2011 Achievement Report

International Project for the Development of Infrastructure for Rationalizing Energy Use

Project on Human Resources Development for Energy Conservation

(Project for the Promotion of Energy Conservation in Major Industries in ASEAN Countries)

Achievement Report

March 2012

The Energy Conservation Center, Japan

CONTENTS

I. Outlines of Project

ASEAN nations have experienced rapid economic growth, and current predictions are that the consumption of energy will also rapidly increase; consequently, the efficient use of the energy and the prevention of global warming will be necessary considerations. In this, the 12th year of the project, the activities of the relevant organization ACE, as part of the ASEAN nations, are more enhanced and more deeply rooted. The change in awareness has spread with regard to the reduction in energy consumption by all nations, which can be attributed to the recent rise in energy prices as a result of the escalation in oil prices and the enforcement of the Kyoto Protocol of February 16, 2005. The third year of Phase 3 has been regarded as the year for the enforcement of the protocol and the dissemination of past achievements by more self-reliant efforts, as well as the result of the integrated achievements of activities in the past 11 years. More specifically, the decision has been made to establish a platform to promote energy conservation and disseminate the achievements of a diagnosis of energy conservation conducted in the facilities across 10 business categories for all ASEAN nations in the past 11 years. In particular, the following activities were organized by the Philippines (semiconductors) and Indonesia (thermal power plants).

- ♦ Instruction in Energy Conservation Assessment
  Energy Conservation OJT by a specialist from Japan was provided at a facility that wanted the transfer of the technology for energy conservation assessment to the planners of energy conservation policies and to personnel involved in energy conservation assessment of the visited countries. We reported the results of the assessment of energy conservation to the relevant facilities for use in conserving energy in the future.
- ♦ Holding a Seminar or Workshop
  With the participation of personnel from the relevant facilities, including personnel from other industries and related facilities as well as government officials from other ASEAN nations, a seminar was offered where presentations were made regarding conservation activities, examples of improvements in disseminating successful examples, and sharing expertise with ASEAN nations.
- ♦ Introduction of Energy Conservation Technologies and High Efficiency Facilities in Japan
  This is a new enterprise this year. When the results of the assessment of energy conservation were reported to the facility or during the seminar and workshop, we introduced Japanese energy conservation technologies and high efficiency facilities as a contribution to the involved nations for the enhanced efficiency of the use of the energy.
  The Major Industry Project this year is as follows:

1? Services at site in Philippines: Oct. 10-14, 2011.

(1) OJT in the assessment of energy conservation took place in a semiconductor facility in Manila, the Philippines. The duration was only two days at the request of the facility. The assessment team was organized by the persons from the Ministry of Energy of the Philippines, and the engineers of the diagnosed facility accompanied then. The leadership was assumed by the engineer of the Ministry of Energy. Furthermore, and as a follow up diagnosis, visited the pharmaceutical plant diagnosed in 2009, and could confirm the satisfactory enforcement of energy conservation activities.

(2) Afollow up assessment was made on the pharmaceutical plant that had an assessment of energy conservation in 2009. The items that were identified for improvement last time were satisfactorily completed or in the planning stage; we were able to confirm satisfactory implementation of energy conservation activities.

(3) A total of 74 people participated in the seminar and workshop, and a constructive exchange of information was made through the presentations below and the conference.

? Presentations from the Philippines and Japan regarding energy conservation policies and programs.

? Presentation by involved parties from ASEAN nations on the example of implementation of energy saving

? Presentation by the site assessment team on the results of an assessment of energy conservation.

? As an attempt to introduce energy conservation technologies and high efficiency facilities from Japan, started for the first time this year, an introduction was made on the high efficiency refrigerator by Mitsubishi Heavy Industries Ltd., which belongs to JASE-World.

2? Services on-site in Indonesia: November 21-25, 2011

(1) OJT in the assessment of energy conservation was conducted at the national thermal power plant located in Jakarta, Indonesia, which uses natural gas. A site assessment team was organized by the engineers of the Ministry of Energy and Mineral Resources and of the relevant facility. The assessment of energy conservation was led by the engineers of the thermal power plant, and the staff members of the Institute of the national power company assumed a role in the seminar and workshop held on the last day.

(2) A total of 80 people participated in the seminar and workshop, including the participants from the national thermal power plants, in addition to the engineers above, and a constructive exchange of information was made through the

presentation below and the conference.

- ? Presentation by Indonesia and Japan regarding the energy conservation policy and its program.
- ? Presentation of the results of an assessment of energy conservation by the site assessment team.
- ? As the second introduction of energy conservation technology and high efficiency facilities from Japan, a presentation was made by an invited engineer from J-Power, an affiliated company of JASE-World, regarding the high efficiency operation of similar thermal power plant businesses in Japan.

To conclude, we would like to express our deepest gratitude for the full cooperation by the related organizations of various nations, ACE, and the personnel from the involved companies for this enterprise.

II. Philippines (semiconductor facility, etc.)

1. Outlines of Activity

Among the various projects for Structural Improvement for International Energy Use, a commissioned project of METI, to implement the Project for Promotion of Energy Conservation for the Major Industries in ASEAN Nations, we visited Manila in the Philippines from October 9th to 15th for OJT in the assessment of energy conservation for a semiconductor manufacturing facility and a follow up assessment of a pharmaceutical company, as well as to hold a seminar and workshop to exchange information among the persons from Industries in the Philippines and the ASEAN nations. A total of 21 engineers from the Ministry of Energy of the Philippines and the diagnosed facility, ECCJ, and ACE, participated in the energy conservation OJT of the semiconductor manufacturing facility. The satisfactory implementation of the items that were generally identified was confirmed in the follow-up assessment of the pharmaceutical facility that had been assessed in 2009. A total of 47 persons participated in the seminar and workshop and successfully completed it.

Members of the visit: Tsutomu Okamoto/ Technical Cooperation Dept., ECCJ
Taichiro Kawase, Kazuhide Kunitoku/ Technical Expert

Schedule of activity:

Oct. 10	Visit DOE & conference
Oct. 11-12	OJT Diagnosis (Semiconductor manufacturing facility A)
Oct. 13	Follow-up diagnosis (Pharmaceutical facility)
Oct. 14	Seminar and workshop

2. Energy Conservation OJT(Semiconductor Manufacturing Facility-A)

(1) Attendee: 26 persons

DOE (8 persons): Ms. Genevieve L. Almonares, Mr. Marlon Romulo U. Domingo, Mr. Maximino G. Marquez, Ms. R. P. Parreno Jn., Ms. Vilma P. Reyes, Ms. Rose V Sarulory, Mr. Darwin P. Galang, Ms. Einor P. Quinto

Facility-A (13 persons): President Takeo Kikuchi, Adviser Nobuyoshi Suzuki and others

ACE (one person): Mr. Junianto M

ECCJ (three persons): Tsutomu Okamoto, Taichiro Kawase, Kazuhide Kunitoku

(2) General description of the Facility: Facility-A

This is an affiliate facility of a semiconductor manufacturing company in Japan that started operation of the first workshop in 1997 and the second in 2007. The major product is a power semiconductor by purchasing semiconductor chips for the material for assembly into a semiconductor product, a so-called downstream semiconductor manufacturing facility.

On the first day of the visit and workshop, an explanation of the workshop and the outlines of CSR activities were made by the vice president. Then an explanation of energy conservation activities followed by the director of the facility. Additionally, this facility won the DOE Energy Conservation Prize of the Philippines in 2010 for its energy conservation program.

The number of employees is approximately 850, including 12 engineers. Major posts above the director including the president are occupied by Japanese. It is continuously operated for 24 hours with two shifts per day. Annual production is 35,660,000 pieces, power consumption 17.77 million kWh, equivalent to the scale of a type-1 designated energy management factory in Japan.

(3) General description of assessment

1) Members of the assessment team

Because there were only three to four OJT trainees from the DOE and one person from ACE, with the short duration of 1.5 days, grouping was not made, and the OJT on energy conservation was conducted with all members as one team. The team leader was Mr. Maximino G. Marquez / DOE. The assessment team consisted of total seven or eight persons including an engineer from the facility and three persons from ECCJ, including the OJT trainees above.

2) The procedure for assessment

"Due to the secrecy of the facility, it will not be possible to see the details." There was such anticipation from the e-mail communication between DOE and ACE regarding this activity; however, just after the greeting on the first day, the members became intimate enough to allow admission to all facilities except for the clean room, whose inside could be seen through the surrounding glass window.

We also received answers to the delivered survey slip before departure from Japan, which allowed us draft an assessment plan before starting site activities. It was confirmed that the core facility was excluded from the assessment of energy conservation, which was limited to the peripheral facilities, i.e., the diagnosis was limited to the thermal recovery facility, the drying facility, and the refrigerating facility.

In consideration of the restrictions of only 1.5 days for the OJT this time, the assessment was conducted along with the procedure; the interviews of the energy conservation program of the facility, the inspection of the workshop facility, the data gathering from the measurement using the measuring instruments and the record of operation, the data analysis and planning of energy conservation measures, and then the report of the assessment to the people of the facility.

3) Preparation of Measuring Instrument

A radiation thermometer from DOE, two contact thermometers from ECCJ, a hygrothermograph, a clamp on power monitor, a thermo camera, and a contact thermometer: total seven instruments were provided. Pre-instruction was provided on how to operate the instruments and on the points for use. With regard to the clamps on the power monitor, it was confirmed that special care should be taken, and the operation should only be made by an engineer from the workshop. All the prepared instruments were effectively used, and we acquired plenty of data. The thermometers were utilized for the measuring of temperatures around cold-water pumps, the cooling tower, and the AHU. The power meter was utilized for measuring the current of the motor for the pump.

For general facilities, a strong request was submitted to have an oxygen meter for combustion gas analysis and the hot-wire anemometer or Vane anemometer, in addition to the power monitor and the thermometer as the required measuring instruments. These are frequently used instruments and which are absolutely necessary for the assessment of combustion management and inverter control.

4) Measurement and Data Gathering

Guidance was made to OJT trainees in advance on the purpose of measurement, the items of measurement, the points of measurement, and the measuring instruments used. We also tried at the site to conduct the inspection while explaining the purpose of the inspection for each facility. Through this method, the points of OJT and the assessment were well disseminated to the trainees. Data gathering and data analysis were substantially conducted by the specialists from

ECCJ, mainly due to the restricted working time. Some part of the measuring work was conducted by the engineers of DOE and the workshop.

?)Diagnosis of Utility Facilities

(i) Water Supply Facility (including refrigerating machine)

(i) -1 Rough estimation of COP for No. 3 chiller

Generally, the performance of the cold-water chiller is estimated using COP, a performance formula defined as below:

Chiller COP = Chiller Cooling Heat (kW) / Chiller input power (kW)

= Carnot COP x Efficiency of Actual Cycle x Efficiency of Refrigerating Compressor

where,

Carnot Efficiency = (Evaporating Temp. of Refrigerant)/ (Condensation Temp. of Refrigerant – Evaporation Temp. of Refrigerant)

The temperature of each refrigerant was estimated using the measured surface temperature of each exit pipe of the evaporator/condenser because the direct measurement of the refrigerant evaporation/condensation temperature was not possible. As a result, the refrigerant evaporation temperature was estimated as 4 degrees Celsius, and the refrigerant condensation temperature as 50 degrees Celsius.

Carnot COP = (4+273)/((50+273)-(4+273)) = 6.0

Chiller COP (estimated) = 6.0 x 0.81 x 0.8 = 3.9

The difference in the Carnot COP and Chiller COP comes from the efficiency degradation by the expansion valve, ingress of heat into the refrigeration cycle, performance of evaporator, performance of condenser, and the efficiency of the compressor. The next step is the evaluation of COP (user COP) in relation to the cooling heat actually received by the cold-water user side. The user COP is given by the following equation. It was not possible to measure this due to the shortage of time.

User Cooling Heat (kW) = Cold Water Flow x Specific Heat of Cold Water x (Entry Temp of Cold Water –Temp of Returning Cold Water)

User COP = User Cooling Heat (kW) / Refrigerator Compressor Motor Input (kW)

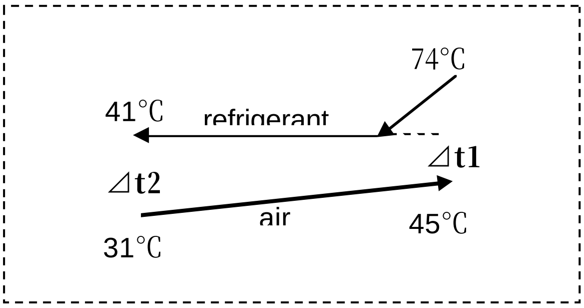
The difference of Chiller COP and User COP comes from the ingress heat of the cooling water pipe/pressure loss in the cooling pipe. We are awaiting the cause of the degradation of COP to be clarified and removed.

