2006 Achievement Report

International Project for Increasing the Efficient Use of Energy International Project for Improving Infrastructure for the Efficient Use of Energy (Programs for Promotion of Energy Conservation in Major Industries in ASEAN Countries)

Report on the Results

March, 2007

The Energy Conservation Center, Japan

Preface

In recent years, prevention of global warming has become a common issue for mankind on one hand, while sustainable economic development is actively demanded on the other. Thus, we are trapped in a situation in which we must overcome two challenges that completely contradict each other. Necessary for overcoming this situation are technical innovations, such as the development of technologies for the efficient use of energy, technologies for utilizing energy with minimum burden on the environment, and energies having little impact on the environment.

To contribute to the balanced development of economy and the environment in developing countries, we need to implement assistance that is acceptable and appropriate to each country, by assessing the reality of energy usage and environmental conservation measures, and thoroughly examining the state of infrastructure development, lifestyles, and other national conditions in respective countries.

Under this situation, we entered a new phase of activities in 2004, with an aim to implementing energy audits and improvement measures, and strengthening the mechanism for greater dissemination, based on the results of energy audit surveys and energy audit technology transfers implemented between 2000 and 2003, which targeted one industry each in the ten ASEAN countries. We have continued on with those activities in 2005 and 2006.

As an effective means of achieving our objectives, we have made on-going efforts to compile a Technical Directory and a Database/Benchmark/Guideline for each industry.

Meanwhile, in the effort to strengthen the mechanism for implementing and disseminating our activities, we have conducted follow-up surveys in plants that have been audited in the past, to assess the implementation status of recommended improvement measures, as well conducted walk-through energy audits in other plants to ensure the transfer of energy audit techniques. This year, we focused our attention on the cement industry in Lao PDR, the steel industry in Thailand, and the cement and oil refining industries in Myanmar.

Additionally, we held seminar-workshops in each country, with the participation not only of people from the host country, but also of governmental authorities and plant personnel of different industries in other countries as well. They were invited to present successful cases of energy conservation measures, to enhance information sharing in the ASEAN region and create a foundation for dissemination activities. The seminar-workshops also provided a forum for discussing the concept and formulation policies regarding the Technical Directory and database, and some specific examples were presented.

We feel that the activities implemented during the third year of the project have been highly meaningful, particularly in the sense that they have promoted the steady development of a foundation for promoting energy conservation activities directed to achieving the abovementioned goals.

We hope this project will contribute to energy and environmental conservation in industrial sectors in the ASEAN countries, and thereby allow each country to achieve environmentally friendly and sustainable economic growth. We also hope this project will serve as a bridge of technical exchange and friendship between Japan and the ASEAN countries.

March 2007

The Energy Conservation Center, Japan

Contents

Overview

The ASEAN countries are continuing to make rapid progress in economic development, and energy consumption is expected to dramatically increase in the future. It will therefore become increasingly important to utilize energy effectively and to give due consideration to preventing global warming.

This project has now entered its seventh year, and the activities of our counterpart, the ASEAN Centre for Energy (ACE), and relevant parties of the ASEAN countries have expanded and taken its root firmly. Moreover, against increasing energy prices accompanying the recent rise in crude oil prices, gradual changes in consciousness have begun to take place toward reducing energy consumption in those countries.

FY2006 marked the third year of phase 2 activities. It has been tagged as a year for bringing together the results of phase 1 activities implemented over the past four years, and for further strengthening independent efforts to apply and disseminate those results. In other words, phase 2 aims to establish a foundation for applying and disseminating actual improvement measures centering on those discussed and recommended by each country in the past, based on the achievements and results of energy audits conducted at plants in ten different industries in the ASEAN countries.

Specifically, the following activities were implemented in Lao PDR (cement industry), Thailand (steel industry), and Myanmar (cement and petroleum industries).

- ♦ Follow-up surveys of plants audited in the past and walk-through audits of new plants
  The implementation status of proposed improvement measures and problems arising on dissemination were assessed, and improvement measures were proposed for new plants.
- ♦ Creation of technical directory (TD)
  Information on effective technologies in the ASEAN countries and cases of successful implementation of various technologies related to the cement, steel, and petroleum refining industries were introduced and shared, to promote the implementation and dissemination of these technologies.
- ♦ Creation of database/benchmark/guideline (DB/BM/GL)
  Numerical targets were established for energy conservation activities and a framework was developed for providing guidelines directed to achieving those targets, with the objective of putting those activities into practice. One of the tasks for FY2006 included the creation of the database for cement industry.

Surveys including energy audits, and seminar-workshops were implemented in the abovementioned three countries. In order to make sure the technology transfer, practical guidance was provided to local personnel through following up the implementation status of energy audit technologies that have been transferred to the countries by Japanese experts in the past. In plants where implementation of improvement measures does not progress as expected, discussions were held concerning impediments to their implementation and possible solutions. Some useful clues were found for the promotion of future implementation and dissemination of such measures.

In addition to the above discussions, seminar-workshops were held in the respective countries. In addition to personnel from plants in the host country, plant personnel and governmental authorities from various industries in the ASEAN countries (including plant personnel who took part in past energy audits) were invited to participate and present activities and examples of improvement measures they have implemented. The seminar-workshops attracted a large number of participants, and provided a significant forum for sharing and disseminating information.

Local activities of the project in FY2006 began with an inception workshop held in July 2006 in conjunction with the projects on buildings and energy management infrastructure development. In the workshop, an implementation plan was formulated for smooth commencement of the project, and necessary preparations on the site were verified. Thereafter, a series of surveys and seminar-workshops were steadily held in three countries up to November 2006, and the summary workshop/post workshop was held in February 2007 in conjunction with the projects on buildings and energy management infrastructure development. Gathering together representatives (focal points) from the ASEAN countries, presentations were given to share the results of activities implemented in three countries with all ASEAN countries, and discussions were held on the creation of technical directory, and the development of database/benchmark/guideline (DB/BM/GL) by each country. The post workshop concluded with a discussion concerning policies and initiatives for FY2007 and onward.

The following specific activities were implemented in FY2006 in the project of major industry.

I. October 2 – 6, 2006 (business trip from Oct. 1 to 8):
On-site activities in Lao PDR (primary survey)

1. An audit survey and follow-up survey on hydro electric power plant, and an audit survey of sewing plants have been conducted in Lao PDR in the past. In FY2006, a walk-through energy audit was newly conducted at a cement plant, and results of the energy audit were presented and discussed at the plant.

2. Seminar-workshop in Lao PDR

Approximately 60 people participated in the seminar-workshop held in Lao PDR, which included the activities shown below. An active exchange of information was held through lively discussions.

(1) Energy conservation policies and programs (Lao PDR and Japan)

(2) Presentation of energy conservation examples by participants from various industries in Lao PDR and other ASEAN countries

(3) Presentation of the results of energy audit conducted at a cement plant in Lao PDR

(4) Presentation by ACE on policies for creation of technical directory (TD) and development of database (DB).

II. November 13 – 24, 2006 (business trip from Nov. 11 to 26):

On-site activities in Thailand and Myanmar (secondary survey)

1. In Thailand, a survey of a sodium hydroxide plant has been conducted in the past. In FY2006, the follow-up survey of the plant was omitted, but an energy audit was newly conducted at a steel plant. In Myanmar, an energy audit and follow-up survey were newly conducted at a cement plant and a petroleum refinery, respectively, and the result of surveys was presented and discussed at the relevant plants.

2. Seminar-workshops in Thailand and Myanmar

The seminar-workshop attracted 70 participants in Thailand and 56 participants in Myanmar. The following activities were implemented, and an active exchange of information took place through lively discussions. In the seminar held in Thailand, all presentations pertained exclusively to steel industry, and made this particular seminar-workshop the first to be held on a specific industry.

(1) Production activities in the steel industry in Thailand and Japan's energy conservation technologies / energy conservation policies and programs in Myanmar and Japan

(2) Presentation of energy conservation examples by participants from various industries in the host country and other ASEAN countries

(3) Discussions on policies for creation of technical directory (TD)

III. February 27 – 28, 2007 (business trip from Feb. 25 to Mar. 1):

Summary/post workshop held in Brunei Darussalam (in conjunction with the projects on buildings and energy management infrastructure development)

The following summary and discussion sessions were held with the attendance of 20 participants - 11 from the ASEAN countries, 5 from ACE, and 4 from ECCJ. The participants confirmed that the goals of activities implemented in the aforementioned three countries have been achieved as outlined in the implementation plan, which was adopted at the previous inception workshop.

1. Summary Workshop

Session 1: Energy conservation in major industries

- Results, achievements, and evaluation of activities implemented during FY2006
- Evaluation of activities implemented by each country and measures for future improvement
- Status of the creation of TD and DB in each country
- Status of the creation of TD and DB for major industries in ASEAN
- Policies for initiatives to be implemented in FY2007 and onward

Session 2: Energy conservation in buildings

Session 3: Development of energy management infrastructures

2. Post Workshop

Session 1: Summary of discussions held in the summary workshop for each project

Session 2: Basic implementation plan for FY2007 and onward

During FY2006, the project focused on providing assistance for building a foundation for sustainable energy conservation activities in each ASEAN country, and higher-grade activities were implemented that called for greater independent efforts by each country. Owing to the cooperation of all countries in implementing the activities, significant achievements have been made this fiscal year. At the same time, however, the following issues have surfaced as the project has progressed. Greater efforts must be made to address these problems in FY2007 and onward.

(1) Starting FY2005, audit surveys were decided to be conducted under the leadership of a core team employing an OJT method, but we found that the team was still highly dependent on assistance from Japanese experts. More self-help efforts are expected from the core team in making the necessary preparations, including collecting questionnaires and arranging for measurement instruments.

(2) In regard to the creation of an in-house DB for cement industry which was to be undertaken during FY2006, a draft database has been prepared, but the plan has not been accomplished, due to a number of inadequacies. It is necessary to make stakeholders understand the

significance of creating an in-house DB, and to cooperate closely with ACE and focal points toward the early development of the DB.

(3) Engineers from countries other than the host country participated voluntarily in the FY2006 audit surveys. Their participation was highly significant in terms of promoting the sharing of the project's achievements and disseminating them among the ASEAN countries. Further efforts should be made to increase voluntary participation from other countries as well, in the future.

Lastly, this project has been made possible with the full cooperation of ACE, relevant organizations in each country, and representatives of relevant companies. We would like to take the opportunity of this paper to extend our deepest gratitude to them all.

Below is a list of abbreviations used in this report.

EE&C	Energy Efficiency and Conservation
TD	Technical Directory
DB/BM/GL	Database / Benchmark / Guideline

ACE	ASEAN Center for Energy
METI	Ministry of Economy, Trade and Industry
ECCJ	The Energy Conservation Center, Japan

Lao PDR

MEM	Ministry of Energy and Mines

Thailand

DOE	Department of Energy
DODE	Department of Alternative Energy Development and Efficiency
BSI	Bangkok Steel Industry Public Co., Ltd.

Myanmar

MOE	Ministry of Energy
EPD	Energy Planning Department
MOI2	Ministry of Industry No.2 (No.2: Heavy Industry)

Malaysia

PTM	Pusat Tenaga Malaysia (Malaysia Energy Center)

I. Purpose and Background of the Project

This project aims to contribute to promoting energy conservation and environmental conservation in Southeast Asia by helping disseminate and promote energy conservation technologies in major industries. Specifically, it strives to contribute to promoting energy conservation measures in major industries in the ASEAN countries by supporting the activities of those countries. The project was established in 2000 under the leadership of the ASEAN Center for Energy (ACE), with the objective of suppressing constantly increasing energy consumption in the industrial sectors in the ASEAN region. Formally, it is called the Promotion of Energy Efficiency and Conservation Project, but commonly referred to as PROMEEC for Major Industries in ASEAN countries. It is a project that is certified by the conference of energy-related ministers of ten ASEAN countries and implemented in cooperation with the Japanese Ministry of Economy, Trade and Industry. The Energy Conservation Center, Japan (ECCJ) also takes part in the project in support of the technical and operational aspects of energy conservation in industrial sectors in the ASEAN region.

The objectives of the project are as follows.

1. To strengthen cooperative relationships between the ASEAN countries and Japan in the energy sector
2. To promote energy efficiency and conservation in major industries in the ASEAN countries
3. To promote the transfer of energy-related technologies from Japan to the ASEAN countries and introduce Japan's good practices in energy conservation
4. To enhance the capacities of the ASEAN countries through energy audits and on-the-job training (OJT) in such audit surveys
5. To create the database/benchmark/guideline (DB/BM/GL) in the ASEAN countries

This cooperation project is being implemented in three phases, as shown below, based on consultations with ACE and the ASEAN countries. FY2006 marked the third year of phase 2 activities. Based on activities that have been implemented in all ASEAN countries by March 2004 in phase 1, a foundation has so far been created for promoting energy conservation activities in all ASEAN countries on an equal basis.

Phase 1: Transfer of Japan's technologies and experiences to the ASEAN countries (completed in FY2003)

Phase 2: ASEAN-Japan joint implementation of improvement measures in the respective countries and dissemination to other countries

Phase 3: Promotion of energy conservation through self-help efforts of the ASEAN countries

In FY2004, efforts were launched to create a foundation for promoting the implementation and dissemination of energy conservation measures based on the foundation created in phase 1. Specifically, activities revolved around conducting follow-up surveys at plants where energy audits were carried out in the past, creating a technical directory (TD), and assisting each country in creating a DB/BM/GL for each industry. During FY2006, relevant activities were implemented, targeting the cement industry in Lao PDR, the steel industry in Thailand, and the cement and oil refining industries in Myanmar.

In the respective countries, local support was obtained in conducting OJT-based walk-through energy audits in new plants for steady transfer of energy audit technologies, and in carrying out follow-up surveys for assessing the implementation status of proposed improvement measures and problems in plants audited in the past. Seminar-workshops were also held, featuring lecturers invited from various plants of different industries in the host country and other ASEAN countries. Through dissemination activities, cases of successful implementation of improvement measures and examples of advanced energy conservation technologies were introduced to the ASEAN countries. Finally, to promote the creation of the TD and DB/BM/GL in the respective countries, a working plan was reported as well as already-finished works for the reference. These activities aimed to provide a basis for developing a foundation for promotion of energy conservation in each country and to establish a network for dissemination among the ASEAN countries.

Lastly, the post workshop was held bringing together the representatives from the ASEAN countries in order to share the achievements and results of activities that have been implemented in the respective countries and to discuss basic plans for future activities.

Lao PDR (Cement Industry)

1. Activity Overview

An audit survey at the hydro power plant was conducted in the phase 1 of PROMEEC activities in Lao PDR. As the first stage of activities in phase 2, a follow-up survey of the hydro power plant and an energy audit at the sewing plant were conducted. This year an audit survey was planned at the cement plant as the second stage of activities in phase 2. The cement plant was the state-run Lao Cement Co., Ltd. (LCC), located in Vang Vieng District, approximately 200 kilometers, or about three hours by car, to the north of Vientiane Province.

The energy audit at Lao Cement was carried out over three days, with the participation of four members from the Lao Ministry of Energy and Mines (MEM) and 20 engineers from Lao Cement. The results of the audit survey were presented by a Lao Cement engineer at the seminar-workshop held later in Vientiane.

1.1 Date

October 2 – 6, 2006

1.2 Venue

Cement plant:	Lao Cement Co., Ltd. (LCC) in Vang Vieng (located approx. 200km north of Vientiane)
Seminar-workshop:	Dong Chang Palace Hotel in Vientiane

1.3 Schedule

Oct. 2 (Mon.)	Travel to Vang Vieng; energy audit at the cement plant (LCC)
Oct. 3 (Tue.)	Energy audit at the cement plant (LCC)
Oct. 4 (Wed.)	Energy audit at the cement plant (LCC)
Oct. 5 (Thu.)	Energy audit at the cement plant (LCC); travel to Vientiane
Oct. 6 (Fri.)	Seminar-workshop

1.4 Participants

Lao Ministry of Energy and Mines (MEM):

Mr. Khamso Kouphokham	Deputy Chief of EMD, Electrical Engineer
Dr. Xayphone Bounsou	Electrical Engineer

ASEAN Center for Energy (ACE):

Ms. Evangeline L. Moises	Chief, Information & Event Division
Mr. Ivan Ismed	Project Officer

Malaysia Energy Center (Pusat Tenaga Malaysia; PTM):

Mr. Zul Azri Hamidon Energy Audit Engineer, Electrical Engineer

Ms. Norazean Mohd. Nor Technical Assistant, Electrical Engineer

The Energy Conservation Center, Japan (ECCJ), International Engineering Dept.:

Kokichi Takeda, Hideyuki Tanaka, Taichiro Kawase

About Lao PDR
(Source: Web site of the Japanese Ministry of Foreign Affairs (February 2007 data))

1. Area: 240,000 sq km (approx. 0.6 times the area of Japan)

2. Population: 5,609,000 (Third National Survey conducted March 2005)

3. Ethnicity: Lao Loum (lowland) (60%) and 49 other ethnic groups

4. Language: Lao

5. Religion Buddhist

6. Government: People's democratic republic (established February 1973); Unicameral assembly

ASEAN membership in July 1997

7. Major industries: Agriculture, manufacturing, forestry, mining, and hydroelectric power generation

8. GDP (per capita): $491 (2005) [GDP growth rate 7.3% (2005)]

9. Total trade: (1) Exports $456 million (Oct. 2004 – Sept. 2005)

Garments, metals and minerals, electric power, wood products

(2) Imports $686 million (Oct. 2004 – Sept. 2005)

Fuel, industrial products, raw materials for garments

10. Exchange rate: $1 = 9,650 kip (as of Feb. 2007)

11. Economic overview:

The country has introduced a market economy, and is pursuing open economic policies. It is showing signs of gradual recovery from the Asian economic crisis.

Long-term goals: Departure from less developed country (LDC) status by 2020, basic resolution of poverty by 2010, etc.

12. Energy situation:

The country supplied approx. 670 ktoe of energy in 2004 (coal: 26.2%, petroleum: 58.3%, electric power: 15.5%). 3,327GWh of power was generated by hydroelectric power generation, and while some areas import power, close to 65% of power generated by the country is exported. The country appears to be dependent on imports for petroleum, but no precise

	information is available. Although not included in the aforementioned figure, the country consumes approx. one-fourths of total biomass that is commonly used in the ASEAN countries. Including biomass, households account for 50% of energy consumption, industries 20%, transportation 26%, and other sectors, the rest. (Source: Materials presented at PROMEEC meetings, etc.)

2. Audit Survey on Energy Conservation at Lao Cement

Of the five cement plants operated by three cement companies in Lao PDR, Lao Cement Co., Ltd. (LCC), which owns two plants, was selected for this project's OJT practice.

2.1 Overview of Lao Cement Co., Ltd.

Lao Cement's plants are located in the outskirts of Vang Vieng District, approximately 200km north of Vientiane Province, amidst a picturesque setting where the Nam Song River flows abundantly through a deep limestone valley that closely resembles China's famous Guilin. The survey team consisted of 11 members, including 4 governmental personnel (Ministry of Energy and Mines) and 7 representatives from ASEAN and ECCJ. Since two plants were located on the same premises, the team spent three days in Vang Vieng to provide auditing guidance.

(1) Name of company: Lao Cement Co., Ltd. (established in 1993)

(2) Location: Vang Vieng District, Vientiane Province, Lao PDR

(3) Period: October 2 – 5, 2006

(4) Survey members (audit team 1/2):

Lao government (MEM):

Mr. Khamso Kouphokham	Deputy Chief of EMD, Electrical Engineer
Dr. Xayphone Bounsou	Electrical Engineer
Mr. Viengsay Chantha	Engineer
Mr. Khamsith Ackhavong	Engineer

ASEAN Center for Energy (ACE):

Ms. Evangeline L. Moises	Chief, Information & Event Division
Mr. Ivan Ismed	Project Officer

Malaysia Energy Center (PTM):

Mr. Zul Azri Hamidon	Energy Audit Engineer, Electrical Engineer
Ms. Norazean Mohd. Nor	Technical Assistant, Electrical Engineer

The Energy Conservation Center, Japan (ECCJ):

Kokichi Takeda, Hideyuki Tanaka, Taichiro Kawase

(5) Lao Cement participants (audit team 2/2):

Mr. Thongchan Sounaphon	Deputy Director of Plant No.1
Mr. Vichith Souvannarath	Deputy Director of Plant No.2
Mr. Bouasavath Sophetmany	Mechanical Engineer
Mr. Singeunh Leuangvansay	QC Engineer
Mr. Houmphonh Soududuang	Head of Raw Material
Mr. Thong Phoune Bosisakhoune	Deputy Head of Department
Mr. Korsavanthong	Head of Planning
Mr. Amkha Dethosonedy	Head of MTB
Mr. Phovanh Phomany	Head of Electricity
Mr. Bouasone Keopasert	Head of Department
Mr. Sisomphou Khongphalanh	Head of Department
Mr. Litthi Siriboun Heuang	Head of Department
Mr. Phoungeun Phimmasone	Head of Raw Material
Mr. Chanthay Vongnakhone	Head of Spare Parts
Mr. Khamla Noiphewphanh	Head of Production Plan
Mr. Keonkothoung	Head of AD
Mr. Vanh Malathong	Head of CMD
Mr. Chanthaehon Inthacvong	Head of CCR
Mr. Nantha Phuyphuthasak	Electrical Engineer
Mr. Oudomsine Khamsisopha	Electrical Engineer

(6) Activity schedule at Lao Cement

Table II-2-1 shows the schedule of activities at Lao Cement.

Table II-2-1 Schedule of activities at Lao Cement

Date/Time	Activity	Person in charge	Remarks
Oct. 2 (Mon) 2:30 - 6:30 pm	1. Travel from Vientiane → Vang Vieng 2. Self introductions 3. General explanation of PROMEEC activities 4. Explanation of the schedule 5. General description of Plant No. 1 6. General description of Plant No. 2	 All members Ms. Evangeline / Mr. Tanaka Mr. Khamso Mr. Thongchan Mr. Vichith	
Oct. 3 (Tue) 8:50am - 6:00pm	1. Interviews at the plant 2. Lecture on energy conservation measures and audit methods 3. Tour of facilities	All members Mr. Kawase All members	

	4. Discussion concerning preliminary questionnaire 5. Confirmation of measurement areas and methods	All members All members	
Oct. 4 (Wed) 8:50am - 6:00pm	1. Data collection and measurement 2. Lecture on data analysis methods and heat balance 3. Lecture on electricity conservation	All members Mr. Kawase Mr. Takeda	
Oct. 5 (Thu) 8:50am - 12:00pm	1. Discussion on audit results and energy conservation measures 2. Summary and presentation of completion certificates 3. Travel from Vang Vieng → Vientiane	All members Mr. Khamso, Ms. Evangeline/ Mr. Tanaka	

2.2 Overview of Cement Production Facilities

Lao Cement is a state-run company, possessing two plants in Vang Vieng District. An overview of the plants is as shown below. The two plants stand 500m apart on the same premises, and substancially constitute one large plant.

	Plant No. 1	Plant No. 2
Date of construction	Dec. 1994	Jan. 2002
Nominal capacity (tons/year)	90,000	210,000
Kiln type	Shaft kiln	Rotary kiln with NSP
Fuel	Coal	Coal
No. of employees	244	294

There are three cement companies in Lao PDR. One is a state-run company, one is a private company, and the other is a semi-private company. Combined, their production capacities total 600,000 tons/year, with Lao Cement accounting for 50%. However, as domestic demand equals 1.3 million tons/year, the difference is covered by imports from Thailand, China and other countries. Therefore, the Lao Cement’s primary goal was to increase production by increasing the number of operating days. Impressively, both plants now operate more than 300 days per year.

The cement facility has been constructed by the Chinese company, but it is interesting to note that the major equipment and instruments are made by Japan, the United States, the United Kingdom, and Germany. Three Chinese engineers work in Plant No. 2 still today, to provide guidance on production technologies. However, they do not provide guidance on energy conservation.

2.3 Walk-through Energy Audit at Cement Plants

(1) Audit procedure

The energy audit proceeded as follows, with the local team encouraged to take the initiative in its execution. Due consideration was given to the OJT perspective and the participation of PTM engineers.

Lecture on an overview of the cement production process and energy conservation measures

Briefing on audit items and data collection/measurement items

Grouping of members into audit teams

Data collection and measurement

Data analysis and reporting

ECCJ experts were placed in charge of the first two activities, for the purpose of providing preliminary information. Attachment II-1 and II-2 show materials that were used in the lecture. In consideration of the time factor, audit items were narrowed down to kiln heat balance, air leakage prevention, and speed control of large-scale rotary machines.

Members were grouped into audit teams by the focal point, Mr. Khamso Kouphokham, and engineers of the plants and PTM. Data collection and measurement were carried out almost entirely without the assistance of ECCJ experts, though data analysis required help from ECCJ experts. An engineer in the local team (electrical engineer affiliated with Plant No. 2) gave a report on the results at the seminar-workshop held later. The report of the audit is provided in Reference II-3.

(2) Status of energy conservation initiatives

Energy conservation initiatives at the cement plant are said to have begun after participation of a Lao Cement engineer in the 2004 PROMEEC Vientiane Seminar (*1). In Lao Cement, fuel SEC (*2) and electricity SEC are being managed, but they are matters of concern only to certain executives, and are not satisfactorily disseminated to the actual work site. No organizational efforts have been made, such as establishing energy conservation committees and appointing energy managers, nor have small group activities such as *kaizen* activities (*3) been adopted. The only information posted on bulletin boards was a graph showing cement production trends.

We found no signs of untidiness in the cement plants that are commonly found in developing countries. They gave the impression of being relatively well organized. Plant No.

1 employs relatively old facility called shaft kiln, but it was well maintained and being used carefully. The employees were courteous, and their willingness to listen to the survey team left an agreeable impression on the team members. Truly the employees do not possess knowledge of energy conservation methods at the moment, but we felt that they are fully capable of promoting energy conservation on their own if taught what they need to know.

*1: Mr. Vichith Souvannarath (Director of Plant No. 2) participated in the 2004 PROMEEC seminar. He raised a question and obtained information on electric power consumption rate in cement plants in Japan.

*2: SEC: specific energy consumption

*3: *Kaizen* activities have been introduced by JICA experts in the past.

(3) Overview of audit results

1) Kiln heat balance and its utilization

Kiln heat balance was calculated to obtain the gas load of the kiln inside. Using the gas load, it is possible to estimate the maximum amount of clinkers that could be produced. Kiln heat balance also shows where energy is being consumed, and hence, where energy conservation opportunities lie. Heat balance was calculated according to an Excel program supplied by ECCJ. See the following section for equations constituting the program. Data that are necessary for running the program were either measured on-site or collected from operation records. In the limited time available, estimated values were used in part of input data. Therefore, the accuracy of the calculation results could not be expected to be high, but we were able to obtain a rough number. For greater accuracy, it would have been necessary to consult with a process contractor. Maximum potential of clinker production was estimated under the assumption that it is generally proportionate to the gas load of kiln inside. Data disclosed by the Japan Cement Technology Association were utilized as target values of the gas load. As a result, it was estimated that production capacity of kiln No. 1 could be increased from the present 230 tons/day to 266 tons/day, and the production capacity of kiln No. 2 could be increased from the present 780 tons/day to 988 tons/day. Table II-2-2 shows the principal data used in the calculation.

