and thus the green energy saving experience of the park can be promoted and copied.

**Green energy saving projects can be built based on the actual service conditions of energy**

Chen Hui, deputy head of Operation Guarantee Department of CKS told the reporter from China Economic Herald that CKS Lihu Park mainly used electrical energy and consumed power of 4.688 million kwh in total in 2017, of which, central air conditioner (refrigerator, water pump and draught fan) consumed over 35% of power, offices consumed around 35% of power, production consumed 20% and other devices consumed 10%. The natural gas used throughout the year was 201,400 cubic meters for heating in winter and staff canteen.

According to Chen Hui, from the actual service conditions of energy and in combination with the technical expertise and industrial development plan of the unit, the park

mainly focused on the following two aspects in green energy saving projects: firstly, as power consumption occupied over 80% of total energy consumption and central air-conditioners were major consumers of power, the power energy saving and air conditioner energy saving were our priority. Secondly, based on IoT technology, management modes and philosophies were innovated through green energy saving projects.

### Green energy saving projects were carried out through six measures

The reporter from China Economic Herald learned that CKS Lihu Park saved around 1.1 million kwh of power every year with comprehensive energy saving rate reaching 20%. Are you wondering how they manage it? Let's find it out after visiting the park with Chen Hui.

'Building B1 is the main building of the park. We installed 1 set of solar water heating system on the roof for supplying hot water for B1 building', says Chen Hui. Each vacuum tube produces 7.5 liters of hot water and daily hot water amount produced can reach 19.5 tons, which solved the hot water issue for employees living in B1 building when the sunlight is sufficient in winter.

'In terms of green lighting, LED lighting is applied for building decoration in the park with usage rate of 100%', explains Chen Hui. Over 13,000 LED lights of all types are used in the park with total power of 200KW. Compared with common energy saving lights, LED lights can save over 60% of energy. It's worth mentioning that these LED lights are all products independently produced by CKS. On the basis of LED lighting, body

sensors are added to the lighting of public areas such as elevator lobby during operation to further lower power consumption. In this way, the LED lighting can save power of 360,000 kwh compared with common energy saving lights throughout a year.

'We also installed distributed photovoltaic power station covering an area of 4,250 square meters with installed capacity of 419 KW on the roof of all buildings in the park,' says Chen Hui. The project has been connected to grid and generated power since December 29, 2016. According to Chen Hui, 99% of the power generated by the project is for self-use and contract-based energy management mode is applied. Electric charges are paid to investors on a monthly basis according to certain discounts of market price, based on consumed power of photovoltaic power station every month. In 2017, the electricity costs saved were RMB 128,300. The power generation and operation data of the power station are subject to online monitoring and statistics of third-party platform.

Air conditioner energy saving has been the priority in the energy saving reconstruction of public buildings in China. Within CKS Lihu Park, central air conditioner system has 20 water pumps with total power of 1,170 KW, one in service and one standby. 'To better realize air conditioner energy saving, we mainly transformed the water pump frequency conversion of central air conditioner,' explains Chen Hui. 'The project had been completed in December 2016 with system energy saving rate reaching 25% after over one year of actual use. The actual power saved annually is over 150,000 kwh,' adds Chen Hui.



Meanwhile, power demand side management platform consisting of main station layer, communication layer, collection layer has been constructed in the project. The collection layer of the park has a total of 80 collection points distributed in building group of B1 - B6 to realize the full coverage of power settlement points and targeted monitoring over key energy consumption line. The platform was put into operation in May, 2017. According to Chen Hui, 'several energy consumption vulnerable links have been found since the operation of platform with 6 energy saving diagnosis provided including transformer load rate, transformer harmonic wave status, power factor, three imbalances and abnormal power consumption at night, which provided basic data for energy management.'

'In addition, we developed cloud platform for comprehensive management,' Chen Hui told the reporter from China Economic Herald. By virtue of sensing technology, cloud computing technology, big data technology, heterogeneous network integration technology, network transmission encryption technology, the cloud platform integrates all application sub-systems, data resources, network resources into unified information portal. Through analysis and treatment of all kinds of data, more senior application scenarios are provided to realize linkage management and control among sub-systems, thereby achieving efficient and scientific concentrated management, lowering operation cost and enhancing management level. It's known that the platform was completed independently by IoT technical team of the

unit and put into use in December 2017.

The green energy saving project construction of the park can be promoted and copied.

After learning about the series of technologies, are you more curious about the amount of energy saving benefits brought by the above efforts? Chen Hui told the reporter of China Economic Herald that the project produces significant direct energy saving effects. LED lighting saves power consumption of 360,000 kwh every year compared with common lighting. The photovoltaic power station generates power of 470,000 kwh and the water pump frequency conversion saves power of over 150,000 kwh every year. The power demand side and comprehensive cloud management platform bring direct energy saving benefits of over 100,000 kwh and greatly reduce labor costs.

In terms of environment benefits, the green energy saving project of the park continuously reduces power consumption by around 1.1 million kwh every year, equivalent to the saving of 135 tons (calorific value in theory) or 440 tons (coal consumption for thermal power generation) of coal equivalent according to relevant standards. Meanwhile, it cuts carbon dioxide emission by 1,096 tons, carbon dusts by 299 tons, sulfur dioxide by 33 tons, nitric oxide by 16 tons.

Certainly, in addition to direct energy saving benefits, the project realized indirect management efficiency. According to Chen Hui, 'the underlying role of the project is to achieve delicacy management flow, enhance management efficiency, guarantee energy

safety,eliminate management dead zone,optimize the effect of scheduling mechanism,thereby contributing to the establishment of a set of long-effective energy-saving management mechanism through power demand side platform and comprehensive management platform.'

According to Chen Hui,there are many development zones and innovation parks similar to CKS Lihu Park in China with similar energy types and usage modes,which make it possible for the technologies to be promoted and copied. With matured technologies such as LED lighting,rooftop photovoltaic power station,water pump frequency conversion,power monitoring,the construction will basically not affect

normal scientific research and office work.

Meanwhile,Chen Hui held that the project investment features low investment threshold and can adopt contract-based energy management mode to reduce capital pressure on owners. Overall,with the investment recovery period of around 4 years,it's a good investment project.

The cloud platform for comprehensive management,according to Chen Hui,is highly targeted and practical for energy saving management and property management of the park. CETC is striving to expand market in this field and make more parks green with better technologies and services so as to contribute to the building of beautiful China. ■

(Bai Xue,reporter from China Economic Herald).

## Expert Perspectives

### Vigorously Deepen Multilateral Cooperation to Jointly Promote Energy Efficiency Improvement

Shaoshan Xu

Energy efficiency improvement is an important guarantee to meet the growing demand of energy for global modernization, the practice and innovation to promote the harmonious coexistence of mankind and nature, and an important prerequisite for the goal of tackling climate change. At present, the global energy consumption is mainly concentrated in the fields of industry, building and transportation. With the acceleration of global modernization, if the demand of energy relies on the development of the original raw resources, both energy security and ecological environment capacity will be under tremendous pressure. Energy efficiency

improvement is not only the prioritized source to meet the growth of energy demand, but also the inevitable requirement of global high-quality development. It is estimated that the global power consumption will increase by 60% by 2030, part of the energy consumption is caused by applications of electrical appliances, lighting and other devices that improve the quality and comfort of life. The consequent increasing of energy consumption will bring challenges to all governments. Therefore, it is an important task to deeply tap energy saving potential to improve energy efficiency, and promote the optimization of global energy efficient technologies.



From 2013 to 2019, the energy consumption per unit of GDP has dropped by 24.6% in China, the accumulated energy saving equivalents to 1.27 billion tons of standard coal, which is closed to the current annual energy consumption of Beijing-Tianjin-Hebei region and Yangtze River Delta. China has an average annual energy consumption growth of 2.7% to support the average annual economic growth of 7%, which provides strong support for the sustained and healthy economic development. As one of the countries with the fastest reduction in energy intensity in the world, energy conserved by China accounts for about half of the global energy saving in the same period, which plays an important role in promoting the global sustainable development.

In addition, under the framework of the International Partnership for Energy Efficiency Cooperation (IPEEC), China took the lead in establishing the cooperation mechanism of "Top Ten Energy Efficiency Best Available Technologies (BATs) and Best Practices (BPs)". The National Development and Reform Commission (NDRC), as the focal point of China to promote the international energy efficiency cooperation

, actively coordinates the formulation and release of the international TOP TENS lists, and highlights the great importance on energy conservation and energy efficiency improvement in membership countries. The corresponding promotion events conducted have further enhanced the influence and importance of TOP TENS in domestic and abroad.

As the technical supporting organization, China Quality Certification Centre also undertakes the role of China's secretariat of TOP TENS. In order to strengthen the influence of TOP TENS in China, it was adopted as one of the key promotion elements in the promotion agenda of the National Energy Conservation Week held in the consecutive year of 2019 and 2020. Furthermore, the promotion events of releasing special reports, opening official WeChat account, applying for certification and others were conducted to share experience and improve energy efficiency.