(i) -2 Evaluation of condenser performance

The heat exchanging performance of the condenser has a significant influence on the chiller COP. Lowering of condensation temperature of the refrigerant by one degree results in the rise of COP by 3%, i.e., the compressor power saving by 3% is possible. Then, it was decided to evaluate the heat exchanging performance of the condenser. Generally, the performance of the heat exchanger is evaluated as the difference of the log mean temperature difference (LMTD) of the high temperature fluid and the low temperature fluid

L MTD = (⊿t1 - ⊿t2) / ln (⊿t1 / ⊿t2)

w here, ⊿t1, ⊿t2 stand for the temperature difference of the two fluids at the entry and the exit of the condenser.

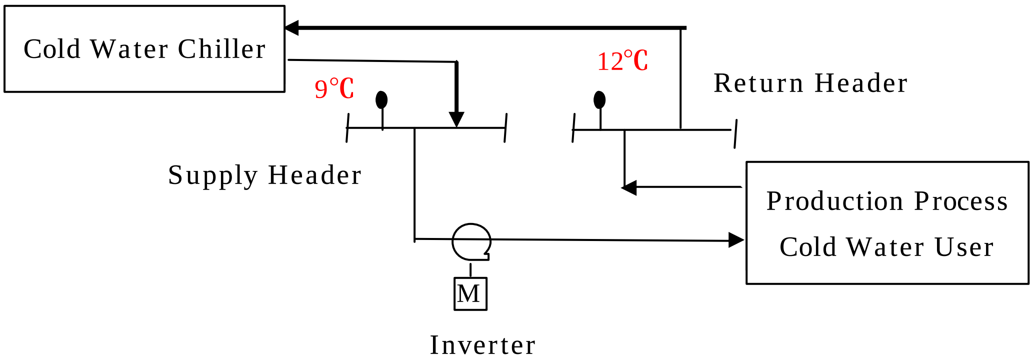


The measured condenser was the air-cooling type. The high temperature fluid was the refrigerant R410A, and the low temperature fluid was the air. The temperature of the high temperature fluid was estimated using the surface temperature of the entry pipe to the expansion valve (supposed to directly measure the fluid temperature). Meanwhile the temperature of the low temperature fluid was measured by the thermometer directly inserted in the airflow. The exit temperature of the low temperature fluid was 45 degrees Celsius, significantly exceeding 41, the entry temperature of the high temperature fluid. Because such a reverse phenomenon never occurs on the condenser, it was considered a measuring error. It was necessary to take the measurement again by changing the measuring point of the low temperature fluid, etc.

(i) -3 Improvement of chilled water pump efficiency at part load

Generally, it is possible to significantly save energy by lowering the speed of rotation, when the rotating machinery, such as the pump/fan, is operated with a low load. Especially for the centrifugal machinery, the energy saving performance proportional to the cube of the speed of rotation can be expected.

Then, it becomes necessary to know the load for the cold water pump. Because there was no in-line flow meter, the opening of the discharge valve was found fully open. Due to this, the cold water was regarded as flowing at the rated flow. Meanwhile, the measured temperature of the cold water supply and return at the cold-water header was 9 and 12 degrees Celsius, respectively. Normally the temperature difference of the cold water supply and return is designed as 5 degrees, then it was estimated that the cooling load at the process side was 3 degrees/5 degrees x 100 = 60% when measured; the loading was estimated at approximately 60%. Then, it can be argued that the flow rate could be reduced to 60% if the difference in the supply and return temperatures is increased to 5 degrees. If the inverter is to be implemented, the speed of rotation could be lowered to 60%. If the cold water is assumed to flow in a closed system, the power saving of the pump is roughly estimated as (1- 0.63) x 100 = 78.4%



(ii) Utility Water Facility

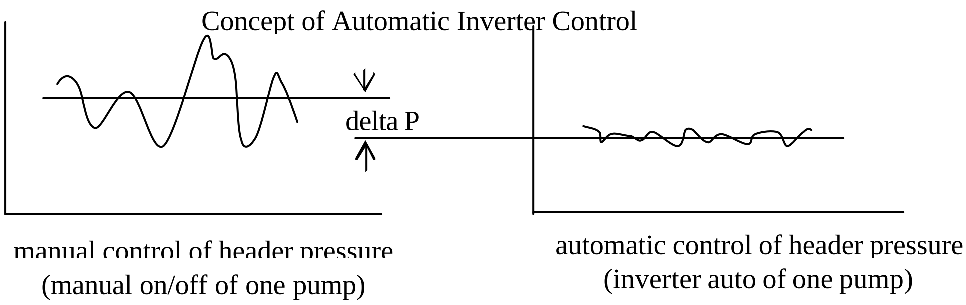
(ii) -1 Waste heat recovery to pre-heating RO feed water

The temperature control of material water did not apply to the Reverse Osmosis Membrane/RO equipment of this facility. Therefore, there was no need to use the exhaust heat of warm water or cold water. However, the temperature of the material water for RO equipment for the semiconductor facility in Japan is controlled to 24 degrees. This is to maintain the viscosity of water going through the RO film to the most appropriate figure. The recommendation then was for an exchange of opinions between ORGANO on the need for temperature control of the material water.

(ii) -2 Application of inverter to water pumps

Generally, the quantity of utility water varies corresponding to the demands of the process. This variation can be roughly grasped by recording the variation in the discharge pressure of the pump. Our recommendation was to record the variation both by day and season.

By adopting PID control using the inverter speed as an operational variable, the power for pump can be saved by controlling the discharge pressure of pump to a constant figure. The saved pump power can be estimated if the pressure variation and the flow are known, as below:



Calculation : kW saving = delta P(m) * Q(ton/min)/(6.12 * η)

(iii) Compressed Air Facility

(iii) -1 Reduce intake air temperature

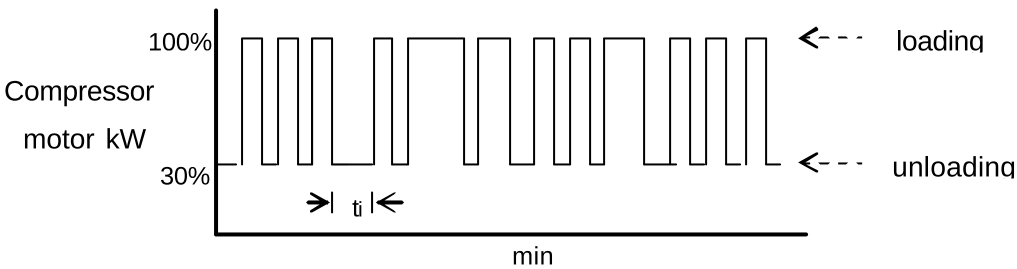
The required power for the air compressor is proportional to the absolute temperature of the suction air. If the suction air temperature drops from 20 degrees to 10 degrees Celsius, the required power will decrease by

((273? 20)? (273? 10))/(20? 273)x 100 = 3.4? .

The suction air was taken from the wall near the ceiling through the propeller fan in the compressor room of the first shop. It was the air at higher altitude over 5 m from the ground level and relatively lower temperature outdoor air.

(iii) -2 Reduce unloaded operation losses

The power is wasted during unloaded running of the air compressor for many facilities. Especially the screw type compressor will consume 30% of the rated power during the unloaded running. To quantitatively grasp the unloaded operation loss, the motor power for the compressor was measured every 5 minutes for 24 hours to calculate the percentage of unloaded time and estimated the energy loss;



Cumulative unloading time = Σti

To cut down the no-load operation loss, usually multiple operation of smaller machines or an inverter type compressor is employed. If multi-operation is adopted already, it is enough if only one set of machinery has the inverter function.

(iii) -3 Reduce pressure drop between air supply and end user

Compressed air is a costly utility. Normally, the pressure loss between the compressor room and the end user is designed to be 0.5 bars or less in Japan. For this purpose, countermeasures can be adopted to replace the small tube with larger ones, change the piping to a loop system, remove the bypass pipe, and minimize the number of pressure loss elements such as valves. This shop already adopted the loop type. The next step to be implemented is the measurement of the pressure at the end user. If it exceeds 0.5 bars or less, the measures above shall be adopted.

(iii) -4 Minimize air leakage

Air leakage test was already conducted at this shop, and achieved the cut down of compressor power.

(iii) -5 Reduce end-user's air pressure

The purposes of the compressed air at the end user of this shop are for the pneumatic cylinders and for air blowing. The required pressure for the pneumatic cylinders is 2–3 bars, and that for air blow is 1–2 bars. There is a possibility of reducing the supply air pressure at the compressor room from 6 bars down to approximately 4.5 bars. If there is a facility that requires a little higher pressure, for example 5 bars, a small increaser (booster) can be implemented to increase from 4.5 bars to 5.5 bars for the necessary quantity. By adopting this, the supply air pressure could be left unchanged as low as 4.5 bars.

(iv) Air Conditioner (Outdoor unit only)

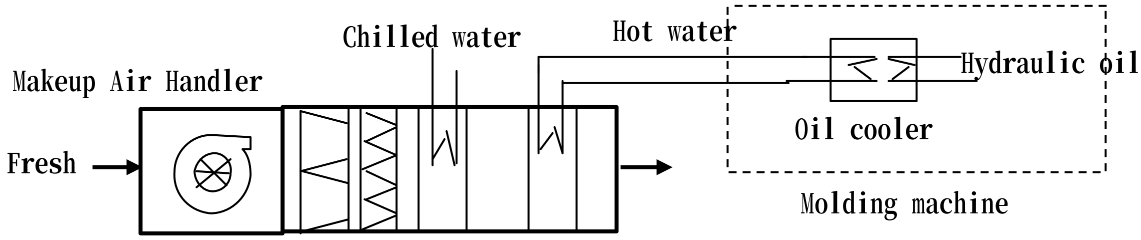
(iv) -1 Application of inverter to makeup air fan

Three Makeup Air Handlers/MAH are installed in the first shop for supplying the temperature/humidity controlled air to the many Recycle Air Fan Filter Units/RAFFU arranged along the side wall of the clean room. MAH has the outdoor air supply fan, which was operated with the constant speed using the commercial frequency of 60 Hz in the beginning. Now the speed is lowered using 45 Hz by an implemented inverter. However, even if the Hz is lowered, it is still constant speed operation.

The future subject is the implementation of variable speed operation with regard to the outdoor air conditions (temperature/humidity). By adopting this, it will be possible to conduct the energy saving operation with the lowered speed of fan during the dry season or at night when the latent heat load is low.

(iv) -2 Reduction of reheating losses

The first function of MAH is the dehumidifying of the outdoor air. For this purpose, it has both cold water and warm water coils to dehumidify the outdoor air by cooling, and after that, re-heating with the warm water coil. The exhaust heat from the molding machine (the hydraulic oil cooler) in the clean room is recovered as warm water as the heat source for re-heating. The steam is used as the heat source for the warm water coil in Japan, which raises the energy cost. This is an example of double energy savings that do not require steam and at the same time will decrease the air conditioning load for the clean room.



(iv) -3 Minimize air conditioning load in clean room

In the downstream process in the semiconductor facility, 45% of the energy consumption is required for air conditioning the clean room. Therefore, reducing the air conditioning load in the clean room has a direct impact on energy savings. In this shop, the measures for reducing the air conditioning load have already been implemented, such as the heat insulation on the high temperature surface in the clean room or the recovery of the heat generated from the hydraulic oil cooler for the warm water.

(iv) -4 Review the key operating conditions of clean room

For the clean room, the pressurizing, ventilation, and cleanliness classifications are very important conditions for operation for reducing the count of microparticles to a certain specified level. It is necessary to set the differential pressure with the next room to 0.03–0.05 H_2O. The airflow necessary for pressurizing is the function of the opening area of the clean room. The reduction of air flow will result in the energy saving: for this purpose the opening area such as the crack at the side wall/ceiling connection, through holes on the side wall for utility pipes/cables, differential pressure damper, etc. shall be minimized. For ventilation, the frequency of ventilation (air change) to maintain the cleanliness classification shall be satisfied. If it is the class 10,000, the recommended ventilation frequency is 60–120 times /hour.

If the cleanliness class is too strict, it will waste energy. It is necessary to relax the cleanliness class within the range where the product yield does not drop.

The assessment regarding the relaxing the operating conditions of the clean room was not taken up because the entrance in the clean room was not allowed at this OJT diagnosis.