Table II-2-2 Principle data used in the calculation

Data	Unit	Kiln No. 1	Kiln No. 2
Kiln type	-	shaft	NSP
Raw material (dry weight)	t/d	370	1200

Moisture	wt% on wet RM	14	0
Clinker	t/d	230	780
Coal	t/d	44	122
Lower heating value	kcal/kg	5600	5600
Exhaust gas temperature	degC	200	320
Cooler vented air	%	-	10
Waste gas O2	vol%	5	6

Kiln No. 2 heat balance

Heat input		Heat output	
Heat of fuel combustion	873.8	Heat of clinkering	470.0
Sensible heat of fuel	0	Sensible heat of clinker	19.2
Sensible heat of raw material	0	Sensible heat of cooler air bypass	-
Sensible heat of combustion air	0	Heat of evaporation of moisture contained in raw material	0
		Sensible heat of exhaust gas	167.4
		Sensible heat of cooler vented air	7.3
		Heat radiation from kiln surface	30.4
		Heat radiation from pre-heater surface	8.0
		Heat radiation from cooler surface	4.0
		Unaccounted-for heat loss	167.5
Total heat input	873.8	Total heat output	873.8

Reference temperature: Room temperature
Unit: kcal per kg of clinker (kcal/kg-cl)
Clinker cooler: Grate-type

Estimated maximum clinker production capacity

	Kiln No. 1	Kiln No. 2
Kiln type	Shaft	NSP
Gas load (m3N/kg-cl)	1.91	1.71
Designed production capacity (t-cl/d)	200	700
Actual production capacity (t-cl/d) @ Oct. 3, 2006	230	780
Estimated maximum production capacity (t-cl/d)	266	988
Gas load in Japan (m3N/kg-cl)	1.65	1.35

Note 1: The above estimates are based on many assumptions. They are to be used for preliminary examination, and not for detailed examination.

2) Estimation of air leakage rate

Air leakage is likely to occur in the grate cooler, sliding parts around the kiln, suspension pre-heater, grinding mill, and electric dust collector. No matter where a leakage occurs, however, it increases power consumption of the fans. Air leakage in the grate cooler or kiln causes increased fuel consumption. The older the facility becomes, the greater the possibility of air leakage. An effective method for early detection of air leakage is to measure oxygen level in questionable areas. In this audit, oxygen levels could not be measured due to a malfunction of the gas analyzer. Oxygen level is not only important for detecting air leakage, but it has great impact on the accuracy of heat balance.

3) Speed control of large-scale rotary machines

In cement plants, rotary machines consume the largest amount of power. In most cases, they are much larger than necessary and put a considerable amount of power to waste. Even if they are designed in an appropriate size, energy loss occurs when the control damper is closed in times of low production volume. A rough estimate of energy loss can be obtained by observing the opening of the control damper and the load on the rotary machine drive motor (electric current). Table II-2-3 below shows the data collected and the estimated reduction in power when speed control is applied.

Table II-2-3 Estimated power reduction

Fan no. (*3)	Service	Rated current (Ad)	Rated voltage (Vd)	Rated kW (name plate) (*1)	Actual current (Aa)	Power savings (kWsaving)	Damper opening (%)
G6	Cement mill EP fan	214.8	380	(1041)	188	62	38
G14	Cooler fan	102.6	380	55	73	31	73
G15	Cooler fan	70.6	380	37	54	18	61
G16	Cooler fan	85	380	45	48	32	60
G17	Cooler fan	86	380	45	60	26	56
G23	Primary air fan	56.8	380	21.6	24	0	100
K1	Coal mill fan	102.5	380	(46.5)	56	75	50
K2	Coal mill fan	201	380	(87.8)	113	145	78
B26	Low mill fan	53.4	380	(41.6)	29	39	42
E13	Low mill EP fan	214.8	380	(1041)	180	0	100
F23	IDF fan	62.7	6000	630	51	0	100(*2)
						∑428	

*1: Figures in parentheses are rated power values calculated according to the following equation.

Rated kW = head (Pa) x flow rate (m3/min) / 60000 / fan efficiency

*2: F23 adopts speed control based on fluid coupling.

*3: G23 is a roots blower, and the others are centrifugal fans.

The amount of power saved by applying speed control is estimated by comparing actual operation and rated operation along the performance curve. Unfortunately, we were not able to obtain the performance curve for fans other than F23. Therefore, as a simplified method, we compared electric currents and estimated power savings according to the current method using the equation below. The current method should be used only when making rough estimations, as it is not too precise.

Power savings = design kW x {1–(actual ampere/design ampere)^3}
/fan efficiency x motor efficiency

Fan efficiency and motor efficiency were assumed as 0.7 and 0.8, respectively.

If the yearly number of operating days is assumed to be 300 days,

Annual savings = 428 x 300 x 24 = 3,081,600kWh

4) Proposals for Lao Cement

a. Increased cement production

As mentioned earlier, Lao Cement's existing kilns have the potential to increase cement production 15% to 26%, though these figures are rough estimates. To mitigate as much as possible the present burden of importing cement to cover for the lack of production capacity, serious consideration should be given to increasing production. When doing so, it is important to take one step at a time, while calculating gas load and checking for any bottlenecks in the production facilities.

b. Speed control

A number of fans operate with the damper in the semi-open position, and waste several million kilowatt-hours of power. The most effective method of reducing waste of power is to control speed by means of an inverter. If the inverter is successfully implemented, a unit power consumption improvement of 13 kWh/t-clinker (*4) could be expected. The introduction of speed control should be promptly considered.

*4: 428kW x 24h / 780t-clinker/d = 13.1kWh/t-clinker

c. Air leakage prevention

Air leakage causes energy waste. Since the most effective method of detecting air leakage is to measure oxygen level, we recommend the purchase of a portable oxygen analyzer. A zirconium sensor would be an appropriate oxygen meter, as it has a long service life and provides sufficient precision. See Attachment II-3 for details on air leakage estimation method.

d. Management of grinding balls

Grinding efficiency is greatly influenced by the diameter of grinding balls. The balls wear and become smaller with time, causing grinding efficiency to drop and raw mill SEC to increase. Conversely, by monitoring raw mill SEC, it is possible to estimate the degradation of grinding balls and assess their appropriate charging time. The amount of balls inside the ball mill also influences grinding efficiency. As shown in Fig. II-2-1 below, it is a good idea to plot SEC values daily.

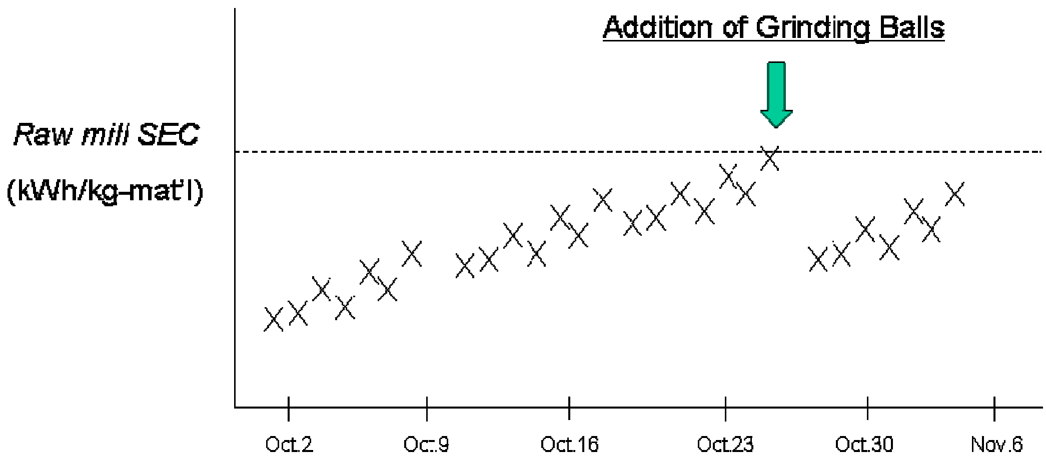


Fig. II-2-1 Management of grinding SEC in a ball mill

5) Creating an energy management system

The effectiveness of an energy management system (EMS) has already been proven in developed countries. Table II-2-4 shows the major items composing an EMS.

Table II-2-4 Items for an energy management system

Item	Activity	Activity example
Energy conservation organization	Organization Responsibilities	Energy conservation promotion committee Energy managers Employee training
Energy conservation monitoring	Tracking data Establishing goals	Data recording and distribution SEC management Energy conservation indicators (ex. O2%)
Energy conservation technologies	Technical evaluation	Technical evaluation Energy audit
Operation and facility maintenance	Daily activities	Yield (prevention of off-spec products) Preventive maintenance (prevention of unscheduled shutdown)

As mentioned earlier, energy management activities are scarcely implemented at Lao Cement’s plants. The following activities should provide a good start.

a. Organizing an energy conservation committee

b. Appointing energy managers

c. Providing employee training (ex. participation in outside training)

d. Recording energy data and distributing them to relevant departments

Additionally, it is important that plant top managements give their full support to the above activities.

3. Seminar-workshop

3.1 Overview

(1) Date/Time

October 6, 2006 (Fri.) 8:30am – 5:30pm

(2) Venue

Dong Chang Palace Hotel, Vientiane, Lao PDR

(3) Presentations in the seminar-workshop

58 participants attended the seminar-workshop. In the seminar, ASEAN Center for Energy (ACE) introduced the ASEAN Energy Efficiency and Conservation (EE&C) program, and the Lao Ministry of Energy and Mines introduced the present situation of energy consumption in Lao PDR, in addition to ECCJ's introduction to its guidance and program for EE&C in Japan's industries. They were followed by presentations on examples of energy conservation activities in the ASEAN region by representatives from Lao PDR, Malaysia, Myanmar and the Philippines.

A plant engineer reported the results of audit survey conducted at Lao Cement's plants, as already mentioned, and ECCJ made several comments regarding the cement production equipment and electric facilities.

In the workshop, ECCJ discussed barriers and countermeasures to EE&C promotional activities, and ACE reported on the current development status of the technical directory (TD) and database/benchmark/guideline (DB/BM/GL) for major industries.

(4) Participants

Lao PDR:

Dr. Daovong Phonekeo	Deputy Director General, Dept. of Electricity
Mr. Khamso Kouphokham	Deputy Chief of Energy Management Div, MEM
Mr. Vanthong Khamloonvylayvong	Deputy Manager of Nam Ngum Hydro Power Plant

Approx. 40 general participants from Lao PDR also attended (metal mining, table salt, etc.)

.

ASEAN Center for Energy (ACE):

Mr. Ivan Ismed	Project Officer

Ms. Evangeline L. Moises Project Officer

Malaysia Energy Center (PTM):

Mr. Zul Azri Hamidon Energy Audit Engineer

Ms. Norazean Mohd. Nor Technical Assistant

Ms. Meena Kumari Assistant Project Manager

The Philippines:

Mr. Marlon Romulo U. Domingo Department of Energy, Energy Efficiency Division

Myanmar:

Ms. Daw Hla Hla Kyi Deputy General Manager, Myanmar Petrochemical Complex

The Energy Conservation Center, Japan (ECCJ):

Kokichi Takeda, Hideyuki Tanaka, Taichiro Kawase

3.2 Results of the seminar-workshop

Mr. Khamso Kouphokham (Deputy Chief, MEM; focal point (FP) representing Lao PDR) presided over the seminar, which opened with the participation of 58 guests.

(1) Opening ceremony (congratulatory speech and opening address)

1) ACE

Ms. Evangeline Moises delivered a speech written by Dr. Weerawat Chantanakome (executive director, ACE) and introduced ACE's activities, PROMEEC activities and the seminar program.

2) ECCJ

Mr. Hideyuki Tanaka (project leader) gave a brief address, mentioning the significance of the project, its development and recent status, and Japan's cooperation and contribution to ASEAN.

3) Ministry of Energy and Mines (MEM)

Dr. Daovong Phonekeo delivered an address, citing the declaration on EE&C initiatives adopted by the ASEAN Ministers' Meeting, which was held this spring, and emphasizing the importance of conserving energy in response to increasing crude oil prices. On behalf of the ministry, he also expressed his appreciation of activities implemented by METI/ECCJ and ACE.

(2) Session 1: Policy and Initiatives on EE&C

1) Overview of EE&C Programs on ASEAN (Ms. Evangeline Moises, ACE)

Ms. Moises described the role of ACE in the ASEAN region, and introduced major EE&C activities by EC-ASEAN and SOME-METI, and PROMEEC activities. She also made a call for participation to the award system.

2) Overview of Plans & Programs on EE&C in Lao PDR (Mr. Khamso Kouphokham, MEM)

Lao PDR is at the stage where it will be preparing future plans, including energy conservation laws and regulations. It should first of all consider the application of energy conservation measures to governmental buildings, formulation of demand-side management (DSM) promotion plans by Electricité du Laos (EDL), and the development of an energy manager system.

3) Initiatives and Programs of ECCJ on EE&C in Industry in Japan（Mr. Hideyuki Tanaka, ECCJ）

Mr. Tanaka introduced energy conservation policies in Japan and ECCJ’s activities. He also discussed the harmonization of 3Es and the energy conservation law, the designation of plants, energy managers and national examination, education and training, and the national convention of excellent successful cases.

(3) Session 2: EE&C Best Practices in Industries

1) Case Study 1 – Hydro Power Plant (Lao PDR, Mr. Vanthong Khamloonvylayvong)

Nam Ngum Hydro Power Plant has received its first PROMEEC audit by ECCJ experts in 2002, and a follow-up audit in 2004. In this presentation, it was reported that the plant is making on-going efforts to implement energy conservation and improvement measures that were proposed in 2004. Through measures to repair the turbine runner for increasing the turbine efficiency, to strengthen lighting control, and to enhance operational management of facilities inside the power station, it has succeeded in increasing power generation by 15MWh and in saving 53MWh of power during the year. Mr. Khamloonvylayvong repeatedly expressed gratitude to ECCJ.

2) Case Study 2 – Industries in Malaysia (Malaysia, Ms. Meena Kumari M. Nair)

Mr. Nair gave a report on the energy conservation activities of the Malaysia Energy Center (PTM), emphasizing the achievements of the Malaysia Industrial Energy Efficiency Improvement Project (MIEEIP). An audit of 48 plants by the PTM audit team showed that the plants as a whole have the potential to save energy worth RM108 million (more than 3 billion yen). The implementation of appropriate measures could produce outstanding results.

3) Case Study 3 – Oil Refinery (Myanmar, Ms. Daw Hla Hla Kyi)

Myanmar Petrochemical Complex is a state-run company operated under the control of the Ministry of Energy. It received the first PROMEEC audit by EECJ experts in 2000 and a follow-up audit in 2004. The presentation was almost entirely devoted to a description of refining processes and an overview of the first audit. Subsequent energy conservation activities simply consisted of managing excess air in furnaces. Ms. Kyi repeatedly expressed gratitude to ECCJ.

4) Case Study 4 – Iron/Steel, Cement & Food (Philippines, Mr. Marlon Romulo Domingo)

A representative from the Philippine Ministry of Energy gave a report on energy conservation activities in the Philippines, particularly of manufacturers who were awarded the "Don Emilio Abello Energy Efficiency Awards" in 2005, including a steel bar manufacturer, a galvanized and color sheet steel manufacturer, a cement company, and a pineapple processing company. Dramatic improvements in SEC were shown using numerical data.

5) Results of the energy audit of two cement plants (Lao Cement Co., Ltd.: Mr. Natha Phyphthasak; ECCJ: Mr. Taichiro Kawase, Mr. Kokichi Takeda)

Mr. Natha Phyphthasak from Lao Cement gave a presentation on past and present energy conservation activities and future activity plans of the company's two plants. Lao Cement has been actively working to improve electricity SEC. As a result of its efforts, it has achieved an SEC of 133.5 kWh/t-cement in Plant No. 2 to its target of 125 kWh/t-cement. Although there was no mention of any activity goals during the energy audit of the plants, it appears that some activities have actually been implemented to a certain extent for some time.

As future plans, Mr. Phyphthasak talked about employee training, strengthening of preventive maintenance, productivity improvement, and the establishment of an energy conservation organization. The advice that ECCJ gave at the conclusion of audit survey was adopted as a future plan of cement plants.

In regard to the results of audit survey, Mr. Kawase explained the conclusion drawn from heat balance calculation in the kiln as a quick evaluation. At the same time, he advised Lao Cement to create an energy management system, citing the significance of employee training and daily facility management as reasons. Mr. Takeda gave an explanation of audit results (quick estimation) related to the speed control of large-scale rotary machines.

(4) Session 4: The Way Forward

1) Barriers and Measures to Implement EE&C in Industry (ECCJ: Mr. Taichiro Kawase)

Mr. Kawase discussed barriers and measures to implementing EE&C, using materials supplied by ECCJ and citing other presentations that were delivered ahead on the same day.

2) Updates on the development of the technical directory (ACE: Mr. Ivan Ismed)

Mr. Ismed explained the purpose, method of development, and format of the technical directory (TD), and presented an example of a TD sheet.

3) Updates on the development of the database/benchmark/guideline for major industries (ACE: Mr. Ivan Ismed)

As materials on the industry-based database were not available in time for this seminar, Mr. Ismed explained the purpose, method of development, and format of the database/benchmark/guideline for major industries using materials on the PROMEEC database/benchmark/guideline for buildings instead.

(5) Questions and answers

As mentioned previously, a Q&A session followed each presentation session. Some examples are provided below.

Q: In regard to hydro power generation in Lao PDR, energy conservation proposals made after the first audit were implemented only to a small degree. What was the obstacle to their implementation?

A: (Mr. Vanthong Khamloonvylayvong) Lack of funding was the problem.

Q: The achievement of energy audits become improved in Malaysia, but are they being implemented?

A: (Ms. Meena Kumari) Some of large companies put into implementation proposals in energy audits. Most of other companies are still contemplating their implementation, due to a funding problem.

Q: Good practices in the Philippines are quantitatively evaluated by SEC improvement rate. According to the presentation, SEC improved from 130 to 70 in the case of the cement plant. However the improvement seems so large that it should be reconfirmed.

A: (Mr. Marlon Romulo Domingo) We will reexamine it later.

Q: Among the companies participating in today’s seminar, are there any companies that conduct in-house energy audits?

A: Only one company—Lane Xang Minerals Ltd. (gold producer)

(6) Closing address

The seminar-workshop concluded with closing speeches by Ms. Evangeline L. Moises and Mr. Hideyuki Tanaka.

(7) Impressions and comments

Mr. Khamso Kouphokham, the Lao PDR focal point, sincerely worked to coordinate various activities, including arrangement for accommodations, transportation to and from the airport, travel and visit to the plants, adjusting schedules with the plants, and arranging for interpreters and the seminar. The participation of two Malaysian engineers (PTM) in the audit had great significance, because technical transfer among the ASEAN countries is one of the goals of the PROMEEC project. Hereafter, we hope to also receive the cooperation of the Energy Conservation Center of Thailand (ECCT) and the Indonesia's national energy conservation company (KONEBA).

Lao Cement's response to the audit survey was excellent. 20 engineers, including two deputy plant directors, devoted four days to participating in the audit survey. The plant director delivered a speech, and all of 20 engineers introduced themselves in English. A number of them have graduated from universities in the former Soviet Union, including Czechoslovakia, Ukraine, Georgia, and Russia. They were also highly disciplined, and we had an impression that they could respond to anything if proper training was given. The only regret is that Mr. Zamora (ACE) could not participate due to other urgent business.

(8) Proposals for FY2007 PROMEEC activities

1) Extending the audit duration

This project was originally planned for the purpose of supporting follow-up audits. In the case of follow-up audit, the duration could be as short as two or three days, because the processes of the plant are already known and audit items are already decided. The current five-day schedule is sufficient.

However, the recent audit we made was substantially a new audit, though it was referred to as a follow-up audit. Actually, a half-day was spent on traveling from the hotel in the city to the plants in the locality, and a half-day on an observation tour for understanding processes and facilities of the plant. In addition, one full day was spent on preparatory works prior to audit, for example, a lecture on process principle and energy saving measures, an explanation of audit procedures including measurement task, and the organization of audit groups, etc. Another one day was spent on data collection, measurement, and fine observation of equipment and machineries. A half-day was spent on reporting the brief results of the audit to the plant management, and the following half-day was spent on traveling from the plants back to the city. The final day was dedicated to the seminar-workshop. The survey took up a total of five days, but only two days were devoted to actual audit activities on the audit site, excluding the preparatory works and reporting to the plant management.

In some of the ASEAN countries, important industries frequently locate their factories in the locality distant from the city. It therefore takes time to travel to a plant from the city. If the distance requires a day's travel, then it would be necessary to flexibly deal with the circumstance, for example by extending the audit schedule by one day. If two or more plants are to be visited, the additional time it would take to travel from one plant to the next must be considered.

In the case of plant audits in the ASEAN countries, it seems very difficult to obtain necessary information on processes, etc in advance. Even if preliminary assessment is attempted through the use of questionnaires distributed in advance, little information can be obtained from the plant, and much work must be done on-site, after all in most cases.

One of the objectives of this project was to transfer audit skills through on-the-job training (OJT). Therefore, minimum time was also allocated for training the members of audit team.

Based on the above, the present schedule of five days is sufficient enough in the case of a follow-up audit, but insufficient to a new audit of plants. We propose a longer schedule when implementing a new audit. The extension of audit duration should be considered when formulating the next year's activity plans for the project.

2) Strengthen the preliminary preparation

A preliminary questionnaire was sent to the plants prior to visiting this time around, but we failed to obtain sufficient responses. The currently-distributed questionnaire have been formulated for contemporary Japanese plants which usually possess a data management system, and as a result have contained so detailed questions. However, considerations should be given to creating a new questionnaire that contains the minimum necessary questions that match actual situations in the ASEAN countries.

Furthermore, the host plant should be informed of the detailed plans of the audit in advance. At the least, the schedule and audit items should be conveyed to the plant in an early stage and an approval should be taken from top management of the plant.

ACE and the focal points should bring forward the date for starting the preliminary preparation. Starting preparation two months ahead of audit survey is seemingly a bit late. A speedier response is expected from ACE.

3) Prepare measuring instruments

It is necessary to prepare at least a thermometer with thermocouple sensor, a gas analyzer, and an electric power monitor. ECCJ's instruments were old models and deteriorating, aging, or otherwise in an unusable state. Considerations should be given to leasing them from Sumikin Management Co., Ltd. and other companies.

Another enticing option is to borrow measuring instruments from ASEAN institutions such as PTM and ECCT. If handling engineers are accompanied with the package, they could provide guidance as audit instructors. This scenario would also be consistent with the objective of the PROMEEC project to promote guidance through engineers within the ASEAN region.

4. Attachments

(1) “Cement Process and Energy Saving”

(2) “Promotion of Energy Conservation Activities in Factories (Electricity)”

(3) “Report on Energy Audit of Lao Cement Co.”

(4) “ASEAN PROMEEC Seminar/Workshop Program”

1. “Overview of Plans & Programs on EE&C in Lao PDR”
2. “Initiatives and Programs of ECCJ on EE&C in Industry in Japan”
3. “Case Study 1 – Hydro Power Plant (Lao PDR)”
4. “Case Study 2 – Industries in Malaysia (Malaysia)”
5. “Case Study 3 – Oil Refinery (Myanmar)”
6. “Case Study 4 – Iron/Steel, Cement & Food (Philippines)”
7. “Results of Energy Audit of Two Cement Factories”
8. “Barriers and Measures to Implement EE&C in Industry”

III. Thailand (Steel Industry)

1. Activity Overview

In the phase 1 of PROMEEC activities in Thailand, an energy audit at sodium hydroxide plant was conducted two times on Nov. 24-28 of 2003 and Jan. 12-16 of 2004. In the phase 2, no follow-up survey of the phase 1 activities was carried out, but it was planned to give instruction in energy audit for other industrial field, i.e. for steel industry. The OJT of energy audit for steelworks was carried out at Bangkok Steel Industry Public Co., Ltd. (BSI) near the coast south-south-east of Bangkok, 30 to 40 minutes' car ride from the city center. On the site of BSI, energy audit activities were carried out for 3 and a half days; 7 officers from Thai Department of Alternative Energy Development and Efficiency (DEDE) and 8 staff members of BSI participated in the audit works.

In the seminar workshop, the result of audit survey was reported by the manager of BSI. The seminar workshop in Thailand was confined to the steel industry. Representatives from 3 member states of ASEAN also made a presentation on energy conservation activities in the steel industry in their respective countries.

1.1 Date

November 13 –17, 2006

1.2 Venue

Steelworks: Bangkok Steel Industry Public Co., Ltd. (BSI)
(Approx. 30km south-south-east of Bangkok)

Seminar Workshop: Twin Towers Hotel, Bangkok

1.3 Schedule

Nov. 13 (Mon)	Energy Audit at the Steelworks (BSI)
Nov. 14 (Tue)	Energy Audit at the Steelworks (BSI)
Nov. 15 (Wed)	Energy Audit at the Steelworks (BSI)
Nov. 16 (Thu)	Energy Audit at the Steelworks (BSI), Preparation for the Seminar Workshop
Nov. 17 (Fri)	Seminar Workshop

1.4 Participants

Thailand:

Department of Alternative Energy Development and Efficiency (DEDE), MOE

Dr. Prasert Sinsukprasert Senior Engineer

Mr. Sarat Prakobchart Senior Engineer

ASEAN Center for Energy (ACE):

Ms. Evangeline L. Moises Chief, Information & Event Division

Mr. Ivan Ismed Project Officer

Japan: ECCJ, International Engineering Department, Technical Engineer

Koukichi Takeda, Hideyuki Tanaka

About Thailand

(1) General Information about Thailand (Source: web site of the Japanese Ministry of Foreign Affairs (November 2006 data))

- Area: 514,000km^2 (approx1.4 times as large as Japan)
- Population: 62,420,000 (2005)
- Capital: Bangkok
- Ethnicity: Majority is Thai; other ethnic groups are: Chinese, Malay, and minorities living in the mountains.
- Language: Thai
- Religion: Buddhists (95%), Islam (4%)
- History: The kingdom of Thailand was established in the 13th century by the Sukhothai dynasty, which was succeeded by the Aytthaya dynasty (14th – 18th century), Thornburi dynasty (1767-1782) and the present Chakri dynasty 1782–). In 1932, Thailand became a constitutional monarchy by a revolution.
- Political System: Constitutional Monarchy
- Economy: Agriculture occupies 40% of the working population, but less than 10% of GDP (2004). On the other side, manufacturing industry occupies approx. 15%, but 35% of GDP (2004) and 85% of the export.
  GDP per capita: 2,722 Dollars (2004)
  Export: Export items: Computers, cars and their parts, ICs, natural rubber (2004)
  Partner: 1. USA 2. Japan 3. China 4. Singapore 5. Hongkong
  Import: Import items: Crude oil, machines and their parts, electrical appliances and their parts, chemical products (2004)
  Partner: 1. Japan 2. China 3. USA 4. Malaysia 5. UAE
- Economical overview:
  The rate of economic growth in 2003 was 6.9%, in 2004 it was 6.1%. In 2005, economic growth slowed down a little due to the Sumatra Offshore Earthquake and tsunami disaster, drought damage, and worldwide steep rise of petroleum prices, and the growth rate sank to 4.5%.

(2) Energy situation (Source: IEA 2004 Statistics (2006 Edition))

In Thailand a certain amount of fossil fuels are produced domestically. Production and Consumption of fossil fuels in 2004 were as follows:

Approx. 20 million tons of coal were produced, but approx. 7.5 million tons were inported. 60% of domestic demand were used for electric power generation, and 40% was consumed in the industry.

Domestic petroleum production occupied 20% of domestic consumption, and 80% of the demand were covered by import. Petroleum was refined domestically, and approx. 10 % of the products were exported. 60% of the domestic demand were consumed by the transportation sector, followed by households, industry and energy conversion sector.

Natural gas production covered more than 70% of the demand. More than 90% of natural gas were used for energy conversion, and the rest were mainly consumed in the industry. Natural gas was partially utilized for non-energetic purposes.

Biomass was consumed for energy conversion, in the industry and in the household.

Electricity was mostly provided domestically, and only a few percent were imported from adjacent countries. Electricity is mainly used by households and in the commerce, followed by the industry.