In the future, TOP TENS will continue to play the role of promoting bilateral and multilateral exchange and docking of energy efficient technologies, and build a broader "bringing in" and "going out" platform. ■

## Expert Perspectives

### Application of Energy Efficient Technologies and Practices is the Vital Measure to Realize Energy Efficiency Improvement

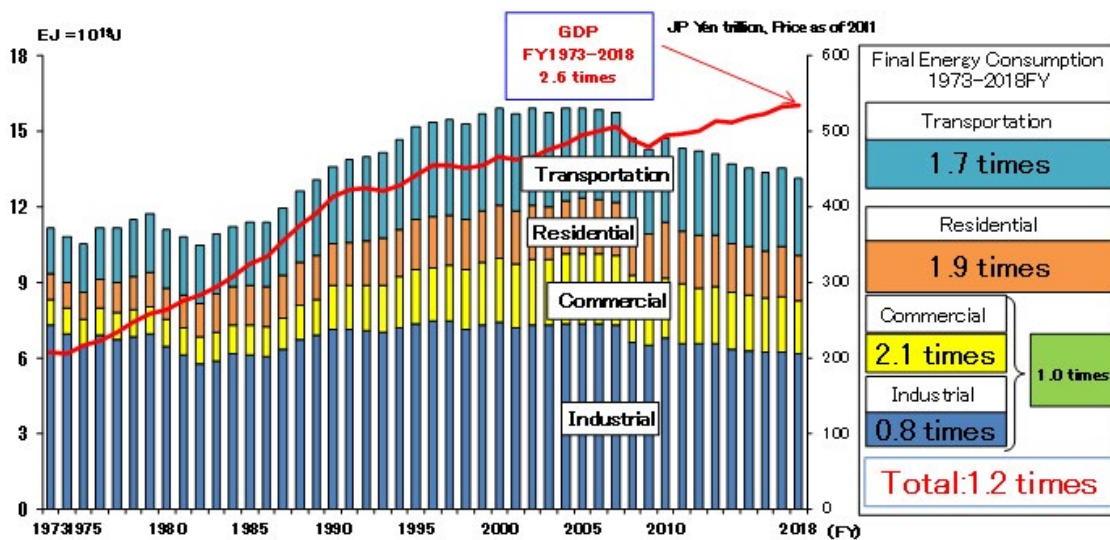
Jointly written by METI/ANRE and ECCJ

Recently breakthrough in environmental technology and investment are being sought around the world to reach the goals of the Paris Agreement. In the future, it is expected that the movement toward the realization of innovative technologies and zero emissions will be accelerated worldwide. In order to achieve this, it is expected that further strengthening of efforts in each field such as energy efficiency & conservation, renewable energy, and energy storage will be required. Particularly, expectations for promoting energy efficiency are becoming higher than before in terms of improvement of efficient use of energy in a sustainable manner. Since closer information sharing among a wider range of stakeholders is important for the

effective and efficient promotion of energy efficiency & conservation, it is desirable to strengthen international cooperation activities in this field more than ever before.

#### Japan's Final Energy Consumption

In the 1970s, Japan has experienced the oil crises and not only its industries but also the other sectors including commercial, residential, and transportation etc. have suffered from soaring energy prices. However, subsequently, the Japanese government and industries have united their efforts to promote energy management activities while they sought rationalized production at the same time. They worked hard toward developing energy



Source: METI/ANRE

efficient technologies and devices, systems with high efficiency in the use of energies. As a result of those efforts, Japan's GDP has grown to become 2.6 times larger than that of 1973. On the other hand, due to the robust efforts of public and private sectors as well, the amount of energy consumption has been reduced to become less than 2.6 times i.e. 1.2 times larger than that of 1973. However, if we see the picture in more detailed manner, there are different stories in terms of respective sectors. Performance of the industrial sector was relatively good i.e. their energy consumption level became 0.8 times larger than that of 1973, while the others were not quite similar e.g. commercial sector 2.1 times, residential sector 1.9 times and transportation sector 1.7 times, respectively. Therefore, it is reasonably said that there is still some room for improvement in energy saving in those sectors from now on.

### The measures Japan took to improve energy efficiency

Regarding energy efficiency improvement towards 2030, the Long-Term Energy Supply and Demand Outlook 2015 aims to achieve 50.3 million kl crude oil equivalent reduction of energy consumption, which requires further 35% efficiency improvement from 2013 to 2030. In order to achieve this target, Japan will take various measures in each sector.

For example, Japan has introduced the Top Runner program which requires manufacturers and importers to improve energy efficiency of appliances and materials towards the most efficient level, including labelling program for influencing the consumer behavior. Currently, the program covers 32 items and through this approach, Japan has promoted energy efficiency intensively. Rather than reducing energy consumption, utilizing energy in more efficient manner is a key to achieve both energy



efficiency and economic activities. In addition, under the Top Runner Program, Japan has set the Fuel Economy Standards, and last year, Japan revised it for passenger vehicles including Electric Vehicles (EVs) and Plug-in Hybrid Vehicles (PHVs) starting in model year 2030. In order to assess fuel efficiency of these newly-added electric vehicles together with combustion vehicles, the Well-to-Wheel concept has been introduced. Furthermore, Japan has been implementing financial supporting mechanisms for investment in highly efficient production equipment in the industrial sector, renewal of energy efficiency equipment in the entire factory and business buildings, and support for net Zero Energy Houses (ZEH) and net Zero Energy Buildings (ZEB) demonstration projects in the residential and commercial building sectors.

### The contribution of TOP TENS to energy efficiency improvement in Japan

In order to estimate the impact of the TOP TENS, let's first consider the effect of the Energy Conservation Grand Prize Award (hereinafter 'the Award') system in Japan on energy conservation activities in Japan as a whole. Quantitatively, for example, 39 cases were selected in the Award of 2019. The energy saving effect of them, including the spillover effect, is about 100,000 tons of oil equivalent per year. This accounts for 0.04 % of Japan's final energy consumption. On the other hand, its qualitative significance is that the best practice database of the Award was supposed to be a treasure trove of energy related information such as energy management

method, autonomous small group activities in various sites at various business entities, application of advanced technology, process of know-how creation, etc. The cost-effectiveness was so high, including the sales promotion effect of using its logo and the educational effect of the presentation competition that it could successfully make continuous contributions for 45 years.

Based upon those findings, if we think about the possible contribution of TOP TENS to energy efficiency improvement in Japan, we must consider the difference in the countries and information involved in both systems. TOP TENS could help promote energy efficiency-oriented work more widely than the Award. If TOP TENS works well enough, not only it gains more quantitative benefits in energy conservation than that of the Award, but also it helps upgrade production methods in industry, develop new standards when introducing new technologies, contribute to human resource development and raise social awareness, etc. on a larger scale and more extensively under international cooperation.

### Significance of the TOP TENS and further expectations for the TOP TENS in the future

The significance of the TOP TENS task group is that by utilizing the status of the G20 EELP, it will be possible to continue to lead the world in the energy saving sector as an international energy saving award system. In the future, if the coverage can be expanded to include renewable energy, energy storage, etc., while still focusing on energy saving, it is thought to be more influential. In addition, we will learn from successful examples from around

### <Major energy efficiency measures in each sector>

<b>Industrial Sector &lt;approx. -10.42 million kL&gt;</b> <ul style="list-style-type: none"> <li>➤ Major 4 Industries (steel, chemical, cement, and paper/pulp) ⇒ Promotion of commitment to a low-carbon society</li> <li>➤ Strengthened energy management in factories ⇒ Improvement of energy efficiency by making production lines observable</li> <li>➤ Development and introduction of innovative technology ⇒ Introduction of environment-conscious iron manufacturing process (COURSE60) (CO<sub>2</sub> reduction by approx. 30% by hydrogen reduction of iron ore and CO<sub>2</sub> separation from blast furnace gas) Introduction of technologies to use CO<sub>2</sub> as raw material etc. (CO<sub>2</sub> and water are used with solar energy to produce major chemicals.)</li> <li>➤ Introduction of highly efficient facilities across several types of industries ⇒ Low-carbon industrial furnace, high-performance boiler, cogeneration, etc.</li> </ul>	<b>Commercial Sector &lt;approx. -12.26 million kL&gt;</b> <ul style="list-style-type: none"> <li>➤ Energy efficiency in buildings ⇒ Mandating energy efficiency standards for newly constructed buildings ⇒ Realization and Promotion of ZEB (Net Zero Energy Building)</li> <li>➤ Introduction of High-efficiency Equipment ⇒ Promotion of efficient light including LED etc.</li> <li>➤ Making energy consumption visible by BEMS; Energy management ⇒ Introduction to about half of the buildings ⇒ Promotion of national movement</li> </ul>
<b>Transportation Sector &lt;approx. -16.07 million kL&gt;</b> <ul style="list-style-type: none"> <li>➤ Diffusion of next-generation automobiles and improvement of fuel efficiency. ⇒ One out of two cars are to be next-generation cars. ⇒ Fuel cell vehicle: Maximum annual sale of 100,000 or more</li> <li>➤ Traffic flow control</li> </ul>	<b>Residential Sector &lt;approx. -11.60 million kL&gt;</b> <ul style="list-style-type: none"> <li>➤ Energy efficiency in houses ⇒ Mandating energy efficiency standards for newly constructed houses ⇒ Promotion of ZEH (Net Zero Energy House)</li> <li>➤ Introduction of High-efficiency Equipment ⇒ Promotion of efficient light including LED etc.</li> <li>➤ Making energy consumption visible by HEMS; Energy management ⇒ Introduction to all houses ⇒ Promotion of national movement</li> </ul>

Source: METI/ANRE

the world (Japan / Energy Conservation Grand Prize Award, ASEAN / ASEAN Energy Award, CEM / Energy Management Leadership Awards, etc.) and build more sustainable systems. By doing so, it will be possible to make continuous contributions to the world.

In future activities, it is expected that more countries could cooperate within the TOP TENs task group and

develop robust promotion and dissemination activities to enhance the capacity building in the member countries and improve the social awareness of energy efficiency & conservation. ■

## Expert Perspectives

### Scale up Energy Efficiency Investments: U.S. Top Tens Energy Efficient Technologies

Andrea Mott, Meredydd Evans, Sha Yu, Aaron Staniszewski, Artur Denysenko, Lindsay Parker

Energy efficient technologies have significant potential to drive down current building energy consumption and mitigate future growth in demand, without sacrificing current building comfort. The building sector accounts for 40% of the United States energy consumption, while globally it was about one-third<sup>[1,2]</sup>. Widespread implementation of energy efficient buildings can reduce

energy costs, emissions, and even improve the quality and public health of buildings. Energy efficiency investments and savings can also create direct jobs in installing technologies or indirect jobs further upstream the supply chain, or even more broadly across industry as energy bills are reduced. Energy savings overall can help drive growth in the economy<sup>[3]</sup>.

#### Notes:

[1] EIA, 2017d. FAQ: How much energy is consumed in U.S. residential and commercial buildings?, U.S. Energy Information Administration. Retrieved from <https://www.eia.gov/tools/faqs/faq.php?id=86&t=1> (Accessed August 29, 2017).

[2] IEA, 2013. Transition to Sustainable Buildings: Strategies and Opportunities to 2050, International Energy Agency. Retrieved from <http://www.iea.org/Textbase/npsum/building2013SUM.pdf>.

[3] Nadel, S., Elliott, N., & Langer, T. (2015). Energy Efficiency in the United States: 35 Years and Counting. ACEEE Report, June. <https://www.aceee.org/research-report/e1502>.



Buildings can reduce energy use through energy efficiency measures. U.S. residential and commercial buildings could decrease their energy consumption by half just by using commercially available energy efficient technologies<sup>[4]</sup>. Moreover, in countries with rapidly developing economies, where improvements in living standards will spur higher energy demand, the use of these products can help mitigate the increase in energy consumption.