(v) Other Knowledge

(v) -1 Energy Management Structure

According to the answer to the advance survey slip, the program for energy conservation of this facility has reached a high level. Specifically, the confirmation has been made on the assignment of the energy manager, implementation of monitoring/recording of energy data, the setting of energy reduction goal, development of medium/long term plan for energy conservation, active promotion of small group activity, and co-working together with the semiconductor group in Japan, etc.

The most impressive was the small group activities, which started from 2007 on the energy conservation activity by visualization: 64 groups (742 persons) have been organized now. The thorough implementation of turning off the lights not only in the office, passageway, and cafeteria, but also in the workplace, the partial use of light or turning off using a pull switch was observed.

(v) -2 Maintenance of Utility Facilities

In the shop building, a corridor surrounds the clean room in the center, and outside of it, AHU, storage house, office, and cafeteria are arranged. The cold water facility and the air compressor room are outside of the shop building.

The clean room and the corridor are well maintained, and the thorough management of energy such as turning off the lights was enforced. However, the AHU room and the cold-water facility (outdoors) were not well maintained. For example, the heat-insulated surface of the cold-water header (supply/return) was quite wet with water. Probably the water penetrated into the insurance layer, i.e., heat penetration occurred.

Besides that, it was supposed that the plate for the heat exchanger to recover the exhaust heat of the molding machine was contaminated, based on the measured data for temperatures. The overhaul cleaning was necessary because the deterioration was advancing on the heat insulation surrounding the heat exchanger. Also, the cold-water facility installed outdoors had advanced deterioration of the heat radiation fin. The time to change the heat insulation for the piping had come.

(v) -3 Energy Saving of Lighting Equipment

Thorough measures had been implemented for energy saving regarding the lighting. The introduction was made on management, such as turning off the lights, but also on the facility, and the various measures were implemented. For example, the introduction of ambient task lighting and the transition to the high efficiency fluorescence light/LED light was in progress. Besides that, it was reported that there was a plan to lower the height of the ceiling light for energy saving of general lighting.

(4) Data Analysis and the Simplified Report

On the last day, the results of the OJT assessment and problems were reported to the executives of the facility as a prompt report. This prompt report was presented at the seminar and workshop by Mr. Maximino Marquez, a member of the local team.

(5) Personal Comment

Due to the extremely short period of 1.5 days, the qualitative assessment became the core of the assessment of energy conservation of semiconductor facility A, which made me disappointed, because I excitedly made the pre-investigation report as an expert. The facility had an active small group activity. As soon as I stepped into the shop, I was strongly impressed by the cleanliness and the thorough implementation of blackout/brownout of the lights. It is undoubtedly the fruit of the visualization activity launched by the deputy vice president four years ago. Various measures for energy conservation are taken in this shop; however, those measures are weighted toward electrical energy. I think the optimum use of energy as a total shop should be pursued by integrating heat and electricity. Besides that, the maintenance of the utility facilities looked a little weaker as compared with the production facilities. Especially, AHU, the air compressor room, the outdoor cold water facility need replacement of the insulation and repair of the measuring instruments.

3. Follow Up Diagnosis

(1) Attendants: 12 persons

Department of Energy/ DOE (three persons): Mr. Maximino G. Marquez, etc.
Facility-B (five persons): Mr. De Leon / General Affairs Manager, etc.
ACE (one persons): Mr. Junianto M
ECCJ (three persons): Tsutomu Okamoto, Taichiro Kawase, Kazuhide Kunitoku

(2) The Point of Follow Up Investigation

An OJT assessment was made in 2009 in this facility. This time, the investigation was made on the status of implementation of the energy conservation measures that were suggested and instructed at the OJT last time.

(3) Result of Follow Up

The explanation was provided by the facility manager regarding the activities that took place after the follow up investigation last time. Out of 10 items, 8 items were already done, and 2 items were in progress, so the status was worthy of praise.

The major results are listed as below;

(i) Cooling Tower

Suggestion 1: To cut down the motor power of IDF fan by raising the cooling water supply temperature.

Status: Done. The temperature was raised from 31 to 32 degrees Celsius.

Suggestion 2: Implement the inverter for the cooling water pump.
Status: Installation under consideration

(ii) Chiller for Cold Water

Suggestion: Add a bypass pipe to the primary cold-water pump, and stop the primary pump.

Status: Done, however changed to the stop of the secondary pump.

(iii) Recovery in Boiler Room/Steam Supply

Suggestion 1: Recover the unrecovered condensate in Boiler Room/the second floor.

Status: Done

Suggestion 2: Repair of the defective steam traps

Status: Done. Ultrasonic leak test is conducted every half year. (Outsourced to Spirax Sarco Inc.)

(iv) Insulation

Suggestion: Repair of the deteriorated insulation of boiler room/the second floor.

Status: Done

(v) Compressed Air

Suggestion 1: Low pressure operation when the micronizer is stopped.

Status: Conducted as required

Suggestion 2: Change of compressor setting pressure

Status: Done. The pressure setting of the base machine has been changed to 115 psi/cutout, 105 psi/cut in

(vi) Sludge Treatment Equipment

Suggestion 1: Aeration control using the dissolved oxygen meter (DO meter)

Status: Done. Purchased the DO Meter and utilizing it for control.

Suggestion 2: Implementation of inverter for roots blower.

Status: Done. Utilized for aeration control together with DO Meter

(vii) Other Activities

Transition from T8 lamp to T5 lamp: 50% done.

Cleaning of AHU filter (backwash)

Re-use of the recovered reject water of CEDI

(4) Personal Comment

It was not possible to take the quantitative back up because the substantial survey time was only two hours. Though the technical difficulty level of the suggestions was not very high, its high execution rate looked commendable.

4? Seminar and workshop

(1)Date and Place

October 14, 2011 08:30 a.m. to 05:00 p.m.

Makati Palace Hotel 3F Convention Hall

(2) Attendants: 74 persons

A total of 74 persons joined including the administrative officials of the Philippine government such as ECCJ, ACE, DOE, etc. The lecturers were invited also from inside the Philippines, a variety of programs as a whole, and hot discussions continued until around 5:30 p.m. The outlines of the seminar were as below.

At the beginning of the seminar, Mr. Matanog M. Mapandi, assistant secretary of DOE, Mr. Junianto M, on behalf of ACE, and Mr. Okamoto, on behalf of the government of Japan, made the opening speech. In the address by ECCJ Mr. Okamoto, he expressed his gratitude for the support from various nations after the March 11 this year.

Shown below is a summary of the presentations made by each presenter at the seminar:

(3) Summary of the Presentation

SESSION I: Policies, Programs, and Initiatives on EE&C

(i) Overview of ASEAN EE&C Programs and APAEC 2010-2015

The introduction of ACE, the outlines of APAEC, the role of ACE in it, cooperation projects of (A) PROMEEC enterprise and MTPEC, (B) AEMAS with EU, and SOME-EU, (C) joint project with USA, award program, and other projects which are proposed by Korea and UNDP now by Mr. Junianto M from ACE. Among those, as a project with the USA, it was decided at the meeting in Hanoi, Vietnam in December 2011 to support the implementation of a labeling system and testing devices within the ASEAN area.

(ii) Overview of Energy Efficiency in the Philippines

The presentation was made on the prediction of departmental energy demand of the Philippines and the Action Plan from this year until 2030 by Ms. Genevieve L. Almonares/Science Research Specialist of DOE, Energy Efficiency and Conservation Division.

(iii) Japan's EC Policy and Measures and EE&C Experiences

In the beginning, PPT material was presented regarding the support from each country after March 11, the description of the extent of damage, and the location of the Fukushima Daiichi Nuclear Power Station. Then the presentation followed regarding the energy conservation policy of Japan and the energy conservation experience in the industry as below:

- ? The trend in Japanese energy use record, and a comparison of each sector between the countries.
- ? The history of energy conservation policies in Japan
- ? How Japanese companies are working on energy conservation.
- ? Top Runner Program
- ? How to access the AEEC website for checking excellent examples and the introduction of those examples.

(iv) Results of OJT Energy Audit at Wacky Corporation

The presentation was made on the results of the energy conservation OJT on a semiconductor manufacturing facility by Mr. Maximino G. Marquez/DOE. The presentation of the company was made with the name Wacky Corporation, and the comment from Mr. Maximino was added to the last page of the PPT material prepared by the two experts, Mr. Kawase & Mr. Kunitoku (ref. Material – A)

(v) Energy Management Practice

The introduction was made by Mr. Christopher T. Bellaflor regarding the examples of the Toshiba semiconductor manufacturing facility, which received the two awards for ASEAN Best Energy Management Practice and ASEAN Best Special Energy Project. In the presentation, this facility was certificated as No. 2 under the AEMAS Gold Standard in August this year. An introduction was made on the termination of the use of three low efficiency refrigerators, new construction of a high efficiency water-cooling refrigerator, and the integration of refrigerator piping, the adoption of LED lights, the chemical cleaning of cooling water piping, the recovery of exhaust heat, and the improvement/small group activities regarding management.

(vi) Energy Conservation activities of semiconductor manufacturers in Japan

The presentation was made by the expert Mr. Kunitoku/ECCJ on the example of the cut down of standby electricity and the application of the inverter to the fan and motor, which received the award in Japan as the most excellent example of energy conservation. Besides that, useful measuring instruments were explained using a PPT presentation “Recording Instrument in EC activity.”

(vii) Training plan for energy management personnel

The explanation was provided by the President Mr. Bernard E. Pacia, Energy Efficiency Practitioners Association of the Phils., Inc./ENPAP, regarding the outlines of energy management, the training and certification system of the energy consultant in Philippines.

SESSION III: The Way Forward

(viii) Updates on the Development of PROMEEC EM Tools

The explanation was provided by Mr. Junianto M/ACE, regarding the status of development of the technical directory, in-house database, and ASEAN Energy Management Service and System.

SESSION IV: EE&C Technologies

(ix) Japanese State-of-the-Art Smart Energy Products

As an introduction to a high efficiency product in Japan, Mr. Okamoto/ECCJ introduced JASE-World, and as an example of technologies, a demonstration and an explanation was provided on how to access the Centrifugal Chiller of Mitsubishi Heavy Industries, Ltd. Then, the high efficiency large scale refrigerator of Mitsubishi Heavy Industries Ltd. was explained using the PDF file "MHI High-Efficiency Centrifugal Chiller" (Attachment-B) from Refrigeration Systems of Mitsubishi Heavy Industries Ltd., and its supplemental PPT material "Supporting Technology for High Efficiency Operation of Chilled Water Supply system" (Attachment-C), which was prepared by extracting information from the Mitsubishi Heavy Industries Technical Review. This is a newly started item this year. Initially it was planned that the presentation would be made by a specialist from Mitsubishi Heavy Industries Ltd. (MHI) regarding the High-Efficiency Centrifugal Chiller; however, he could not come due to the sudden cut down of the time schedule, then a specialist of ECCJ took over it on a short notice.

The seminar was closed with the greeting by Ms. Evelyn N. Reyes, Director, Energy Utilization Management Bureau/DOE

(4)Personal Comment

When an expert from ECCJ made a presentation using a real measuring device, questions were asked by the attendants who showed great interest in the real device. The presentation using a real device worked well. Additionally, it can be said that, as a business related presentation, the explanation on how to make a contact regarding the High-Efficiency Centrifugal Chiller of MHI using PPT material for introduction of the Website prepared by JASE-World was meaningful.

Additionally, the time schedule was changed from the plan made by the Inspection Workshop. The plan was to invite an expert from outside ECCJ to offer meaningful information to ASEAN nations, however as explained above, the invitation was not possible. I assume that it was a loss of a very valuable opportunity for this country. I hope FP will initiate closer coordination of the time schedule etc.

Pictures of Activities: PROMEEC Industrial Enterprise @Philippines


2011-10-10 Lecture by an expert at DOE


2011-10-10 Diagnosis by an expert at a facility


2011-10-11 OJT members at Assessment of energy conservation, the 2nd day.