2. Energy Conservation Survey at the Steelworks of Bangkok Steel

Among numerous steelworks in Thailand, the steelworks of BSI producing reinforcing bar was selected as a site of OJT (on-the-job training).

2.1 Overview of the Steelworks of Bangkok Steel

The steelworks is located approx. 30km south-south-east of Bangkok, near the Thai Bay. After crossing many rivers, and passing a newly built cable-stayed bridge, we arrived at the steelworks of the Bangkok Steel company. Seeing some similar bridges under construction, we had an impression that the infrastructure was being built up rapidly in Thailand.

The Audit Team consisted of 7 officers of the Thai government (DEDE), 2 members of other ASEAN countries and 2 members of ECCJ, 11 persons altogether.

Since it had been planned to carry out activities only at the steelworks of BSI during our stay in Thailand, we could give an OJT in audit for three and a half days at the steelworks.

(1) Company Name: Bangkok Steel Industry Public Co., Ltd. (Founded in 1964)

(2) Location: 27 Poochaosamingprai Rd. Phrapradang, Samutprakarn 10130, Thailand

(3) Period: November 13 – 16, 2006

(4) Survey members (audit team 1/2):

Thai Government (DEDE, MOE):

Mr. Sarat Prakobchart	Senior Engineer
Mr. Somchat Tanglikhasit	
Mr. Vachira Jindaphet	
Mr. Chawalit Boonsang	
Mr. Amornsak Rangsakorn	
Mr. Pornchai Thernnoo	
Mr. Cheerawat Nuannuam	

ASEAN Center for Energy (ACE):

Ms. Evangeline L. Moises	Chief, Information & Event Division
Mr. Ivan Ismed	Project Officer

Japan: ECCJ, International Engineering Department, Technical Engineer

Koukichi Takeda, Hideyuki Tanaka

(5) Bangkok Steel engineers (audit team 2/2):

Mr. Chaitat Tanormsub	Personnel Department Manager

Mr. Viroon Kemphet	Steel Factory Manager
Mr. Somchai Khamphoo	Rolling Mill Production Manager
Mr. Taned Dejamornton	
Mr. Pongsthorn Rienthong	
Mr. Sumrong Boonchalee	
Mr. Pornthep Suwanmanee	
Mr. Taweechai Sornchui	
Mr. Jakaphol Nounkhain	
Mr. Anan Thaicharoen	

(6) Activity schedule at Bangkok Steel

Table III-2-1 shows the schedule of activities at BSI.

Table III-2-1 Schedule of activities at BSI

Date/Time	Activity	Person in charge	Remarks
Nov. 13 (Mon) 9:40am-5:20pm	1. Confirmation of the schedule 2. Introduction of the steelworks by BSI. 3. Explanation of mini-mill industry in Japan, audit procedure, and successful examples in electrical facilities by ECCJ. 4. First inspection of the steelworks	All members Mr. Chaitat, Mr. Somchai Mr. Tanaka, Mr. Takeda All members	
Nov. 14 (Tue) 9:30am -5:20pm	1. Discussion of measurements on site 2. Walk-through audit of furnace (temperature measurement etc.) 3. Discussion of preliminary questionnaire	All members	
Nov. 15 (Wed) 8:50am -5:20pm	1. Discussion of energy conservation measures 2. Explanation of analysis of heat radiation from furnace wall 3. Walk-through audit of electrical facilities	All members	
Nov. 16 (Thu) 8:50am -2:00pm	1. Discussion of energy conservation in compressors 2. Discussion of audit results	All members + Mr. Hin Navawongse (ISIT)	

2.2 Overview of the Facilities in the Steelworks

(1) Overview of the Steelworks

After explanation of the aims and schedule of the visit by the DEDE officers in the audit team, three managers of BSI briefed the facilities of the steelworks and the result of preliminary questionnaire, using a company brochure and a power point slide show. The outline of the company is as follows:

The company was established in 1964. At first, only rolling mills were operated, using purchased materials as a raw material. In 1973 electric furnace were introduced, and the production capacity for reinforcing bars was increased to 450,000 tons per year. At present, a portion of billets are purchased, and the capacity of rolling mills increases to 600,000 tons per year. In the premise of the steelworks there is a zinc plating plant and a crane manufacturing plant. The zinc plating plant and the crane manufacturing plant are not included in the object of the audit survey. In the week when we visited the steelworks, No.2 of the 2 rolling mills was not operated.

Product:	Concrete reinforcing steel bar
	Deform bar, Round bar: ϕ6–ϕ40
	Production Capacity: 500,000t/y
	Actual Production: 314,877t/y (2005)
	(Zinc-plated steel sheets: 130,000t/y (1983, 1992, 1997))
Equipment:	25-ton furnace×2 (furnace capacity : 300,000t/y), CC (continuous casting machine)×2
	Continuous heating-furnace×2, RM (continuous rolling mill)×2
	A part of raw materials are purchased from the domestic market.
Employee:	600
Plant operation:	Steel production: 3 shifts, Rolling: 4 shifts

(2) Concrete reinforcing bar manufacturing plant

1) Manufacturing process

Manufacturing process of concrete reinforcing bar is shown in Fig. III-2-1. Purchased ferrous scraps are melted in the electric furnace (EAF), and the molten steel is received by a ladle. The molten steel is then conveyed from the ladle through the tundish (T/D) to the continuous casting machine (CCM), and molded into billets there. The hot billets are cooled down, and then reheated in the reheating-furnace to nearly 1,200°C; then, the billets are hot-rolled into concrete reinforcing bars or round bars by the rolling mill. The products are cooled down, cut into prescribed sizes and shipped in bundles with required quantity.

In this process energy is consumed as follows:

Fuels: bunker oil grade C: For reheating-furnace and preheating of ladles

light oil (kerosene): Electrical furnace burner

LPG: Preheating of tundish

Electrical Power: Electrical furnace (melting scraps),

Receiving and distribution facilities,

CCM, RM, dust collector, motors for operating other appliances, lighting etc.

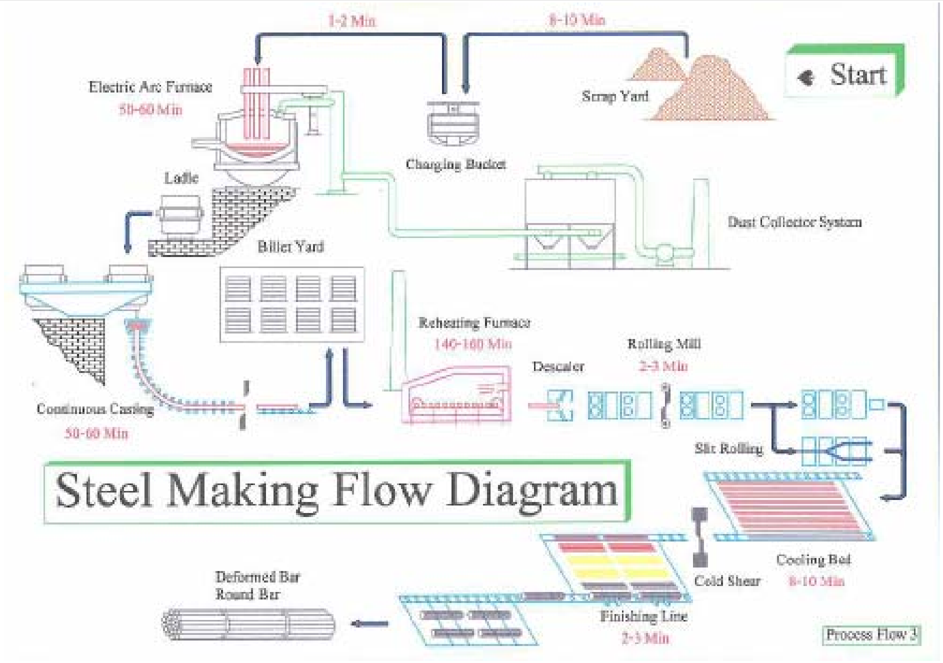


Fig. III-2-1 Concrete reinforcing bar manufacturing process

2) Main equipment

Electrical furnace: 25-ton a.c.furnace×2 (DEMAG (1973), SOE (1993)) gutter tapping type, equipped with oxygen and carbon blow-in pipe, and kerosene burner.

Continuous casting machine (CC): billet CC (3 strand)×2 (1973, 1993)

Billet sizes: □130-7m and 11m

Reheating furnace: Former furnace (1964, now out of use), Now there are 2 furnaces.

Furnace #1: 50t/h heating-furnace (1993, DANIELI, pusher-type)
Internal dimension: 7,600W×1,600H×20,000L (mm)
Heavy oil burner: 6 heating zones, 6 soaking zones,
Rated oil rate: 1,900L/h
Equipped with recuperator (when fuel oil rate is 1,400kg/h and air ratio m = 1.1, air preheating temperature is 300°C)
Combustion air fan: 20,000m3N/h×67kW motor
Furnace #2: 70t/h heating-furnace (1996, walking beam type)

Continuous rolling mills (RM): 2

RM #1	Continuous rolling mill (1993): 50t/h
RM#2	Continuous rolling mill (1996): 70t/h
Dust collector:	Integrated dust collector using bag filter, direct dust-drawing from electric furnace (2 furnaces) and dust-drawing from building (2 furnaces), 2 dust collectors are tied-in each other through ducts
Blowers:	(4,670m^3/min (60°C) – DC600kW)×2, (3,115m^3/min (60°C) – DC400kW)×2
Air compressor:	1 turbo compressor with vane-control type (IHI, 2003)

2.3 Walk-through Energy Audit at the Steelworks

(1) Energy consumption

Energy sources used in the steelworks are, as stated above, bunker oil grade C, light oil (kerosene), LPG and electricity. Changes in production of the concrete reinforcing steel bar and energy consumption are shown in Table III-2-2. Also energy unit prices are shown in Table III-2-3.

The table contains “oxygen”: Oxygen is used for burning light oil during the operation of an electric furnace, and is blown, together with carbon powder, into the furnace; oxygen contributes to scrap melting and to raising the molten steel temperature, and to reducing SEC for electricity. Oxygen should be treated as a part of energy sources, but as data for carbon powder consumption are lacking, oxygen will not be considered in the discussion below.

Energy unit prices increased in the last 2 years to 1.4 – 1.5 fold, and electricity increased to 1.2 fold as Table III-2-3 shows. Table III-2-4 shows energy consumption situation in the steelworks.

BSI intends to promote energy conservation particularly by reducing fuel consumption of heating-furnaces (bunker oil grade C). Obtained data also show that in 2005 only bunker oil grade C increased.

Table III -2-2 Production and SEC of Concrete Reinforcing Bar in the BSI Steelworks

FY			2003		2005	
Production of concrete reinforcing bars t/y			320,456	(100)	314,878	(98.3)
Sales volume Million Baht/y			4,000	(100)	5,500	(137)
Energy consumption			12,708	(100)	15,277	(120.2)
Bunker oil	kL/y	for steel				
Grade-C		heating-furnace, for				
(43,892kJ/kg,		preheating ladles	3,233	(100)	2,292	(70.9)
spec.grav.0.9554)			37,900	(100)	36,000	(95)
Diesel oil	kL/y	for EAF burners	8,251	(100)	8,212	(99.5)
LPG	kg	for preheating T/D	230,508	(100)	204,755	(88.8)
Oxygen	km^3/y	for EAF injection				
Electricity	MWh/y	for operating EAF and appliances				
Specific Energy Consump						
Bunker oil Grade-C		L/t	39.7	(100)	48.5	(122)
Diesel oil		L/t	10.1	(100)	7.3	(72)
LPG		kg/t	0.12	(100)	0.11	(92)
Electricity		kWh/t	719	(100)	650	(90)

Table III-2-3 Energy Unit Prices

Energy	Unit	2003		2005	
Bunker oil Grade-C	Baht/L	7.548	(100)	11.146	(148)
Diesel oil	Baht/L	12.288	(100)	17.814	(145)
LPG	Baht/kg	14.162	(100)	16.130	(114)
Oxygen	Baht/m^3	4.200	(100)	4.196	(100)
Electricity	Baht/kWh	2.194	(100)	2.658	(121)

Table III-2-4 Percentage of Energy Consumption Process by Process

Energy	Energy/Use		Ratio (%)		Fuel & Electricity Ratio (%)	
Fuel	Heavy oil	Furnace #1	35.4	100	51.2	100
		Furnace #2	27.5			
		CGL	4.2			
		Boiler (CGL Plant)	0.5			
		Others	10.1			
	Diesel oil	EAF1 & 2	22.0			
	LPG	Tundish	0.3			
	EAF		45.1			
	Motor (>20kW)		38.6			

Electricity	Cooling system	5.7	100	48.8	
	Air Compressor	2.8			
	Air Conditioning	1.7			
	Lighting	0.6			
	Others	5.5			

CGL: Continuous Galvanizing Line

(2) Energy conservation activities at BSI

At BSI, an Energy Saving Team was organized to promote energy conservation.

Energy conservation activities conducted by BSI itself in the past were described as follows:

1) Roof and wall materials (steel sheet) of the rolling mill plant were, partially and at regular intervals, replaced with semi-transparent plastic plates so as to take daylight into the building. (Reduction of lighting electricity = Δ178MWh/y)
2) Material of fan blade in the cooling tower fans were changed from aluminum to glass fiber-reinforced plastics. (Reduction of motor power supply = Δ35MWh/y)
3) Drying air nozzle for concrete reinforcing bar quenching and annealing (QTB) was equipped with a solenoid valve in order to open the nozzle only when it is used. (Reduction of air compressor motor power supply = Δ89MWh/y)
4) The opening at the entrance of the heating-furnace was reduced to approx. 50%. (Reduction of fuel oil = Δ7,632L/y)
5) De-scaling air nozzle mounted on the reinforcing bar binder was equipped with a solenoid valve in order to open the nozzle only when it is used. (Reduction of air compressor motor power supply = Δ60MWh/y)
6) The hydraulic chain transfer system was changed into an electromotor-driven type, and the system is operated only when it is needed. (Reduction of electricity = Δ192MWh/y)
7) Pinch rolls and roller conveyers for reinforcing bars were changed into pipe conveyers. (Reduction of electricity = Δ292MWh/y)
8) Dust collectors are added, and air compressors are renewed (Air compressors of vane-type are replaced with turbo-type)

These activities brought a cost reduction of 2,150,000 Baht (approx. 7 million Yen) per year.

(3) Explanation by the Audit Team

Representatives of ACE in the audit team gave a verbal explanation of the METI-ASEAN PROMEEC project. ECCJ explained the following 3 subjects using a power point slide show.

1) “Energy conservation activities conducted by mini-mill industry in Japan”

Parts of the seminar materials which are useful for the steelworks audit were explained briefly to the participants.

2) “Audit Procedure”

Procedure of steelworks audit and important check points concerning energy management and equipment observation were explained.

3) “Examples of audit of electric equipment in steelworks”

Examples contained in the seminar materials were explained.

(4) Walk-through energy audit of the steelworks and measurement results

Now that members of the audit team obtained the knowledge concerning the steelworks and the audit method, all members of the team inspected the site. As mentioned above, the steelworks consist of two production lines. We inspected only the #1 RM which was being operated, DEMAG electric furnace and CC, power supply system and dust collecting facilities. We carried out the on-site audit three times during the visit.

The situation of the steelworks was as follows:

As a result of the walk-through energy audit of the steelworks, we found out several matters for which energy conservation measures are necessary

(Thermal area)

1) The electric furnace is charged with scraps three times (50%, 36%, 14%), Tap-tap interval was 70 minutes, power consumption was 584kWh/t in average.
2) Tap-temperature of the electric furnace are often raised up to 1,700°C.
3) The bunker oil grade C is used for preheating the ladle. Exhaust gas is not utilized.
4) 25t ladle on the CCM stand has no lid.
5) The tundish has a cover, but the opening is too large. The cover seems not so effective.
6) Molten steel flows uncovered from the ladle to the tundish and then to the mold. This part should be covered by a sleeve.
7) There is no LF.
8) Billets are not cared for. No hot-charge is employed.
9) Retention temperature of furnace is 1,050°C

   Fuel oil consumption was 1,040L/3h, 810L for 3h20min, 2,980L for 14h40min.
10) The exhaust gas has not been measured. According to old data, it was 4%.
11) Scale loss of steel material in the furnace is 25kg/t.

   If scale composes Fe_2O_3, loss of iron would be 1.75%. In Japan, it is typically 0.7%. It should be reduced to 1%.

12) Preheated air temperature of the furnace is as low as 166.5°C.

(Electrical area)

1) Power factor (Pf) of the transformer station in the steelworks was 0.87.
2) In the rolling mill plant (#1RM), semitransparent plastic plates were placed in the roof and walls at the same distance to take in daylight. Therefore, ceiling lights were turned off in daytime except for local lighting.
3) Fan blades in the cooling tower were changed from aluminum into glass fiber. The life of these blades is 10 years, and the motor power can also be reduced.
4) 0.65 MPa is minimum required pressure of compressed air because of drying process for the GTB (hardening of products). There are 4 air compressors. Normally two or three compressors were operating. One was under maintenance. Actually, the discharge pressure of turbo compressor in operation was 0.48MPa.
5) A peak time in electricity charge is 6:30pm – 9:30pm
6) Installing receiver tank in the air compressor system. There was a question concerning sizing of receiver tank, which was answered later in the seminar.

As mentioned above, nearly 20 team members participated in the energy audit at the steelworks of BSI everyday. But the audit and discussion were mainly conducted by ECCJ.

(5) Walk-through energy audit of #1 heating-furnace : measurement result and improvement measures

Temperatures of the heating-furnace surface, temperature of exhaust gas and combustion air were measured, and compared with the data at the control panel in the operating room.
Data concerning combustion in the heating-furnace #1 is shown in Fig. III-2-2.

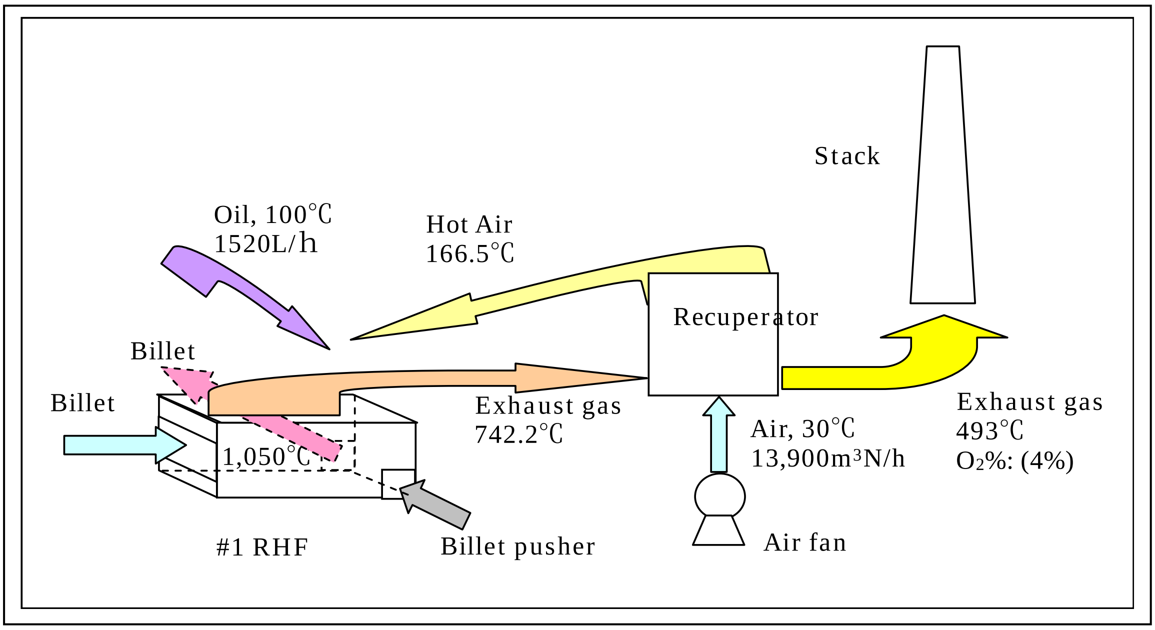


Fig. III-2-2 Data concerning combustion in the heating-furnace #1

1) Heating-furnace surface temperature

The surface temperature of the heating-furnace was, as Table III-2-5 shows, rather high. In the same table, the guideline of surface temperature for heating-furnace in Japan is indicated. Compared to these values, the heating-furnace has generally high surface temperatures. The bottom surface of the heating-furnace was inaccessible, and the temperature could not be measured.

Table III-2-5 Measured surface temperature of the heating-furnace (average)

Surface of the furnace	Top	Sides				Bottom (inaccessible)
		Front (inlet)	Side		Rear (outlet)	
			left	right		
Surface temperature	165°C	137°C	100°C	80°C	150°C	-
Guideline in Japan (inside the furnace 1,050°C)	110/ 100°C	95/ 90°C				120/ 110°C□

(Standard values in Japan: upper values are standard values, and lower values are target values.)

2) Opening of the heating-furnace

The furnace has 3 openings. The inlet opening for billet charging has a size of 7m×400mm. The space between side of billet and furnace wall is 400-500mm at one side, and the space between upper side of billet and upper side of inlet opening is 270mm (Billet-size: approx. 130mm x 130m x 6m). Billet was pushed by the pusher to the direction perpendicular to the furnace longitude, and conveyed to the rolling mill line. This pusher doors and the billet inlet are equipped with an elevating slide gate. The slide gate did not close tightly, and opened unnecessarily long time. It took 40 seconds, while 10 seconds would be sufficient. The size of the opening in the gate is approx. 0.5m (H) x 1m (W) by visual measurement. The vicinity of the opening was very hot and inaccessible. No dimension was not written on the drawing of furnace structure.

3) Calculation of heat radiation from the surface of heating-furnace #1

Condition for calculation: For 4 surfaces with temperature exceeding the target temperature of the Japanese guideline, the difference between the heat radiation at the present temperature and at the target temperature shall be calculated. The result of calculation is shown in Table III-2-6. According to the result, it is possible to reduce fuel consumption by approx.1.5%.

Table III-2-6 Calculation of heat radiation from the surface of heating-furnace #1

Location		Top	Front	Left	Right
Area, A(m^2)		9.01×21.5	9.01×2.2 (lower 0.5m is foundation)	21.5×2.7	9.01×2.7
Measured Temp. Ta(°C)		165	137	100	150
Target Temp. Tt(°C)		100	90	80	90
Ambient Temp. T0(°C)		30			
Calcu-lation formula	Natural convection	$Qn = [hc\times(Ta - T0)^{0.25}]\times(Ta - T0)\times A$ (W)			
	hc	3.26	2.56		
	Radiation	$Qe = 5.68\times\varepsilon\times\{[(273+Ta)/100]^4 - [(273+T0)/100]^4\}\times A$ (W)			
	Emissivity,ε	0.3 (Aluminum painted surface)			
Present heat radiation		Q1 = (Qn + Qe)= (362,889+120,965)W → 483.9kWh/h → 1,742MJ/h			
Heat radiation at target temp.		Q2 = (Qn + Qe)= (49,966+161,498)W → 211.5kWh/h → 761MJ/h			
Improvement		ΔQ = Q1 – Q2 = 981MJ/h Fuel oil saving = 981MJ/h /41.934MJ/L = 23.4L/h →Δ1.54%			

(Right side is 80°C and below the target value, hence no improvement is necessary. Left side should be improved to this value; No improvement is necessary for bottom side)

4) Combustion calculation for the heating-furnace #1

The combustion situation of the "bunker oil grade C" at 1,520L/h was to be studied. Based on the composition of "bunker oil grade C" obtained from BSI, and assuming the element composition as follows, the combustion situation was studied.

Fuel supply: 1,520L/h →1,452.2kg/h

Combustion air: 13,900m^3N/h

Composition of bunker oil grade C:

C:	86.22%
H:	11.51%
S:	1.87%
N:	0.30%
Others:	0.10%

Theor. combustion air : A0 = 10.80m^3N/kg-oil → 15,683.8m^3N/h

Theor. wet combustion gas: G0 = 11.442m^3N/kg-oil→ 16,616.1m^3N/h

Theor. dry combustion gas: G0'= 10.153m^3N/kg-oil→ 14,744,2m^3N/h

According to these data, air amount (13,900 m^3N/h) supplied through the combustion air fan (design capacity: 20,000m^3N/h) is less than theoretical combustion air (15,683.8m^3N/h). The air amount corresponding to the difference must enter through the openings of the furnace. In case that iron scale is formed at a rate of 25kg/t (*1), oxygen amount (or air amount) necessary for oxidation of iron will be as follows.

(*1: It can also be assumed that iron loss is occurring at a rate of 25kg/t. But this loss would be considerably higher than usual. So the scale amount was assumed, which is less than the iron loss).

Heating-furnace capacity: Capacity is 40t/h when bunker oil grade C is used at a rate of 1,520L/h
(Capacity is 50t/h when bunker oil grade C is used at a rate of 1,900L/h)

Composition of scale: Fe_2O_3 100% (Fe = 70%、O_2 = 30%)

Iron loss as scale: 700kg/h (= 25kg/t-Billet×0.7×40t/h)

Oxygen amount needed for iron oxidation: 210.6m^3N/h

Air = 1,002.9m^3N/h, nitrogen amount= 792.3m^3N/h

According to the information from BSI, the exhaust gas contains 4% oxygen. It is assumed that it contains 4% oxygen at present. Then, the corresponding surplus air will be as follows:

Surplus air corresponding to 4% oxygen: A1 = 3,655.6m^3N/h

[Calculating formula: A1×0.21/(14,744.2 + 792.3 +A1) = 0.04]

Total wet exhaust gas: 21,064.3m^3N/h (= 16,616.4m^3N/h + 792.3m^3N/h+ A1)

Total dry exhaust gas: 19,192.1m^3N/h (= 14,744.2m^3N/h + 792.3m^3N/h+ A1)

Hence, the air intruding from outside will be 6,442m^3N/h (= 15,683.8–13,900+1002.9 +3,655.6), and together with the air supplied by the blower it will amount to 20,342m^3N/h, i.e. the air intruding from outside occupies 31.7% of total quantity. (Gases from fire-proof constructions were ignored). In this situation, combustion management (air ratio management) cannot be done successfully. Measures such as narrowing the openings in the furnace body must be taken immediately.

5）Effect of reduction of air ratio

a. Actual air ratio

The oxygen concentration in the exhaust gas was not measured, but based on data in the past, it is assumed that oxygen concentration is 4% at the stack inlet. The actual air rate is, as mentioned above, 20,342m^3N/h. This air rate includes also the air used for oxidation of billets. Therefore, although oxygen concentration in the exhaust gas is 4%, the air ratio is not1.235 (= 21/(21-4)), but 1.3 (= 20,342/A0).

b. It is assumed that scale forming will be reduced to the half if surplus air is reduced to the half so that the air ratio becomes m = 1.15. In order to achieve this, openings in the furnace should be reduced as far as possible, combustion air supplied by the air blower should be increased so that the air rate becomes controllable.

Surplus air: 2,352.6m^3N/h (= A0×0.15)

Air needed for scale forming: 501.5m^3N/h (= 1,002.9m^3N/h1×0.5)

Nitrogen: 396.2m^3N/h (= 501.5m^3N/h×0.79)

Total wet exhaust gas: 18,863.4m^3N/h (= G0+2,352.6m^3N/h-501.5m^3N/h×0.21)

Total dry exhaust gas: 16,991.5m^3N/h (=G0'+ 2,352.6m^3N/h - 501.5m^3N/h×0.21)

Oxygen in exhaust gas: 2.29% (= [2,352.6-501.5]×0.21/16,991.5 (m^3N/h))

Therefore, the apparent air ratio will be 1.12 (= 21/(21-2.29)).