The Top Tens Task Group is a global collaborative project to identify, evaluate, and disseminate the best available energy efficient technologies and practices in use today and to accelerate the widespread application of technological innovations worldwide. The countries in the Task Group worked together to create a framework methodology that would allow each country to create a domestic list of energy efficient technologies and/or practices for a given sector, with the goal of broadening awareness by promoting it to businesses, policymakers, energy program administrators, and other targeted stakeholders. The Task Groups then identified leading energy savings technology solutions that are commercially available, widely deployable, scalable, and have an innovative component.

Following the framework established by Task Group, the Pacific Northwest National Laboratory

of the U.S. Department of Energy developed the report “Best Available Technologies in the U.S. Buildings Sector”, which identifies Top Ten building technologies for the U.S.’s commercial and residential building sectors, and details how they were chosen<sup>[5]</sup>. The buildings sector is a strategic choice for the U.S. because of the strength of their technology and innovation in the building efficiency sector, and because the extensive built environment in the U.S. presents broad opportunity for realizing economic and energy security benefits through energy efficiency retrofits, as well as investment opportunity for new builds. The list of potential technologies covered a broad range in both residential and commercial buildings, including sensors and controls, lighting, HVAC, and windows and envelope. The scope of the building technologies was limited to exclude renewable energy and plug load appliances.

The Top Ten technologies were assessed through a robust process, including literature review, initial screening, expert consultation, and technical and modeling analyses of financial viability, energy savings potential, and economic characteristics, and then selected by applying a Top Tens Scoring Methodology. The list can be found on pages 316 to 321.

These Top Ten technologies can achieve significant energy savings across commercial and residential buildings in the United States, driving down current building energy

Notes:

[4] BTO, 2015. Quadrennial Technology Review: Chapter 5: Increasing Efficiency of Building Systems and Technologies Supplemental Information, U.S. Department of Energy. Building Technologies Office.

[5] Staniszewski, A., Denysenko, A., Evans, M., Parker, L., & Yu, S. (2018). Best Available Technologies in the U.S. Buildings Sector. Pacific Northwest National Laboratory, Richland, WA.

consumption and mitigating future growth in demand without sacrificing comfort. Energy consumers, program administrators, developers, designers, and policymakers can use this list to consider the benefits of these technologies and invest in a more energy efficient future. While this study considers U.S. building sectors exclusively, the technologies have global applicability and could achieve large savings beyond the U.S. Market.

The Top Ten technologies have larger implications than just reducing energy. By identifying, promoting, and

showcasing the best available technologies, international collaboration on Top Tens can drive the market for more efficient building technologies and help improve the stringency of building energy codes and appliance standards over time. Buildings and communities will become more energy efficient and more resilient. Combining the joint efforts of the member countries, the Top Tens initiative has the potential to transform the market to adapt greener and more cost-saving practices. ■

# Promotion Events of TOP TENs

## Promotion Events of TOP TENs

CQC, ECCJ, PNNL

The development and release of the international TOP TENs Lists highlights the priority given by the member states to energy conservation and energy efficiency improvement, and the influence and significance of TOP TENs has been further enhanced by the promotion events. On the international level, relying on the G20 side events, BRICS Energy Efficiency Working Group Meeting, China-U.S. Energy Efficiency Forum, China-Japan Comprehensive Forum on Energy Saving and Environment Protection, China-Russia Energy Efficiency Working Group Meeting and other bilateral and multilateral cooperative mechanism, the exchange and docking of the energy efficient technologies has been facilitated vigorously, and the corresponding

platform to promote the 'going out' and 'bringing in' of energy efficient technologies has been established. On the domestic level, the member countries carry out various promotion events to facilitate the spread and application of energy efficient technologies and practices in the key energy-using sectors. Among the member countries, the promotion events carried out by China, Japan and the U.S. are the most representative and fruitful.

### I.China

**1.Facilitate energy conservation and energy efficiency improvement by holding TOP TENs promotion events in the occasion of the National Energy Conservation Week**



In order to increase the influence of TOP TENs and encourage the applicants to continue to innovate, research and develop, apply and promote advanced energy efficient technologies and practices, TOP TENs was adopted as one of the key promotion elements in the promotion agenda of the National Energy Conservation Week held in the year of 2019 and 2020. In 2019, at the opening ceremony of the National Energy Conservation Week, the applicants of the enlisted in the international TOP TENs lists were awarded. Officials from the National Development and Reform Commission, the Ministry of Housing and Urban-Rural Development, the Ministry of Ecology and Environment and China Certification and Inspection Group gave the attendance to the ceremony to witness the moment of glory. In 2020, cloud promotion was adopted and the National Development and Reform Commission set up TOP TENs special column on its official website to demonstrate the technical advantages, management concept and achievements of TOP TENs and its role to promote energy conservation and energy efficiency improvement, so as to assist the applicants to explore market in the context of COVID-19.

## **2. Release special reports to share experience**

To further summarize and promote the good practice and experience in the process of realizing energy conservation and energy consumption reduction, play a exemplary role in driving more sectors to tap the energy conservation potential, and promote high-quality development, the National Development and Reform Commission organized the China Economic Herald to

report the energy efficient technologies and practices, and shared part of the excellent cases and experience on how to conserve energy and reduce energy consumption.

## **3.Enhance energy efficiency by certification**

Upon the recommendation of TOP TENs technical supporting institution and the strict assessment by the nearly-zero energy buildings(NZEB) certification agencies, one of the TOP TENs energy efficient practices 'Passive House Technology Center of Sino-German Ecopark' obtained the first batch of NZEB certificate in 2019, which fully demonstrated the advantages of the selected TOP TENs energy efficient practice in terms of building comprehensive energy-saving rate, renewable energy utilization rate and other indexes, and provided reference for improving building energy efficiency level and promoting the healthy and orderly development of NZEB.

## **4.Register a WeChat official account to strengthen we-media promotion**

TOP TENs WeChat official account was registered to timely release its cooperation progress, achievements, excellent practices and experience. The we-media promotion was strengthened to provide special publicity network platform for TOP TENs.

## **II. Japan**

### **1. Participate in energy & environment related forum to contribute to the international cooperation in energy efficiency and conservation field**

ECCJ has been taking an active part in energy and

environment related forums, such as ENEX (Energy and Environment Exhibition) held in 2020, to exhibit TOP TENs lists and introduce the economic benefits of TOP TENs in energy efficiency and conservation improvement.

## **2. Enhance regional visibility and cooperation**

ECCJ has been cooperating with ASEAN in improvement of ASEAN Energy Awards system in various fields. In this context, ECCJ made aware of TOP TENs activities in terms of its objectives, systems, procedures and achievements at a workshop held in Japan in 2016. ASEAN showed its interest and expectation of participating TOP TENs in the future.

## **3. Make steady efforts to disseminate energy efficiency and conservations awareness through publications, newspapers etc. related to the TOP TENs**

TOP TENs could raise the hottest topics for discussion in the field of energy efficiency and conservation. At the same time, it points out practical improvement measures. With the guidance of the government sectors, the support from the technical institutions and positive attitude of corporations in Japan, TOP TENs enjoys increasing popularity in Japan. ECCJ carried out in-depth reports featured in Japanese Smart Energy Products and Technologies 2020 which has been edited continuously in Japan as a kind of public and private cooperation work in Japan. Electric Daily News, one of Japan's leading newspaper in energy and electricity related sector, wrote about the presentation made in G20 official side event held by Japan in 2019 in terms of what was selected as

the 2nd batch of TOP TENs and the significance of the total system.

## **III. U.S.**

### **1. Held workshops to promote energy efficient technologies**

The U.S. Department of Energy, the Pacific Northwest National Laboratory, and the Clean Energy Solutions Center held workshops to provide an overview of energy efficient building technologies and share case studies to elaborate the innovation, reliability, replicability, and investment benefits of these technologies. Meanwhile, the wide resource network of the Clean Energy Solutions Center was utilized to share and promote the best energy efficient technologies and case studies.

### **2. Organized technical discussions to facilitate technology upgrade**

The Pacific Northwest National Laboratory organized several technical discussions and invited the government, research institutions, and businesses to discuss energy saving potential and implementation measures in the buildings sector as well as policies and programs that can further facilitate technology deployment and market transformation. Specifically, the TOP TENs energy efficient technologies were discussed with experts, including the advantages and energy savings potential of existing technologies and the trends of technology development in the buildings sector.

### **3. Shared TOP TENs technologies with China Green Buildings Study Tour Group**

The U.S. Trade and Development Agency (USTDA)

hosted a China Green Buildings Study Tour, which brought public and private energy sector officials from China and the U.S. to share best practices in clean energy development. The U.S. Department of Energy and the Pacific Northwest National Laboratory shared TOP TENS

technologies with the study tour group during the China Green Buildings Business Briefing organized by the USTDA and discussed how these technologies can be used to promote energy efficiency in buildings. ■



# Appendix: G20 Energy Efficiency Leading Programme (G20 EELP)

## G20 Energy Efficiency Leading Programme

Edited by Nan Hu, Ying Zhang, Yingjin Jiang

### Executive Summary

Energy efficiency, including energy conservation, is a long-term priority for G20, as it constitutes the optimum utilisation of energy resources. G20 members agree that increased collaboration on energy efficiency can drive economic activity and productivity, strengthen energy security and improve environmental outcomes. As consumers of over 80% of global energy, G20 members can play a significant role in access to energy by continuously improving their energy efficiency performance. Moreover, G20 members have accumulated a wealth of experience and have a demonstrated strength in developing energy efficiency programmes, channeling energy efficiency investments, and driving energy efficiency improvements.

The G20 Energy Efficiency Action Plan (EEAP) adopted in 2014 is a practical plan to strengthen voluntary energy efficiency collaboration in a flexible way. It allows countries to share knowledge, experiences and resources by choosing, on an opt-in basis, the activities that best reflect their domestic priorities and interests.

In recognition of this, G20 members adopt the G20 Energy Efficiency Leading Programme (EELP), which provides the basis for the comprehensive, flexible, and adequately-resourced long term framework necessary for strengthened G20 voluntary collaboration on energy efficiency (see Text box 1). It includes the G20 Voluntary Pillars for energy efficiency cooperation, which characterises international bilateral and multilateral cooperation on energy efficiency as beneficial, innovative, inclusive and sharing.