2011-10-14 Opening address of Seminar


2011-10-14 Attendants to the seminar


2011-10-14 Presentation by an expert at the seminar

Attachment (omitted)

Ⅰ: Assessment of energy conservation

1. Briefing of OJT Energy Audit for A-Facory
2. Presentation of Energy Conservation activities of semiconductor manufacturers in Japan
3. Briefing of Follow-up Survey at Amherst Laboratory

4. Tentative Power Recording for Energy Audit
5. FEP ENERGY AUDIT
6. Reply Questionnaire (final)
7. Briefing of OJT Energy Audit
8. Diagnosis Report of A-Facory OJT Diagnosis and B laboratories Follow Up
9. Result of OJT Energy Audit at A-Facory
10. Initial Findings and Recommendations
11. Briefing of Follow-up Survey at B Laboratory
12. Progress in Implementation for proposal of 2009 OJT Audit

Ⅱ: Seminar / Workshop

1. PROGRAM OF ACTIVITIES
2. Overview of ASEAN EE&C Programs and APAEC 2010-2015
3. Overview of Energy Efficiency in the Philippines
4. Japan's EC Policy and Measures and EE&C Experiences
5. Results of OJT Energy Audit at Wacky Corporation
6. ENERGY MANAGEMENT PRACTICE
7. Presentation of Energy Conservation activities of semiconductor manufacturers in Japan
8. Recording Instrument in EC activity
9. Training plan for energy management personnel
10. Updates on the Development of PROMEEC EM Tools
11. Japanese State-of-the-Art Smart Energy Products & Technologies
12. MHI High-Efficiency Centrifugal Chiller
13. Supporting Technology for High Efficiency Operation of Chilled Water Supply system

Material A: Results of Energy Audit OJT at Wacky Corporation

PROMEEC for Major Industries in Manila, Philippines

Result of OJT Energy Audit at Wacky Corporation

11-12 Oct., 2011

ECCJ Advisory Group

Tsutomu Okamoto/Kazuhide Kunitoku/Taichiro Kawase

DOE

Maximino /Elinor/Darwin

ECCJ

1

Schedule of Energy Audit

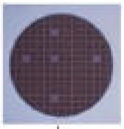
10/11(Tue)	Briefing of energy audit Expectation of factory towards energy audit Confirmation of reply to questionnaire Site tour & focusing Measurement & data collection
10/12(Wed)	Measurement & data collection (continued) Discussion & recommendation

Added

Semiconductor Manufacturing Factory

Upstream processes

Circuit design → photo mask → patterning on wafer → photo resist → etching → ion bombard ⇒ aluminum electrode ⇒ wafer test



Downstream processes

Wafer dicing ⇒ chip mounting ⇒ wire bonding → mold packaging → trim & form → burn-in → reliability test → product

2

Target Facilities

Utility Plants

(Boiler & Steam System)

Refrigeration & Air-Conditioning System

Water Supply System

Compressed Air System

Production Processes

Clean Room

Ventilation System

Air Conditioning Load (thermal load)

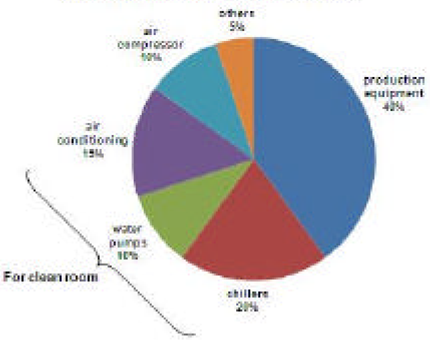
Other Facilities

ECCJ

4

Breakdown of Electricity Consumption

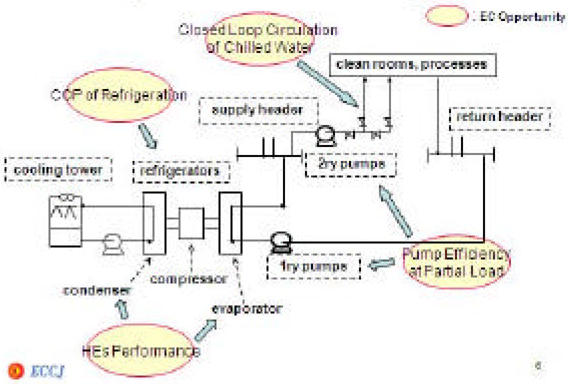
(Semiconductor Downstream Processes)



5

Refrig

Refrigeration & Chilled Water System



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6

Comments

(1) Rough Estimation of COP for Chiller No.3

Condensing temp, tc = 50℃
(assume that tc is 5℃ higher than temp of air leaving the condenser)
Evaporating temp, te = 4℃
(assume that te is 5℃ lower than temp of CW leaving the evaporator)

∴ $COP_{carnot} = (4+273) / ((50+273) - (4+273))$
$= 6.0$
$COP_{estimated} = 6.0 \times 0.81 \times 0.8 = 3.9$

Next step : calculate COP_{actual}, then compare with $COP_{estimated}$
$COP_{actual} = Qcw \times Cpw \times (tcwin - tcwout)$ @evaporator

7

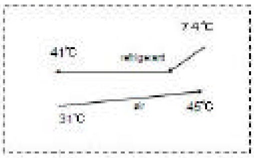
Comments

(2) Evaluation of Condenser Performance

Condenser type : Air cooled

Temp of air leaving condenser (45℃) is higher than refrigerant temperature (41℃). It is impossible.

There is some error in measurement.



8

Comments

(3) Closed Loop Circulation of Chilled Water

Plant introduced a closed system at the design stage.

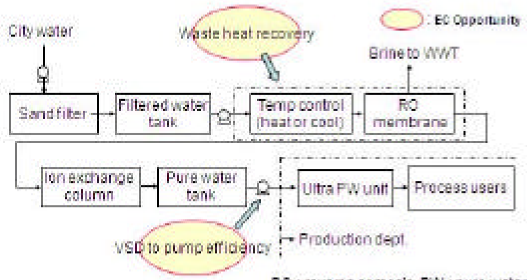
(4) Improvement of CW pump efficiency at part load

CW supply temp : 9℃, return temp : 12℃
⊿(supply – return) = 3℃
Generally, ⊿temp is designed to be 5℃.
Small⊿ suggests that process side cooling requirement may be lower than designed value.
In other words, CW rate may be over-sized, compared to actual requirement.
By introducing an inverter into the CW pump, pump power may be reduced.
In addition, an inverter contributes to energy saving at part load operation.

9

Water Supply

Water Supply System



RO : reverse osmosis, PW : pure water

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10

Comments

(1) Waste Heat Recovery to Pre-heating RO Feed Water

In Japan, RO feed water is temperature-controlled typically at 24℃, for the purpose of keeping optimum viscosity of water flowing through RO membrane.
This plant, RO feed water is not temperature-controlled.
RO unit was supplied by Japan's Organo, water treatment facilities supplier.
Discussion with supplier is recommended concerning a necessity of feed water temperature control.

11

Comments

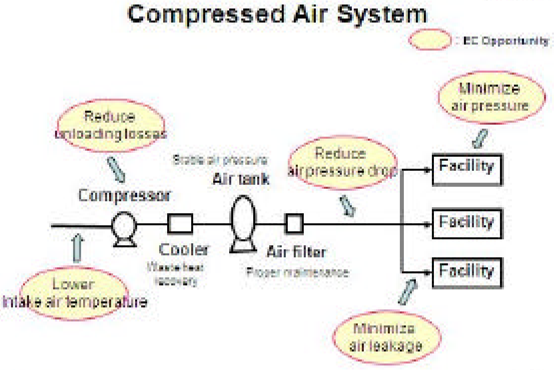
(2) Application of Inverter to Water Pumps

VSD, typically inverter, improves pump efficiency at part load, and for over-sized pumps.
Before introduction, investigate an extent of load fluctuation, from the standpoint of daily change, seasonal change.

12

Compr Air

Compressed Air System



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13

Comments

(1) Lower Intake Air Temperature

$$L = \frac{\kappa}{\kappa-1} \times R \times Ts \times \left[\left(\frac{Pd}{Ps}\right)^{\frac{\kappa-1}{\kappa}} - 1\right] \times \frac{\varphi}{\eta ad \times \eta t} \quad (kW)$$

Required compressor power, L is proportional to suction temperature Ts (absolute temp, degK)
This means that the lower temperature of air, the less energy consumption of compressor power.

In the compressor house of factory 1, outdoor air is in-taken through the window near the roof. Air at the higher place is relatively cool, and suitable as an intake air of compressor.

14

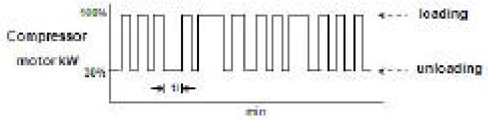
Comments

(2) Reduce Unloading Losses

Approximately 30% of power is wasted during unloading operation

→ Study on/off operation, or larger air tank,

or inverter-controlled compressor



Cumulative loading time = Σti

Next Step : Measure a fraction of unloading time per day

Comments

(3) Reduce Pressure Drop between Air Supply and End User

In Japan, pressure drop is designed to be less than 0.5 bar.

In order to do that, the following measures are taken:

- replace with a large-size piping
- loop air distribution system
- remove a detour route of piping

Plant has already introduced loop system.

As the next step,

- measure end-of-pipe pressure
- introduce the above-mentioned measures

Comments

(4) Minimize Air Leakage

Plant has already performed air leakage test, and implemented air leakage measures.

(5) Reduce End-user's Air Pressure

- Operated frequently at the air pressure higher than required
- Required air pressure :

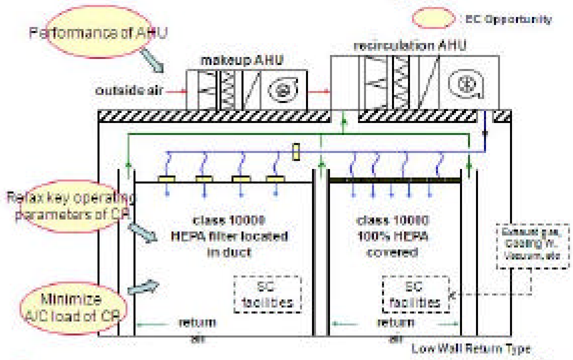
  Air cylinder 2 – 3 bar (most cases), confirm req'd pressure

  Air blow (water removal) 1-2 bar
- Study air booster :

  for user which consumes small amount,

  but requires high pressure (for example, 5 bar)

Clean Room Air Conditioning System



Comments

(1) Application of Inverter to Makeup Air Fan

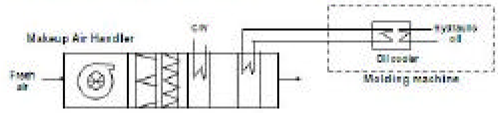
→ The inverter has been introduced, and the frequency of fan motor current has been decreased from 60 Hz to 45 Hz.

Comments

(2) Reduction of Reheating Losses

→ Make-up air handler (MAH) has a heat recovery coil, through which hot water flows. Hot water is heated by hot hydraulic oil of the molding equipment in the clean room, and then heat is released in the hot coil to reheat the cool dehumidified air in the MAH.

→ **This is very smart heat recovery measure,** because it eliminates reheating by steam and remove heat load of the air conditioning.



Comments

(3) Minimize Air Conditioning Load in CR

Plant has already insulated the hot surface of process equipment.

It greatly contributed to a reduction of air conditioning load in the clean room.

Comments

(4) Review the Key Operating Conditions of CR

a. Lowering pressurization pressure

⇒ Recommend ⊿P (from neighboring room) 0.03-0.05 inwg

→ Minimize openings in CR (cracks in wall/ceiling joints, penetrations of cables & utility lines)

b. Lowering air change rate

→ Examine a relationship of air change vs cleanliness

c. Review of cleanliness → avoid excessive cleanliness

This was not examined in the audit, because of time availability.

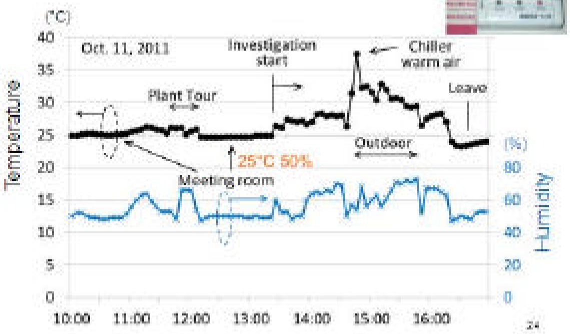
A Comment on your EC Activities

- Remarkable results were obtained with maximum efforts and minimum cost.
  - Lighting, Inverters, Thermal isolation,......
- All employees are involved in the EC activities.

It's very difficult for us EC experts to make good recommendations at such a excellent plant.