Fuel saving achieved from reducing the air ratio from the present value (m = 1.3) to m = 1.15 can be calculated as follows. Quantity of heat needed to heat decreased amount of exhaust gas will be saved as a result of reducing the air ratio. Besides, as a part of oxygen in the exhaust gas is used for forming scale, the exhaust gas will be reduced by improvement from the present value 20,853.7m^{3}N/h (= 21,064.3 - 210.6) to 18,758.1m^{3}N/h (= 18,863.4 – 105.3).

Condition of calculation:

Exhaust gas temperature: 742.2°C

Specific heat of exhaust gas: 1.381kJ/m^{3}N・K

Outside air temperature: 30°C

Heat of combustion of bunker oil grade C: 43,892kJ/kg

Reduction of bunker oil grade C: Ox = 66.1kg/h

Calculation of Ox:

{[(1,452.2-Ox)kg/h/1,452,2kg/h]×(20,853.7-18,758.1)m^{3}N/h
+ Oxkg/h/1,452,2kg/h×20,853.7)m^{3}N/h}×1.381kJ/m^{3}N・K×(742.2-30)°C
= 43,892kJ/kg×Oxkg/h

Reduction rate: 4.6% (= 66.1kg/h/1,452,2kg/h = 0.0455)

However, the scale formation exhausts a latent energy as heat of oxidation of iron. Considering heat of iron oxidation (=5.588MJ/kg-Fe), average specific heat of scale =0.9MJ/kg-scale・K) and average specific heat of iron (= 0.699 MJ/kg-Fe・K), and assuming steel material is heated to 1,050°C, then heat of approx. 1,746MJ/h will be required. This corresponds to approx. 40kg/h fuel oil. Accordingly, fuel oil of 26kg/h (= 27.2L/h) can be saved. Thus, reduction of approx.1.8% can be achieved.

6) Recuperator efficiency

As shown in Fig. III-2-2, the recuperator does not seem to be operating efficiently. For a furnace such as the heating-furnace #1 with exhaust gas temperature 742.2°C, at least 35% of waste heat is required to be recovered by the Japanese energy conservation law, in which recuperator outlet temperature of 460°C, and preheated air temperature of 310°C are targeted. This is the case when heavy oil is used, the outside air temperature is 20°C and air ratio is 1.2.

At BSI, as air infiltrates through the openings of the furnace body, not all combustion air passes the recuperator. Therefore, the fuel reduction is shown as follows:

a. Present situation:

Heat taken away by combustion exhaust gas:

Q = 20,717,754kJ/h (= 21,064.3m^{3}N/h × 1.381kJ/m^{3}N/h・K×(742.2-30)°C)

Heat brought in by preheated air:

P = 2,466,555kJ/h(= 13,900m^{3}N/h×1.3kJ/m^{3}N/h・K×(166.5-30)°C)

Calorific value of fuel: F = 63,739,962kJ/h (= 1,452,2kg/h×43,892kJ/kg)

Fuel reduction: $100 \times P/(F-Q+P) = 5.4\%$

Rate of waste heat recovery: 11.9% (= $100 \times P/Q$ = 2,466,555kJ/h/20,717,754kJ/h)

b. When air preheating temperature is 310°C (here, exhaust gas rate does not change):

Heat brought in by preheated air: P'= 5,059,600kJ/h

(= 13,900m^{3}N/h×1.3kJ/m^{3}N/h・K×(310-30)°C)

Fuel reduction: 100・P'/ (F-Q+P')= 10.5%

Rate of waste heat recovery: 24.4%

(= 100×P'/Q = 5,059,600kJ/h/20,717,754kJ/h)

Accordingly, the difference of fuel reduction between both cases will be 5.1%.

c. When air ratio is 1.15 (preheated to 310°C) (here, exhaust gas rate is reduced):

Heat brought in by preheated air:

P"= 6,747,832kJ/h (= 18,538m^{3}N/h×1.3kJ/m^{3}N/h・K×(310-30)°C)

Fuel reduction: 100・P"/ (F-Q+P")= 13.6%

Rate of waste heat recovery:

37% (= 6,747,832kJ/h /18,538m^{3}N/h×1.381kJ/m^{3}N・K×(742.2-30)°C)

By lowering the air ratio, exhaust gas rate is reduced. Thus further reduction of 3.1% can be achieved. If the air ratio is reduced from 1.3 to 1.15, and whole air infiltrating into the furnace is preheated, the fuel consumption will be reduced by 8.2%, 124.6L/h (= 1,520L/h ×0.082).

7) Air entering through the openings in the furnace

As already mentioned, the size of the openings are as follows: Opening in front of the furnace (billet inlet), approx. 2.0m^2, is always open; billet pusher side opening and billet outlet opening, approx. 0.5m^2 respectively open 50 times per hour, each time for 30 seconds. When measured, the opening time was 40 seconds, but here an average value of 30 seconds is used. This means openings of approx. 0.8m^2 are always open.) Thus, on the whole furnace, openings of 2.8m^2 are always open.

It was reported that the internal pressure of the furnace is kept in the level of several Pascals, but air infiltration may easily exceed 1m/sec. At 30°C, infiltration velocity is 0.71m/sec, which corresponds to 6,442m^{3}N/h. Furnace pressure should be kept +1 to 10 Pa (or water column 0.1–1.0mmH2O) at the elevation of material charge in order to prevent air infiltration from outside and gas blowing out from inside. Furnace pressure sensor is often located on the furnace ceiling. In this case, buoyancy of hot gas must be taken into consideration between the material charge and the ceiling. For the reheating-furnace, as shown in fig. III-2-3, the buoyancy is approximately 1mmH2O (=10Pa) per 1m of hot gas column at 1,100 – 1,200°C.

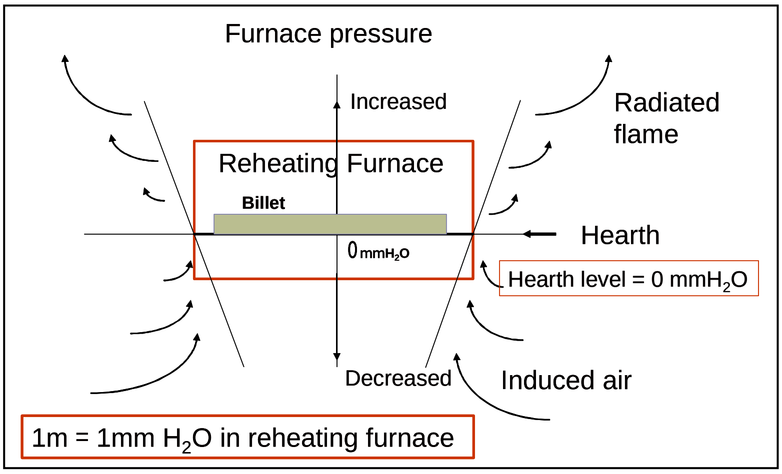


Fig. III-2-3 Relation between furnace pressure, air inflow and gas

Therefore, although the furnace pressure is positive at the ceiling, it is possible that the pressure becomes negative at the elevation of material charge, if the pressure is regulated too low, and air can infiltrate easily into inside.

Heat radiation occurs through the openings in the furnace body, but the material inlet is next to a preheating area with low temperature. The material outlet has a small opening area and large hot gas blowing out was not observed, and therefore heat radiation through there can be ignored.

8) How much fuel can be saved when "hot billets are charged into the furnace?"

For example, when billets are charged into the furnace on the condition of 100°C hotter than room temperature and at a rate of 40t/h:

Specific heat of normal steel (soft steel): 0.507kJ/kg・K (100–150°C)

Heat brought in by billets: 2,028,000kJ/h

(= 40,000kg/h×0.507kJ/kg・K×(130–30)°C)

Fuel saving (per 100°C): 46.2kg/h (= 2,028,000kJ/h/43,892kJ/kg)

Saving rate 3.2% (= 46.2kg/h×100/1,452.2kg/h)

The above saving is achieved per 100°C of the difference between the material charge and the room temperature, but in reality, specific heat increases slightly with temperature so that a little more fuel saving can be achieved. At present, billets are cooled down before charging into the furnace. It would be necessary to keep them hot in an insulated box, and to charge them into the furnace at a temperature as high as possible. Handling of the hot material charge can be made easier by utilizing lifting magnet that is heat-resistant up to 600°C.

9) Summary of energy saving measures for the heating-furnace #1

The measures mentioned above are summarized below.

Table III-2-7 Energy saving measures for the heating-furnace #1

Measures		Method, Condition	Fuel saving and %saving	
1.	Reduce heat radiation from furnace body (max.temp.: 165°C)	By improving thermal insulation of furnace body: Δ981MJ/h	Δ23.4L/h	Δ1.5%
2.	Reduce combustion air (air ratio at present: 1.3, scale forming: 25kg/t, air inflow from outside: 31%)	Reduce air ratio to 1.15 (scale forming could be reduced by 50%) Close openings in the furnace, change furnace pressure, and control combustion air rate	Δ27.2L/h	Δ1.8%
3.	Increase heat recovery rate of recuperator (return to the original specification value)	Raise the heating temperature to the equipment specification value (preheating air temperature: 300–310°C). Intensify recuperator maintenance and preheat whole air.	Air ratio remains unchanged: 1.3 Δ77.5L/h Air ratio reduced: 1.15 Δ124.6L/h	Δ5.1% Δ8.2%
4.	Make openings in the furnace body smaller, shorten opening time.	Reduce air infiltration and supply necessary air by blower speed control. Increase furnace pressure.	Heat radiation is reduced. Calculation was not made due to lack of information.	
5.	Charge hot billets	Use an insulation box with heat-resistant lifting magnet.	By raising temperature by 100°C: Δ48.3L/h	Δ3.2%

For the combustion management of heating-furnace it is important to reduce the air ratio, and in order to facilitate this, it is necessary to reduce uncontrollable infiltration of air. Recuperator should be able to operate according to the specification or near; for this purpose, equipment management should be improved as well as operation management. Thermal insulation of inside and outside of the furnace should be improved to avoid heat radiation. Billets should not be cooled down, but charged into the furnace at a temperature as high as possible. To realize this, thermal insulation box or cover and heat-resistant lifting magnet can be used.

The effects shown in Table III-2-7 were calculated separately, and some of them contain assumption; when all of these measures are realized, the result may not necessarily correspond to the sum of these effects.

(6) Electric furnace and continuous casting machine

1) Specific energy consumption of electric furnaces is very high

We obtained operation data of two 25-ton electric furnace on October 29, 2006.

According to the data, average values of 29 times of heating a day are as follows:

Scraps charge: 3 times, 13.1t＋10.2t＋3.4t = 26.7t

Tap-tap interval: 63.5 minutes

Yield: 84.5%

Oxygen consumption: $46.19m^3N/t$

Kerosene: 6.75L/t

Electricity: 584kWh/t (melting 431kWh/t＋refining 153kWh/t)

From the viewpoint of energy conservation, consumption of electricity seems to be considerably high. Oxygen, carbon powder (no data available) and kerosene are used in normal quantity, but low yield hints that considerable amount of iron was burnt or scraps are of bad quality. Steel tapping is conducted as gutter tapping. We suggest that the electric furnace operating speed should be increased, and an EBT (Eccentric Bottom Tapping) device, pretreatment (separation of impurities) of scraps to improve yield, and preheating of scraps should be adopted.

2) Heat radiation from the 25-ton ladle and the tundish

During charge of molten steel to the continuous casting machine, the 25-ton ladle is not covered by a lid. The tundish has a lid, but it covers only the half of the tundish so that heat radiation occurs. It would be necessary to cover the 25-ton ladle and the tundish properly. Here, we will make rough calculation of the saving effect by covering them.

a. For the 25-ton ladle:

Assuming that half of the molten steel remains in the ladle during charge of molten steel to the continuous casting machine, the heat radiated from the upper surface of the ladle can be calculated roughly in the following manner. Fig. III-2-4 shows a ladle with approximate dimensions. Only heat radiation from the molten steel surface in the middle and from the refractory material on the inner surface shall be considered as heat radiation surface.

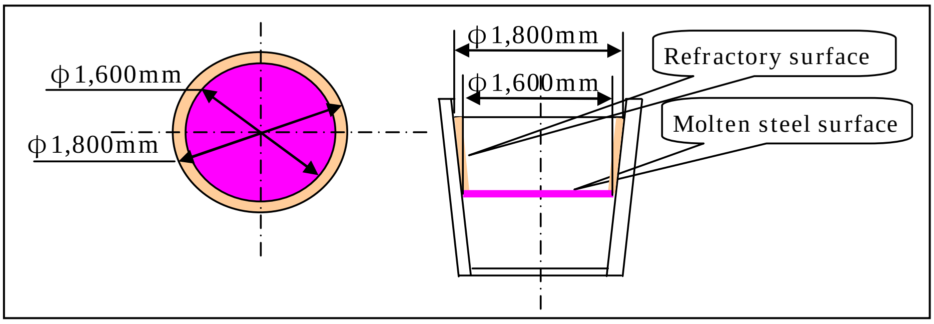


Fig. III-2-4 Heat radiation from the 25t-ladle

Calculation conditions

Molten steel surface: Temperature T = 1,650°C,emissivity: ε= 0.28, area: 2.0m^2

Refractory surface: Temperature T = 1,500°C, emissivity ε= 0.85, area: 0.54m^2

Outside air temperature: T0 = 30°C

Specific heat of molten steel: 0.867kJ/kg・K (molten steel temperature 1,600–1,650°C)

Duration of holding molten steel in the ladle:

32 minutes (= 25t/(3×0.13^{2}m^2×2m/min×7.85t/m^3)

(CCM has 3 strands, casting rate: 2m/min)

Equation of heat radiation : 5.68×ε×{[(T+273)/100]^4-[(T0+273)/100]^4} (W/m^2)

Heat radiation from molten steel surface: 435kW, 232kWh (32 min/process)

Heat radiation from refractory surface: 257kW, 137kWh (32min/process)

Total heat radiation: 369kWh = 1,328,000kJ

Molten steel temperature fall: 61°C (= 1,328,000kJ/(25,000kg×0.867kJ/kg・K))

If the ladle is covered with a lid, the lid will reduce the temperature fall to half so that molten steel temperature fall would be approximately 30°C.

b. For the tundish

At present, the tundish is equipped with a lid, but it covers only the half of the tundish. Heat radiation released from this area is calculated in the same manner as for the ladle.

Calculation conditions for the

Molten steel surface: Temperature T = 1,600°C,emissivity: ε= 0.28, area: approx. 1.0m^2 (Roughly half of the upper surface of tundish.)

Refractory surface: As molten steel level in the tundish is kept almost constant during the casting, radiation from the refractory surface can be ignored.)

Specific heat of molten steel:

0.867kJ/kg・K (Molten steel temperature 1,600–1,650°C)

Duration of holding molten steel in the tundish: 32 minutes

Calculation using the same formula as for the ladle results:

Heat radiation from molten steel surface: 157kW, 84kWh (32 minutes) = 350,333kJ

Molten steel temperature fall: 16°C (= 350,333kJ/(25,000kg×0.867kJ/kg・K))

If the tundish is covered with a lid, the lid will reduce the temperature fall to half so that molten steel temperature fall would be approximately 8°C.

According to the results shown above, the temperature fall would be 38°C. Thus, it would be possible to reduce the electric furnace tap temperature from the current 1,650–1,700°C by approximately 40°C.

This temperature reduction of 40°C results in savings of 867MJ (= 25t×40°C×0.867kJ/kg・K); converted into electric power, it corresponds to 240kWh, which is equivalent to 9.6kWh/t.

(7) Energy audit for the electricity area

The audit period was just 4 days, but thanks to eager assistance of the steelworks we achieved so excellent results that we can expect a good following-up by Thai staff.

1) Improving power factor

a. Power factor was as low as 0.76 at the primary transformer station of the works, and they said that the works was paying additional fee for low power factor. Additional fee is charged if power factor is below 0.85. We recommended to examine the possibility of introduction pf phase-lead capacitors for improving the power factor, including effective use of the existing capacitors equipped in EAF. Improvement of power factor may have electric energy saving effect due to reduction of line loss and transformer copper loss.

b. Electric furnaces are the main cause to lower power factor. We recommended in particular to examine measures for improving the power factor of EAF.

☆Calculation of energy saving effect by improving the power factor

・Given condition:

Electricity data of July 30, 2006 were used.

Average power: W＝28,335[kW]

Power factor: 0.76

Reactive power: $Q = W / \cos\theta \times \sqrt{(1-\cos\theta^2)} = 28{,}335/0.76\times0.65 = 24{,}234$ [kVar]

Fee for power factor: $T_R = 14.02 \mathrm{x} R$ [B/M] (data of the year 2004 were used)

R: (maximum 15-minute reactive power) – (corresponding maximum 15-minute power) x 61.97%.

・Fee for power factor: (rough calculation using annual average power)

Basis for determining additional fee for low power factor:

$$Q \geq 28{,}335\times0.6197 = 17{,}559 \text{[kVar]}$$

Before improvement of power factor:

$$T_{R1} = 14.02\times(24{,}234 - 28{,}335\times0.6197)\times12 = 1{,}123{,}002 \text{ [B/y]}$$

After improvement of power factor:

Case in which the power factor fee is added:

$$1 \geq Q/(W\times0.6197) = P\sin\theta/(P\cos\theta\times0.6197)$$

P: Apparent power

$$\therefore \quad \tan\theta \leq 0.6197$$

$$\theta \leq \tan^{-1}(0.6197) = 31.786[°] \quad \cos\theta \leq \cos 31.786° = 0.85$$

Accordingly, in the example of the year 2004, the power factor fee is not added if power factor is 0.85 and above.

・Effect by improving power factor to 0.85 and above:

Result of rough calculation under the above condition: approximately 3.4 million yen /year (assuming that 3 yen correspond to 1 baht). Therefore, if investment payback period needs to be 3 years or shorter, an investment of about 10 million yen can be realized. Here, we recommend that data be examined precisely taking a utilization of existing capacitors of EAF in consideration, in order to achieve further improvement of power factor. The above is a result of rough calculation using provisional data; actual data should be used for the study of power factor improvement.

Estimated dimensions of capacitors for improving power factor are shown in Table III-2-8.

Table III-2-8 Calculation of required capacity of capacitors for improving power factor

No.	Use	Present values (July 30,2006)			Required capacity of capacitors	
		Elt. Power W[kW]	Power factor cosθ	Reactive power Q[kVar]	Power factor 0.85 [kVar]	Power factor 0.95 [kVar]
BI6902	Power supply (main power)	28,335	0.76	24,234	6,671	14,918
BI 10	RM 2	409	0.64	491	238	357
BI 20	BI 21–BI 24 Distribution	1,501	0.73	1,405	475	912
BI 30	RM 1	2,288	0.69	2,400	982	1,648
BI 40	BI 41–BI 44 Distribution	4,169	0.72	4,018	1,435	2,648
BI 50	EAF(DEMAG)	9,801	0.87	5,554	-520	2,333
BI 60	EAF(SOE)	12,266	0.80	9,200	1,598	5,168

(Notes)・For example cases of present load situation shown in the above table, average values of July 30, 2006 were used.

・Calculation formula

Reactive power: $Q = W/\cos\theta \times \sqrt{(1-\cos\theta^2)}$

Capacitor for improving power factor from $\cos\theta_1$ to $\cos\theta_2$

$$\Delta Q = Q_1 - Q_2 = W \times (\tan\theta_1 - \tan\theta_2)$$
$$= W \times (\sqrt{(1-\cos\theta_1^2)}/\cos\theta_1 - \sqrt{(1-\cos\theta_2^2)}/\cos\theta_2)$$

2) Pump

The following pumps were being operated with discharge valve throttled. Electric energy saving may be realized by eliminating valve pressure loss.

Electric furnace: EAF(SOE) Inter Pump Return No.6 (IM(C) 110kW)

Continuous casting machine:

CCM cooling water pump: flow control valve is being throttled.

Rolling mill: Cooling water pump for RM2: pump No.2 (QTB-RM2)

Rolling mill: Cooling water pump for RM1: discharge valve was fully open.

Other plants: All pumps should be inspected concerning discharge valve throttling.

☆ Calculation of energy saving effect by inverter speed control

Fig. III-2-5 explains how to achieve electric energy saving by changing pump rotational speed with an inverter.

a. Determine (Qb, Hn, Lb) at the point C in case that discharge valve is fully opening.

Hn: total pump head excluding discharge valve pressure loss.

Lb: brake power

b. Calculate quantities (Qa, Ha, La) at point A in the current operation.

The curve OC is a parabolic curve that passes through the origin, and $H = Hn/Qb^2 \times Q^2$ or $H = Ha/Qa^2 \times Q^2$. Extend the curve OC using this formula, and find the intersection point A or C with the performance curve.

c. Calculate the pump rotation speed Nn when operating the pump at point C using the following formula:

$Nn = No \times \sqrt{(Hn/Ha)}$

d. Calculate the brake power when operating the pump at rotation speed Nn at point C using the following formula:

$Ln = La \times (Nn/No)^3$

e. Calculate electric energy saving obtained by converting throttling of discharge valve into reduction of revolution in current flow.

$\Delta kW = Lb/\eta pb - Ln/(\eta tc \times \eta mc) \times \eta pa/\eta pc$

η_{tc} : inverter efficiency

η_{mc} : motor efficiency when the inverter is operated at point C

η_{pa}, η_{pb}, η_{pc} : pump efficiency at points A , B and C.

Notably, electric energy saving decrease as net head HA increases.

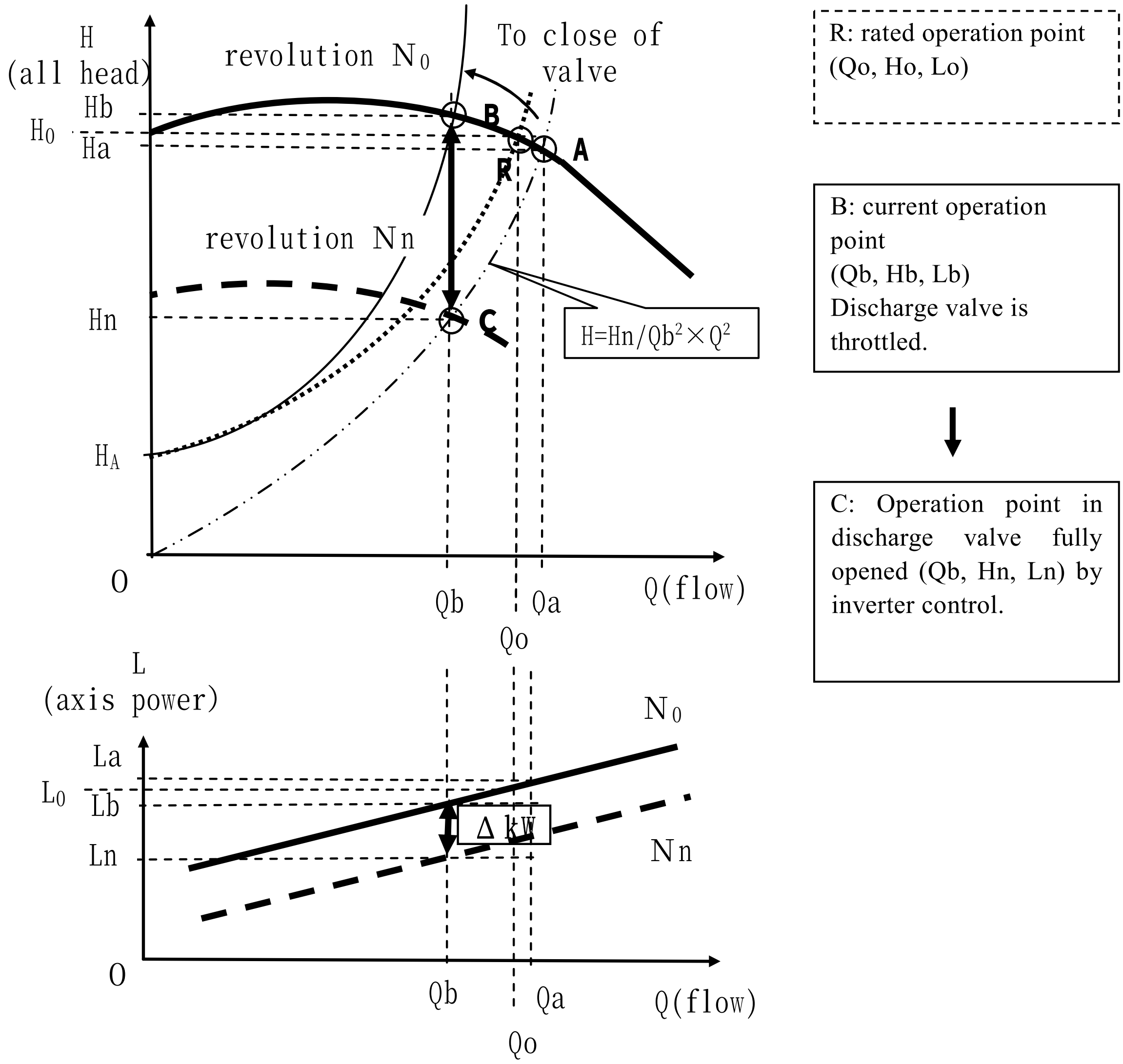


Fig. III-2-5 Electric energy saving by changing pump rotational speed

3) Fans and blowers

a. Rolling mill 1: The combustion air blower of heating-furnace (90kW) is damper-controlled. Here, electric energy saving could be achieved by applying inverter-control and thus eliminating loss by damper. However, for applying inverter it is necessary to investigate the applicability of variable speed control to the existing facilities taking due consideration of mechanical strength of the blower. The heating-furnace for the rolling mill 2 has not been examined.

b. For the main dust collector for the electric furnace, energy saving operation is conducted by variable speed control of d.c.-motors (600kW x 2, 400kW x 2). The gas cooler fans were not examined.

☆ Study of application of inverter to the combustion air blower of heating-furnace

The combustion air blower is operated in automatic mode, and it is not possible to fix a particular operating point. For this reason, the blower operation is divided into some cases concerning opening of the blower damper as shown in Table III-2-9, and for each case, input electric power, operating time and air flow rate are measured, or estimated from the performance curve.

Table III-2-9 Example of examination of the heating-furnace combustion blower

Operation case	Air flow[Nm^3/h]	Operating time[h/y]	Electric energy saving ΔkW[kW]
CASE-1	Q_1	T_1	ΔkW_1
CASE-2	Q_2	T_2	ΔkW_2
–	–	–	–
CASE-i	Q_i	T_i	ΔkW_i

Electric energy saving ΔkW is calculated by the following formula.

$\Delta kW = Lb/\eta pb - La \times (Nn/No)^3/(\eta tc \times \eta mc) \times \eta fa/\eta fb$

η_{tc} : Inverter efficiency,

η_{mc} : Motor efficiency when operating the inverter at point B

η_{pa}, η_{pb}, η_{pc} : pump efficiency at points A , B and C.

Accordingly, annual electric energy saving will be calculated as follows:

$\Delta kWh = \Delta kW1*T1+\Delta kW2*T2+ \cdot\cdot\cdot\cdot +\Delta kWi*Ti$ [kWh/y]

To be confirmed

Load/unload control is not applied to turbo compressors.

4) Air compressors

a. Normally operates the turbo type air compressor, which is controlled in load/unload mode. However, to achieve further energy saving, it is necessary to remove an inefficiency occurring during partial load operation. In order to do so, present operation should be analyzed concerning how long and how much partial load operation occurs through measuring air rate, operation period, etc. for at least one week.

b. Reduction of air consumption (reducing air leakage, applying high-performance air nozzle, applying air blower in place of air compressor, etc.) and reduction of operating pressure should be pursued continuously.

5) Improving automatic sequence in the rolling mills

a. Reducing heat loss by optimizing the open/close timing of heating-furnace door.

b. Reducing idling loss of the tables and rolling mills.