G20 members commit to significantly improving energy efficiency in the G20 by enhancing energy efficiency cooperation and encouraging G20 members to pursue energy efficiency through a variety of national programmes, policies and measures that reflect the socio-economic diversity within the G20.

Acknowledging that the work conducted by participating members under the 2014 EEAP constitutes the foundation for G20 collaborative action on energy efficiency, the EELP covers the existing activities under the EEAP on Vehicles, particularly heavy-duty vehicles, Networked Devices, Finance, Buildings, Industrial Processes (Industrial energy management), and Electricity Generation. In addition, the EELP expands these work areas to include five new key areas of collaboration: Super-efficient Equipment and Appliances Deployment initiative (SEAD), Best Available Technologies and Practices (TOP TENS), District Energy Systems (DES), Energy Efficiency Knowledge Sharing Framework, and Energy End-Use-Data and Energy Efficiency Metrics. The long-term perspective for each key area is outlined in the EELP, which enables participating G20 members to maximise the energy efficiency opportunities on offer and voluntarily contribute to the long-term progress of energy efficiency in the G20. All G20 members remain free to join or withdraw at any point from Task Groups depending on their own national circumstances, priorities and

domestic developments. This flexibility implies that non-participating countries are not bound by the work of the task groups they are unable to join.

The International Partnership for Energy Efficiency Cooperation (IPEEC) will continue to ensure overall coordination and fully support collaboration under the EELP. In this role, IPEEC will cooperate fully with other international organisations<sup>[1]</sup>. To support effective resourcing for the EELP, G20 members and other participating countries will aim to support and strengthen IPEEC through active participation in their selected areas of work, direct voluntary contributions to those areas of work (financial or in-kind) and, if they are IPEEC members, ongoing voluntary member contributions to IPEEC (financial or in-kind). In order to strengthen the global voice for energy efficiency, G20 members support IPEEC working with the IEA and other international organizations, including IEF, OPEC, OECD, APEC, BRICS, SE4ALL and C2E2, and with stakeholders, and G20 members will explore the feasibility of innovative collaborative arrangements for international cooperation on energy efficiency.

**Text box 1 - The EELP: a long term, comprehensive, flexible and adequately resourced framework for G20 voluntary collaboration on energy efficiency**

- Long-term: Energy efficiency needs time. Based on best practices and knowledge sharing, investments, awareness

#### Notes:

[1] the International Energy Agency (IEA), the International Energy Forum (IEF), the Organisation of the Petroleum Exporting Countries (OPEC), the Organisation for Economic Cooperation and Development (OECD), the Asia-Pacific Economic Cooperation (APEC), Sustainable Energy for All (SE4ALL), Copenhagen Centre on Energy Efficiency (C2E2)

and skills mature over several years. A long-term forward looking strategy will help avoid locking-in inefficient assets, boost profitability, increase investors' confidence, and go beyond short-term measures that aim for the low-hanging fruit only, and maximise the full potential of energy efficiency gains available.

- Comprehensive: Energy efficiency is rarely the result of one single decision or programme. Energy gains are achieved by combining and utilising experiences of different policy tools in the short-term and long-term objectives, across different sectors of the economy.

- Flexible: Energy efficiency national policies need to be dynamic and updated over time to benefit from lessons learned from national and international developments and constant technological innovation, among other things.

- Adequately Resourced: Like all programmes, energy efficiency needs to be adequately resourced by dedicated human, institutional and financial resources, to allow its deployment at all levels of national and local economies. Support is needed to: i) create an enabling national policy environment, and ii) generate direct investments by public and/or private stakeholders into energy efficiency solutions, systems and technologies.

## 1. G20 as a Leading Force in Improving Energy Efficiency in the World

### 1.1 The multiple benefits of energy efficiency for advancing global sustainable development

Energy efficiency benefits are not limited to maximum utilisation of energy resources, but beyond to include reduced greenhouse gases emissions. Acknowledging the dangers of climate change, environmental degradation and resource constraints, both developed and developing countries have increasingly recognised sustainable development as an important goal.

Energy efficiency contributes greatly to socio-economic development and quality of life. In addition to helping reduce final energy consumption, improved energy efficiency contributes to energy security, reduced greenhouse gas emissions, retained environment pollution, reduced energy infrastructure spending, reduced energy poverty, enhanced public health and industrial competitiveness, among others<sup>[2]</sup>.

Energy efficiency is a priority for many G20 members and one of the most important choices in energy utilisation. It has been shown that energy efficiency has consistently reduced annual energy consumption over the past decade. For instance, between 2001 and 2011, energy efficiency improvements have allowed 18 IEA member countries to avoid the equivalent of 1,731 million tonnes of oil-equivalent (Mtoe)<sup>[3]</sup>. These energy savings exceeded total oil consumption by more than 400 million toe, and were much higher than total electricity and natural gas consumption<sup>[4]</sup>. By the quantity in energy supply and demand balance, and the cost-effectiveness of all energy balancing measures, energy efficiency could

Notes:

[2] The IEA has identified more than 20 different types of economic, social, and environmental co-benefits – See IEA (2014), Capturing the Multiple Benefits of Energy Efficiency.

[3] IEA (2014), Energy Efficiency Market Report.

[4] IEA (2013) Energy Efficiency Market Report.



be regarded as an important energy resource comparable to other conventional sources of energy (coal, oil, gas, and electricity).

## 1.2 The G20 is capable of taking the lead in improving global energy efficiency

The G20 holds a crucial position in the global economy and energy landscape, especially in terms of energy security. The G20 covers the world's major economies, accounting for around 84% of the world's total economic output, more than 80% of primary energy consumption and 80% of global greenhouse gas emissions. Given this, and given its important political weight, the G20 can take on an exemplary role in leading the world towards energy efficiency improvements and their financing, as well as in promoting the development of technology to ensure future sustainable development through the utilisation of all indigenous energy resources. G20 members have considerable successful experience in energy efficiency measures, and in achieving energy reductions. Between 1990 and 2013, the annual energy consumption per unit of gross domestic product (GDP) decreased by 1.4% across G20 members. In Germany, China, India, Indonesia, the United Kingdom (UK), and the United States (US), energy consumption per unit of GDP decreased by 2% each year during that period. From 1990 to 2013, the G20's total energy consumption savings reached about 4.3 billion toe, and about 10.4 billion

tonnes of carbon dioxide emissions were avoided<sup>[5]</sup>.

As the world's major economies, the economically attractive opportunity to invest in energy efficiency creates market demand for finance in G20 members that requires enhanced capital flows into energy efficiency investments. According to the IEA, the potential size of global investment opportunities for energy efficiency was estimated at USD 310 billion in 2012<sup>[6]</sup>, and is growing every year. Recognising this, more and more governments and financial institutions in the G20 have given energy efficiency finance a high priority. The volume of capital investment into energy efficiency has accelerated, investments have become increasingly incentivised, and a growing number of financial innovation measures have begun to develop in this area.

To tap into this potential, members initiated the EEAP in 2014, thereby elevating energy efficiency as a key G20 issue. In 2015, G20 Leaders reaffirmed the importance of continued progress on energy efficiency, restated their commitment to increase support for energy efficiency, and agreed that energy efficiency plays an important part in ensuring sustainable energy<sup>[7]</sup>. This followed the agreement of the first G20 Energy Ministers to provide a long-term perspective to international collaboration on energy efficiency<sup>[8]</sup>.

## 1.3 Further strengthening the outlook for international collaboration on energy efficiency

Notes:

[5] <http://g20-energy-efficiency.enerdata.net>

[6] IEA (2014) Energy Efficiency Market Report.

[7] See G20 Leaders' Statement 2015.

[8] G20 Energy Ministers Communiqué. This Communiqué was then referenced in the G20 Leaders Statement, during their Summit which took place in Antalya from 15-16 November 2015.

In 2011, United Nations Secretary General Ban Ki-moon presented three objectives to achieve the transition to clean energy and global clean, low-carbon growth. These objectives were restated in September 2015 as Goal #7 of the 'Sustainable Development Goals' (SDGs) agreed by the United Nations General Assembly<sup>[9]</sup>, which aims to:

- (1) Ensure universal access to modern energy services.
- (2) Increase substantially the share of renewable energy in the global energy mix.
- (3) Double the global rate of improvement in energy efficiency.

In December 2015, at the 21st Conference of Parties (COP21) of the United Nations Framework Convention on Climate Change (UNFCCC), member states reached a new international agreement on climate change, called the Paris Agreement. The Paris Agreement aims to curb the global average temperature rise above pre-industrial levels to 2 degrees Celsius (2°C), and proposes to limit the temperature increase to 1.5°C above pre-industrial levels. The Paris Agreement aims to achieve an equal balance between anthropogenic emissions from sources and the removal of greenhouse gases through sinks in the second half of this century, all within the context of sustainable development and efforts to eradicate poverty. By the end of October 2015, a total of 119 Intended Nationally Determined Contributions (INDCs) had been submitted to the UNFCCC, covering a total of 146 countries, which

collectively are responsible for 86% of global greenhouse gas emissions based on 2012 levels<sup>[10]</sup>. All G20 members submitted INDCs and made commitments to address climate change<sup>[11]</sup>. In the aftermath of the signing of the Paris Agreement, countries are now developing and implementing their own INDCs (to become Nationally Determined Contributions – or NDCs – upon ratification of the Paris Agreement), which marks an important step in the transition towards a low-GHG economy.

Another noteworthy development has been the statement by Leaders of the Asia-Pacific Economic Cooperation (APEC) forum, made in their Declarations of 2011, of an ambitious goal for the APEC region to reduce energy intensity by 45% by 2035 compared to 2005.

Energy efficiency is one of the most important mechanisms through which countries can act to mitigate climate change in the short-term to long-term. According to the IEA, energy efficiency can contribute up to 49% of the energy related CO<sub>2</sub> emission reductions that are needed to limit global temperature increases to less than 2°C by 2050<sup>[12]</sup>. The above developments reflect the growing emphasis placed on energy efficiency internationally.