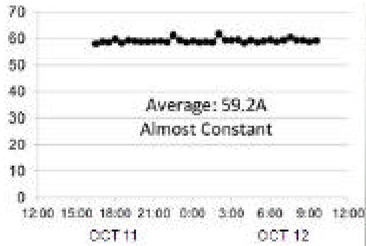
23

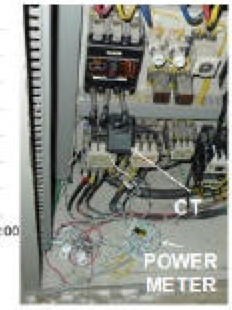
Thermo Recorder data



24

Pump Current measurement





Motor Input Power
= 1.732 x 220V x 59.2A x 0.85(PF) = 19.2kW

25

F1 Chilled water pump #3

	observed	specification	guesses
Chilled water temp	9-12degreeC	7-12degreeC	low load
pump flow		1,694L/min	>1,694L/min
total head	(total head 20m)	35m	low total head
pump in/out pressure	0-2kg/cm2		
moter output power		19.5kW	17.3kW (90%)
moter input	19.2kW		
flow ajustment valve	fully open		

Thermal load is low.
Chilled Water Flow is high.
Chilled Water Flow can be decreased.
If the Flow is decreed 20% using an inverter,
the power will be decreased.
P2=P1x0.8x0.8x0.8/0.95 (inverter efficiency: 0.95)
=19.2kWx0.54=10.3kW 46%reduction

26

Recommendation list

Target	Observation	Recommendation	Guessed Effect
Chilled Water Pump#3	Thermal load: small CW Flow: too much	Inverter adoption flow 80%	19kW --> 10kW
RO pump (F1)	Intermittent operation	Inverter adoption Continuous OP.	4kW --> 20%reduction
Meeting room Temp./Humid.	25°C 50%	1 degee up	3-6%% A.C. power reduction
Key parameter monitoring	not perfect	monitor and control	

Your EC activities would be a very good model in Philippines.

27

27

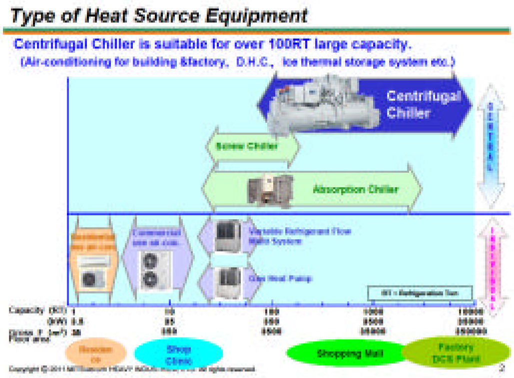
ECOs Recommendation

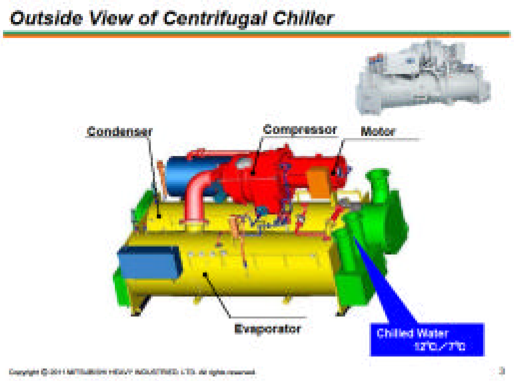
1. Overall Plant's performance
2. Lighting Fixtures Re-arrangement
3. Re-painting of walls and ceilings of old manufacturing area
4. Replacement of old luminaires including inefficient lamps
5. Installation of anti-heat coating glass partitions and glass windows
6. Insulate refrigerant pipings
7. Provide protection to outdoor condenser
8. Consider motor replacement with high-efficiency motors
9. Provide single switch to lighting and exhaust fan in the restrooms of male and female.
10. Installation of Facilities Energy Management System

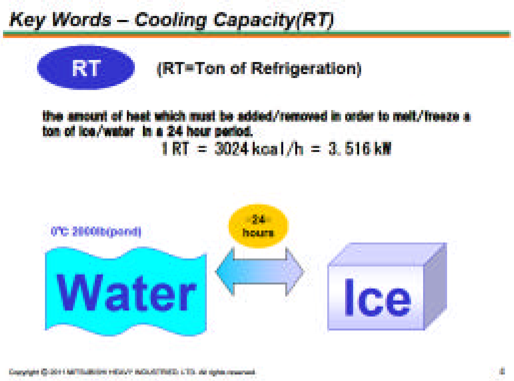
ECCJ

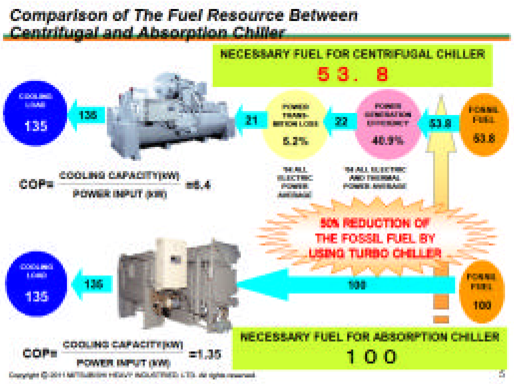
28

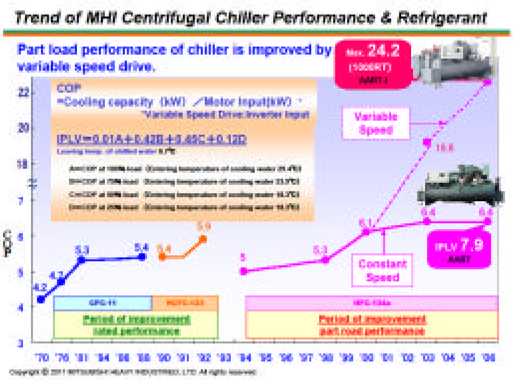
Material B: MHI Promotion Document

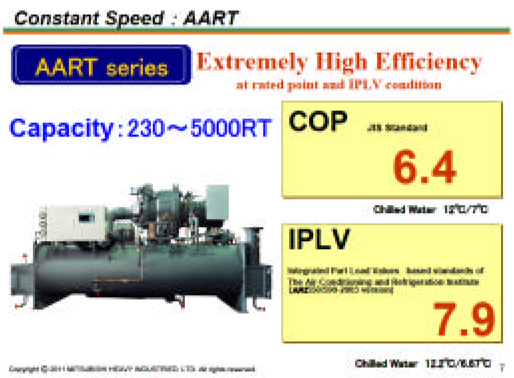


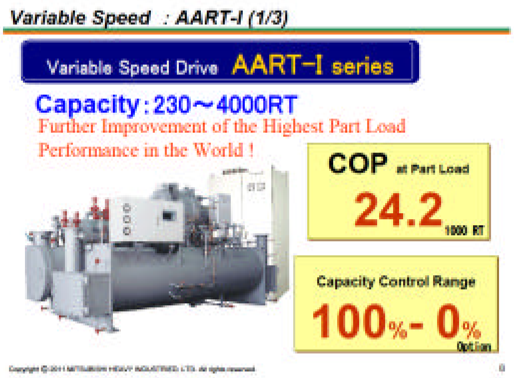


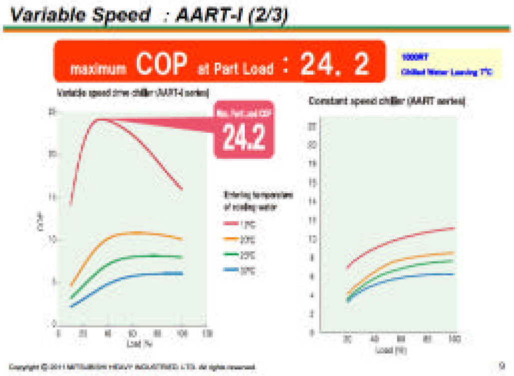


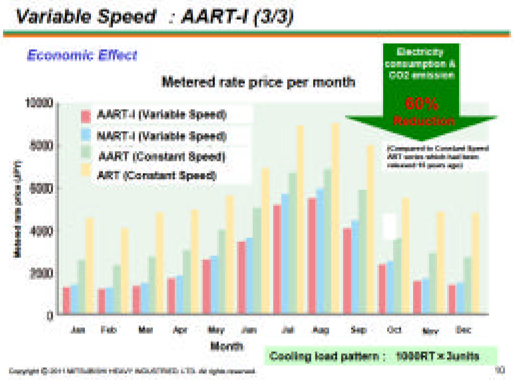


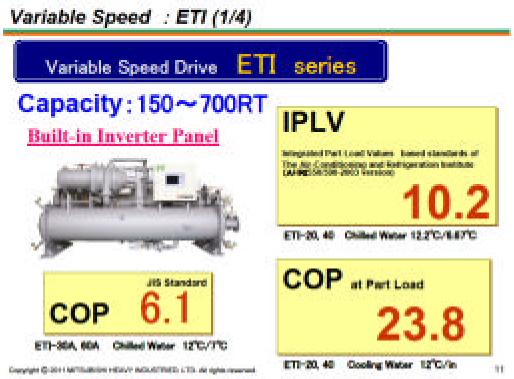


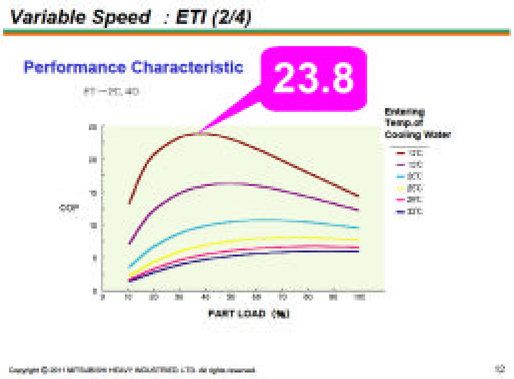


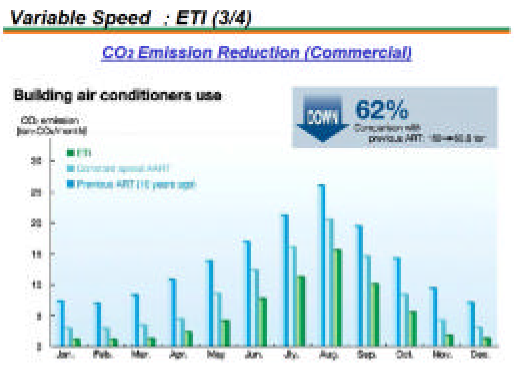


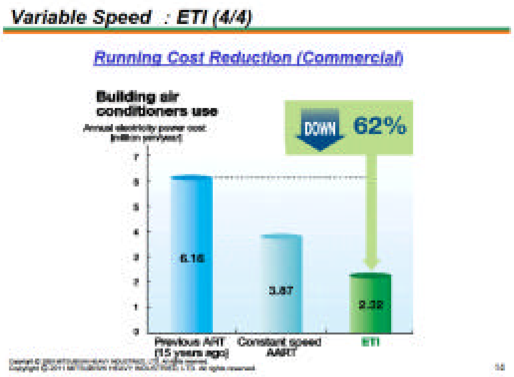

Variable Speed : AART-I (2/3)
maximum COP at Part Load : 24. 2
Variable speed drive chiller (AART-I series)
24.2
Constant speed chiller (AART series)
Entering temperature of cooling water
Load (%)


Variable Speed : AART-I (3/3)
Economic Effect
Metered rate price per month
Electricity consumption & CO2 emission
60% Reduction
AART-I (Variable Speed)
NART-I (Variable Speed)
AART (Constant Speed)
ART (Constant Speed)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Cooling load pattern : 1000RT×3units


Variable Speed : ETI (1/4)
Variable Speed Drive ETI series
Capacity : 150～700RT
Built-in Inverter Panel
IPLV
10.2
ETI-20, 40 Chilled Water 12.2℃/6.67℃
COP
JIS Standard
6.1
ETI-30A, 60A Chilled Water 12℃/7℃
COP at Part Load
23.8
ETI-20, 40 Cooling Water 12℃/in


Variable Speed : ETI (2/4)
Performance Characteristic
23.8
Entering Temp.of Cooling Water
COP
PART LOAD (%)


Variable Speed : ETI (3/4)
CO2 Emission Reduction (Commercial)
Building air conditioners use
DOWN
62%
ETI
Constant speed AART
Previous ART (15 years ago)
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jly.
Aug.
Sep.
Oct.
Nov.
Dec.


Variable Speed : ETI (4/4)
Running Cost Reduction (Commercial)
Building air conditioners use
DOWN
62%
6.16
3.87
2.32
Previous ART (15 years ago)
Constant speed AART
ETI

Supporting Technology for High Efficiency Operation of Chilled Water Supply system

From MHI Technical Report Vol. 48 No.2(2011)

- Real-time Display of Achievable COP
- Total Operation Controller for Chilled Water Supply System

1

Real-time Achievable COP Display

Achievable COP is usually different from the rated COP because operation condition is different from the rated one.