The tables and rolling mills operate at normal rotating speed also during the idling of rolling. We recommend that the tables and rolling mills be stopped or operated at a reduced speed during the idling in order to save electric energy.

3. Seminar-workshop

3.1 Overview

(1) Date/time

November 17, 2006 (Fri) 8:30am – 4:30pm

(2) Venue

Twin Towers Hotel, Bangkok, Thailand

(3) Summary of the seminar/workshop

70 participants attended the seminar-workshop. On the part of Thailand, the activities of ISIT (Iron and Steel Institute of Thailand) were presented, and the Steelworks of BSI reported the results of the factory audit. On the part of ASEAN, representatives from Malaysia, Indonesia and Philippines reported example cases of energy conservation activities in their respective countries.

ECCJ presented energy conservation activities with regards to measures for furnace facilities and electric equipment in the electric furnace industry in Japan. This seminar in Thailand was concentrated on the steel industry; it was the first attempt focused onto one single industrial sector. In this respect it was different from previous seminars in which information exchange among representatives from various industrial sectors had taken place.

(4) Participants

Thai-side members:

Mr. Tammayot Srichuai	Director, DEDE, MOE
Ms. Amaraporn Achavangkool	Senior Scientist, Technical and Efficiency Promotion Division, (DEDE), MOE
Dr. Prasert Sinsukprasert	Senior Engineer (DEDE), MOE
Mr. Sarat Prakobchart	Senior Engineer (DEDE), MOE
Mr. Hin Navawongse	ISIT
Mr. Somchai Khamphoo	Rolling Mill Production Manager

and many other participants.

ASEAN Center for Energy (ACE):

Ms. Evangeline Moises	Chief, Information & Event Division
Mr. Ivan Ismed	Industrial Project Officer, PROMEEC

Malaysia:

Mr. Ghazali Talib	Principal Engineer, PTM, Malaysia

Indonesia:

Mr. Zulham Lubis	PT, Krakatau Steel, Indonesia

The Philippines:

Mr. Loreto C. Carasi	Dept. of Science and Technology, Philippines

Japan: ECCJ, International Engineering Department, Technical Expert

Kokichi Takeda, Hideyuki Tanaka

Thai general participants

From the iron and steel sector in Thailand, approximately 40 persons participated in the seminar.

3.2 Results of the seminar-workshop

Altogether 70 persons participated in the seminar/workshop. The seminar/workshop were proceeded with Dr. Prasert Sinsukprasert in the chair. Handouts at the seminar/workshop are shown in 4. Attachments.

(1) Opening ceremony (Congratulatory speech and opening address)

1) ACE

As SOME meeting was drawing near, Dr. Weerawat of ACE was absent, and Ms. Evangeline read his message on behalf of him. After brief introduction of ACE and PROMEEC, projects being conducted by ACE were introduced.

2) ECCJ

Mr. Tanaka, a technical expert, made a speech on behalf of Japanese side (METI and ECCJ). He talked about the aims and circumstances of this project, recent situation, and Japan’s cooperation and contributions to ASEAN. He also thanked the participants for their help regarding the visit of the steelworks.

3) Representative of Thai ISIT

Mr. Hin explained that energy consumption in the iron and steel sector is very high, and that it is important to make efforts for energy saving. He said that many persons dealing with electric furnace and rolling mill were participating in this seminar.

4) Representative of Thai DEDE

Mr. Tammayot Srichuai greeted the participants. Then he told as follows: "60% of petroleum are imported. Electricity is expensive, and 36% of the electricity supply are consumed in the industry. The iron and steel sector is consuming the electricity most, but there is still a large potential for energy saving in this sector. Petroleum consumption should be reduced by EE&C activities, energy saving campaign etc. Thailand aims at becoming the center of EE&C activities of ASEAN." He thanked ACE, ECCJ, ISIT for their assistance, and BSI for accepting audit activities.

(2) Session 1: EE&C in the iron and steel sector

1) Overview of Steel Industry in Thailand (Mr. Hin Navawongse, ISIT)

He outlined the steel industry in Thailand using a handout which is attached to this document. Demand of iron and steel in Thailand decreased in 1998 to the half of the demand in previous year; in 2005 it increased to nearly 14 million tons. But the demand began to decrease again, and in 2006 the demand presumably decreases 15% below the previous year's level. Billets, slabs, hot-rolled and plated steel sheet are imported.

In the handout, SEC for each product is shown. Recently, SEC are gradually worsening. With regards to products, concrete reinforcing bars consumed energy most; approximately 1/5 of total energy consumption was used for this product.

2) Overview and EE&C of Steel Industry in Japan (Mr. Tanaka, technical expert, ECCJ)

He outlined recent situation of energy conservation activities and technologies in mini-mill steelworks in Japan.

(3) Session 2: Presentation of EE&C cases in the iron and steel sector

1) Case Study 1 (Mr. Ghazali Talib, PTM, Malaysia)

At first, the representative of Malaysia briefly described the cases studied in the MIEEIP (The Malaysia Industrial Energy Efficiency Improvement Project). Regarding the iron and steel sector, energy conservation activities at the steelworks producing annually 700,000 tons of concrete reinforcing bars and wires were reported. Six million RM are expended monthly for electricity. Recuperators for heating-furnaces had low efficiency due to sulfur depositing so that one more stage was added to the existing stage, changing it into a two-stage type of recuperator. Air compressor was changed from piston-type into screw-type. Water supply pump in the hardening process was changed into VSD-type, and electric energy saving of 25% were achieved. Then, he told that equipment for separating iron-rich materials from iron scraps was introduced. This equipment would be able to reduce cost by 4.4 million RM.

2) Case Study 2 (Mr. Zulham Lubis, PT, Krakatau Steel, Indonesia)

Krakatau Steel is producing reduced molten iron and rolled products in the electric furnace. Annual production is 2 million tons of steel products. In this steelworks, 30% of energy source is N-gas which is mainly used for producing reduced molten iron, 60% is electricity which is used mainly for EAF, and 10% is petroleum which is used for rolling mills. Energy cost accounts for 22% out of the total cost for producing crude steel.

Regarding as energy saving, the following measures are being taken:

utilizing waste heat of the ladle exhaust gas to preheat slabs,

hot-charging of slabs (530°C),

shortening the transfer time of billets,

use of thermal insulating covers,

adoption of EAF-electrode lift control,

adding oxygen to melting furnace.

Thanks to the above measures, approximately 9.4 million dollars could be saved annually.

3) Case Study 3 (Mr. Loreto C. Carasi, DOST, the Philippines)

Mr. Loreto reported energy conservation activities in 2 steelworks producing concrete reinforcing bars and a zinc plating plant respectively.

In the steelworks producing concrete reinforcing bars, the following measures were taken: reducing air ratio in heating-furnaces,

furnace internal pressure control,

avoiding infiltration of outside air through openings,

repair and replacement of recuperators,

reducing heat radiation from furnace body,

intensifying the maintenance of burners,

intensifying the monitoring,

replacement or modification of pumps,

avoiding compressed air leakage,

utilizing daylight etc.

Further, energy saving groups are organized. In the zinc plating plant, besides system improvements, small but many energy conservation measures, similar to ones taken in the concrete reinforcing bars plant, were carried out.

(4) Session 3: EE&C cases on electric equipment (Mr. Takeda, technical specialist, ECCJ)

He presented three cases of energy saving measures for electric equipment in the steel industry.

(5) Session 4: Report on the audit results of BSI steelworks (Mr. Somchai Khamphoo, BSI)

BSI reported the results of energy audit. After the brief explanation on the company outline, the situation of energy usage was explained. Concrete reinforcing bars are manufactured using electric furnaces and rolling mills. On the contrary to Japan, fuel is consumed more than electricity. Fuel is consumed in two heating-furnaces, whereas 50% of electricity is consumed in the electric furnace. Therefore, BSI thinks that reduction of fuel in the heating-furnace is urgent. So far, 9 improvement measures including use of daylight, improvement of the cooling tower, and replacement of air compressor, have been implemented ,which gave birth to cost savings of about 210 million Baht per year.

As a result of the audit survey, improvement measures such as improving heating-furnace, preventing air compressor leakage, measures against excessive capacity of EAF cooling pump, utilization of exhaust gas from the ladle, covering ladle of CCM and tundish, hot-charging of billets were proposed.

Responding to the reporting, ECCJ showed Japanese standards for air ratio of the heating-furnace, rate of waste heat recovery, and surface temperature of the furnace wall. ECCJ gave information about heat radiation from the furnace walls, compressed air leakage, and calculation method for the receiver tank of compressed air.

(6) Session 5: The Way Forward

1) Technical Directory (Mr. Ivan Ismed, ACE)

Purpose of TD, how to prepare it, format of TD etc, were explained and some examples were shown for better understanding. Mr. Ivan gave further explanations using examples of TD sheet. His explanation that already 50 cases in major industry, and 33 cases in buildings can be seen on the homepage of ACE drew great attention of participants.

2) Database/benchmark/guideline for major Industries (Mr. Ivan Ismed, ACE)

Purpose and importance of DB and future plan for DB were explained.

(7) Questions and answers, and comments

At the end of each presentation there was time for questions and answers. Participants made many questions. The most important questions will be shown below:

Q: How much electric power is consumed by the electric furnace? - Data in BSI were shown in a previous section.

Q: How much oxygen is used? - Operation data concerning oxygen will be obtained from BSI afterwards.

Q: How many shaft furnaces are existing in Japan? How much dioxine emitted from these shaft furnaces?

A: Exhaust gas is cooled down in the shaft furnace. Subsequently the exhaust gas is burned. It is said that almost all dioxine is removed by dust collector (bag filter). Numerical data have not been published.

Q: Oxygen concentration in the exhaust gas in the heating-furnace is 6%. Is it too much? Scale formation is 2% on total material iron. Oxygen of 6% means that air ratio is 1.4 . It is too high, considering that the Japanese standard is 1.2.

(8) Closing address

Dr. Prasert Sinsukprasert gave a closing address, and the seminar in Thailand finished with a great success.

4. Attachments

(1) “ASEAN PROMEEC Seminar/Workshop Program”

1 “Overview of Steel Industry in Thailand”

2 “Overview and EE&C of Steel Industry in Japan”

3 “Energy Efficiency and Conservation for Industries; Case Studies of EE Improvement in Steel Industries”

4 “Energy Efficiency and Conservation Best Practices at PT. Krakatau Steel-Indonesia”

5 “Energy Conservation for the Philippine Steel and Iron Industries: Case Studies”

6 “Promotion of Energy Conservation Activities in Factories (Electricity)”

7 “BANGKOK STEEL INDUSTRY PUBLIC CO., LTD”

8 “Comments for EE&C in Iron & Steel Factory”

9 “Development of a Technical Directory for Major Industries and Buildings for ASEAN Member Countries”

10 “ENERGY EFFICIENCY AND CONSERVATION (PROMEEC) – INDUSTRIES/ BUILDINGS”

IV. Myanmar (cement and oil refining industries)

1. Activities Overview

Phase 1 of PROMEEC activities in Myanmar began with the implementation of an energy audit at the Mann petroleum refinery (December 16-21, 2001). The first step of phase 2 (December 8-15, 2004) consisted of a follow-up survey at the Mann refinery and an energy audit at the Thanlyin oil refinery followed by a seminar. The second step in phase 2 started this year with a follow-up survey of the Thanlyin refinery and a new audit survey of the Kyankhin Cement Plant (KCP).

1.1 Date

November 19-24, 2006

1.2 Venue

Cement plant (new audit survey):	Myanmar Ceramic Industries, Kyankhin Cement Plant (located approx. 250 km north-northwest of Yangon, near the western bank of the Irrawaddy river)
Oil refinery (follow-up survey):	Myanmar Petrochemical Enterprise, No.1 Refinery Thanlyin (located approx. 20 km south-east of Yangon)
Seminar-workshop:	Sedona Hotel in Yangon

1.3 Schedule

Nov. 19 (Sun.):	Travel (from Yangon to Kyankhin) and discussions regarding energy audit works
Nov. 20 (Mon.):	Cement factory energy audit (KCP)
Nov. 21 (Tue.):	Cement factory energy audit (KCP)
Nov. 22 (Wed.):	Travel (from Kyankhin to Yangon)
Nov. 23 (Thu.):	Follow-up survey (No. 1 refinery, Thanlyin)
Nov. 24 (Fri.):	Seminar-workshop

1.4 Participants

Myanmar

Ministry of Energy (MOE)

Mr. U Aye Kyaw	Director
Mr. U Mg Mg Ohn	Thaw Chief Officer

Ministry of Industry No.2 (Heavy Industry Division, MOI-2)

Mr. U Ohn Myint Director

Mr. U Thaung Nyunt Assistant Director

ASEAN Center for Energy (ACE):

Mr. Ivan Ismed Project Officer

Mr. Junianto M Manager of Computer Center & IT

Malaysia:

Mr. Nor Hisham bin Sabran: Energy Expert, PTM Malaysia

Japan:

Technical Experts, International Engineering Department of ECCJ

Fumio Ogawa, Koukichi Takeda, Hideyuki Tanaka

About Myanmar

(1) General situation in Myanmar (Source: Web site of the Japanese Ministry of Foreign Affairs (July, 2006 data))

- Size: 680,000 km^2 (approx. 1.8x the area of Japan)
- Population: 52.17 million (Government of Myanmar, Statistical Year Book 2002)
- Capital: Naypyidaw (Pyinmana) (approx. 300 km north of Rangoon (Yangon), not formally announced. Former capital is Yangon.) Relocation to be essentially completed by March 2006.
- Ethnicity: Burman (approx. 70%) and numerous other ethnic groups
- Language: Myanmar (said to resemble Japanese grammatically.)
- Religions: Buddhism (90%), Christianity, Islam, etc.
- Brief history: After several centuries of occupation by a number of groups, the Burmans established the First Burmese Empire in the later half of the 11th century (Pagan dynasty, 1044-1287). This was succeeded by the Taugoo and Konbaung dynasties, which lasted until 1886 when it was annexed to the British Colony of India. Myanmar became an independent republic on January 4, 1948.
- Government: Military regime (provisional government)
- Economics: Principal industry: Agriculture
  GDP per capita: US$107 (estimate for 2005)

(2) Energy situation (from IEA 2004 Statistics (2006 Edition))

There is a certain amount of fossil fuel production in Myanmar. Production and consumption for 2004 are discussed below.

Myanmar mined roughly 1 million tons of coal (bituminous coal and lignite), exporting around 80% of that amount. Of the rest, 80% is used by industry and the other 20% goes to household use.

All of Myanmar's refined oil is used domestically, with 77% going to the transport sector, 12% to household use and 11% used by industry. Petroleum production was roughly 1 million tons in 2004 but is said to have fallen to around two-thirds of that amount in 2006.

Myanmar also produced around 320 PJ (10^{15} J) of natural gas, of which roughly 80% was exported. The natural gas is used for power generation and as fuel by the industrial sector. In Myanmar, natural gas is seen as the key to reducing energy consumption. Myanmar also generates around 6,400 GWh of electricity, with 47% used by the public and household sector and 30% by industry, with 23% going to transmission loss, etc.

2. Energy Audit Survey of the Myanmar Ceramic Cement Plant

Myanmar has 3 government-run cement companies and a number of privately-owned companies. The cement industry is a major industry in Myanmar, consuming large amounts of natural gas and electricity. Daily production from all companies is 9,000 tons (equivalent to roughly 3.2 to 3.3 million tons annually), but domestic demand is around 15,000 tons per day, therefore an increase of production is strongly demanded under the circumstances of import restrictions. In the audit survey, KCP, one of the government-run enterprises, was selected as the PROMEEC target plant.

2.1 Overview of the Myanmar Ceramic Cement Plant

The factory is located near the western bank of the Irrawaddy river, 250 km north-northwest of Yangon. Travel from Yangon was on the east bank of the Irrawaddy by car, but due to the lack of bridges across the river, the route involved traveling north up the river to the nearest bridge and then south back down the river. The survey team consisted of government officials and representatives of the Thayet cement plant (TCP – located approx. 200 km south-east of Yangon) together with participants of ASEAN and ECCJ, 13 people in total. Arriving in the evening of the first day, we had a meeting for having an overview of the factory, affirming the aims of the visit and formulating an overall plan.

On the second day, we took a look over the entire plant, starting with the limestone quarry. As discussed below, we made our observations from the viewpoint of reducing thermal and electrical energy consumption. In consultation with Myanmar Ceramic, we chose the equipment around No. 3 rotary kiln as a target of audit survey, and in the evening conducted on-site measurements. On the third day, we continued measurement work to collect some additionally required data on the same site. In the afternoon, we analyzed the collected data, provided guidance for calculation and made suggestions as to the materials to be presented by the plant engineer at the seminar-workshop of the 24th day. In the audit survey, 17 Myanmar participants worked in concert with the ASEAN and ECCJ, making a group of 23 in total, and successfully obtained the expected results.

(Summary of the visit)

(1) Name of Company: Myanmar Ceramic Industries, KCP, (MOI-1)

(2) Plant location: Approximately 4 miles west of Kyankhin City

(3) Dates: Nov. 19, 2006: Travel from Yangon, meeting

Nov. 20-21: Audit and discussions

Nov. 22: Travel to Yangon

(4) Visiting survey members: Audit team (1/2)

From Myanmar:

MOE:

U Aye Kyaw, Director Energy Planning Department (Myanmar FP)

U Mg Mg Ohn Thaw Chief Officer, Energy Planning Department

MOI-2:

U Ohn Myint Director

U Thaung Nyunt Assistant Director, Ministry on Industry No.2

Major Aye Shwe Chief Engineer, Myanmar Economic Corporation (MEC)

U Saw Lwin Assistant Chief Engineer, Cement Plant (Myaingalay), MEC

U Min Aung Deputy General Manager (Production), TCP

U Win Myint Thein Assistant General Manager (Planning), TCP

U Khin Mg Cho Assistant General Manager (Planning), Kyaukse Cement Plant

ASEAN countries:

Mr. Nor Hisham Bin Sabran Energy Expert, PTM (Malaysia)

ACE:

Mr. Ivan Ismed Project Officer

Mr. Junianto M Manager of Computer Center & IT

Japan:

Technical Experets, International Engineering Department of ECCJ

Fumio Ogawa, Koukichi Takeda, Hideyuki Tanaka

(5) Myanmar Ceramic: Audit team (2/2)

Mr. U Saw Fernando	Deputy General Manager (Planning)
Mr. U Aung Soe Naing	Assistant General Manager (Planning)
Mr. U Myint New	Assistant General Manager
Ms. Daw Khin Khin Win	Assistant General Manager (QC)
Mr. U Aung Baw	Manager (Rotary Kiln Department)
Mr. U Thein myint	Manager (Electrical Department)

Mr. U Win Naing Assistant manager (Planning)

2.2 Overview of Cement Manufacturing Plant

(1) Plant overview

Product: Ordinary (Portland) cement

Production volume: 330,000 t/y (April 2005 to March 2006)

Facilities: Respectively in 1975 and in 1985, two wet-process rotary kilns manufactured by Kawasaki Heavy Industries were installed. The capacity of each kiln is 400 tons per day.

No. of employees: Total number unknown; cement plant workers consist of 3 teams with 18 workers in each team.

Shift system: 12-hour 2 shifts; 24-hour continuous operation

(2) Cement manufacturing processes and equipment

1) Manufacturing processes

The limestone quarry is roughly 10 km from the cement plant. The limestone is crushed into pieces 150 mm or less in size and mixed with locally mined laterite, clay and sand before being shipped to the cement plant by rail. The mixture is milled and mixed with water before being fed as a slurry into the cement kiln. Since the plant start-up, the kiln has been fuelled by natural gas. The clinker produced is powdered together with gypsum in a cement mill to form cement. It is then bagged for shipping. The processing sequence is as follows:

Limestone quarry → Shipped by truck → 1st stage crusher → Belt conveyor transportation (BC) → 2nd stage crusher → Shipped by rail → Silo → Raw materials blending → Raw material mill → Silo → slurry formation → Wet-process rotary kiln → Clinker cooling → Cement mill → Silo → Packing → Shipment by truck, etc.

2) Major equipment

The first half of equipment was constructed and brought on service in fiscal 1975, and the remaining half in fiscal 1985. Like Japan, the Myanmar financial year runs from April to March.

Limestone crushing equipment

1st stage crusher: wo crushers (to 150 mm or less), each with a capacity of 300 t/h (actual capacity: 240 t/h)

2nd stage crusher: two crushers (to 25 mm or less) each with a capacity of 150 t/h;

(actual capacity: 120 t/h)

Raw material milling equipment

Raw material mill: wet-type mill: tube mill (2,500 mm (D) x 12.5 m (L))
drive motor: 800 kW (mill rotation: approx. 20 rpm)
capacity: dry-base: 35 t/h (actual capacity: 32.5 t/h)
electricity SEC: Av. 20.1 kWh/t-material (FY2004, FY2005)
No. of machines: 4
A mixture of limestone, laterite, clay and silica sand is milled.

Slurry: pump motors: 3 (30, 55 and 75 kW)

Clinker burning equipment

Burning equipment: kiln type: wet-process rotary kiln, 6 supports
kiln motor: 120 kW, 1.2 to 0.4 rpm
size: inside dia.: 3,300 mm x 125 m (L); refractory thickness: 180 mm
capacity: 16.7 t/h (400 t-cl/d) (Actual capacity: 320 t/d)
No. of kilns: 4
fuel: natural gas: 1,430 to 3,500 m^3N/h
calorific value: 948 Btu/SCF
distribution air: 36 m^3N/min.
combustion air: 120 m^3/min., 40°C, 1,200 mmAq
fan motor: 45 kW

ID fan: 2,350 m^3/min., 180°C, 250 mmAq; motor: 170 kW
dust removal: multi-cyclone

Clinker cooling equipment

Cooling equipment: horizontal-grate air cooling
external dimensions: 2.5 x 3.3 x 13.6 m (W x H x L)
(effective size: 1.68 x 12.0 m (W x L); grate area: 20.2 m^2)

Cooling air fan: air rate: 1,100 m^3/min., 45°C, 230 mmAq; motor: 75 kW

Exhaust air fan: air flow: 930 m^3/min., 180°C, 150 mmAq; motor: 45 kW

Annual capacity with each unit running for 300 days is 480,000 tons. However, because one unit is permanently idle due to a lack of fuel (natural gas), annual production capacity is currently 363,800 tons.

Cement (finish) mill

Finish mill: mill type: closed-circuit side-drive type
size: 2,750 mm (dia.) x 8.219 m (L)

drive motor: 800 kW (mill rotation: 19 rpm)
capacity: 22.5 t/h (actual capacity: 20 t/h)
No. of mills: 4
actual crushed material: clinker: 18.48 t/h
gypsum: 1.18 t/h

Mill fan: air flow: 39,000 m^3/h., 45°C, 300 mmAq; motor: 55 kW

Bag filter fan: air flow: 36,000 m^3/h, 90°C

Cement silo

No. and capacity: 12 silos, 31,000 tons

Bagging equipment (packers)

Capacity: 50 t/h each (actual capacity: 35 t/h)
No. of packers: 4
Shipping methods: Truck, freight train, ship

(3) Energy usage and consumption

The kinds of energy sources used in the cement plant are natural gas, diesel fuel and electricity. Natural gas is used only in the cement kilns, while diesel is used for vehicles. Electricity is used for lighting and for other equipment, including electric locomotives. KCP is particularly interested in reducing its energy consumption in terms of reducing its use of natural gas. Table IV-2-1 shows the annual change in cement production and energy consumption.

Table IV-2-1 Cement production and energy consumption

Year	2004	2005	2006
Clinker production (t/y) (ratio)	284,815 (100)	294,882 (103.5)	
Cement production (t/y) (ratio)	323,712 (100)	354,170 (109.4)	
Energy consumption			
Natural gas (in kilns) (MCF/y) (948 Btu/SCF = 37,333 kJ/m^3N, based on Kawasaki Heavy Industries specifications.)	2,058.29 (100)	2,144.79 (109.4)	
Electricity (MWh/y)	34,352.5 (100)	36,625.0 (106.6)	
Energy consumption			
Natural gas (kcal/kg-clinker)	1,726.34 (100)	1,737.7 (100.7)	
Electricity:			
Raw material crushing	21.63	18.57	21.47
(KWh/t-mat.)	23.67	23.23	24.58
Clinker burning (KWh/t-mat.)	33.18	39.89	40.56
Clinker milling (KWh/t-mat.)	2.12	2.77	2.43
Packaging (KWh/t-mat.)	104.49 (100)	105.01(100.5)	115.04 (110.1)
Plant overall (KWh/t-mat.)			

Natural gas calorific value: 948 Btu/SCF = 8,436.4 kcal/m^3 = 35,321.5 kJ/m^3

(If CF is taken as SCF, (273.15 + (60-32) x 5/9)/273.15 = 1.05695, which gives a calorific value for natural gas of 35,321.5 x 1.05695 = 37,333 kJ/m^3N.)

2.3 Walk-through Energy Audit at the Cement Plant

This plant was constructed in 2 phases, by Kawasaki Heavy Industries, Ltd as a contractor and a number of other Japanese companies as a sub-contractor. The operation of the first-phase began in 1975 and the second phase commenced in 1985. Due to a lack of natural gas, only 3 of 4 production lines are currently operating. KCP is particularly interested in reducing its energy consumption in fuel (natural gas). KCP also expressed a wish to hear suggestions as to where electrical power can be saved. So, we inspected the facilities with these points in mind. The raw materials are transported from nearby limestone and laterite quarries. The plant produces Portland cement and has an annual production capacity 480,000 tons, though production currently stands at 360,000 tons per year. The cement is produced using wet process rotary kilns in which limestone, laterite, clay and sand are milled, then blended before being fed into rotary kilns, where the mixture is burned to form clinker.

(1) Walk-through energy audit

1) We went to the limestone quarry and inspected the 1st-stage crusher. This crusher crushes limestone ores, which are unloaded from dump trucks, into pieces 150 mm or smaller. Its power consumption drops from 25-30 A during crushing to 13 A when idle. We confirmed that energy management practices were observed. In fact, the 1st-stage crusher and conveyor belt were stopped manually during breaks of 1 hour or more, such as during the lunch break. The dust-collector was operated with 50% opening of the damper, which indicates an opportunity of energy saving of fan power.

2) Electric room in the cement plant

Table IV-2-2 Recent data of power consumption

Month & Year	Electricity Consumption	Remarks
May 2006	2,376,300 kWh	Power factor = 0.9
June 2006	3,151,000 kWh	
July 2006	2,886,700 kWh	
August 2006	2,830,200 kWh	
September 2006	2,630,200 kWh	
October 2006	2,790,800 kWh	

3) Emergency generator: Diesel generators (2 sets)

4) Raw material mill

After milling, the mixture is converted to a slurry and fed into slurry tanks. The water content of the slurry was set at 43%.

5) Cement mills

4 cement mills were located in the same yard as the raw material mills.

6) Kilns

Of 4 kilns, only Nos 1, 2 and 3 were running. Our impression was that the area around the kilns was quite hot. The fuel used is natural gas, which is supplied at a pressure of 3.5 kg/cm^2. The supply was controlled using a flow control valve, and the combustion air was regulated using dampers, which were fixed at roughly 50% open during normal operation.

We have no data for the oxygen concentrations in the exhaust gases as no measurements were taken. The available data we have is one at the start of operations, and we were told that the oxygen data was 1.5% at that time, while the location of the measurement was not known. Because large amounts of CO_2 are emitted from the limestone in the kilns, this data is indicative that the real oxygen content in the combustion exhaust gas is higher than 1.5%.

7) Clinker cooler

The damper on cooling air duct were 20% opened. Part of this air is vented by the exhaust fan, and the rest goes into the kiln.