## 2. G20 Voluntary Pillars for Energy Efficiency Cooperation

G20 members are encouraged to strengthen bilateral and

Notes :

[9] <https://sustainabledevelopment.un.org/post2015/transformingourworld>

[10] UNFCCC, [http://unfccc.int/focus/indc\\_portal/items/8766.php](http://unfccc.int/focus/indc_portal/items/8766.php)

[11] UNFCCC, <http://www4.unfccc.int/submissions/INDC/Submission%20Pages/submissions.aspx>

[12] These are consistent with the existing G20 Principles for Energy Collaboration agreed in 2014. 13 These are consistent with the existing G20 Principles for Energy Collaboration agreed in 2014.

multilateral cooperation on energy efficiency, as well as to share experiences on energy efficiency improvements with G20 members and non-G20 members, in order to play a leading role in improving energy efficiency in the long-term.

G20 members agree to improve energy efficiency cooperation on the basis of the following four voluntary pillars<sup>[13]</sup>:

- (1) Mutual beneficial: Enable mutual benefits through bilateral and multilateral cooperation between G20 members by utilising members' wealth of experiences.
- (2) Innovative: Encourage and support innovative energy-efficient technologies and practices through research and development, demonstration and dissemination, as well as developing open and effective energy efficiency programmes that encourage energy technology transfer.
- (3) Inclusive: Encourage countries at different stages of economic development, with different natural resource endowments and population densities, to implement energy efficiency improvements according to local conditions, and share developed corresponding energy efficiency aims and formulations of collaboration that are in accordance with their national development objectives.
- (4) Sharing: Encourage and strengthen the collection, dissemination and analysis of knowledge and information for G20 members, to carry out energy efficiency improvements and to provide technical

support.

### 3. G20 Long-Term Aim to Improve Energy Efficiency

In recent years, G20 members have formulated various energy efficiency programmes within their national economic and energy development strategies that clearly demonstrate the great importance they attach to energy efficiency.

G20 members agree to adhere to the Voluntary Pillars for Energy Efficiency Cooperation, which are "mutually beneficial, innovative, inclusive, and sharing".

G20 members commit to significantly improving energy efficiency in the G20 by improving energy efficiency cooperation and encouraging G20 members to develop active energy efficiency programmes, policies and measures based on each member's own social and economic context.

G20 members agree to the EELP, as a long-term energy efficiency programme, and in doing so, take a leading role in achieving sustainable energy efficiency growth during future G20 presidencies.

G20 members will work to significantly improve energy-efficient technologies and equipment coverage, as well as effectively work to enhance capacity building and the policy and regulatory environment for energy efficiency investments, taking into account different national realities, capabilities and levels of development within countries, and respecting national policies and priorities.

G20 members are encouraged to develop voluntary

Notes:

[13] These are consistent with the existing G20 Principles for Energy Collaboration agreed in 2014.



national energy efficiency programmes, in line with each members respective circumstances.

#### 4. Key areas of collaboration

The EEAP outlined six key areas of work on energy efficiency<sup>[14]</sup> that initially formed the backbone for international collaboration on energy efficiency organized by the International Energy Partnership for Energy Efficiency Cooperation (IPEEC) under the G20 mandate.

The EELP adds five new key areas (Super-Efficient Appliances Deployment initiative, TOP TENS, District Energy Systems, Energy Efficiency Knowledge Sharing Framework, and Energy End-Use-Data and Energy Efficiency Metrics). This expansion stems from interested G20 members desire to scale up improvements in energy efficiency. G20 members and guest countries, based on their national priorities and capabilities, will select and voluntarily participate for as long as they consider appropriate in the key areas of work and Task Groups in which they are interested. The long-term perspectives and pathways outlined in each key area of collaboration are not mandatory for participating G20 members, but are only intended to reflect the general direction of activities which members can pursue. This flexibility also implies that non-participating countries are not bound by the work of the task groups they are unable to join.

##### 4.1 Key area 1: Vehicles

Globally, the transport sector is estimated to account for around 20% of total energy use, with heavy-duty vehicles

(HDVs) alone consuming around half of all transport fuels. G20 nations account for over 90% of global vehicle sales, so their policies largely determine the energy, air quality, and climate impacts of the sector globally.

The Transport Task Group (TTG) is led by the United States, and participated by 13 member economies.

##### 4.1.1 Long-term perspective and pathway

The long-term perspective of the TTG is to support participating and other interested countries in developing and implementing world-class policies and programmes to reduce the energy and environmental impacts of motor vehicles, especially HDVs.

Countries are encouraged to develop their own policy goals and milestones, towards world-class clean fuel and vehicle standards. Examples of existing policies and programmes, which G20 members could all aspire to, are:

- (1) Introduction of mandates for clean fuels with a maximum sulfur content of 10~15 parts per million (ppm) to reduce emissions and enable advanced emission control technologies;
- (2) Introduction of stringent tailpipe emissions standards to minimise harmful pollutant emissions. For light-duty vehicles (LDVs), world-class standards are Euro 6, U.S. Tier 2/3, or equivalent standards. For HDVs, these are the Euro VI, U.S. HD2010, or equivalent standards;
- (3) Development of standards and programmes to improve fuel efficiency and reduce GHG emissions

Notes:

[14] Vehicles, Networked Devices, Finance, Buildings, Industrial Process (Industrial Energy Management) and Electricity Generation

from LDVs and HDVs, to the greatest extent possible. Some countries aim to reduce the fuel consumption of new LDVs by 50% from a 2005 baseline by 2030, and to reduce the fuel consumption of new HDVs by 30% from a 2010 baseline by 2030;

(4) Support to Green Freight programmes to help freight companies achieve cost-effective energy efficiency improvements in their vehicle fleets.

Other actions and options, such as promoting the use of low GHG complementary fuel, including sustainable biofuels, onboard capture and storage, or electric vehicles / new energy vehicles - have been successful in several G20 countries, and are useful to showcase world-class policies and programmes to reduce the energy and environmental impacts of motor vehicles. Examples include policies and programmes to support low-carbon biofuels as well as electric and hybrid electric vehicles.

Robust national compliance programmes, including in-use compliance programmes, an important part of all policies and programmes, help ensure standards are effectively implemented and enforced, and expected results are achieved.

#### 4.1.2 Achievements

Since 2015, the TTG has achieved a number of important milestones, including:

(1) Secured G20 Energy Ministers' agreement to develop G20 Policy Roadmaps for reducing the energy and environmental impacts of motor vehicles, with specific

focus on HDVs.

(2) Produced an international assessment of existing regulations and programmes<sup>[15]</sup>.

(3) Conducted a survey of participating countries on their institutional needs and technical challenges to inform the development of the Policy Roadmaps.

(4) Led policy exchanges on experiences and best practices on key issues.<sup>[16]</sup>

#### 4.1.3 Planned work

The TTG will focus on supporting domestic progress in participating and other interested countries by sharing experiences on best practices in energy and environmental policies for vehicles and fuels, especially HDVs, including by:

(1) Developing Policy Roadmaps outlining future policy and programmatic improvements in participating and other interested G20 members.

(2) Engaging the financial community to provide guidance on financing for energy-efficiency investments (e.g. for oil refinery upgrades to produce low-sulfur fuels).

(3) Encouraging ongoing policy exchanges on experiences and best practices on key issues to support nations in developing and implementing world-class policies and programmes to reduce the energy and environmental impacts of vehicles and fuels.

(4) Exploring the creation of an annual workshop of Achievement for participating G20 members to recognize

Notes:

[15] International Council for Clean Transport (ICCT), Policies to Reduce Fuel Consumption, Air Pollution, and Carbon Emissions from Vehicles in G20 Nations.

[16] These included among others: compliance and enforcement and sustainable alternative fuels (natural gas, electricity, hydrogen, and sustainable biofuels).



their commitment and progress in the area of clean fuel and vehicle standards.

## 4.2 Key area 2: Networked Devices

The number of devices connected to the network is expanding rapidly, and eventually almost all appliances will be networked. By 2030, networked devices may represent as much as 6% of current final global energy consumption<sup>[17]</sup>. In this context, the small amount of energy demand from individual products to remain 'connected', will have very large impacts in terms of energy consumption<sup>[18]</sup>. Much of that consumption could be reduced through improved energy management. At the same time, efficient networks and networked devices have the potential to substantially raise the overall energy productivity of economies. To take advantages of these opportunities, since 2015 the United Kingdom and the IEA have led the Networked Devices Task Group (NDTG)<sup>[19]</sup>, bringing together nine countries of the G20 to identify energy efficiency policy options for networked devices.

### 4.2.1 Long-term perspective and pathway

The work of the NDTG has led to the establishment of the Connected Devices Alliance (CDA), a platform for international cooperation among 350 government and

industry representatives which pursues two aims:

- (1) Realise a world where devices and networks optimise energy management while delivering increased energy productivity across all sectors.
- (2) Maximise network-enabled energy savings and minimise the energy consumption from all networks and network-connected devices.

### 4.2.2 Achievements

Since 2015, the NDTG has held four international workshops and developed a series of new initiatives to improve the energy-efficiency of connected devices, and has:

- (1) Devised Design Principles on key features of energy-efficient networked devices, networks and communication protocols for designers, manufacturers and authors.
- (2) Decided on Policy Principles for participating countries to encourage a common framework for the development of government policies.
- (3) Agreed to a first set of Definitions that provide a common understanding of key elements and underpin the development of policies in this area for participating countries.
- (4) Launched a Centre of Excellence<sup>[20]</sup> with information for participating governments and industry on best practices and energy savings opportunities in networked

Notes:

[17] It is estimated that there will be 50 billion networked devices by 2020 (More Data Less Energy, OECD/IEA, 2014)

[18] Already, the current annual standby power consumption of networked devices is estimated at over 600 TWh, which is greater than Canada's total annual electricity consumption for 2011.

[19] NDTG is short for Networked Devices Task Group.

[20] The web portal is operational at <http://cda.iea-4e.org>



devices and networks.

(5) Researched the issues of 'Energy Aware Devices' and 'Intelligent Efficiency'.

(6) Explored opportunities for Recognition Awards<sup>[21]</sup> for industry and governments and for Market Monitoring activities for participating countries to track policies and potential savings relating to networked devices.

#### 4.2.3 Planned work

The CDA will continue to provide a platform for international collaboration between governments and industry to achieve the above stated aims. In 2016, the group has and will focus on promoting the Policy and Design Principles so that they are actively supported and propagated as appropriate by participating G20 governments, industries, product manufacturers, designers and standards-making bodies. This will happen through continuation of the initiatives mentioned above, and the hosting of workshops.

Beyond 2016, the CDA will focus on progressing work under each initiative, with particular attention to: expanding its membership. investigating the scope for new voluntary efficiency targets for products. promoting the use, by industry and participating governments. and developing methodologies to measure energy efficiency outcomes. It is envisaged that at least one workshop will be held annually to monitor progress.