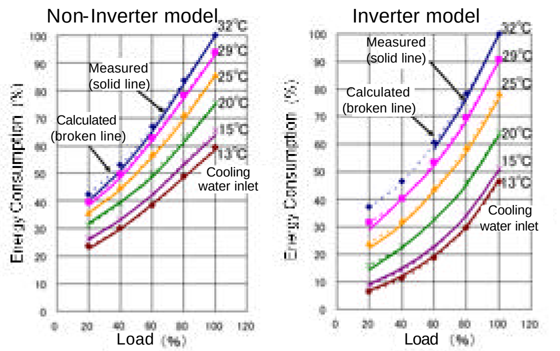
If Achievable COP and Measured COP are known, they help to keep high efficiency operation.

Real-time Achievable COP calculation method was established for both Inverter model and Non-inverter model.

2

Accuracy of COP Estimation

Deviation of Calculated COP and Measured COP is less than 3%



3

Total Operation Controller for Chilled Water Supply System

“Ene-Conductor”

It controls

- Chiller unit On/Off and Load allocation
- Chilled Water Flow
- Cooling Water Flow
- Cooling Tower Fan Speed

In order to maximize

Total System Efficiency

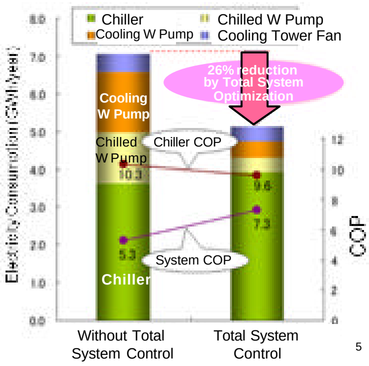
4

Simulation Results

Simulation Condition

Centrifugal Chillers (Inverter)	No of units	3
	Capacity	1000USRt
	Rated COP	6.1
Cooling Towers	No of units	3
	Fan Power	2 x 7.5kW
Chilled Water Pumps	No of units	3
	Input Power	2 x 37kW
	Pump efficiency	75%
Cooling Water Pumps	No of units	3
	Input Power	2 x 45kW
	Pump efficiency	0.75

Location: Japan



5

Ⅲ? Indonesia(Thermal Power Plant)

1? Outlines of Activities

During November 21–26, the group visited Jakarta/Indonesia for execution of an Energy Conservation Project, conducted the assessment of energy conservation OJT of a thermal power plant, and sponsored a seminar and workshop aiming at information exchange with the related persons from industries in Indonesia and ASEAN nations. Attendants to the diagnosis OJT were 6 persons from the central government, 16 people from the thermal power plant to be diagnosed, 3 experts from ECCJ, and 2 engineers from ACE: at total of 27 persons attended. For the seminar and workshop, a total of 80 persons attended from the local industries and involved people from ACE & ECCJ, in addition to the attendants above.

Member Tsutomu Okamoto/Technical Cooperation Division of ECCJ, Sadao Higaki,
Hirokichi Takeda/Technical Expert

Schedule of Activities	Nov. 21- 24	Diagnosis OJT and the report of its result
	Nov. 25	Seminar and workshop

2? Facility Assessment of energy conservation OJT (Thermal Power Plant B)

(1) Attendants for the first day of diagnosis: 32 persons

- Member (6 persons): Ms. Ani, Ms. Dewi, Mr. Dedi Suntoro, Mr. Andriyanto
  Ms. Endang Widayati, Mr. Sonden Winarto
- PT PLN HQ (4 persons): Mr. Basuki Siswanto, Ms. Tiva Winahyu DH
  Mr. Alsusilo Handoko, Mr. Arif Susetyo
- Thermal Power Plant B(10 persons): Mr. Rizki Dwi Kusworo, Mr. Arief Teguh and other members
- PT PJB / excluding Thermal Power Plant B (4 persons) & others (3 persons)
- ACE (2 persons): Mr. Pham, Mr. Bernard,
- ECCJ (3 persons): Tsutomu Okamoto, Sadao Higaki, Hirokichi Takeda

(2) Outlines of the Facility Thermal Power Plant B

Thermal Power Plant B belongs to PT PLN/PERSERO, a national power company of Indonesia, whose total power generation capacity is 1,650 MW. It has nine power generation units now, and two units of them (No.4 & No.5) are for steam power generation, and the rest of the seven are gas turbines for combined cycle power generation, a modern power plant as a whole. It started operation in 1981, and its initial generation facilities were supplied by GE, and however Mitsubishi Heavy Industries Ltd. took over all its new installation, revamping, and rehabilitation. The table below shows the power generation capacity and the list of generators in the facility.

For information, the power generation facility subjected to the assessment of energy conservation OJT this time, was the No. 5 power generation facility built by MHI in 1982 in the table below. It is a normal circulation water-tube type boiler of evaporation speed 636 t/h, and gas / heavy oil combined combustion, combined / extracting / re-heating / condensing turbine with the power generating capacity of 200 MW.

The personnel organization of the power plant is seven managers for operation, maintenance, shift, human resources, engineering etc., and a general manager (Plant Chief) above them. Those facilities built before 2000 are called “Block 2” and operated with 10 personnel per shift, a total of 300 employees work in the whole power plant; and the affiliate / subcontracting companies, other than that.

Year of Installation	Total Generating Power/Type	Power Generation Capacity x Number of Units	Fuel	Supplier of Main Equipment
1982	400 MW/ STG	200 MW/ST x 2	Gas ? Heavy Oil	MHI, MELCO
1993	500 MW/ CCGT	107 MW/GT x 3 + 185 MW/ST x 1	Gas	GE
2010	750 MW/ CCGT	270 MW/GT x 3 + 70.6 MW/ST x 3	Gas	MHI, MELCO

(STG: Steam Turbine Generator, CCGT: Combined Cycle Gas Turbine)
(MHI: Mitsubishi Heavy Industries, Ltd, MELCO: Mitsubishi Electric Corp.)

(3)Outlines of Diagnosis

1) Member of Assessment team

From the attendants listed above, 16 persons participated in the assessment of energy conservation OJT, excluding experts from ACE and ECCJ. It consisted of four persons from MEMR, three from thermal power plant B, six from the national power company other than the thermal power plant B, and three from other parties. The 16 persons were divided into two groups for the assessment of energy conservation OJT on the thermal energy facility and the electrical energy facility. A leader and a secretary were selected from each group. Staff of thermal power plant B was selected for the leader for each group. A doctor from the research institute of the national power company was selected as the reporter for the seminar on the last day.

2) Procedure for Diagnosing

The diagnosis was conducted in accordance with the following procedures: the hearing of the energy conservation activities of the facility, inspection of the shop facility, measurement using the measuring instrument and the data collection from the record of operation, data analysis and planning of energy conservation measure, and reporting the result of the diagnosis to the related people in the facility. At each point of diagnosing work, the meaning of each work was explained to the attendants; and the midway data analysis was made, and the process of data analysis was explained and instructed. In order to ensure the interactive explanation and instruction, ingenuity was made by explaining to the attendants in front of a whiteboard to measure and record by the attendants themselves.

3) Measuring Instrument

The instruction was provided for the six measuring instruments from Japan regarding the purpose and methods of taking measurements. At the practical measuring, an expert showed an example of measuring, and then let the attendants measure and record it.

No.	Name of Instrument	Manufacturer, Type No., Spec.	Purpose
1	Thermo Camera	NEC AVIO Infrared Technologies Co., Ltd. Type No.: F30W Spec.: Measuring Temp.: -20? 350?	Measuring the surface temperature of machinery, piping, etc.
2	Contact-type thermocouple thermometer	TESTO Type No.: 905-T2 Spec.: Range: -50°C to 350?	Measuring the surface temperature of machinery, piping, etc.
3	Radiation Thermometer	CUSTOM Type No.: IR-303 Spec.: Range: -55°C to 350?	Measuring the surface temperature of machinery, piping, etc.
4	Ultrasonic Leak Detector	EXAIR Type No.: ULD Spec.:Detect the leakage of compressed air, etc. as far as max. 6.1 m away.	? Checking the leakage of compressed air ? Checking the operation of steam trap
?	Listening Rod	A long screw driver was used.	Checking the operation of stem trap
?	Luxmeter/ Thermometer/ Hygrometer/ Anemo-multi-meter	Manufacturer: MK Scientific Corporation Type No.: LM8000 Spec.: Temp. Range: 0°C to 50ºC Humid. Range: 10% to 90%RH Lux. Range: 0–20,000 Lx	? Checking the Air Conditioning ? Checking the Lighting

4) Facility Subjected to the Energy Conservation OJT

The number 5 power generation facility, which was subjected to the energy conservation OJT diagnosis this time, is equipped with a normal circulation water-tube boiler, which mainly uses heavy oil as fuel, but also natural gas can be combusted. However, when the OJT was made, only the heavy oil was used. A combined/extracting/re-heating/condensing turbine, the startup was in 1982, the manufacturer was Mitsubishi Heavy Industries, Ltd. The design conditions, and the operating conditions at the OJT diagnosis with ( ), are indicated as below;

Steam Generation: 636 t/h (624 t/h)

Steam Temp. /Pressure of Turbine: 12.65 MPaG/538℃ (127 MPaG/541℃)

Output of Steam Turbine Generator: 200 MW (201 MW)

5) Contents of Assessment of energy conservation OJT

Due to time restrictions, the following was focused on as the contents of the instruction of assessment of energy conservation at this power plant.

(i) The calculation of the efficiency of boiler, the efficiency of steam turbine generator, and the total efficiency of power plant facility

(ii) Confirmation of lagging/insulation status of machinery and piping

(iii) How to check the operation of steam traps

(iv) Compressed air system for control

(v) Illumination inspection of lighting equipment by sampling

(vi) Other electrical equipment

6) Result of Assessment of energy conservation OJT

(i) -1 The instruction for calculation of boiler efficiency, the efficiency of steam turbine generators, overall efficiency of power generating facilities

The instruction was provided by having the attendants calculate the efficiency based on the acquired data, besides instructing them on how to calculate efficiency. The following was also taught:

- The O2 percentage in the exhaust gas is automatically controlled: the labo test showed 1% to 2% of O2 content, which was the no-problem level for a boiler whose major fuel is the heavy oil.
- The equation of each efficiency is as below, however the reheated calorie was added to the boiler output heat, and the reheated calorie of boiler was added to the steam turbine input heat, because the steam turbine was the re-heating type.

[Equation of Boiler Efficiency]

$$\text{Boiler Efficiency } (\eta) = \frac{\text{Heat Output}}{\text{Heat Input}} \times 100 \ [\%]$$

$$= \frac{Q \times (h_g - h_f)}{F \times GHV} \times 100 \ [\%]$$

Where

Q : Quantity of generated steam per hour [kg/h]

F : Quantity of consumed fuel per hour [kg/h]

h_g : Enthalpy of generated steam [kJ/kg]

h_f : Enthalpy of feed water [kJ/kg]

GHV : Gross (High) heating value of fuel [kJ/kg]

[Equation of Steam Turbine Generator]

$$\text{Boiler Efficiency Steam Turbine Generator } (\eta) = \frac{\text{Power Output}}{\text{Heat Input}} \times 100 \ [\%]$$

$$= \frac{E \times 3{,}600}{S \times h_s} \times 100 \ [\%]$$

Where

E : Generated Power [kWh]

S : Quantity of Inlet Steam per hour [kg/h]

h_s : Enthalpy of Inlet steam [kJ/kg]

[Equation of Overall Efficiency of Power Plant]

$$\text{Overall Efficiency of Power Plant } (\eta) = \frac{\text{Total Power Output}}{\text{Total Boiler Heat Input}} \times 100 \ [\%]$$

$$= \frac{G_O \times 3{,}600}{F_O \times GHV} \times 100 \ [\%]$$

Where

G_O : Total generated Power [kWh]

F_O : Total quantity of consumed fuel per hour [kg/h]

GHV : Gross (High) heating value of fuel [kJ/kg]

[Result of Calculation]

The results of each efficiency calculation were as follows, and the figures were reasonable for a power plant with this class of steam condition.