(2) Description of energy-saving technology in the cement plant

Prior to measurement work, we used the PPT presentation from ECCJ to explain actual energy-saving activities in Japan's cement industry and the audit procedure for electrical equipment. Currently, the wet-process kiln disappeared. Some 90% of kilns are NSP (New Suspension Pre-heater) kilns, and the remaining 10% are SP (Suspension Pre-heater) kilns. The average fuel consumption (the equivalent in coal) is 105 kg (2,725.6 MJ/t-cement) and the electricity consumption is 99 kWh/t-cement. The fuel consumption of the wet-process kilns was 1,357 kcal/kg-clinker in the past of Japan (5,681 MJ/kg-clinker). Mr. Takeda explained about energy saving measures for the fans and blowers, including the calculation of estimated savings in electric power if inverters were installed. Following this explanation, target equipment for energy audit were selected, and measurement and information to be collected were decided.

(3) Measurement works

In order to take a heat balance and identify an energy saving opportunity, the surface temperatures were measured on the kilns and clinker coolers. We were particularly concerned about the damage of the internal refractory which may cause kiln's external surface abnormally high. As for electrical equipment, the fans and blowers around the kiln were inspected. In order to evaluate the actual efficiency, air intake rates and electricity consumption were measured and compared with the specifications. The necessary instruments were provided by several sources; radiation thermometers by ECCJ, infrared thermometers by the Myanmar DOE, contact thermometers/anemometers/clamp-on power meters by Malaysia's PTM.

2 days were spent on 2 times of temperature measurements around the kiln. Then, using these data and the information which were provided by KCP, the heat balance of the kiln were calculated. Some part of calculation was carried out by KCP engineers. The result was presented in the seminar by themselves. The infrared radiation thermometers supplied Mr. Aye Kyaw of the Myanmar focal point were particularly helpful for temperature measurements. These were digital models donated by UNIDO and were both quickly responding and accurate. The radiation thermometer supplied by the ECCJ had some bias to show a little higher ,and moreover was unable to follow the rotating kiln.

On the next day, we reviewed the measurement data taken on the previous day, and then started the measurement concerning. The power monitor and velocity meters brought by Malaysia were proven very helpful. As a target equipment, the fans were selected with relatively narrow-throttled damper (20% or 50% opening), because more energy saving were expected in these fans. The fan performance curves were promptly prepared for studying the energy saving potential. The factory engineers were so cooperative as to prepare the necessary data. In addition, luckily enough, the equipment was constructed by Japanese companies and almost all documents were orderly maintained.

(4) Measurement results

Figure IV-2-1 shows a typical profile of temperature inside the wet-process rotary kiln. The internal temperature reaches a maximum of between 1,400°C and 1,450°C. As a consequence, the temperature goes high around the kiln, which results in considerable amount of heat radiation to the surrounding.

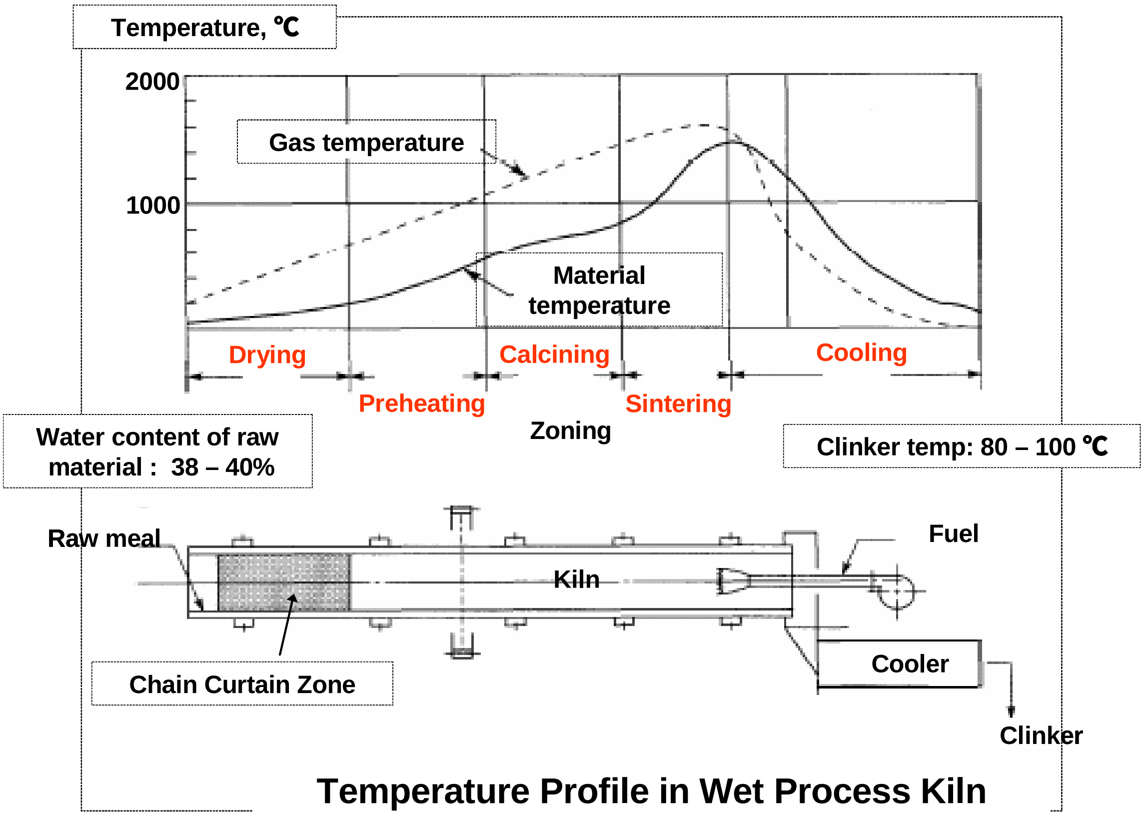


Figure IV-2-1 Typical temperature profile inside a wet-process rotary kiln

The result of temperature measurement of the surfaces around the kiln are shown in tables IV-2-3, IV-2-4 and IV-2-5. These data were used for heat balance calculation.

Table IV-2-3 Temperature measurement of the surfaces around the kiln

Length from the inlet (m)	0 31.5 56.5 81.5 120 125				
Interval (m)	31.5	25	25	38.5	5
Kiln dia (m)	3.36	3.36	3.36	3.36	3.36
Zone	Drying	Preheating	Calcining	Sintering	Cooling
Kiln surface temp. (°C)	60-68	155-192	248-250	234-333	336-360
Ave. kiln surface temp. (°C)	63	175	249	300	348

Table IV-2-4 Temperature measurement of the clinker cooler surface

Cooler surface	Front face (Kiln side)	Side face		Rear face	Top face	Bottom face
		Kiln side	Rear side			
Dimension (m)	2.5 x 3.3	5 x 3.3	8.6 x 3.3	2.5 x 3.3	2.5 x 13.6	2.5 x 13.6

Measured temp. (°C)	118	86-98	50-74	73	42	(35)
Ave. surface temp. (°C)	118	94	65	73	Top surface is covered with dust and bottom is the same temp. as room	

Table IV-2-5 Temperature measurements of the hood surface between kiln and cooler

Hood position	Front vertical face (Kiln side)	Side face (Cylindrical)	Rear vertical face
Dimension (m)	φ6.5/φ3.36 (Opening)	φ6.5 x 2.5L	φ6.5
Measured temp. (°C)	62	44, 46, 52, 57	62
Ave. surface temp. (°C)	62	50	62

(5) Calculation of heat balance and interpretation of the result

1) Heat balance calculation for the wet-process rotary kiln

a. Premises

Ambient temperature: 35°C

Fuel data: Natural gas: 2,500 m^3N/h

Calorific value: 40,914.5 kJ/m^3N (KCP data 1,039Btu/SCF)

Combustion air: 60 m^3/min, 42°C, 5.88 kPa → 55.1 m^3N/min,

specific heat: 1.306 $kJ/m^3N \cdot K$

Slurry: 37.9 t/h, 35ºC, water content: 43% (271.6 kg-H_2O/min)

Clinker: 13.5 t/h, 70ºC,

specific heat: 0.192 kcal/(kg-cl • ºC) = 0.804 kJ/(kg-cl • K)

fuel SEC: 570 kcal/kg-cl = 2,386.5 kJ/kg-cl

heat of sintering: -100 kcal/kg-cl = -418.7 kJ/kg-cl

CO_2 gas emissions: 0.27 m^3N/kg-cl

Clinker cooling air: 669 m^3/min, 47ºC, 2.45 kPa → 585 m^3N/min

Cooler vent air: 730 m^3/min, 135ºC, 1.47 kPa → 496 m^3N/min

Kiln exhaust gas: fan: 1,140 m^3/min, 120ºC, 2.45 kPa → 812 m^3N/min

Note that exhaust gas temperature at the kiln outlet is 130°C and it cools by 10°C in the duct.

Exhaust gas specific heat: 0.388 $kcal/m^3N°C$ = 1.624 $kJ/m^3N \cdot K$

Heat radiation from equipment surfaces (kiln, etc.):

The formulae below are used to calculate the heat loss due to radiation and natural convection. The kiln is assumed to be a horizontal cylinder.

Radiation (Qr): 5.68 x ε x A x $\{((t1+273)/100)^4 - ((t0+273)/100)^4\}$ 3.6/1000 (MJ/h)

Here, ε: (radiation factor) is 0.8.

A: Area of radiating surface (m^2)

t1: Temperature of the hot surface (°C)

t0: Outside air temperature (°C)

Natural convection (Qc): k x (t1-t0) x A x 3.6/1000 (MJ/h)

Here, k: Heat transfer coefficient

For a flat surface, k for upper horizontal surface = 3.26 x $(t1\text{-}t0)^{0.25}$

k for vertical surface = 2.56 x $(t1\text{-}t0)^{0.25}$

k for lower horizontal surface = 1.74 x $(t1\text{-}t0)^{0.25}$

For a horizontal cylinder, k = 2.44 x $\{(t1\text{-}t0)/d\}^{0.25}$

d: outer diameter of the cylinder (m)

b: Heat balance calculation

• Heat input

Heat of combustion of natural gas:

Qi1 = 2,500 m^3N/h x 40,914.5 kJ/m^3N = 102286250 kJ/h = 102,286 MJ/h

Sensible heat of combustion air:

Qi2 = 55.1 m^3N/min x 1.3kJ/(m^3N • K) x (42 - 35)ºC x 60 min/h

= 30,085 kJ/h = 30 MJ/h

Sensible heat of slurry:

Qi3 = 0 (No heat input since the temperature is 35°C.)

Sensible heat of clinker cooling air:

Qi4 = 585 m^3N/min x 1.3 kJ/(m^3N • K) x (47 - 35)ºC x 60 min/h

= 547,560 kJ/h = 548 MJ/h

• Heat output

Heat of clinkering:

Qo1 = 13,500 kg-cl/h x (2,386.5 - 418.7) kJ/kg-cl

= 26,565,300 kJ/h = 26,565 MJ/h

Sensible heat of clinker (cooler outlet):

Qo2 = 13,500 kg-cl/h x 0.804kJ/(kg-cl • K) x (70 - 35)ºC

= 379,980 kJ/h = 380 MJ/h

Sensible heat of cooler vent air:

Qo3 = 496 m^3N/min x 1.306kJ/(m^3N • K) x (135 - 35)ºC x 60 min/h

= 3,886,656 kJ/h = 3,887 MJ/h

Heat of evaporation of water contained in slurry:

$Qo4 = 37{,}900$ kg/h x 0.43 x [(100–35)ºC x 4,1868 kJ/(kg• K) + 539 x 4,1868 kJ/kg] = 41,212,297 kJ/h = 41,212 MJ/h

Sensible heat of kiln exhaust gas:

$Qo5 = 812$ m^3N/min x 1.624 kJ/(m^3N • K) x (130 - 35)ºC x 60 min/h = 7,516,522 kJ/h = 7,517 MJ/h

Heat radiation from kiln

Dividing the kiln into 5 sections and applying the formulae on the previous page yielded the following results:

$Qo6 = 17{,}780$ MJ/h

Heat radiation from clinker cooler:

Dividing the clinker cooler into several sections by temperature range and applying the formulae yielded the following results:

$Qo7 = 226$ MJ/h

Heat radiation from the hood between kiln and clinker cooler:

Dividing the kiln-to-clinker cooler hood into several sections by temperature range and applying the formulae yielded the following results:

$Qo8 = 76$ MJ/h

The above data were summarized in Table IV-2-6.

Table IV-2-6 Heat balance table for KCP No. 3 wet-process cement kiln

Heat Input (MJ/h)		Heat Output (MJ/h)	
1. Heat of combustion of fuel	102,286	1. Heat of clinkering	26,565
2. Sensible heat of fuel	0	2. Sensible heat of clinker	380
3. Sensible heat of combustion air	30	3. Sensible heat of cooler vent air	3,887
4. Sensible heat of slurry	0	4. Heat of evaporation of water in slurry	41,212
5. Sensible heat of clinker cooling air	548	5. Sensible heat of kiln exhaust gas	7,517
		6. Heat radiation from kiln	17,780
		7. Heat radiation from kiln hood	76
		8. Heat radiation from clinker cooler	226
		9. Unaccountable heat losses	5,221
	102,864		102,864

2) Refractory degradation of the wet-process rotary kiln

Considering the high surface temperature of the wet-process rotary kiln, we were concerned about the condition of the refractory inside the kiln. Figure IV-2-2 shows the arrangement of refractory in the kiln section where high surface temperature was observed. Table IV-2-7 is properties of the refractory materials.

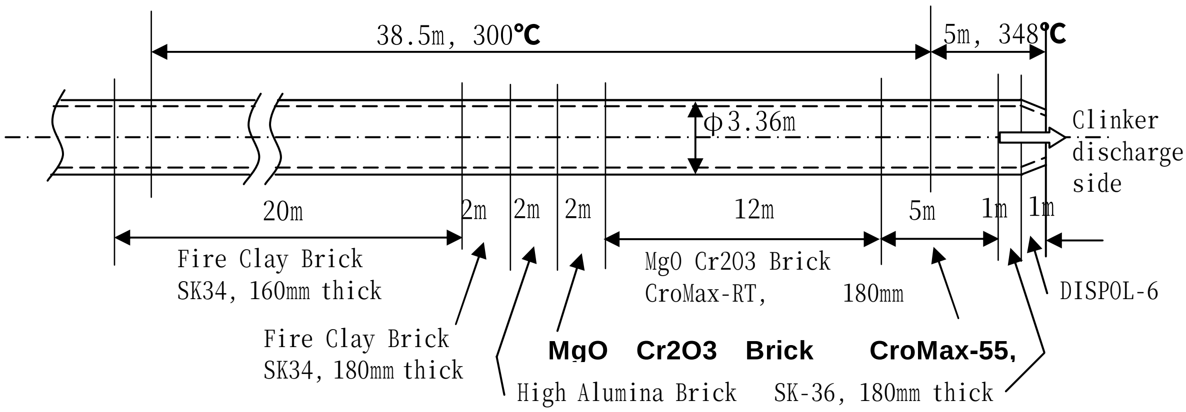


Figure IV-2-2 Refractory arrangement in the kiln section

Table IV-2-7 Properties of the refractory materials

Name	Thermal Conductivity		Refractoriness °C (load kg/cm^2)	Chemical Composition (%)		
	350°C kcal/mh°C	350°C W/mhK		SiO_2	Al_2O_3	Fe_2O_3
SK-34	0.9	1.047	1,370<	60>	38<	2.0>
Sk-36	1.15	1.337	1,480<	48>	51<	2.0>
CM-55	1.71	1.989	1,600<	Cr_2O_3 17>	MgO 55<	9.0>
CM-RT	2.10	2.442	1,630<	Cr_2O_3 11>	MgO 70<	6.0>
DP-6	1.20	1.396	1,500<	45>	54<	2.0>

The high temperature (300°C to 350°C) was observed on the kiln surface, which indicated that the refractory was likely to be degraded. Consequently, we made a trial calculation on the thermal situation around the refractory at 6 m distant from the clinker outlet.

a. Premises

Internal kiln temperature: 1,400°C (= ti)

Surface temperature of kiln's steel casing (= t3, measured at 300°C)

Ambient temperature: 35ºC (= t0)

Heat radiation from kiln surface: a summation of heat transfer of radiation and natural convection.

Radiation: Qr: $5.68 \times \varepsilon \times A \times \{((t3+273)/100)^4 - ((t0+273)/100)^4\}$ (W)

Here, ε (emissivity) is 0.8.

A: area of radiating surface (m^2)

t3: surface temperature of kiln steel casing (°C)

Natural convection: $Qc = k \times (t3-t0) \times A \times 3.6/1000$ (W)

Here, k: heat transfer coefficient: $2.44 \times \{(t3-t0)/d\}^{0.25}$

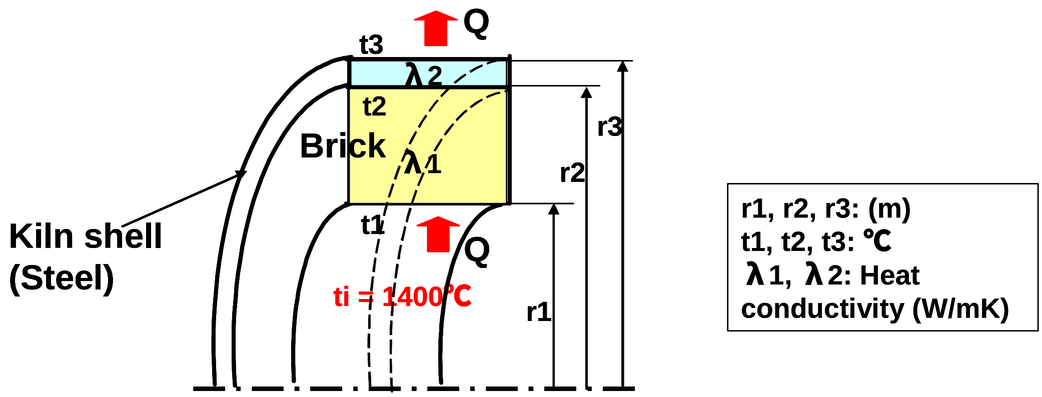
d: outer diameter of kiln (= 3.36 m)

b. Results

Once heat transfer rate is decided as the above, we can calculate the kiln surface temperature (t3) or the refractory temperature (t1) respectively by using the kiln refractory heat transfer calculation shown in the below (Figure IV-2-3). Then the calculated t3 is compared with the measured value of 300°C, giving the following results:

- If refractory temperature inside the kiln is 1,400°C, t3 = 378°C
- If surface temperature of kiln steel casing is 300°C, t1 = 927°C

This is the results for a refractory thickness of 180 mm. Generally if the refractory erodes, casing surface temperature rises high, while if clinker deposits on the refractory, kiln surface temperature drops low. Accordingly, great care should be taken in the progress of refractory degradation if surface temperature is high. Heat radiation from kiln steel casing increases when surface temperature is high. Regular measurement of surface temperature is recommended.



The heat conduction in a cylindrical walls expressed by the following formula, and the heat values through the respective layers are equal.

$$Q = \frac{2\pi\,(t1 - t3)}{\frac{1}{\lambda 1} LN\left(\frac{r2}{r1}\right) + \frac{1}{\lambda 2} LN\left(\frac{r3}{r2}\right)}$$

Figure IV-2-3 Heat transfer calculation for kiln refractory

3) Exhaust gas rate from kiln section

While the fuel used in natural gas, there was no detailed information on natural gas at the cement plant. So we used (discussed later) to attempt to calculate the air ratio and oxygen content in the kiln.

a. Preconditions

Natural gas (fuel) : based on the same data used in the audit of Thanlyin refinery

Amount used: 2,500 m^3N/h = 41.67 m^3N/min

Components (mole %): CH_4: 95.0%, C_2H_6: 4.0%, C_3H_8: 0.7%, iC_4H_{10}: 0.3%

Calorific power: 1,039 Btu/SCF

b: Calculation of the theoretical amount of combustion air

The theoretical amount of combustion air is 227 m^3N/min when natural gas is burned at 41.667 m^3N/min as shown in Table IV-2-8.

Table IV-2-8 Theoretical amount of combustion air(mole, m^3N)

Gas component		Oxygen	CO_2	H_2O, Steam
CH_4	0.95 mole	0.95 mole	0.95 mole	1.90 mole
C_2H_6	0.04 mole	0.14 mole	0.08 mole	0.12 mole
C_3H_8	0.007 mole	0.035 mole	0.021 mole	0.028 mole
iC_4H_{10}	0.003 mole	0.0195 mole	0.012 mole	0.015 mole
Total	1.0 mole	1.1445 mole	1.063 mole	2.063 mole
N-Gas: 1.0 mole		1.1445 mole x 22.4m^3N = 25.6368 m^3N Air = 25.6368 m^3N/0.21 = 122.08 m^3N	23.811 m^3N	46.211 m^3N
41.667 m^3N/min/22.4 m^3N = 1.860 mole/min		Air = 1.860 mole/min x 122.08 m^3N = 227 m^3N/min = A0	44.288 m^3N/min	85.953 m^3N/min

The air entering the kiln is as follows (see kiln heat balance calculation):

From the combustion air blower 55.1 m^3N/min

From the clinker cooler air blower 585 m^3N/min

Vent air from the clinker cooler -496 m^3N/min

Total = (55.1 + 585 - 496) m^3N/min = 144.1 m^3N/min

These results show that the amount of air supplied to the kiln is insufficient by approximately 83 m^3N/min (= 144.1 - 227 m^3N/min) or more. It seems that around 100 m^3N/min of air is infiltrating somewhere, or that there are some kinds of error in the airflow rate, for example, measurement errors.

c. Calculation of kiln exhaust gas rate

The exhaust gas rate at the theoretical combustion are as follows, based on the kiln heat balance calculation and Table IV-2-8:

Nitrogen in the combustion air: A0 x 0.79 = 179.3 m^3N/min

CO_2 produced in combustion: 44.288 m^3N/min

H_2O produced in combustion: 85.953 m^3N/min

CO_2 released during calcination:

0.27 m^3N/kg-cl x 13,500/60 kg-cl/min= 60.75 m^3N/min

H_20 evaporated from the slurry:

271.6 kg-H_2O/min/18kg-H_2O x 22.4 m^3N= 338 m^3N/min

Total = 708.3 m^3N/min

The amount of exhaust gas discharged by the kiln exhaust gas fan is 812 m^3N/min, indicating that 103.7 m^3N/min of air is leaking from somewhere into the kiln exhaust gas. This value is equivalent to an air ratio of 1.46. Presumably, this air is being drawn in somewhere between the kiln outlet and the fan. Possible sources of air leakage are sleeves on the seals at each end of the kiln and the inspection holes below the kiln burner, as well as the air drawn in through the clinker exit. But the seals on slurry inlet were in very good condition. It is possible that air is infiltrating from the periphery of the clinker cooler, but we could see no evidence of leakage that would make a noise.

d. Clinker cooler heat balance

The heat required for cooling hot clinker (assumed to be 1,200°C) to 70°C is equated with the sum of cooler heat radiation and heat brought out by cooler vent air.

• Heat required for cooling the clinker

13,500 kg-cl/h x (1,200-70)°C x 0.804 kJ/kg-cl • K = 12,265,000 kJ/h

Clinker specific heat = 0.804 kJ/kg-cl • K

• Heat brought out by cooler vent air

The amount of air entering the cooler is referred to as (585 + Q) m^3N/min with a temperature of 42°C. The amount of air infiltration is Q m^3N/min. Hot air leaving the cooler is divided into two parts, one of which has 496 m^3N/min and goes to the IDF. The other part has (89 + Q) m^3N/min and goes to the kiln. Given an air temperature of 135°C for the former and X°C for the latter,

496 m^3N/min x 60 min/h x 1.306 kJ/m^3N • K x (135 - 42)

+ (89 + Q) m^3N/min x 60 min/h x 1.306 kJ/m^3N • K x (X - 42) = 12,265,000 kJ/h

So,

X = 42 + 110,393/(89 + Q)

Assuming that Q is 100 m^3N/min, the temperature of air entering the kiln is 626°C, while if. Q is 150 m^3N/min, the temperature is 504°C. In either scenario, the clinker will not cool to 70°C unless a considerable amount of air infiltrate from somewhere. Clearly, we need to check whether the clinker is really cooled to 70°C, whether the air rates through fans are accurate, whether there are leaks. In addition, we need to calibrate the measuring instruments.

4) Reduction of slurry water content

KCP operates its plant with a slurry water content of 43%, which seems a little bit higher according to the Japanese experience, although the wet-process kilns disappeared in Japan now. For the reference, the figure in the Ceramic Engineering Handbook is 34-37%, while the guidelines in the NEDO-ASEAN PROMEEC Report (FY2000) allow for 38-40%.

Energy saving effect of reduction of slurry water content is as large as 1% of natural gas consumption in case of 1% cut in the water content, shown in the following calculation;

Amount of water corresponding to 1%:271.6 kg/min/43 = 6.316 kg/min

The amount of heat required for water evaporation and to heat the slurry to 130°C:

(100–35)ºC x 4,1868 kJ/kg • K+ 2,256.7 kJ/kg + 2.0934 kJ/kg • K x (130-100)ºC

= 2,592 kJ/kg

Heat required for 1% water content: 6.316 kg/min x 2,592 kJ/kg = 16,372 kJ/min

Natural gas calorific value: 40,914.5 kJ/m^3N

Reduction in natural gas:

16,372 kJ/min/40,914.5 kJ/m^3N = 0.4 m^3N/min (= 24 m^3N/h)

The reduction in natural gas is equivalent to roughly 1%. Accordingly, a 3% reduction in slurry water content would cut the natural gas consumption by roughly 3%.

5) Potential to increase the production of clinker

Table IV-2-9 shows the correlation between exhaust gas rate and burned clinker experienced in cement kilns in Japan.

Table IV-2-9 Correlation between exhaust gas rate and burned clinker in Japanese cement kilns

Kiln Type	kJ/kg-clinker	Source	m^3N/kg-clinker
Shaft kiln	3,936	Yogyo Kogaku H/B	1.65
Dry long kiln	6,226	JCA (1961)	2.62
Wet kiln	**5,681**	JCA (1961)	**2.38**
Lepol kiln	3,994	JCA (1961)	1.68
SP kiln	3,337	JCA (1981)	1.40
NSP kiln	3,237	JCA (1981)	1.35

(JCA: Japan Cement Association)

The data provided earlier shows that heat input required for clinker burning at the KCP is 7,577 kJ/kg-cl (= 2,500 m^3N/h x 40,915 kJ/m^3N/13,500 kg-cl/h). This is roughly 1.33 times the figure of 5,681 kJ/kg-cl for Japan's wet-process kilns shown in Table IV-2-9. Further, the kiln exhaust gas rate is 812 m^3N/min, indicating that the gas rate per kilogram of clinker is 3.61 m^3N/kg-cl, which is 1.52 times the figure of 2.38 m^3N/kg-cl shown in Table IV-2-9. This indicates that it is possible to burn at least 1.3 times the current clinker burning rate with the current energy consumption of natural gas.

The following suggestions are drawn with regard to fuel reduction:

a. Decrease the heat loss from kiln surface.

Study measure for lowering the surface temperature of the cooling zone in the kiln where the temperature exceeds 250°C. This can be achieved by changing the refractory material or by increasing the current single layer to double layers and using insulating materials with lower thermal conductivity.

b. Calibrate the measuring instruments for correcting inconsistency in kiln heat balance

The air intake for natural gas burning seems to be too high. Considering that the air rate estimated from the performance curve of air fans is smaller than the theoretical combustion air rate, it is possible that some amount of air is aspirated from the rear section of the kiln and from the cooler. Otherwise, there may be errors in the measuring instruments. Of particular concern is the finding that the cooling air supplied by the clinker cooler is not sufficient to fully cool the clinker. More inspection at the plant are required.

c. Take measures to lower the water content in the slurry.