### 4.3 Key area 3: Finance

Energy efficiency requires enhanced finance to support its deployment across G20 economies at the national and local levels. The Energy Efficiency Finance Task Group (EEFTG), led by France and Mexico and counting 14 G20 members, aims to remove barriers, enhance policy support, and drive public and private sector action to drive greater capital flows towards energy efficiency in the G20.

#### 4.3.1 Long-term perspective and pathway

To achieve this, in the long-term, the EEFTG aspires to scale-up energy efficiency investments significantly, as investments must increase multiple times to meet the Sustainable Development Goal on energy. This will require participating G20 members to work together to:

- (1) Build robust, investment grade<sup>[22]</sup> national policy and investment frameworks.
- (2) Identify and replicate best practices in finance among participating G20 members.
- (3) Optimise public resources to lever and scale-up private sector investments in participating G20 members.
- (4) Facilitate the dialogue between participating G20 policymakers and the private and public sector finance community, industry and international organisations.

#### 4.3.2 Achievements

Since 2015, the EEFTG has increased the visibility of the

Notes:

[21] These would be in partnership with SEAD under their .Global Efficiency Medal., see section 4.7

[22] 'Investment grade' refers to a rating that indicates a relatively low risk of default. By extension, an 'investment grade policy framework' refers to a policy framework that indicates a low regulatory risk, thereby enabling energy efficiency investments.

issue of energy efficiency finance and encouraged greater action by the private and public sectors by:

(1) Developing the Voluntary Energy Efficiency Investment Principles for G20 Participating Countries to address existing barriers in G20 countries and enhance capital flows to energy efficiency investments.

(2) Contributing to the G20 Energy Efficiency Investor Statement endorsed by over USD 4 trillion of private sector institutional investors to fully embed energy efficiency into their investment processes.

(3) Launching and promoting Financial Institutions Energy Efficiency Statements, supported by 106 banks from over 40 countries, to drive energy efficiency investments.

(4) Leading consultative processes<sup>[23]</sup> with participating G20 members, financial institutions, and private sector experts to identify the policy frameworks required for the implementation of the Voluntary Energy Efficiency Investment Principles for G20 Participating Countries.

(5) Publishing the conclusions of their research<sup>[24]</sup>, with identified policy options and case studies to share experiences and best practices among G20 members.

#### 4.3.3 Planned work

The EEFTG plans further collaboration to enhance capital flows to energy efficiency through the following activities:

(1) Working with participating G20 members to enhance

national investment policy environments through the framework of the Voluntary Energy Efficiency Investment Principles<sup>[25]</sup>.

(2) Strengthening these Principles by gathering additional data, implementation experience and commitments, including through the support of the UNEP FI and its partners.

(3) Broadening and deepening private sector engagement, including through the establishment of a Private Sector Energy Efficiency Investment Platform, and other work with long-term investors, banks and insurers with our partner support.

(4) Mobilising IFIs to support finance where most needed (e.g. capacity building), and to directly fund technical assistance for project development, finance intermediaries, and the aggregation of energy efficiency investments.

(5) Engaging with participating G20 members in the framework of the Principles to support cooperation and communicate on the finance and investment aspects of the EELP.

(6) Connecting and communicating with other international initiatives on energy efficiency finance to avoid redundancy, broaden reach and deepen commitment.

(7) Encouraging participating G20 members to incentivise the development of a pipeline of energy efficiency projects and collaborating with partners to help support

---

Notes:

[23] This process included hosting five consultation workshops with over 180 specialists in New York, Washington, Merida, Paris and Beijing, to collect and assess the expert views of representatives from financial institutions, investors and policy-makers, meetings with international organisations to find way for further endorsement of the Principles and Statements cited above.

[24] See 2015 Activity Report of the G20 Energy Efficiency Finance Task Group.

[25] Supported by UNEP FI, IEA, OECD, CEM, World Bank, among others.

this activity.

(8) Promoting policy frameworks and best practices in EEFTG participating countries including through Technical Engagement Workshops.

(9) Encouraging energy efficiency investments and their positive impacts to be systematically considered alongside supply-side investments relating to G20 countries energy systems.

(10) Recognizing the importance of energy efficiency considerations in all relevant decision making to significantly increase and strengthen energy efficiency investments in G20 economies in the context of a balanced progression of the three dimensions of sustainable development.

(11) Reinforcing of the policy framework in each G20 country to drive energy efficiency investments by sectors.

(12) Increasing the effectiveness of public and private financial institutions in using tailored approaches to structure and facilitate energy efficiency investments in each sector of the economy.

#### 4.4 Key area 4: Buildings

Buildings offer significant energy savings as they account for over 30% of global final energy consumption, and it is estimated that G20 members alone could account for three-fourths of the cumulative global building energy savings potential. Recognising this, the Buildings Energy Efficiency Task Group (BEET), led by Australia and the

United States and engaging most G20 members, aims to research, inform, and support the development and implementation of effective building energy efficiency policy options.

##### 4.4.1 Long-term perspective and pathway

International cooperation can help realise the large energy savings potential in buildings by pursuing joint efforts to develop, compare and promote effective national building energy policy options and tools. This includes collaborating on energy rating systems, energy codes, sharing best practices, experiences, expertise, data and analysis.

##### 4.4.2 Achievements

Since 2008, the BEET project has helped advance energy efficiency in buildings and has:

(1) Produced a foundational BEET 1 report, Building Energy Rating Schemes, which found that energy rating programmes have the greatest impact when combined with other policy levers<sup>[26]</sup>, and underscored the need for improved data.

(2) Released the BEET 2 report on Building Energy Efficiency: Opportunities for International Collaboration, which provided options to develop building energy performance metrics to gauge progress and identify areas for improvement<sup>[27]</sup>.

Notes:

[26] These include code enforcement, financial incentives, quality assessments, assessor training, as well as robust outreach and communications efforts.

[27] The report also presented a number of actions that countries could consider taking, such as extending building rating, labelling, and disclosure policies to cover more building types and implementing cost-effective building energy codes for all new construction and renovation.



(3) Issued the BEET3 report on Delivering Energy Savings in Buildings, with recommendations<sup>[28]</sup> to improve compliance with building energy codes, and launched a BEET3 portal<sup>[29]</sup> to share approaches to building code implementation.

(4) Published quantitative data on the energy efficiency performance of buildings in G20 countries, which constitutes one of the broadest and finest sets of data available to date, through the BEET4 report, Building Energy Performance Metrics. The report further highlights the need for smart efficiency policies options to optimize energy consumption in buildings.

#### 4.4.3 Planned work

In 2016, participating countries will work together to identify successful elements of rating schemes as a key path to driving greater energy gains in the buildings sector. They will conduct an international review of residential building energy efficiency rating schemes, looking at elements such as: administrative structures, operational cost-effectiveness, and impact on energy consumption. The objective of this review, which will lead to the publication of a BEET5 report, is two-fold: i) help countries build national energy rating schemes and disclosure systems, and ii) enhance information available to the public on successful elements of rating schemes.

They will also seek to further disseminate best practices

in code implementation to allow participating countries to effectively learn from one another. This may include: further development of the BEET 3 building energy codes portal, reports on best practices in code implementation and compliance, and webinars and dialogues to share experiences in code implementation.

Beyond 2016, participating countries will focus on continuing the development of resources and collaborative models aimed at assisting nations to improve building energy productivity, possibly focusing on effective building codes, rating systems and metrics. All of the above initiatives will help drive greater efficiency gains in the buildings sector, an area with one of the largest potentials for improvement.

#### 4.5 Key area 5: Industrial Processes (Industrial Energy Management)

Industry and commercial buildings cover over 50% of global energy use. By increasing uptake of energy management systems, the energy productivity of energy-intensive industrial processes and firms can be improved and bring about large energy and GHG savings. The Energy Management Working Group (EMWG), led by the United States, and the Energy Management Action Network (EMAK) led by Japan and China aim to realise the energy efficiency potential these sectors offer. They each bring together

---

Notes:

[28] These include: code compliance checking systems, measuring performance of buildings against code design, and incentives (sticks and carrots) for code compliance and encourage beyond-code performance, among other areas.

[29] This BEET3 portal is hosted by the Global Buildings Performance Network (GBPN): <http://www.gbpn.org/laboratory/building-energy-codes-portal>

11 members of the G20.

#### 4.5.1 Long-term perspective and pathway (Energy Management Working Group, EMWG)

In the long-term, the EMWG aims to have 50,000 facilities using energy management systems, such as the ISO 50001 standard. It pursues this objective by:

- (1) Encouraging industrial facilities and commercial buildings to continuously improve their energy efficiency performance (through the ISO 50001 standard).
- (2) Promoting public and private partnerships for cooperation on specific technologies in individual energy-intensive sectors.
- (3) Serving as a discussion forum for best practices.

#### 4.5.2 Achievements

Since 2010, the EMWG has supported technical exchanges among participating countries for greater uptake of effective energy management systems. Most recently, it has:

- (1) Established a certification scheme for auditors of the ISO 50001 standard, to increase consistency in its implementation in participating countries.
- (2) Trained and certified over 40 professionals to assist in the implementation of the standard.
- (3) Published practical case studies (aiming to release 40 by July 2016) with real-world data and users' experiences in energy management systems.
- (4) Facilitated pilot projects to harmonise technical approaches among members, focusing on the United States, Mexico and Canada.

(5) Facilitated technical exchanges, including on: measurement and verification, training and certification of professionals, and development of technical tools, among other things.

(6) Hosted webinars and bilateral meetings to share policy best practices, latest developments, technical tools and approaches, and areas for new joint activities.

#### 4.5.3 Planned work

Looking forward, the EMWG and EMAK have identified work required for further uptake of energy management practices to help realise the large productivity gains in this sector. In 2016 and beyond, EMWG plans to:

- (1) Ensure quality implementation of ISO 50001 worldwide, including through regional workshops in key ISO 50001 markets, such as Latin America, China, and potentially South East Asia.
- (2) Evaluate and promote the value of implementing the ISO 50001 standard, including through: establishing an ISO 50001 Impacts Research Network, conducting impact analyses, and developing a transparent methodology to predict, quantify, and demonstrate the value of ISO 50001.
- (3) Launch the Energy Management Campaign to lock-in participating government, private sector and other stakeholder commitments to support the uptake of ISO 50001 and its robust and consistent implementation worldwide.
- (4) Launch Energy Management Leadership Awards to recognise companies, and organisations, achievements in successfully implementing ISO 50001 projects in participating countries, as well as other types of awards to offer and expand recognition opportunities.