Boiler Efficiency		
Energy output		
Live steam output	GJ/h	1,500.73
Reheat steam output	GJ/h	237.93
Auxiliary steam	GJ/h	-
Blow down	GJ/h	-
Total energy output	GJ/h	1,738.67
Energy input		
Heavy Fuel Oil HHV	kJ/kg	43,324.14
Fuel mass Flow	kg/h	46,188.00
Heat input	GJ/h	2,001.06
Boiler efficiency based on HHV	%	86.89

Steam Turbine Generator Efficiency		
Energy output		
Generation Power	kWh	200,200
	GJ/h	720.72
Energy input		
Main steam input	GJ/h	1,500.73
Reheat steam Energy input	GJ/h	237.93
Total energy input	GJ/h	1,738.67
Steam turbine generator efficiency	%	41.45

Power Plant Overall Efficiency		
86.89×41.45	%	36.0

(ii) Confirmation and Instruction for lagging/insulation

Pictures around the two boilers with thermal mode and normal mode are taken using a thermo camera. The thermo camera is a very effective tool for confirmation of lagging/insulation status as one of the measuring instrument for assessment of energy conservation because it can quantitatively figure out the surface temperature distribution in a wide range. Some part of the boiler side wall showed a little higher temperature (max. 65 degrees Celsius); however, generally the temperature was low and considered to have no problem regarding the insulation status. Furthermore, the thermal insulation of the main steam pipe was good enough, while the defect in insulation was found where the surface temperature of the peripheral two-inch pipes showed a high of approximately 120 degrees Celsius. For the thermo camera and the measuring examples, please refer to the report for the seminar.

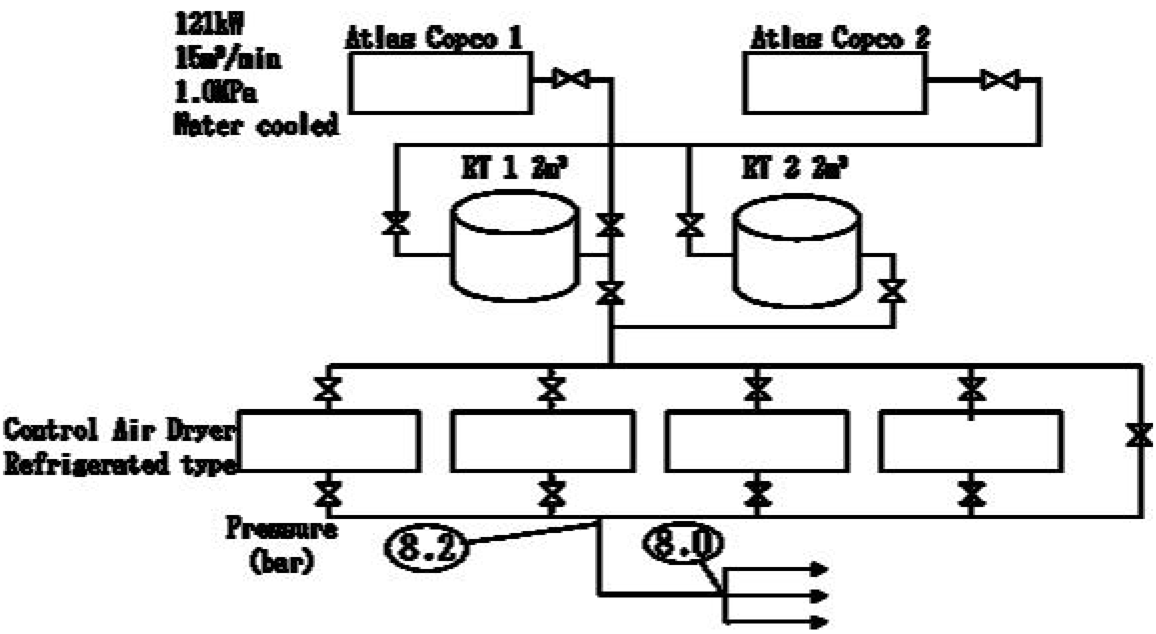
(iii) Instruction for Checking Steam Trap

Not very many steam traps were used in this power plant; however, the major places of use were the heavy oil steam heater for the heavy oil burner and the steam transfer piping, etc. Instruction was provided for checking one of the steam transferring pipes, using a listening rod. (The operating condition was normal.) At the same time, an explanation was provided on the need for a periodic check of the steam trap.

(iv) Compressed Air System for Control

The compressed air system for control of units 4 and 5 was the dual air compressor type, with continuous operation of one set. (Changeover of No. 1-main and No. 2 - standby)

The volume control is by load/unload; the on load/unload pressure was set to 0.74[MPa]/0.86[MPa] for No. 1 machine, controlled based on the outlet pressure of the air compressor. The year of revamping was relatively recent 2002; however, the inverter was not used. (It is indeed an important factor for the energy conservation measure to consider the implementation of energy conservation equipment at revamping.)



System Configuration of Unit 4, 5 Air Compressor Systems for Control

- Receiver tank capacity : 2 [m^3] ×2 [set]
- Dryer : type : Refrigerated type ×4 [set]
- Number of current operating machine : 1[set]
- Automatic control : Start / stop operation : manual operation at control room

Automatic on load / unload change control: yes

- Setting value of load / unload pressure of each air compressor

AC #1: on-load: 0.74 [MPa], unload: 0.86 [MPa]

Specifications and Status of Use of Unit No. 4 &5 Air Compressor for Control

Facility name	Air Compressor				Motor			
	Type	Capacity control	[m³/min]	[MPa]	[kW]	[V]	[A]	[rpm]
ATLAS COPCO 1, 2	Screw	On-load /unload	15	1.0	121	380	125.6	2,980

(iv) -1 Measurement of Unloading Rate

[Table 2.1.2-3 Measurement of Unloading Rate of Air Compressor No.1]

Measured data by audit members

Measurement term : abt. 6 min ? Data interval : 1 [sec], number of data : 6

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Facility Name	On load			Un load		
	Ave. [kW]	[sec]	[%]	Ave. [kW]	[sec]	[%]
ATLAS COPCO 1	128.3	177	51	27.3	169	49

(Remarks) (a) Calculation of Input Power (Only current and voltage are measured)

Loading Power : v3 ×0.38[kV] ×216.6[A] ×0.9 = 128.3[kW]

Unloading Power : v3 ×0.38[kV] × 63.8[A] ×0.65 = 27.3[kW]

The need for acquiring performance test data on the motor was explained because the efficiency/power-factor varies in accordance with the loading factor. Ideally, long term measuring is required including all the loading conditions of compressed air; however, this time it was not possible to make long-term chronological data collection because the measurement was made by a measurer on-site using a clamp type ampere meter and a watch. The measured unloading rate showed approximately 49%, which indicated the occurrence of large unload loss. Furthermore, the frequent on-load/unload was observed (approx. 31 times/hr), which indicated that the capacity of the air compressor largely surpassed the air consumption.

(iv) -2 Confirmation of Pressure of Air Compressor System

- Receiver Tank: 8.5[kg/cm²], After Dryer: 8.2[kg/cm²], Before Control Valve: 8.0[kg/cm²]
- Control Valve Pressure (Output of Reducing Valve): 18 ? 38[psig](0.12 ? 0.26[MPa])(Sampling Check)

The discharge pressure of the air compressor was approximately 0.8 [MPa] (average of unload/on-load pressure), comparatively higher than normal.

- The required pressure at the end user of the compressed air was one of the survey items; however, it was unconfirmed because an interview was not conducted. This is a required item of the survey, for reducing the discharge pressure of the air compressor.

-

(iv) -3 Measurement of Air Leakage

The plan was to survey the air leakage of each worksite using the air leak checker carried by the experts; however, it was not possible due to the shortage of time. For information, it seems the periodical air leakage check is not conducted at this plant.

(iv) -4 Temperature Data

Temperature Data of Air Compressor

Facility name of AC	Intake air Ti [?]	Ambient Ta [?]	Different temperature ?T [?]
ATLAS COPCO 1	34.3	33.0	1.3

Although the installation of the air compressor was indoors, its inlet air temperature was close to the room temperature of the building because it was the water cooling type whose temperature difference was not at problematic level.

(iv) -5 Confirmation of Result of Survey Using a Check List

Check List of Energy Conservation of Air Compressor

No.	Check items	Examination result	Judgment or comment
1-1	Classification of load	(Constant, Variable, Intermittent)	
1-2	Measured data (average)	128.3 [kW], [m³/min], 8.0 [MPa]	[kW] : Input power
1-3	Unload factor [%]	49	Little data
1-4	Air leakage [%]		No check
1-5	Intake air & ambient temperature	Intake air 34.3 [°C], ambient 33 [°C]	Different temp. 1.3 [°C]
1-6	Inspection & maintenance	(daily inspection, BDM, PM (TBM, CBM))	
2-1	Start / stop operation	(machine site operation, remote, automatic)	
2-2	Capacity control method	(suction valve etc., Inverter type, turbo type)	On load / unload control
3-1	Reduction of compressed air consumption	(Implementation, non-implementation)	
3-2	Reduction of delivery pressure	(Implementation, non-implementation)	High delivery pressure
3-3	Changing to small capacity air compressor	(Implementation, non-implementation)	
3-4	Lowering of inlet air temperature	(Implementation, non-implementation)	Unnecessary
3-5	Converting to inverter type air compressor	(Implementation, non-implementation)	
3-6	Number control in operation	(Implementation, non-implementation)	
3-7	Integrating air compressors	(Implementation, non-implementation)	
3-7	Others countermeasure (dryer and so on)	(Implementation, non-implementation)	

(iv) -5 Estimation of Energy Conservation Effect

Because the number of data acquired was small, they were only for reference; however the quantification of the effect of energy conservation was tried.

a) Cut down of Unload Loss

a)-1 Energy Conservation by Implementation of Inverter to the Unit 4 & 5 AC for Control

Present loading is input power 128.3[kW] and loading rate 51[%], while the average power consumption of 65.4[kW] and inverter efficiency of 95[%] at the time when the inverter was implemented; it is assumed that the motor efficiency is approximately equal.

(a) Power saving by Cut down of Unload Loss

?kWh$_1$ = [(128.3 kW × 0.51 + 27.3 kW × 0.49)–(128.3 kW × 0.51 / 0.95)] × 8,760 [h/y]

= (78.8 -68.9) × 8,760[h/y] = 86,724 [kWh/y]

(b) Power saving by Lowering the Discharge Pressure

It is assumed that the discharge pressure is controlled to the present on-load pressure setting of 0.74 [MPa] by implementation of the inverter.

Reduction of Pressure: " 0.8 [MPa] $\Rightarrow$ 0.74 [MPa]" (? 0.06 [MPa])

- Cut down Rate of Power Consumption

$W_2/W_1 = \{(0.74+0.1013) / 0.1013\}^{0.4/1.4}-1] / [\{(0.8+0.1013) / 0.1013\}^{0.4/1.4}-1]$

$= 0.831 / 0.867 = 0.958$

(Note) 1.4 : insulation factor of air

- ?kWh$_2$ = 128.3[kW]×(1–0.958)× 8,760[h/y]×0.51 = 24,074 [kWh/y]

c) The Overall Power Cut down

?kWh$_1$+ ?kWh$_2$ = 86,724 + 24,074 = 110,798 [kWh/y]

a)-2 Cut down of Unload Loss by Downsizing of Unit 4,5 AC for Control

The energy conservation effect was estimated regarding the change of the relevant air compressor to 75 kW, given that a standard specification machine is chosen.

The unloading rate of 49% of this machine downs to approximately 21% when the 75 kW machine operates. However, the input power to the air compressor was approximately proportional to its capacity, and the motor efficiency to be 0.9. Furthermore, it was assumed that the power consumption rate of 75 kW machine during unloading was equivalent to the relevant machine.

?kW = (128.3 kW × 0.51 + 27.3 kW × 0.49) – (83.3 kW × 0.79 + 17.7 kW × 0.21) × 8,760 h/y

= (78.8 – 69.5) × 8,760 h/y = 81,468 [kWh/y]

Power-Saving percentage = 9.3 / 78.8×100 = 11.8 [%]

b) Reduction of Discharge Pressure of Air Compressor

The average discharge pressure of present air compressor 0.8 [MPa] is higher than normal having the possibility of realizing the energy saving by the discharge pressure down. This time, the energy conservation effect was estimated based on a certain precondition, because it was not possible to make clear about the pressure distribution of each part, and the minimum required pressure at the end user.

- Reduction of Discharge Pressure

  Load/Unload average pressure: Present 0.8 [MPa] (0.74/0.86[MPa] ⇒ temporarily assumed as 0.66 [MPa] (0.6/0.72)

  0.6 [MPa]: assumed that, pressure loss of dryer 0.05 + pressure loss of piping 0.05 + minimum required pressure 0.5

  $W_2/W_1 = \{(0.66+0.1013)/0.1013\}^{0.4/1.4}-1]/[\{(0.8+0.1013)/0.1013\}^{0.4/1.4}-1]$

  $= 0.779 / 0.867 = 0.899$

  ?kW = 128.3 kW × (1-0.899) × 8,760 h/y × 0.51 = 57,893 [kWh/y]

(iv) -6 Recommended Items for Future Energy Conservation Plan

The diagnosis this time was a simplified one for OJT; however, it is necessary to acquire the data for a certain period that will allow covering all the loading conditions for the air compressor for conducting the actual energy conservation measure.