The water content of the slurry is between 3% and 9% higher than data experienced in Japan. Reducing the water content by 1% should allow a 1% reduction in fuel consumption. It should be possible to remove more water by adjusting the slurry transfer pump specifications and installing a filter before the slurry enters the kiln.

(6) Electrical energy audit

Though the audit was conducted over only 3 days, the enthusiastic response from the plant allowed us to obtain a large number of results, as discussed below. We expect the Myanmar participants in future to follow-up measures.

1) Fans and blowers

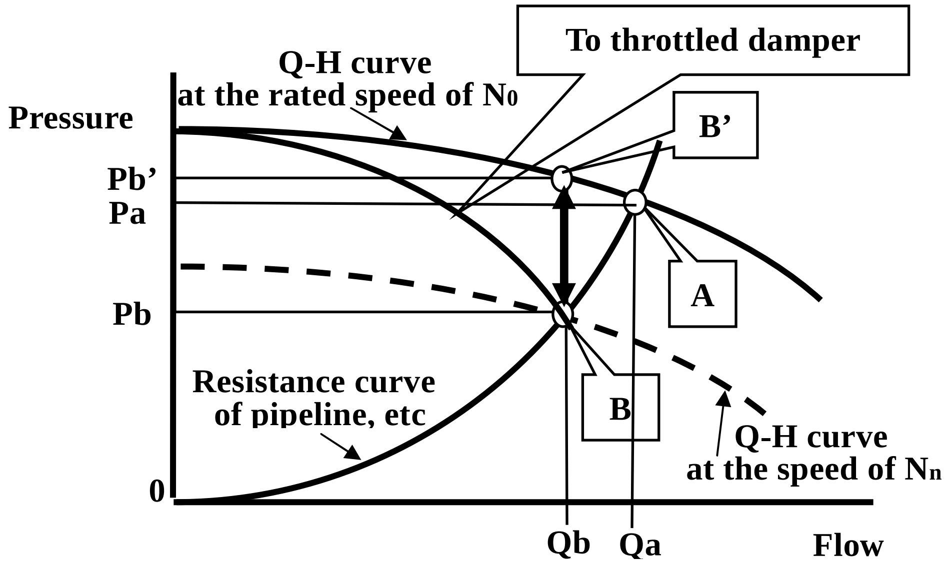
In the audit, many equipment is found to run with dampers throttled . More studies are necessary for reducing the power loss in dampers. Energy saving can be made on the following equipment:

・Primary Crusher: Dust fan

・Rotary Kilns: Air cooling fan, Discharge cooling fan, Primary air blower, Induced fan, Exhaust fan, (3kilns, Nos 1, 2 and 3)

・Finish Grinding Mill: Induced fan

* Sample calculation is given in case that an inverter were installed on the air-cooling fan for No. 3 kiln. Figure IV-2-4 shows the principle of energy saving in fans and blowers.



$$\mathbf{Qb / Qa = Nn / N_0,\ Hb / Ha = (Nn/N_0)^2}$$

$$\mathbf{axis\ power:\ Ln / La = (Nn/N_0)^3}$$

Figure IV-2-4 Energy saving effect through inverter installation illustrated on the performance curve of fans and blowers

Qa is the air flow volume at intersection point A of the performance curve and the resistance curve. The resistance curve is extended according to a square law characteristic passing the current pressure Pb (measured at point B).

Unfortunately, pressure Pb was not measured in this inspection, so we assumed that Qa = Qo for the purposes of making out the example.

The actual air flow volume measurement Qb (at 42°C) is temperature corrected for the standard intake conditions (at 20°C).

Qb = 669 x (273 + 20)/(273 + 42) = 622 [m^3/min]

The air flow ratio is equal to the rotation ratio, as shown below.

Qb/Qa = Nn/No

Therefore, Nn = No x Qb/Qa = 980 x 622/1100 = 554 [rpm]

Electrical power saving is the difference between the current power input at full rotation and the power input at reduced rotation with inverter control.

We assumed that inverter efficiency (ηtb) is 0.9 and the electric motor efficiency (ηmb) is 0.5. However, we did not take into considertaion the fan/blower efficiency (x ηfa/ηfb).

ΔkW = Lb/ηmb' - La x $(Nn/No)^3$/(ηtb x ηmb) x ηfa/ηfb

$$= 54 - 70 \times (554/980)^3/(0.9 \times 0.5) = 25.9 \text{ [kW]}$$

2) Pumps

- Although the slurry pumps are examined for the kiln and finish grinding mill on the site, the discharge valve opening was not known, so future inspection should be performed.

3) Others

- The primary crusher is loaded intermittently, and there is an opportunity in the power savings when the crusher is idle. The same applies to other equipment that is under intermittent load.
- There is a need for inspections of the power factor in power reception and distribution facilities as well as for studying an improvement measure.
- There is an opportunity by replacing the mercury lamps used as ceiling lights with sodium lamps.

3. Follow-up survey of Thanlyin Oil Refinery

We revisited the Thanlyin oil refinery, which is located close to the confluence of the Yangon and Bago rivers, about 30 minutes south-east of Yangon by car. An ECCJ team conducted a walk-through energy audit of this refinery in December 2004, and this visit was intended as a follow-up to that audit.

A complete overview of the Thanlyin refinery is provided in the report of the previous visit (see PROMEEC Report for FY2004).

3.1 Overview of Thanlyin Refinery

(1) Name of Company: Myanmar Petrochemical Enterprise (MPE)

(2) Plant name: No. 1 refinery (Thanlyin Oil Refinery, hereafter referred to as TOR.))

(3) Date of visit: November 23, 2006 (Thurs.), 7:50am to 4:30pm

(4) Location: On the outskirts of Yangon, approximately 30 minutes by car from the city center.

(5) Survey members: Audit team (1/2)

From Myanmar:

U Aye Kyaw	Director, Ministry of Energy (MOE), Energy Planning Dep't
U Maung Maung Ohn Thaw	Staff Officer, MOE, Energy Planning Dep't
U Ohn Myint	Director, Myanma Industrial Construction Services

Participants from other countries

Mr. Nor Hisham Bin Sabran	PTM, Malaysia

ACE

Mr. Ivan Ismed	Project Officer
Mr. Junianto M	Manager of Computer Center & IT

Japan: ECCJ, International Engineering Department Technical Experts

Hideyuki Tanaka, Koukichi Takeda, Fumio Ogawa,

(6) TOR respondents: Audit team (2/2)

U Myint Oo	Deputy General Manager
Daw Yin Yin Oo	Deputy General Manager (Production)

Daw Khin Khin	Assistant General Manager, COD
U Soe Hlaing	Deputy Assistant General Manager, COD
U Sein Than	Mechanical Engineer Superintendent
U Aye Cho	Electrical Engineer Superintendent

Unlike the previous visit, which was insufficiently prepared, an efficient discussion and tour were performed, making use of the information given in the pre-audit questionnaire that was sent in advance, and to which the responses are done, as well as the additional information given in e-mail exchange. However, the raw material currently used (crude oil) is very different from that used 5 years ago (condensate), so data in FY2004 and FY2005 were compared. A site inspection was restricted primarily to the CDU (crude oil distillation unit) units and the power plant. Combustion management and energy saving in the pumps/fans were focused as an energy audit.

3.2 Overview of the Refining Facilities

(1) Production

The properties of the raw material are that it has a low specific gravity and consists mostly of naphtha fraction. This is blended with small amounts of relatively heavier fractions. The raw material is transported from roughly 110 km offshore by 6,500 DWT tanker.

Specific gravity 60/60°	0.75
API Gravity	57
Sulfur content (wt%)	0.005

Based on the actual data, raw material of 114 million IG was processed annually during April 2003 to March 2004, which means approximately 43,460 kL (9,100 BCD) was processed on monthly average. BCD is Barrels per Calendar Day. The raw material is processed in 2 crude distillation units, as follows:

CDU-B: Approx. 6,000 BCD (at 50% load)

CDU-C: Approx. 3,000 BCD (at 50% load) Total: Approx. 9,000 BCD

The main products and production yields are shown as a percentage below:

LPG (mixture of propane and butane) : ?%

Motor gasoline: 68%

ATF (jet fuel): 13%

HSD (diesel): 12%

Solvents and lubricants (mixtures only), etc : ?%.

(2) Energy usage

The only fuel used at the refinery is “off gas” (natural gas). Because the refinery generates its own electricity, all the energy used can be accounted for in terms of natural gas used.

The amounts of natural gas, steam and electricity used are as follows:

Natural gas:	1.6 billion SCF/y
Steam:	360,000 t/y
Electricity:	19 million kWh/y

(3) Proposed items and improvement effects

1) Technical study

As a preliminary step for the energy reduction study, the operating conditions for the plant should ideally be as close to optimal as possible. With this in mind, we recommended a technical study of the CDU with necessary modifications. For example, some improvement needs to be carried out, such as optimizing the operating pressure and boosting the cooling capacity of the top section of the distillation tower.

2) Recommendation

First of all, a portable Orsat-type analyzer was recommended so as to obtain the excess air ratio in the furnace exhaust gas. Then, the energy saving of the machinery at low-load operation was proposed, as well as steam trap maintenance and insulation of bare piping.

3.3 Follow-up survey

On November 23, 2006 (Thurs.), a visiting team of 9, including Myanmar government representatives, together with 6 staff from the oil refinery conducted a follow-up survey. To begin with, the refining operation and its energy consumption were confirmed before going on to conduct an on-site audit. Finally, the visit finished with a discussion of measures for reducing energy consumption.

(1) Status of production and plant operation

Comparing with 2004 and 2005, both the processing conditions and product structure are unchanged, with condensate from the Yetagun offshore natural gas field being processed as the raw material in 2 CDUs (B and C).

1) Raw material properties

Condensate production volumes vary depending on the natural gas production circumstances, while the properties of the raw material also vary slightly. An example of recent properties is shown below:

Specific gravity: 60/60°F 0.7437

API Gravity 58.8

Sulfur content (wt%) Almost 0

2) Product output and plant operation conditions

The products distribution is unchanged from the previous audit. The table below lists the amounts of each product produced in FY2004 and FY2005.

Circumstances are also unchanged in that only the CDU plants are running and all secondary equipment is stopped. However, during the audit 2 years ago, the 2 CDUs were processing a total of roughly 9,000 BCD, while in FY2005 the production was around 7,800 BCD. The reasons for this are as follows:

a. Declines in the supply of condensate

b. Power outages (twice) due to stoppage of the power plant boiler with problems

c. CDU operation halt due to problems in the overhead condensers for CDU-B (probably caused by leakages)

It seems likely that there has been insufficient preventive maintenance due to a lack of investment funding.

Production volumes have declined as a result (Table IV-3-1).

Table IV-3-1 Oil refinery production volumes

Fiscal Year		2004-2005		2005-2006	
Condensate charged		106,644,732 IG		99,850,029 IG	
Products		IG	Yield (%)	IG	Yield (%)
1	NAPHTHA	77,488,351	72.66	75,293,447	75.41
2	ATF (Aviation Turbine Fuel)	14,085,756	13.21	11,401,825	11.42
3	MK (Medium Kerosene)	8,871,982	8.32	7,668,202	7.7
4	GO (Gas Oil)	1,203,993	1.13	961,848	0.96
5	Others	537,993	0.5	447,019	0.45
	Total	102,188,075	95.82	95,792,341	95.94

3) Energy usage

Whereas FO (fuel oil) was also used as primary energy source previously, now energy used comes entirely from natural gas. As well as being burned directly in the CDU furnace, natural gas is also burned in the power plant boiler to generate the electrical power. Accordingly, we can reckon the amount of energy consumed by the refinery almost entirely in terms of its natural gas consumption. The specific energy consumption is expressed as the value of the natural gas consumption (MSCF: Million Standard Cubic Feet) divided by the amount of production volume in Imperial gallons. Table IV-3-2 shows that the figures for FY2005 are a significant improvement over those for FY2004, but some questions remain, as discussed above.

Table IV-3-2 Energy consumption at the Thanlyin Oil Refinery

Item		2001.4-2002.3	2004.4-2005.3	2005.4-2006.3
Production volume (IG)		142,247,290	102,188,075	95,792,341
Power (= N-Gas, MSCF)		1,520MSCF	1,373.1MSCF	1,414MSCF
CDU-B		FO: 2,022,417IG 398,376GJ	N-Gas: 175.5MSCF 184,986.5GJ	N-Gas: 78.4MSCF 73,696GJ
CDU-C		FO: 718,024IG 141,436GJ	N-Gas: 58.4MSCF 61,568.4GJ	N-Gas: 27.8MSCF 26,132GJ
SEC	Power	10.685SCF/IG 11,499kJ/IG	13.437SCF/IG 13,326kJ/IG	14.761SCF/IG 14,639kJ/IG
	CDU “B+C”	FO: 0.0193IG/IG 3,795kJ/IG	2.289SCF/IG 2,413kJ/IG	1.109SCF/IG 1,042.3kJ/IG

(4) Inspection of refining units

An on-site inspection of the CDU-C plant and the power plant was conducted. Both plants were built by Mitsubishi Heavy Industries, but owing to the lack of maintenance since the installation, it is already clear that the plants are not functioning in the full capacity.

1) CDU-C plant

The combustion air is introduced into the furnace chamber through a natural draft with no preheating of the air. The natural gas is burned using 5 burners. The superheated steam generated in the furnace is injected into side strippers, and side streams are not treated in any more than stripping.

Relatively large P-101 (cold crude charge pump) was observed due to low-load operation and because its outlet control valve is throttled.

However, pressure gauges located on the inlet and outlet of P-101 did not worked, so a complete inspection was cancelled.

2) Power plant

This was built in 1979. Steam is generated in a boiler and electricity is generated (3,300 V) in an extraction condensing turbine. A significant number of instruments are no longer used, for example, pH meter and conductivity meter for BFW (Boiler Feed Water), and fuel/air ratio meter, etc.

The following 2 machineries were observed particularly with low-load operation in mind:

P-401 (BFW Feed) Motor 200 kW, discharge-side LIC C/V 20% opened

FDF C-401 Motor 280 kW, damper throttled to 10%.

The motors for both were 3,300-volt and measurement was also cancelled due to danger. It was found that there was insufficient maintenance overall. For instance, steam pipe leakages, steam trap deficiencies and insufficient heat insulation were observed.

(5) Implementation of previous suggestions and progress in their self-help improvement

1) Thermal insulation was enhanced on the heat exchangers, towers, product pipelines and steam distribution pipelines.
2) The amount of steam generated was matched to the needs of the plant.
3) The surplus air to the furnace was kept to less than 5% (air ratio of less than 1.31).
4) Future plans include the installation of additional heat exchangers, condensers and coolers.
5) Steam trap maintenance and replacement will be carried out as necessary, etc.

(6) Recommendations

The recommendations put forward by this follow-up survey team are as follows:

1) Enhance equipment maintenance.
Prevention of equipment problems and breakdowns; control instrument maintenance; basic data collection, etc.
2) Implement measures for low-load operation
Stand-by equipment for fans and boiler supply pumps etc.

(7) Study into the possible use of inverters for power plant auxiliary equipment

As an example of a measure for low-load operation, we conducted an on-site check of a typical fan and pump to study whether inverters could be used as auxiliary equipment to the power plant.

Table IV-3-2 Study results [Power plant fan and pump specifications and damper and valve opening]

Data / Equipment	Flow Qo /now Qb [m^3/min]	PressurePo,Ho / Pb,Hb [kＰa], [m]	Motor Rating Lo [kW]	Input power /Axis Lb [kW]	Damper, Valve Dcl [%]
FDF	1,450 440*	7.6 5 [kPa]	280	142 128	28 (Damper, FIC401)
BFWP	1.175 0.25*	568 [m]	200	116 104	100 (delivery) 10 (LIC-401V)

(Notes) • The input power is calculated as 3.21 kV based on the current, and the power factor is assumed to be 0.8.

• The shaft power is calculated as (input power) x 0.9 (assumed motor efficiency).

• The flow rate is estimated using the calculation data of the shaft power on the performance curve.

• Note also that a fan damper angle of 30° is assumed.

1) Fan (FDF)

The FDF runs with the inlet damper throttled, and if the current operation is maintained in the future, power saving measures must be implemented.

We recommend to measure the current flow rate and pressure and then to replace the fan with a low-capacity fan that still allowed some surplus, or to install an inverter.

* **Sample calculation** if an inverter were installed on the FDF

Qa is the air flow volume at intersection point A of the performance curve and the resistance curve. The resistance curve is extended according to a square law characteristic passing the current pressure Pb (measured at point B).

Unfortunately, pressure Pb was not measured in this inspection, so we assumed that Qa = Qo for the purposes of making out the example.

The actual air flow volume (Qb) is estimated to be 440 [m3/min].

The air flow ratio is equal to the rotation ratio, as shown below.

Qb/Qa = Nn/No

Therefore, Nn = No x Qb/Qa = 1470 x 440/1450 = 446 [rpm]

Electrical power saving is the difference between the current power input at full rotation and the power input at reduced rotation with inverter control.

We assumed that inverter efficiency (ηtb) is 0.9 and the electric motor efficiency (ηmb) is 0.5. However, we did not take into consideration the fan/blower efficiency (x

$\eta fa/\eta fb$).

$$\Delta kW = Lb/\eta mb' - La \times (Nn/No)^3/(\eta tb \times \eta mb) \times \eta fa/\eta fb$$
$$= 142 - 260 \times (446/1470)^3/(0.9 \times 0.5) = 126 \text{ [kW]}$$

2) Pump (BFWP: Boiler Feed Water Pump)

The BFWP runs with the flow rate adjustment valve throttled, and if its current operation is maintained in the future, power saving measures must be taken. We recommend to measure the current flow rate and pressure, and then to replace the pump with a smaller size.

On-site checks were only conducted for the FDF and BFWP in this audit, but an overall review tailored to low-load operation is needed for other auxiliary equipment.

4. Seminar-Workshop

4.1 Overview

A seminar-workshop was held in Yangon, Myanmar on November 24, 2006.

The seminar-workshop began with an opening address given by the Director of the Myanmar MOE, U Aye Kyaw. The seminar-workshop was attended by a total of 56 enthusiastic participants and proved to be both successful and highly productive. This year's seminar-workshops, regardless of the country in which they were held, have all been presided over by the focal point (FP) from the host country, and in Myanmar this role fell in U Aye Kyaw. This resulted in him being a very busy man, since he was also acting as Myanmar's VIP. This seminar-workshop included 3 times of question and answer sessions, and eager questioning from the floor prompted extensive discussions.

(1) Date/Time

November 24, 2006 (Fri.), 8:00 am – 5:30 pm

(2) Venue

Sedona Hotel, GF (Ballroom), Yangon, Myanmar

(3) Seminar-workshop presentations

Reports from Myanmar began with an introduction to the general energy-saving activities of the MOE, followed by three reports on energy saving campaigns from two oil refineries and a cement plant. Reports from ASEAN were presented by Indonesia, Malaysia and Vietnam. See the attached data for the program.

(4) Participants

Myanmar-side members:

U Aye Kyaw	Director, Ministry of Energy (MOE), Energy Planning Dep't
U Maung Maung Ohn Thaw	Staff Officer, MOE, Energy Planning Dep't
U Aung Kyi	Managing Director, Myanma Industrial Construction Services
U Ohn Myint	Director, Myanma Industrial Construction Services
U Myint Soe	Deputy Assistant Director, Myanma Industrial Construction Services
U Tin Oo	Staff, Myanma Industrial Construction Services
U Thaung Nyunt	Assistant Director, R & D, Directorate of Myanma Industrial Planning

Daw Hla Hla Kyi	Deputy General Manager (Production), Myanma Petrochemical Enterprise (MPE), Petrochemical Complex, Thanbayakan, (Mann)
Daw Yin Yin Oo	Deputy General Manager (Production), MPE, No.1 Refinery, Thanlyin
U Saw Fernando	Deputy General Manager (Planning), Myanmar Ceramic Industries, Kyankhin Cement Mill
U Win Khaing	General Secretary, Myanmar Engineering Society
U Than Tun	Joint Secretary, Myanmar Institute of Strategic and International Studies
U Lin	Chairman, Yathar Cho Industry, Ltd.
	and many more.

ASEAN Center for Energy (ACE)：

Mr. Ivan Ismed	Project Officer
Mr. Junianto M	Manager of Computer Center & IT

Indonesia:

Mr. Subagyo PT Kertas Leces, Indonesia

Vietnam:

Mr. Le Tuan Phong Ministry of Industry, Vietnam

Malaysia:

Mr. Nor Hisham Bin Sabran PTM, Malaysia

Japan: ECCJ, International Engineering Department Technical Expert

Fumio Ogawa, Koukichi Takeda, Hideyuki Tanaka

General participants from Myanmar

A total of 56 attendees including sponsors (list of participant to be received later). Participants came from a range of fields, including the electric power, cement, petrochemical, textiles and ceramic industries. Almost all were from state-run businesses, so there were no distinctions based on their industry, rank or position.

4.2 Results of the Seminar-Workshop

(1) Opening ceremony

1) ACE

Because this event coincided with the SOME meeting, Dr Weerawat of ACE was unable to attend, so his message was delivered by Mr Junianto in his place. He began with a brief introduction of ACE and PROMEEC and also touched on the projects being undertaken by

ACE.

2) ECCJ

A greeting was given by Mr. Hideyuki Tanaka, technical expert representing Japan (METI and ECCJ). He spoke on the importance of this project, its background and current status, and Japan's cooperation with and contribution to ASEAN. He also expressed his gratitude for the cooperation given to this visit to the cement plant and oil refinery, and expressed his hope that EC activities can be extended to other production facilities in Myanmar.

3) Myanmar, MOE

Mr. U Aye Kyaw gave a greeting in place of the MOE Director General. After discussing Myanmar's current situation and the importance of this project, he went on to express his thanks to all the representatives and participants. He then briefly described the content of the seminar-workshop before formally opening the event.

（2） Session 1: Policy and Initiatives on EE&C

1) ACE Activities on EE&C (Mr. Junianto, ACE)

Mr. Junianto used the attached materials to explain the ACE activities, the current status of ASEAN, the dialog between the EC and Japan, and future plans.

2) Initiatives and Programs of ECCJ on EE&C in Industry in Japan (Mr. Tanaka, ECCJ)

Mr. Tanaka gave a detailed explanation covering three topics: the current status of energy conservation in Japan, the energy conservation law, and the implementation of energy saving measures in the industrial sector in Japan.

3) Overview of EE&C Activities in Myanmar (U Aye Kyaw, MOE)

Mr. U Aye Kyaw also discussed three topics: the current status of energy and energy policy in Myanmar, the activities that have been undertaken in the past, and Myanmar's future plans. Until now, a reluctance to engage in follow-up activities coupled with the low cost of energy have meant that EE&C activities have had little impact. He went on to indicate that future EE&C activities would have clear goals aimed at pointing the way to energy self-sufficiency. He also stressed the need for better and more effective coordination between five ministries involving in energy issues.

(3) Session 2: EE&C Best Practice in Industries

1) Case Study 1 – Experience and Application of EE&C in the Leces Pulp and Paper Mill - Mr. Subagyo (Indonesia)

This presentation was given by Indonesia's PT Kertas Leces, which underwent a follow-up survey as part of the PROMEEC activities in fiscal 2005. Reports from this company have been presented at successive seminars in the past. A total of 7 people from domestic paper mills attended in the Myanmar audience.

2) Case Study 2 – EE&C for the Textile Industry in Malaysia - Mr. Sabran (Malaysia)

As an energy-saving activity of Malaysia PTM, Mr. Sabran presented examples of energy savings at a glass factory and a textiles factory.

3) Case Study 3 – EE&C for the Ceramics Industry in Vietnam - Mr. Phon (Vietnam)

Mr. Phon gave a presentation on the energy-saving improvements implemented at Vietnam's HAPOCO Ltd, which underwent a follow-up survey as part of the PROMEEC activities in fiscal 2004.

4) Case Study 4 – Progress Report on Oil Industries previously Audited in Myanmar - Mrs. Hla Hla Kyi (Myanmar)

Mrs. Hla Hla Kyi compared the current situation with the situation in 2001 when the first PROMEEC energy audit was conducted and discussed the improvements. However, there was no mention of the results of the follow-up conducted in fiscal 2004. The fact that there have also been considerable changes to the executive personnel at oil refineries suggests that there have been problems with management transitions within the oil refining companies. The content was the same as that presented at the Lao PDR in October 2006.

5) Case Study 5 – Results of Energy Audit at the No.1 Refinery (Thanlyin) - Daw Yin Yin Oo (Myanmar)

This presentation was based on hastily summarized material from the previous day's visit. While the specific energy consumption for FY2005 shows a major improvement when compared with FY2004, close scrutiny over time is needed to determine the validity of the figures.

6) Case Study 6 – Results of Energy Audit at the Kyankhin Cement Plant – U Saw Fernando (Myanmar)

This presentation covered the details of the guidance provided to KCP when the audit team visited the factory, for example, the heat balance calculations for the area around the No.3 rotary kiln (and the potential for lowering the outer casing temperature by repairing the internal refractory) and the potential energy savings in the fans and blowers for the kiln.

The presentation provided a supplementary explanation of the heat transfer calculations (to lower the outer casing temperature) based on the original data when the refractory was designed, provided by Mr.Tanaka.

(4) Session 3: The Way Forward

1) Barriers and measures for implementing EE&C in industry - Technical expert, Mr. Ogawa

Mr. Ogawa explained the topic using data issued in FY2005 and with reference to content discussed by the other presenters at the seminar.

2) Technical Directory – Mr. Ivan

Mr. Ivan explained the purpose of the technical directory (TD) and aspects such as its creation method and format. He also gave an in-depth description of the TD using actual examples. His explanation referred to an actual sample TD sheet that he provided. He also attracted great interest with his explanation of how to view 33 existing examples in buildings and 50 examples in industry on the ACE web site.

3) Database/Benchmark/Guideline for Industry – Mr. Ivan

This explanation covered the purpose and importance of the database as well as future plans.

(5) Q&A session and comments

As mentioned above, 3 time slots were set aside for Q&A sessions, which were very actively utilized by the participants. The main points raised in the Q&A sessions are as follows:

Q: When the boiler in the pulp and paper plant was changed from fuel-oil-fired to gas-fired, did you change the heat tubes also?

A: (Mr. Subagyo) We changed the burners, etc., but not the heat tubes.

Q: Can an inverter be installed on an existing installed motor?

A: I myself have installed an inverter on electric motors that were already installed. To use an inverter with an existing electric motor, there are several things you have to check for. These include whether there are temperature increases caused by increased harmonic loss or insulation problems due to current surges, the effect of motor cooling during low-speed operation, and studies into mechanical strength, including the fans, given repeated acceleration and deceleration. If you check each of these items, you should have no problems.

Q: Where achievements in energy savings are expressed, more emphasis on the monetary side of things may appeal to decision makers and will be easier for them to evaluate.

A: (U Aye Kya) You can talk about the monetary side of things, but in Myanmar we are faced with problems such as an absolute insufficiency in natural gas, so reducing your usage is important since it allows us to use that much more gas effectively in other areas.

U Win Khaing added comments such as, “Myanmar wants to play an active role in the future in the ASEAN Award System,” and “Both the TD and the DB are wonderful. I want to thank METI, the ECCJ and the ACE. Respective audiences, surely everyone will want to use these a great deal.” With these remarks, he gave a forward-looking and highly encouraging speech.

(6) Closing address

U Aye Kyaw called particularly on U Win Khaing (scheduled to visit Japan in December as a BOJ member), who then gave a speech. Saying “The PROMEEC project and seminar-workshops such as today's are very significant and clearly address the needs of Myanmar,” he expressed his gratitude to everyone involved.