#### 4.5.4 Long term objective and pathway (Energy Management Action Network)

The long term objective of EMAK is to reduce energy-intensity drastically in the industrial sector by establishing and enhancing energy management systems and related policy and legal frameworks. EMAK pursues this aim by:

- (1) Building capacity through the sharing of best practices and tools on the use of energy management systems. and
- (2) Creating opportunities for networks between policy makers and industrial practitioners who are responsible for energy management.

#### 4.5.5 Achievements

Since 2009, EMAK has organised seven workshops and two webinars for the purpose of sharing experiences on designing and implementing energy efficiency policies and programmes among many policy makers and energy managers. In 2015, EMAK hosted two workshops in India and Russia:

- (1) The first workshop held in India focused on energy efficiency in small and medium sized enterprises (SMEs) and waste heat recovery measures. The workshop served to identify the barriers to enhancing energy efficiency actions and sharing and implementing energy efficiency policies and programmes for SMEs. It provided a better understanding for the technical opportunities to reuse waste heat in industrial organisations.
- (2) The second workshop held in Russia focused on energy management systems and ESCO<sup>[30]</sup> programmes.

The workshop served to provide experiences and lessons learned from Russia, Japan, China, Australia and UNIDO<sup>[31]</sup> on energy management systems and ESCO programmes.

#### 4.5.6 Planned work

In 2016 and beyond, EMAK plans to:

- (1) Hold workshops to provide best practices on energy management systems for policy makers and energy managers.
- (2) Identify the options (tools and best practices) to overcome energy efficiency barriers.

#### 4.6 Key area 6: Electricity Generation (High-Efficiency Low Emissions - HELE)

Over the past twenty years, global electricity generation expanded approximately 1.6 times, with fossil fuels accounting for the largest share of this growth. According to the IEA<sup>[32]</sup>, this trend is projected to continue until 2040. The Electricity Generation Task Group, led by Japan, aims to support energy efficiency improvements in conventional electricity generation, focusing on its seven participating countries.

##### 4.6.1 Long-term perspective and pathway

In the long-term, power generation technologies - in the form of supply-side improvements in energy efficiency through the introduction of HELE power plants - could be a pragmatic measure to limit GHG emissions. The Electricity Generation Task Group supports collaboration among participating countries with the aim to:

Notes:

[30] Energy services company

[31] United Nations Industrial Development Organization

[32] IEA World Energy Outlook, 2014



(1) Improve understanding of HELE technologies (such as Ultra Super Critical, Integrated Gasification Combined Cycle, and Carbon Capture and Storage) in participating G20 members where fossil fuels are a major source of power generation, and of their technical, financial and environmental aspects.

(2) Develop and disseminate best practices in operation and maintenance.

(3) Continue workshops and side-visits to foster technical cooperation.

#### 4.6.2 Achievements

In 2015, the Electricity Generation Task Group organised two workshops, which brought together numerous G20 members, private sector leaders and international organisations<sup>[33]</sup>:

(1) The first workshop focused on clean coal technology and served as a forum for discussing a wide range of topics, from research and development to finance, to help participants gain a better understanding of technology, options and financial instruments that could facilitate clean coal.

(2) The second workshop enabled knowledge-sharing on HELE technologies and barriers to deployment, including through a site-visit to a coal-fired power plant to allow information exchange on best practices and to identify a detailed approach for further progress.

#### 4.6.3 Planned work

In 2016 and beyond, the Task Group plans to:

(1) Hold technical tours and workshops to allow for discussions on policy options and technologies related to HELE.

(2) Develop a common measurement basis for GHG emission reductions in participating countries through improvements in operation and maintenance.

(3) Encourage the construction and use of HELE technologies as a pragmatic energy option, especially in areas where fossil fuels continue to be a major source of electricity generation.

(4) Encourage further collaboration on technical and financial barriers and solutions to greater uptake of HELE plants.

#### 4.7 Key area 7: Super-Efficient Equipment and Appliance Deployment initiative (SEAD)

Worldwide electricity consumption is expected to continue growing, driven in part by the increasing use of equipment, appliances, lighting, and other devices. The associated growth in energy consumption poses a number of challenges for governments, including electric grid overloads, power outages, declining air quality, and other environmental challenges such as climate change.

The existing IPEEC SEAD initiative, co-led by the United States and India, brings together 18 participating governments to accelerate and strengthen the design and implementation of appliance energy-efficiency options and related measures, which are proven cost-effective approaches to address the above energy, economic and environmental challenges.

Notes:

[33] This included the Asian Development Bank, IEA, IPEEC, OECD, Organization of the Petroleum Exporting Countries and World Coal Association.

#### 4.7.1 Long-term perspective and pathway

By employing current best practices, SEAD countries can reduce annual electricity demand and therefore annual fuel energy demand. This would decrease GHG emissions and improve the environment, in addition to sizable cost saving.

#### 4.7.2 Achievements

Since its inception in 2009 as an IPEEC Task Group, SEAD has:

- (1) Raised awareness on lighting efficiency by launching the Clean Energy Ministerial (CEM) Global Lighting Challenge, and secured commitments from 13 governments as well as lighting manufacturers/retailers to deploy over 10 billion high-efficiency LEDs<sup>[34]</sup> as quickly as possible.
- (2) Supported the development of energy-efficient measures for appliances in Mexico by investigating the impact of appliance minimum energy performance standards (MEPS)<sup>[35]</sup>.
- (3) Brought together initiatives on Awards, Incentives, and Procurement to promote the manufacture, purchase, and use of energy-efficient appliances, lighting, and equipment worldwide.
- (4) Created a new online SEAD Policy Exchange Forum (SPEX<sup>[36]</sup>) to promote informal and voluntary policy dialogues among participating member governments on cost-effective product options.

#### 4.7.3 Planned work

In 2016 and beyond, SEAD aims to pursue its mandate through a range of activities among participating countries, including:

(1) Promoting policy dialogue, by:

- a) Launching the "Energy Efficiency Leading Program Product Best Practice Exchange Series" to engage efficient product experts from across G20 countries and beyond to share their experiences through a series of virtual and face-to-face workshops from May 2016 to November 2017. This task would be delivered collaboratively through the existing mechanisms offered by SEAD, 4E<sup>[37]</sup> and the IEA, and would reflect the scale of efficiency opportunities in end-use products and complement existing G20 activities taking place under the Networked Devices Task Group.
- b) Supporting country-specific technical exchanges (e.g. U.S.-Mexico Appliance Standards and Labelling Technical Exchange).
- c) Hosting SEAD Policy Exchange Forum (SPEX) webinars to share insights on innovative options, technical questions, and market developments. and focusing on key topics such as: Multiple Benefits of Improving Product Efficiency. Performances Standards Approaches. or Air Conditioner Efficiency.
- d) Identifying and sharing best practices for adoption of energy-efficient products (e.g. computers and motors), and conducting comparative analyses of modelling tools and

Notes:

[34] LEDs: Light-Emitting Diodes

[35] Since 2000, MEPS are saving 6 billion kWh annually in Mexico.

[36] <http://www.superefficient.org/spex>

[37] Energy Efficient End-use Equipment, a technology collaboration programme of the IEA.

results underpinning energy-efficiency devices.

(2) Recognising achievements, by:

a) Launching the SEAD Global Efficiency Medal competition for outdoor and industrial lighting to recognise corporate leadership in manufacturing highly-efficient products.

b) Providing governments with updates on market developments to inform procurement options and new standards in participating G20 members.

c) Developing Recognition Awards with the NDTG to encourage best practices among networked products and protocols (see section 4.2.4).

d) Supporting the expansion and tracking of CEM Global Lighting Challenge, including use of SEAD Street Lighting Procurement Tool.

e) Building on the SEAD Air Conditioning Strategy and collaboration with India to launch the CEM Advanced Cooling Challenge to ensure that rapidly growing global demand for cooling services will be met by highly energy-efficient products.

#### 4.8 Key area 8: Sharing Best Available Technologies (BATs) and Best Practices (BPs) (TOP TENs)

Sharing Best Available Technologies (BATs) and Best Practices (BPs) is an important means to improve energy efficiency and address environmental issues, including climate change<sup>[38]</sup>. The objective of the TOP TENs Task Group is to improve the way in which participating countries share and disseminate information on the BATs

and BPs in use today, as well as to accelerate widespread application of technological innovations.

Established in 2013 to realise this opportunity for collaboration, the TOP TENs Task Group is co-led by China and Australia through the IPEEC, and currently brings together 7 participating G20 members. Participating G20 members develop BATs and BPs lists by assessing data on their domestic companies and public sectors. energy efficiency using an agreed set of TOP TENs methodology. The methodology includes criteria on, for example, the energy savings potential of a technology or practice, its reliability, payback period and level of innovation. Company projects are rated against the criteria and listed accordingly. Each member's domestic lists and the collective international lists all contain case studies which showcase how the technology or practice has been used. The initial lists cover the industrial, building and transportation sectors.

##### 4.8.1 Long-term perspective and pathway

In the long-term, the TOP TENs Task Group will focus on:

- (1) Enhancing the sharing of best available energy efficiency technologies and practices, by establishing a G20 database for energy efficient BATs and BPs through IPEEC.
- (2) Optimising the TOP TENs methodology by developing consistent criteria to compile, evaluate, update and promote the implementation of findings.
- (3) Stimulating cooperation between governments and

Notes:

[38] The 2015 "Paris Agreement" highlighted the importance of technological innovation, development and transfer, deployment, diffusion and exchange of experience as a long-term vision of the Parties.



market actors in exchanging and promoting TOP TENS BATs and BPs.

(4) Promoting the application of TOP TENS BATs and BPs in the participating G20 members including activities such as seminars, capacity-building, pilot demonstration projects, and mobilisation of finance, among other things.

(5) Consideration of domestic awards or recognition schemes to highlight corporate leadership and share the expertise and knowledge more broadly amongst the global business community.

#### 4.8.2 Achievements

Since its establishment in 2013 as an IPEEC Task Group, the TOP TENS Task Group has completed a number of activities including:

(1) Development of a methodology to assist governments to create their lists of best available energy-efficient technologies and practices used by companies in their countries.