There was then an awards ceremony during which certificates were given to those anticipating on the day. Finally, U Aye Kyaw once again stressed the importance of the seminar-workshop, affirming that it had been a resounding success and again thanking everyone involved. He then discussed his hopes for the future before declaring the seminar closed.

5. Attachment

(1) “ASEAN PROMEEC Seminar/Workshop Program”

1. “ACE Activities on Energy Conservation & Efficiency”
2. “Initiatives and Programs of ECCJ on EE&C in Industry in Japan ”
3. “Overview of EE&C Activities in Myanmar”
4. “EXPERIENCE and APPLICATION of ENERGY EFFICIENCY and CONSERVATION in LECES PULP AND PAPER MILL”
5. “Presentation from Malaysia”
6. “Hai Duong Porcelain Company”
7. “Progress Report on Oil Refineries Earlier Audited in Myanmar”
8. “RESULT OF THE ENERGY AUDIT IN NO(1) REFINERY (THANLYIN)”
9. “Presentation from Kyankhin Cement Plant”
10. “Relation between the brick thickness and shell surface temperature”
11. “Barriers and Measures on implementing EE&C in Industry”
12. “Development of a technical directory”
13. “Development of a database for industry/building”
14. “Cement Process & Energy Saving”
15. “Promotion of Energy Conservation Activities in Factories (Electricity)”

V. ASEAN Initiatives

1. Overview of Summary/Post Workshop

Summary/post workshop for three projects on energy conservation in major industries, energy conservation in buildings, and energy management infrastructure development in the ASEAN countries, was held in Bandar Seri Begawan, Brunei. Representatives from ten ASEAN countries, the ASEAN Center for Energy (ACE), and the Energy Conservation Center, Japan (ECCJ) gathered to assess the performance and achievements of three projects in FY2006 and to confirm future initiatives and policies. In the summary workshop for each project, Japanese members reported on the results of activities implemented in FY2006, and discussed the present status, achievements, and issues of activities with input from all participants.

1.1 Date

February 27 (Tue) – 28 (Wed), 2007

1.2 Venue

Oil & Gas Discovery Centre, Seria, Brunei Darussalam

1.3 Participants

The summary/post workshop was attended by 20 participants, including 11 members from ten ASEAN countries, 5 members from ACE, and 4 members from ECCJ. The following is a list of participants.

Brunei Darussalam (2 participants):

Mr. Hj ABD Shawal Yaman	District Electrical Engineer, Dept. of Electrical Service, Ministry of Development, Nagara Brunei Darussalam
Dr. Kha Sheng Tan	Associate Professor and Head of Department of Engineering Science, Universiti Brunei Darussalam, Brunei Darussalam

Indonesia (1 participant):

Ms. Indarti	Head of EC Division, Ministry of Energy and Mineral Resources (MEMR), Indonesia

Cambodia (1 participant):

Mr. Lien Vuthy	Deputy Director, Department of Energy Technique, Ministry of Industry, Mines and Energy (MIME),

Cambodia

Lao PDR (1 participant):

Dr. Daovong Phonekeo	Deputy Director General, Department of Electricity, Ministry of Energy & Mines, Lao PDR

Malaysia (1 participant):

Mr. Hyshamudin Ibrahim	Program Manager, Malaysia Energy Centre (PTM), Malaysia

Myanmar (1 participant):

Mr. U Ohn Myint	Director, Works Planning Dept., Ministry of Industry No. (2), Myanmar

Philippines (1 participant):

Mr. Jesus C. Anunciacion	Chief Science Research Specialist, EE&C Division, DOE, Philippines

Singapore (1 participant):

Mr. Zulkarnain B H Umar	Senior Engineer, Energy Market Authority, Singapore

Vietnam (1 participant):

Mr. Phuong Hoang Kim	Official on Energy and Environment, MOI, Vietnam

Thailand (1 participant):

Dr. Prasert Sinsukprasart	Department of Alternative Energy Development and Efficiency (DEDE), Thailand

ACE (5 participants):

Dr. Weerawat Chantanakome	Executive Director
Mr. Christopher Zamora	Administration and Finance Manager
Ms. Maureen C. Balamiento	Database and IT Specialist
Mr. Ivan Ismed	Project Officer
Mr. Junianto M.	IT Staff

ECCJ (4 participants):

Mr. Tsuzuru Nuibe	Senior General Manager
Mr. Kazuhiko Yoshida	General Manager
Mr. Yoshitaka Ushio	General Manager
Mr. Taichiro Kawase	General Manager

2. Summary Workshop on Major Industries

Summary workshop on major industries was held according to a workshop agenda, chaired by Dr. Prasert of Thailand.

2.1 Report from ECCJ concerning energy conservation activities in major industries in FY2006

During phase 1, ACE-ECCJ conducted energy audits of major industries in ten ASEAN countries. In the third year of phase 2 activities, follow-up audits were conducted in major industries in three countries listed below, and moreover, some visits were made to other plants for the purpose of surveying the status of dissemination of guidance provided in phase 1 audits. Additionally, seminar-workshop was held in each country. An overview of activities implemented in three countries was presented in the summary-workshop.

ASEAN countries visited in the third year of phase 2 and period of visits

Lao PDR	October 2 – 6, 2006
Thailand	November 13 – 16, 2006
Myanmar	December 5 – 12, 2006

Table V-2-1 shows the status of activities in each country.

Table V-2-1 Overview of phase 2 activities in FY2006

Items / Country / Time		Lao PDR Oct. 2～6	Thailand Nov. 13～16	Myanmar DEC. 5～12	
1. Follow-up / Energy Audit		Cement	Iron/Steel	Oil Refining Cement	
2. Seminar-Workshop / 1) EE&C Policy		Lao PDR - MEM ACE ECCJ	Thailand - MOE ACE ECCJ	Myanmar- MOE ACE ECCJ	
2) EE&C Activities	Cement (Lao PDR, Myanmar)	Lao PDR - MEM		Myanmar- MOE	
	Ceramics (Vietnam)			Vietnam-MOI	
	Chemical (Caustic Soda) (Thailand)				
	Garment (Cambodia)				
	Food (Singapore)	Malaysia - PTM			
	Iron/Steel (ECCJ/ASEAN)	Philippines-DOST	ECCJ Indonesia-Krakatau steel Malaysia-PTM Philippines-DOST Thailand-Bangkok Steel		
	Oil Refinery (Myanmar)	Myanmar- MPE		Myanmar- MPE	
	Power (Lao PDR)	Lao PDR-Nam Ngum Hydro			
	Pulp/Paper (Indonesia)			Indonesia - PT Kertas Leces	
	Textile (Malaysia)			Malaysia - PTM	
	Other Industries	Glass Malaysia-PTM			
3) Way Forward		1) What are the Barriers & Measures on the Implementation of EE&C [ECCJ] 2) Development of TD, DB/BM/GL for Industry [ECCJ & ACE]			

1) What are the Barriers & Measures for the Implementation of EE & C [ECCJ]
2) Development of Technical Directory, DB/BM/GL for Industry [ECCJ & ACE]

In the seminar-workshop, Brunei representative gave a presentation on the country's energy conservation policies and energy conservation activities implemented by industries. Representatives from three ASEAN countries in which energy audits were conducted reported on energy conservation activities implemented in major industries in their respective country. The other countries did not give presentations. The following section provides an overview of activities implemented in three countries.

(1) Activities in Lao PDR

During five-day period of activity, the survey team spent the first four days on conducting an audit of two cement plants, and the last day on holding a seminar-workshop.

Twenty plant engineers participated in the audit of the cement plants. After giving an overview of the plant and confirming the content of responses to the preliminary questionnaire, the survey team conducted a walk-through audit mainly of two kilns and some large fans. Based on the obtained data, they calculated heat balance inside the kilns and furthered their understanding of cement processes, as well as discussed on possible energy conservation measures. Two engineers from Malaysia participated voluntarily with measurement equipment, and contributed to a measurement in the audit works. It is epoch-making and highly significant to the objective of the project to disseminate transferred technologies to ASEAN countries.

In the seminar-workshop, 58 people participated in the seminar-workshop, indicating the high level of interest in energy conservation in Lao PDR. The audit result was reported by one of cement plant engineers. On the ASEAN side, Malaysia reported on the efforts of its industries to promote energy conservation, Myanmar on petroleum refining, and the Philippines on energy conservation activities in the steel industry, and created a foundation for an active Q&A session.

(2) Activities in Thailand

During four-day period of activity, the survey team spent the first three days on conducting an audit of a steel plant and the last day on holding a seminar-workshop.

Ten engineers participated in the audit of the steel plant. The plant is actively pursuing energy conservation, and has so far implemented various measures, including using daylight to save lighting energy. The survey here mainly focused on the un-addressed problem of heat loss from the furnace walls and loss due to the infiltration of air into the furnace. Using collected data, calculations of power savings were carried out through on-the-job training (OJT) involving all participants. The early implementation of low-cost measures is expected.

In the seminar-workshop attended by 70 participants, a plant engineer reported on the results of the audit, and representatives from Malaysia, Indonesia, and the Philippines presented case studies on energy conservation at steel plants in their country. This was greatly appreciated by participants from the steel industry, and was the first time a seminar was held focusing on one industry only. It should serve as a reference in planning future seminars.

(3) Activities in Myanmar

During six-day period of activity, the survey team conducted a follow-up audit and a new audit survey at an oil refining plant and a cement plant, respectively. A seminar-workshop was held on the final day. The six-day schedule was established, taking into account the time needed to travel between two plants, but even so, whole two days were spent on travel.

In the follow-up audit at the oil refining plant, it was revealed that a part of proposals recommended in the previous audit had not been implemented. This was because the crude oil had changed from that used during the previous audit, and also because of equipment failures. Nevertheless, it is worth noting that three out of five proposals have been implemented even under the above circumstances.

At the cement plant where a new audit survey was conducted, the surface temperature of the kiln was measured. Using the measurement data, the plant engineers themselves calculated heat loss. As a result, they were not only able to discover damage occurring to the insulating firebrick inside the kiln, but all participants learned the significance of measurement technologies and heat loss calculations, and the exercise proved to be extremely meaningful. Of the 11 plant engineers who participated in this survey, four were from other cement plants. It is hoped that their participation will contribute to promoting the dissemination of transferred technologies throughout the country.

The achievements of the above audit were reported at the seminar-workshop by a plant engineer. Judging from the content and quality of reporting, the technical transfer was conducted with success. 56 participants took part in the seminar-workshop, and from other ASEAN countries, Indonesia presented a case study on the paper/pulp industry, Malaysia on the textile industry, and Vietnam on the ceramic industry.

2.2 Energy conservation activities in the ASEAN countries

(1) Participants of the plant energy audit and seminar-workshop

As shown in Table V-2-2, participants of plant energy audits increased in FY2005 when OJT was adopted, and the trend became even more conspicuous in FY2006. Numerically speaking, the average number of participants per plant increased from 1.6 to 4.2 to 12.5 in three years. However, it is too soon to interpret this trend as a result of increased interest in OJT. We must keep a close eye on future developments, but whatever the reason may be, increase in the number of participants is extremely welcome.

Meanwhile, the number of participants to seminar-workshops has remained constant in recent years, with an average of 71.5 to 56.5 to 61.3 participants per seminar-workshop for the past three years.

Table V-2-2 Number of participants to audits and seminars held in each country

Item		Fiscal year		
		2004	2005	2006
Energy audit	Number of plants audited	7	9	4
	Total number of participants	11	38	50
	Average number of participants per plant	1.6	4.2	12.5
Seminar-workshop	Number of seminar-workshops held	4	4	3
	Total number of participants	286	226	184
	Average number of participants per seminar-workshop	71.5	56.5	61.3

(2) Overview of best practices in energy conservation reported in the seminar

As shown in Table V-2-3, 12 presentations on best practices were given by 7 countries. The activities of the hydro power plant in Lao PDR, the steel industry in the Philippines, the ceramic industry in Vietnam, and the pulp/paper industry in Indonesia were the same as those presented in the past. It is not necessarily a waste to make the same presentation more than once, but cases that have not yet been presented are preferable.

Table V-2-3 Best practices in energy conservation presented by the ASEAN countries

Country	Industry	EE&C Activities
Lao PDR	Hydro-power	Same presentation done in 2005
Malaysia	Iron/Steel Ind	2-stg recuperator, VSD for water pump, Screw air compressor
	General	Overview of MIEEIP project (PTM), Food, Glass, Textile, Iron/Steel
Thailand	Iron/Steel Ind	Daylight, cooling tower fan blade, air compressor replace, etc
Philippines	Food Ind	Insulation, cond.recovery, steam leak, Solenoid valves, etc
	Iron/Steel Ind	Same presentation done in 2005
	Cement Ind	VRM, 5-stg NSP, Damper→VSD, Process A/M, Air leak repair (Kiln), O2 meter for Air leak, Air press 7Bar→6.8
Vietnam	Ceramics Ind	Same presentation done in 2004
Indonesia	Iron/Steel Ind	Slab preheat, slab hot charge, billet insulation cover, etc
	Pulp/Paper Ind	Same presentation done in 2004
Myanmar	Oil Refining	Lower tower pressure, tower off gas recovery
	Cement Ind	

(3) Obstacles and measures for promotion of energy conservation in major industries

Support of corporate top managements

(Current state)

As was pointed out last year, energy conservation efforts have not resulted in significant progress due to such issues as inadequate policies, shortage of human resources, insufficient technologies, lack of funds, and lack of information. The majority of these obstacles have much to do with the attitude of corporate top managements. Most of the problems can be eliminated if management provides sufficient support. For instance, in many cases, plants that are actively supported by top management have been able to make significant progress in energy conservation, regardless of country.

(Countermeasures)

Future PROMEEC activities must also be directed to reforming the consciousness of corporate top managements. Put another way, considerations must be given to make top managements aware of the fact that energy conservation activities produce profits that would strengthen corporate competitiveness. Corporate top managements constantly think in terms of investment risk. Therefore, they are highly unlikely to approve of proposals that require large investments. Fortunately, however, many no or low-cost measures still remain to be implemented in industries in the ASEAN countries. To open their eyes to the effectiveness of no-cost measures, such measures should be proposed.

Capacity building of the core team

(Role of the core team)

One of the objectives of conducting plant audit surveys is to foster a core team that is capable of conducting audits. A core team acquires audit techniques from Japanese experts through on-the-job training, and is expected to utilize the technology it acquires to contribute to promoting energy conservation in other plants. It is composed of a government team including a focal point, an ACE team, and a local audit team (engineers of the auditing plant and other plants).

(Responsibilities of the core team)

1) Selecting the auditing plant (focal point, ACE team)
2) Distributing and collecting preliminary questionnaires (focal point, ACE team)
3) Inviting participants from other ASEAN countries, and collecting and distributing presentation materials (ACE team)
4) Arranging for measurement equipment (focal point, ACE team)
5) Making accommodation arrangements for audit participants (focal point, ACE team)
6) Making arrangements for OA equipment, copying tasks, and conference rooms at the audit plant (focal point, ACE team)
7) Arranging for the seminar-workshop venue (focal point, ACE team)
8) Audit implementation (local audit team; Japanese experts act as advisors)
9) Data analysis, preparation of preliminary report, reporting to the plant (local audit team; Japanese experts act as advisors)
10) Presentation of audit results at the seminar-workshop (local audit team)
11) Presentation of the progress of TD/DB at the seminar-workshop (ACE team)
12) Presentation of the energy situation in the host country at the seminar-workshop (focal point)
13) Making arrangements for OA equipment, copying, and other tasks at the seminar-workshop venue (focal point, ACE team)
14) Preparation of the seminar-workshop venue, compilation of a participant list, collection and distribution of presentation materials (electronic materials) (ACE team)

(Issues for the core team)

The general impression we had on supervising OJT-based plant audits is that energy conservation technologies and audit technologies are not being transferred smoothly to the core team. The following are some problems we found, though they do not necessarily apply to other countries.

1) Preliminary questionnaires are left unanswered in many cases. If responses are not

obtained, interviews must be conducted at the plant, which would take up half a day that should be used for the audit.

2) Prior to commencing the audit, Japanese experts give an overview of processes and energy conservation measures, but they do not seem to be fully understood. The government team and ACE team must gain a good understanding of each industrial process through OJT, as they are expected to be familiar with technical issues, and the ACE team, in particular, is responsible for preparing a TD/DB.
3) The role of each team member was not clearly defined in advance of audit surveys. Audit schedule, including measurement locations and methods, collection of operational data, and role of each member, was worked out by Japanese experts. As a matter of facts, most of audit works were conducted by the Japanese experts, while most members of the core team were following and surrounding the Japanese experts during the audit surveys. It does not constitute the on-the-job training.
4) The measuring equipment that have been prepared did not function frequently. They had better be calibrated before conducting an audit.
5) Hardly any questions are raised, even after an analysis practice was conducted using measurement data, and after results of the audit are presented. Most people did not seem to gain a clear understanding. Perhaps it might be difficult to explain and make them understand in such a short period of time. It is important to select persons with a certain degree of experience and knowledge as a member of the core team.

(Future countermeasures)

1) The government team, including the focal point, should visit the auditing plant at least once before audit surveys, in order to discuss with the plant team about the general outline of the plant, the procedure of audit survey, answers to the preliminary questionnaire, the preparation for implementing OJT, and other matters.
2) All members of the core team should have sufficient knowledge before audit surveys. Moreover, it is advisable to appoint technical assistants familiar with the industrial processes respectively in the government team and ACE team.
3) There appears to be two reasons for the poor response to preliminary questionnaires. One is that the questions are difficult, and the other is because the ACE team lacks sufficient knowledge of processes. In response to the former, the questions should be made simpler, and a detailed guideline on filling out the questionnaire should be prepared. Currently a database format that answers to this goal is being prepared for the cement industry. The latter concerning lack of process knowledge can be addressed only by raising ACE’s awareness of its role and implementing steady training.
4) A factor common to the above issues is perhaps low recognition of the ASEAN countries

that they have to address energy conservation issues through their self-help efforts. In fact, a tendency to depend on the Japanese experts can be observed. It is important for each member to recognize his respective role, and to realize that they are the ones who must take the initiative. Since this recognition could be accomplished in the experience of one audit, it should be repeatedly confirmed on the opportunity of each audit.

(4) Summary of energy conservation activities in the ASEAN countries in FY2006

As also mentioned in last year's report, energy conservation activities are seemingly becoming more and more active in ASEAN countries each year. The primary reason is the recent hike in energy prices. This is adding momentum to energy conservation and cost reduction activities. The other reason is because corporate top managements are becoming more aware of the issue of energy conservation, thanks to the dissemination of PROMEEC activities. Energy conservation activities are expected to gain greater momentum hereafter, as more companies come to realize that energy conservation leads to cost reduction, as well as contributes to corporate profits and environmental conservation. There are still many obstacles to promoting energy conservation in the ASEAN countries, but this PROMEEC program and various energy conservation training programs can be expected to eliminate such obstacles.

2.3 Overview of presentations by three host countries in FY2006

In the summary/post workshop, representatives of three host countries of energy audit reported on EE&C activities in their respective countries.

(1) Lao PDR

The Lao representative presented results of audits conducted at cement plants. Content-wise, it was similar material presented at the seminar-workshop on the plant audit conducted last October, a part of which were exactly the same materials as the ones compiled by the ECCJ experts. Judging from the performance of presentation, the focal point proved to have an excellent understanding of his role in organizing the local team, coordinating activities during the plant audit, etc.

(2) Myanmar

The Myanmar representative discussed Myanmar's energy policies, past energy conservation activities implemented with international cooperation (e.g., UNDP/ADB assistance, UNESCAP assistance, PROMEEC activities), and future plans (UNESCAP assistance, PROMEEC and other ASEAN programs). A description was also given of

FY2006 PROMEEC activities, with a focus on the follow-up audit conducted at the oil refining plant and the new audit conducted at a cement plant. In the description of the cement plant audit, photos were used to realistically explain the task of measuring the surface temperature of the kiln.

(3) Thailand

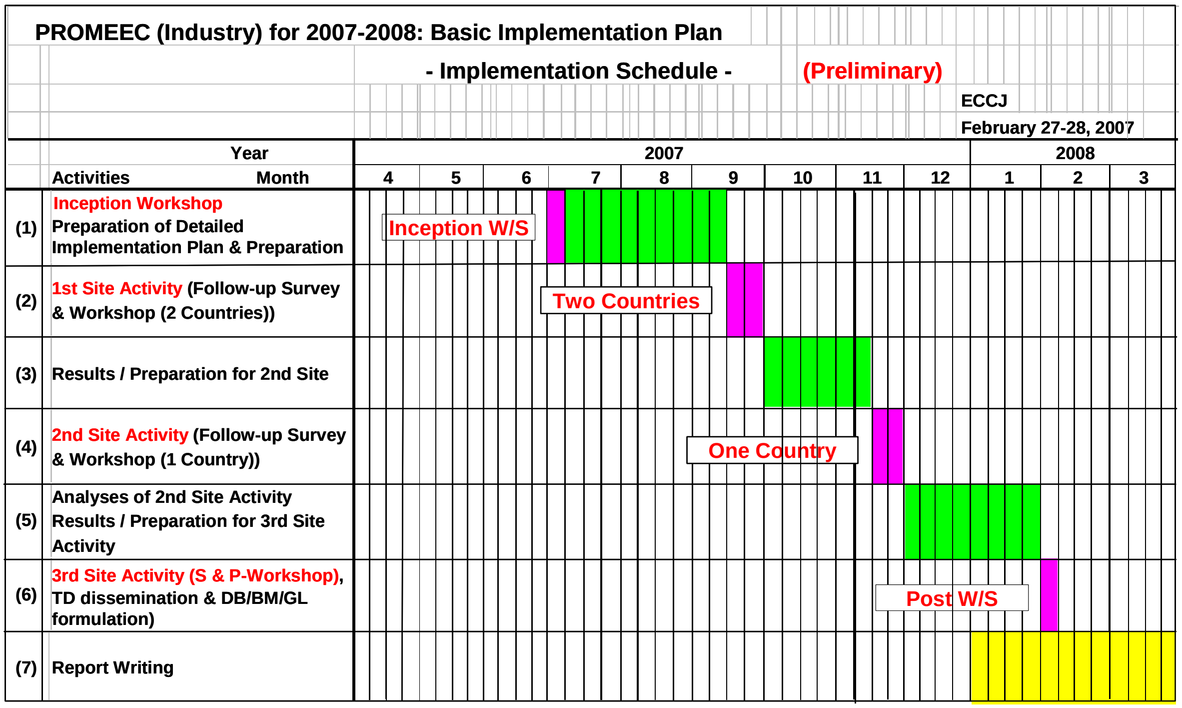
The Thai representative presented results of FY2006 PROMEEC activities, focusing mainly on the energy audit conducted in the steel plant. It was reported that the audit was conducted in cooperation with the steel association, and that the audit results have been uploaded to its web site. The presentation of audit results using the wireless LAN demonstrated in the workshop venue gave a strong impression.

2.4 Plans for FY2007 PROMEEC activities

In FY2007, METI-ASEAN PROMEEC plans to continue implementing the same activities as FY2006, through the concerted efforts of ACE, ECCJ, and focal points (FPs) of the ASEAN countries. As shown in the schedule provided in Fig.V-2-1, site activities are slated to be conducted in September and November 2007, in two countries and one country, respectively. Host countries will be selected on the basis of their commitment to organizing a core team consisting not only of members from the host country but members from other countries as well, and to making steady preparations for the survey. They will be determined at the FY2007 inception workshop. A follow-up survey and energy audit will be conducted in the selected countries through intensive on-the-job training, and thereafter the results will be presented at the seminar-workshop by the audit team. In principle, the survey will be implemented in reference to one industry and two plants per country, and will be conducted over a period of ten days in each country. In implementing the survey, the core team will be required to make the preliminary preparations, including selecting host plants for the audit, organizing an audit team of more than five members and determining a role of each member, conducting preliminary studies, and filling out a preliminary questionnaire.

In the seminar-workshop, the ASEAN countries will be invited to deliver presentations, in addition to presentations by the host country on its energy conservation activities. In the workshop, discussions are planned concerning the compilation of technical directory (TD) and the progress and status of formulating the database/benchmark/guideline (DB/BM/GL). Finally, FY2007 activities will close with the summary/post workshop.

Fig. V-2-1 FY2007 PROMEEC activity plan



3. Post Workshop

3.1 Progress on the creation of technical directory (TD)

A progress report was given on the creation of technical directory by ACE. So far, 75 entries have been registered in the TD for industry and 35 entries in the TD for buildings. The system is near completion, and information provision from ASEAN countries is awaited. An application form should be posted on the ACE web site to facilitate information provision by anyone visiting the web site. Manufacturers of energy conservation equipment and systems should also be cultivated as sources of information. These activities require sustainability and reliability, and the number of personnel and budget for them should be allocated in consideration thereof.

3.2 Progress on the creation of the in-house database/benchmark/guideline (DB/BM/GL)

A progress report was given on the creation of the database/benchmark/guideline for industry (cement industry) which ACE is working on, as well as an overview of the system.

One of project members posed a question concerning the significance of the database to companies, and presented his opinion that the system should be designed upon clarifying its benefits to companies. Another member stated that the significance should be clarified, because if companies do not comprehend the significance of the system, it would be difficult to gather data from them. Discussions concentrated on this issue, partly because not enough efforts were directed to this activity by ACE, and partly because the focal point (FP) did not possess a thorough understanding of the concept of the in-house database. FPs are consistently concerned about the significance of the database/benchmark/guideline as providing criteria and standards for implementing governmental policies, so it may be difficult for them to grasp the concept of the in-house DB. However, PROMEEC activities aim to create the database/benchmark/guideline from the standpoint of plant management, and the database is to be used for in-house energy management (thus it is called the in-house DB). It is important to have the plant understand that the data obtained through the audit are beneficial to plant management, and that energy management should be implemented based on continuous data collection and analyses. ECCJ also explained that one of the primary goals of PROMEEC activities is based on the principle of voluntarily disclosure of data via ACE's web site and sharing it among the ASEAN countries. At the same time, it appears necessary to reexamine whether the existing DB format (cement) contains items that correspond to the objectives of the in-house DB.

The creation of the database/benchmark/guideline is linked to PROMEEC's energy audit activities, which are conducted with an aim to promote OJT, seminar-workshop activities, and the awards system (ASEAN Energy Award), and has been clarified as a tool for promoting energy conservation in the ASEAN countries.

4. Attachments

(1) “ASEAN PROMEEC Summary/Post Workshop” (provided by ECCJ)

1 “Expected Status of PROMEEC Project in Asia and Cooperation by Japan”
2 “Summary of Local Workshops and Energy Surveys in Major Industries at Lao PDR, Thailand and Myanmar”
3 “Major Industry Proposed Plan in 2007-2008”
4 “Summary of Local Workshops and Energy Surveys in Buildings (2006-2007) at Brunei Darussalam, Philippines and Vietnam”
5 “Future Plan for PROMEEC- Buildings (2007-2008)”
6 “Results of Activities (Intensive Seminar-Workshops / Visits, etc.)”
7 “ASEAN Energy Management System –Updated Plan–”
8 “Plan of Award System of Best Practices in Energy Management for Industries & Building”
9 “Proposed Future Plan”
10 “Achievement and Future Plan”

(2) “ASEAN PROMEEC Summary/Post Workshop” (provided by ASEAN countries)

1 “PROMEEC (Industry) 2006 in Lao PDR”
2 “Overview of EE&C Activities in Myanmar”
3 “PROMEEC Thailand 2006 Steel Industry – Activities Summary”
4 “Status of Preparation of Technical Directory for Major Industries and Database for In-house Use by Industrial Sub-sectors in ASEAN”
5 “Finalized Plan of and Current Progress in Award System of Best Practices in Energy Management for Industries and Building”

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