(2) Development of the inaugural International TOP TENS Lists of BATs and BPs which combines the leading examples from participating members. own domestic TOP TENS Lists. The International Lists are designed to showcase examples of best practices and use of technologies that are leading, replicable and available and could be taken up by other members to improve their energy savings.

(3) Commencement of promotion of the domestic TOP TENS lists in the first round of member countries and monitoring the impact of the lists.

#### 4.8.3 Planned work

In 2016 and beyond, the TOP TENS Task Group is expanding its focus by:

(1) Promoting the Domestic and International TOP TENS Lists through such avenues as the websites and social media of the IPEEC and member countries, developing communication materials for companies and policy makers on the purpose of the lists and how to use them effectively to promote energy savings.

(2) Preparing guidelines for TOP TENS members on the collection, identification and promotion of energy-efficient BATs and BPs, and the release of TOP TENS lists.

(3) Encouraging G20 countries to join the TOP TENS Task Group to develop their own lists showcasing leading energy efficiency practices and technology take-up.

(4) Continuing the development of the second round of Domestic TOP TENS Lists.

(5) Continuing to refine and periodically updating of the TOP TENS methodologies and communication to increase their relevance and ease of use.

(6) Considering the expansion of the sectors covered in the lists.

#### 4.9. Key area 9: District Energy Systems (DES)

Cooling currently accounts for a large share of the electricity consumption in various G20 countries. Peak cooling demand is expected to continue on the path of high growth, creating a major strain. When certain conditions are met (in particular, high cooling load and density, and diversity of end-uses), district cooling (DC)<sup>[39]</sup> is a proven

Notes:

[39] District Cooling (DC) consists of providing cooling to multiple facilities from one or more centrally located cooling plants, connected to end-users via a network of supply and return pipes.

cost-effective solution to reduce energy consumption and peak load demand. The same applies to district heating (DH). It will be co-led by Kingdom of Saudi Arabia, China and Russia, as G20 Members, with close support of Singapore, as a permanent guest.

#### 4.9.1 Long-term perspective and pathway

The objective of the Task Group is to encourage DC/DH deployment, focusing on:

- (1) Establishing national institutions to support DC/DH deployment and regulation.
- (2) Developing a national DC/DH strategy, covering key issues such as licensing frameworks, technical regulation and economic regulation.
- (3) Encouraging the use of DC/DH in new participating public projects.
- (4) Defining DC/DH only zones, where DC/DH would be the only used cooling/heating technology.

#### 4.9.2 Achievements

As a new initiative, the DES has not yet initiated work under the G20. However, Saudi Arabia has made good progress in DC, and could serve as an example to other participating countries.

Since 2015, Saudi Arabia has helped promote DC through:

- (1) Establishment of DC arrangements, under the existing Electricity Regulatory Authority (ECRA).
- (2) Drafting (in-train) of a "DC Perspective" by ECRA covering licensing, technical and economic regulation issues/specifications for DC.
- (3) Development of district cooling threshold standards, and agreement that new future participating public buildings

could champion DC.

- (4) Identification of potential DC zones.

#### 4.9.3 Planned work

In 2016 and beyond, building on participating countries' experiences in DC/DH, participating countries will define initiatives, a work programme, and Terms of Reference to address this issue. Work could focus on exchanging experiences, and exploring options for:

- (1) Establishing the necessary institutional framework (e.g. establishing a DC/DH Regulator or regulatory capacities within existing organisations).
- (2) Identifying barriers, challenges and options to greater DC/DH deployment and crafting a DC/DH national strategy, including key elements for higher penetration of DC/DH. These could cover licensing aspects, as well as technical regulation and economic regulations.
- (3) Encouraging participating government projects and public procurement practices to support DC/DH. For example, this could aim at all new participating government projects.
- (4) Identifying and mapping zones where DC/DH would be the only cooling/heating technology used.

#### 4.10 Key area 10: Energy Efficiency Knowledge Sharing Framework

Given the wealth of energy efficiency experience among G20 members, the G20 proposes a framework for a platform that facilitates knowledge sharing on energy efficiency policies, best practices and national experiences. The current proposal is to establish an Energy Efficiency Knowledge Sharing Framework under the International



Energy Forum(IEF)for the G20.The proposed Energy Efficiency Knowledge Sharing Platform will be led by Saudi Arabia.

#### 4.10.1 Long-term perspective and pathway

The objective is to collect and disseminate policies,practices and measures,which will help G20 and other interested countries to improve energy efficiency.

This Framework would extend work already under way to establish an Asian Energy Efficiency Sharing Framework under the IEF,endorsed by Energy Ministers gathered at the 6th Asian Ministerial Energy Roundtable in Doha,Qatar,after a proposal from the Kingdom of Saudi Arabia and supported by Japan. Energy efficiency matters to both energy producers and consumers. The Framework can showcase and amplify achievements in state of the art energy efficiency policies,technologies,and innovation on both the supply and demand sides,while serving as a platform to share experiences and information in respect of financing and implementation of energy efficiency gains.

#### 4.10.2 Planned work

In pursuit of the Framework.s objectives,the IEF will collaborate with other relevant International Organizations,including IPEEC,IEA and OPEC among others,and Agencies to give greater visibility to the energy efficiency policies of the G20 as well as other countries and contribute to strengthen their institutional capacity and international collaboration. The IEF has set a standard in inter-institutional cooperation under the Joint Organizations Data Initiative,where

it works in concert with APEC,Eurostat,the GECF,IEA,OLADE,OPEC,and UNSD.

With the support of G20 and IEF member countries and international organisations and agencies,a first high-level meeting of the IEF Knowledge Sharing Framework on Energy Efficiency can take place in the first half of 2017.

This high-level meeting will set further priorities,mobilise resources and engage with potential partners,including public and private sector stakeholders of interested G20 and IEF countries.

#### 4.11 Key area 11: Energy End-Use Data and Energy

##### Efficiency Metrics

Evaluating the impact of energy efficiency policies is challenging for policy makers. Different types of energy efficiency policies require different data and metrics which are also dependent on the target sector (e.g. residential,industrial,transport,agricultural or commercial). Each task including,prioritising areas for intervention,evaluating the impact of policies,and tracking progress against objectives,requires a different set of data and a range of metrics that is limited by the information available in each country. Within the context of the G20 there would be great value in sharing experiences to improve energy efficiency metrics to allow for better decision making and prioritisation of the most cost-effective energy efficiency options,taking into account specific national circumstances and capabilities.

This work-stream is led by France through the French



National Agency for Energy Management (ADEME) with the support of the IEA. Other G20 members would be very welcome to co-lead the workstream.

#### 4.11.1 Long-term perspective and pathway

The objective of this work-stream would be to provide a forum for participating G20 countries to share knowledge and experience in collecting and analysing energy end-use demand and energy efficiency data including the strategies, approaches and methodologies that can lead to better metrics and ultimately improved decisions and more effective policies. The value of the work-stream is independent of the range of policies being implemented in each G20 country and also does not depend on the G20 countries having any similar policies or goals.

#### 4.11.2 Achievements

As a new workstream, the initiative has not yet achieved as such. It will however rely on the experience of partners:

Both France, through its national agency ADEME, and the IEA have been involved in end-use energy data collection and analysis for many decades.

In particular, ADEME developed and manages the European Commission database on energy efficiency indicators known as ODYSSEE for its 28 members. Through cooperation with the Mediterranean Energy Management Agencies (MEDENER network) a similar database on indicators has been developed for the Mediterranean region. More recently, in the framework of IPEEC, a project (BIEE project) has

been conducted to develop an energy efficiency indicators methodology and database for 19 Latin America and the Caribbean countries, with the Economic Commission of Latin America and the Caribbean. ADEME is also working with the World Energy Council in order to provide a global database on energy efficiency indicators. Complementary to the work led by France, the IEA has a systematic end-use data collection process for its members that shows energy efficiency progress across sectors, drivers of economy-wide trends and quantifies variations in energy demand. The IEA also regularly fosters exchange on energy efficiency data collection through manuals for both policy makers and statisticians in English, Chinese, Russian and Spanish as well as a database of country practices for collecting data across sectors. The IEA uses these resources to provide training to emerging economies and has a key role in partnering with the World Bank to produce the Global Tracking Framework Report for Sustainable Energy for All (SE4All). This report tracks global progress towards the SE4All objectives for energy efficiency, renewable energy and access to modern energy services.

#### 4.11.3 Planned work

The work-stream would be implemented by establishing a knowledge sharing forum under the G20 EELP. The forum would aim to meet face to face twice a year and would also establish virtual systems for sharing experiences of practice. The forum would be aligned with other relevant international activities

to ensure that it builds on existing experience and does not duplicate other initiatives.

The work-stream would be complemented by the identification of pilot initiatives allowing collaboration between participating countries on data quality improvement, as well as indicators design and use for policy evaluation, to be enhanced. The work-stream would be launched through an international workshop on energy efficiency data and metrics to establish a sound platform for the future cooperation. This workshop would include participants from regional bodies involved in data issues relevant to the G20. It would be used as a forum to identify priorities and showcase relevant experience from a range of countries.

An indicative schedule is as follows:

- (1) First workshop in Paris in late 2016
- (2) Issues paper in early 2017
- (3) Agreement of pilot actions to improve data quality among participating countries by mid-2017

A detailed Terms of Reference and work-plan would be developed in the first 6 months of the life of the workstream, based on dialogue with interested G20 members.

## 5. Implementation

G20 members agree that the International Partnership

for Energy Efficiency Cooperation (IPEEC) will be the key coordinating agency for the EELP. In this capacity, IPEEC will fully cooperate with international organizations including IEA, IEF, OPEC, OECD, APEC, BRICS, SE4ALL and C2E2, and others. In order to strengthen the global voice for energy efficiency, G20 members support IPEEC working with the IEA and other international organizations, including IEF, OPEC, OECD, APEC, BRICS, SE4ALL and C2E2, and with stakeholders, and G20 members will explore the feasibility of innovative collaborative arrangements for international cooperation on energy efficiency.

Recognizing the importance of adequate support to energy efficiency, G20 members agree that stable resources will be important to the effective implementation of the EELP, and encourage G20 members to provide the financial contributions necessary to its realisation. G20 members and other participating countries will aim to support and strengthen IPEEC through active participation in their selected areas of work, including through direct voluntary contributions to those areas of work (financial or in-kind). ■