Furthermore, it is recommended to accurately grasp going forward the various quantities such as the maximum air consumption, the average unloading rate, and the pressure drop, etc., necessary for the investigation of energy conservation.

(a) Reduction of Unload Loss of Air Compressor

The unloading ratio of this machine was 49 [%], which was so large that the energy saving effect by reducing this figure is expected. In addition, the AC for units 4 and 5 also has the high unloading rate of approx. 54 [%], under similar conditions as the above.

- Implementation of Inverter Type Air Compressor

  The investment efficiency is the subject of future investigation; it is better to investigate at the time of replacement of the old one or when revamping.

- Change to Smaller Size Air Compressor

  For the purpose of reducing the unloading ratio, we will recommend an investigation to change to a small capacity air compressor, after grasping the maximum required capacity of compressed air. If there is an existing idle machine, it is desirable to make use of it than newly implementing.

(b) Reducing the Discharge Pressure of Air Compressor

After this, we recommended a gradual reduction in the discharge pressure by setting a certain target for a new discharge pressure after the investigation of the pressure distribution of each place and the minimum required pressure for the load side, etc.

(c) Reducing the Air Leakage

It is necessary to continuously know the location of air leakage by daily and periodical checks and by the air leak test during the plant shut down maintenance, and then to make repairs.

(d) Future Investigation for Integration of Air Compressor

The air compressors are installed unit by unit, or use by use; however, the energy saving effect such as the reduction of the number of operated units or unload loss, etc. can be expected by integrating these units. The integration of the air compressors between the units 4 and 5 and the block I and II is a future subject. Because the control room under control is separate, it seems a little difficult to integrate the units 4 and 5 and block I and II; therefore, it should be planned to integrate the air compressors for control of the units 4 and 5 and for units 4 and 5 for the plant. Both are located near each other, and their specifications and the applied pressures are approximately the same and have the interconnecting piping. The multiple unit control system seems to be necessary for the integration of air compressors.

(v) Sampling Illumination Check of Lighting Equipment

The lighting equipment was not considered as the object of the energy conservation OJT in the beginning; however, unnecessary lighting or too bright lighting was found during the walk through on the first day, it was then decided to conduct a simplified diagnosis on a very short notice.

(v) -1 Viewpoint of Energy Saving

(a) Drastic Management of Black Out

Black out of lights when unnecessary and when no one is present.

(b) Proper Illumination Management

Drawing up of a proper illumination standard, reduction of the too bright lighting.

(c) Change to a High Efficiency Lighting Instrument

(v) -2 Result of Survey

The fluorescent lamp (40 W x 2) was the major indoor lighting combined with the natural lighting near the windows, excluding the turbine floor. On the turbine floor, the high-pressure mercury vapor lamp (250 W) area and the high-pressure Natrium lamp (250 W) share the area.

(a) Status of Management of Blackout

The management of blackout was not enough because the lights of the entrance/exit area were not turned off when no one was present or during fair weather, while the lights in some areas were partially turned off.

(b) Standard for Shop Illumination

It seems that there was no definite standard, and so JIS Z 9110 was introduced as requested to offer a lighting standard from Japan.

(c) Measurement of Lighting Intensity

Sampling measurement of lighting intensity was conducted by the team members, using the lux meter brought by the specialists.

Sampling Measurement Data of Lighting Intensity at Various Places

Room name	Place	Time zone	Condition	Lux Std	Illumination [lx]		
Turbine Floor	3rd floor	10.00	cleaning	70-150	87	86	57
Control Room	3rd floor	10.15	cleaning	300-750	529	491	539
MCC Room	2nd floor	10.30	cleaning	150-300	65	112	116
Swich Gear	2nd floor	11.00	cleaning	150-300	26	73	148
BFP (Boiler feed pump)	2nd floor	11.15	cleaning	75-150	250	234	213
CP (Condensate Pump)	1 floor	11.30	cleaning	75-150	90	215	20
Relay House	2nd floor	13.00	cleaning	150-300	300	699	414
AUX Cooling Water	1 floor	11.45	cleaning	75-150	191	115	117

(Remarks): JIS Z 9110 was applied for "Lux Std." with adjustment. "Condition" indicates the status of stain on the lighting equipment (lamp, reflector)

As compared to the lux standard, some of the lights show overs and shorts on the lighting intensity. Most of the areas with shortage of intensity were non-resident; therefore, it was not problematic except when there is a worker; however, the over lighting areas need the reduction of intensity for energy saving regardless of whether manned or unmanned.

(d) Confirmation of Result of Survey using a Check List

Check List for Energy Saving on Lighting Equipment

No.	Check items	Examination result	Judgment or comment
1-1	Measured illumination data [lx]		Sampling measurement
1-2	Unnecessary lamps	[W/set] × [set] = [W]	No check
1-3	Strict light out Management	(enough, indifference, insufficiency)	Many unnecessary lighting
1-4	Light out / on operation place	(manual in room site, remote, auto)	
1-5	Dirty lamp & reflector	(nothing, little, many)	
1-6	Periodical inspection & maintenance	(daily inspection, BDM, PM (TBM, CBM))	
2-1	Task ambient lighting	(implementation, non-implementation)	
2-2	Nature lighting	(implementation, non-implementation)	
2-3	Automatic lighting control	(implementation, non-implementation)	
3-1	More management of light out	(implementation, non-implementation)	
3-2	Reduction of illumination	(implementation, non-implementation)	
3-3	Introduction of high efficiency lighting facilities (lamp and/or reflector)	(implementation, non-implementation)	
3-4	Others counter measure	(implementation, non-implementation)	

(v) -3 Recommended Items for Future Energy Conservation Plan

The status of energy saving on the lighting equipment is considered to be one of the indexes of the implementation status of the energy conservation activities of the facility. For this point, the status of energy saving at this plant looks like there is some room for improvement.

(a) Drastic Management of Blackout

- To enforce the careful blackout for unnecessary areas and unpeopled areas.
- Implementation of automatic switching of lights: Installation of the motion sensor to the walkway, etc. introduction of lux meters in the area with natural lighting
- Implementation of individual switch for lighting: To install a switch for the lighting at the entrance of Relay House etc. that turns on when necessary, and controls the blackout when no one is present.

(b) Proper Management of the Lighting Intensity

- Planning of a proper lighting intensity standard
- Removing the unnecessary lighting instrument
- Re-arrangement of the existing lights
- Adoption of Task-Ambient Lighting: Install fluorescent lights along the walkway and recommend turning off all the ceiling light under normal conditions.

(c) Change to the High Efficiency Lighting Instrument

- Addition of High Efficiency Reflector (mirror type): Fluorescent Light (40 W × 2) ⇒ (40 W × 1): Energy saving by approx. 50[%]
- Change to the Hf type Fluorescent Light: Fluorescent Light (40 W)⇒(32 W): Energy saving by approx. 20[%]
- Change of Mercury Lamp to Natrium Light, etc.: Mercury Lamp for Turbine Floor, etc. Energy saving by approx. 30% to 50[%]

- Introduction of LED Lights: Fluorescent light substitute: Energy saving by approx. 50 [%]: The introduction was made on an example of energy saving in Japan using the LED light.

(vi) Pump, Fan & Blower Facility

The pump, fan, and blower facility was not diagnosed due to the shortage of time; however, it is hoped that the Indonesia side will further continue the activities because there are still many facilities targeted for an assessment of energy conservation in this plant. The pump, fan and blower facilities other than the following are unconfirmed.

(a) Pump Facility

? The Cooling Sea Water Pump (710 kW x 9) are confirmed at site, when it was reported that the discharge valve was fully opened because the load side does not have a flow control valve; therefore, it is assumed that there is still some room for adjustment through the proper grasping of the flow rate.

? The speed of the boiler feed water pump is controlled using the fluid coupling.

? The present status has not been grasped yet on the wash water pump.

(b) Fan & Blower Facility

? It was reported that the inverter was implemented and the suction damper was fully opened for operation of GRF, FDF (2 sets) for unit 4; however, it was not confirmed about GRF, FDF for unit 5 and the block I and II. It remains as a subject for investigation in the future because there is the possibility of the energy saving if the damper control is still used.

The subjected facilities this time are only part of all; however, the effect of transferring the result of the detailed investigation for both the compressed air system and the lighting facility is expected.

Table of Energy Conservation Reviewing Plans

Subjected Facility	Suggested Energy Conservation Items	Energy Saving [%]	Energy Saving [kWh/y]
Comp. Air System	a)-1 Energy saving by implementing the inverter machine for the AC for control of Unit 4 & 5	16	110,798
	a)-2 Cut down of unloading loss by downsizing of AC for control of Unit 4 & 5	12	81,468
	b) Reduction of discharge pressure of AC for control of Unit 4 & 5 (Temporarily: ? 0.14 MPa)	8.4	57,893
	c) Cut down of air leakage	-	-
	d) Future investigation for integration of air compressors	-	-
Lighting Facility	a) Management of blackout of lighting when unnecessary (Auto-on/off, installation of individual on/off switches)	-	-

	b) Adequate management of lighting intensity (Developing the Lux Standard, Removing unnecessary lights, Re-arrangement of layout)	-	-
	c)-1 Implementation of High efficiency reflector	approx. 50	-
	c)-2 Change to the Hf type fluorescent light	20	-
	c)-3 Change of Mercury light to Natrium light, etc.	30-50	-
	c)-4 Introduction of LED light(Fluorescent light substitute)	approx. 50	-

7) Questions and Answers

(Q) Effect of implementation of inverter: (A) The explanation was provided regarding the effect of speed control using the inverter, taking the constant discharge pressure control of pump as an example.

(Q) Harmonic of inverter and Hf fluorescent light: (A) AC reactor or DC reactor is connected to PWM inverter. No problem of harmonic if the Hf fluorescent light is manufactured in accordance with JIS.

(4) Personal Comments

The No. 5 power plant, subjected to energy conservation OJT, has been operated for approximately 29 years; however, maintenance and rehabilitation are properly and adequately conducted because the facility looked to be in good condition, and the instruments were updated to new ones. Also, regarding the status of operation, where the steam condition of the boiler is dominant to the overall efficiency of steam power generation facility, the following other various factors that influence efficiency were well managed.

The various instruments were prepared for this assessment of energy conservation, and instruction was provided for its use: since these instruments are highly effective as they allow quantitative assessment, it is hoped that the assessment of energy conservation is conducted making use of these within the extent only where absolutely no adverse influence is observed on the operation of the facility. The trainee showed a strong interest especially in the thermo camera, which is easy to use because of its small size, and which makes it possible to easily and quantitatively diagnose the location of defective lagging and thermal insulation.

All the team members from Indonesia, which were composed of eight persons mainly from PT. PJB, worked diligently. I expect good work in the future because the technical level of the attendants from Indonesia side was fairly high, and their awareness of energy conservation was also high. However, they did not appear to have much experience in assessment of energy conservation; occasionally the uncertainness of collected data or waiting for instruction approach was observed. It is required for the team members to accumulate actual work experience by further conducting the assessment of energy conservation. To this point, I am very sure that the OJT diagnosis was very meaningful because the attendants from Indonesia actually joined and voluntarily participated in the diagnosis.

3. Presentation on Revamping of Isogo Thermal Power Plant, etc.

Following the presentation by the energy conservation OJT Groups 1 & 2, a presentation was made by J-POWER, regarding the efficient operation and revamping of the facility of Isogo Thermal Power Plant, along with the attachment C (ref. Attachment-E). The active questions and answers were made regarding this presentation. The following is a summary of it;

(Q) What is the difference in IGCC and the conventional coal thermal power generation? (A) The efficiency of most advanced USC/Isogo is 43%, the power generation efficiency of IGCC is 50%, and that of IGFC is 60%. This is an important advantage. It is a facility under testing, and now under investigation for expansion. JP has a plan to construct a 200 MW scale plant.

(Q) Is it necessary to have an activated coal facility for the dry-desulphurization? (A) The activated coal facility is not located near the power plant. Occasionally, coal from China is used. Initial charge of the activated coal is 4,000 to 5,000 t/unit, and its yearly quantity for supplementing is 3,000 to 4,000 t/h/y (per unit).

(Q) Who owns the intellectual property of USC, Mitsubishi, or JP? (A) The development of USC has been undertaken by JP with support from the government. All the heavy industrial machinery suppliers in Japan joined this development. Each supplier has been making an effort to develop unique material and designs, then it can be said that it belongs to the intellectual property of each supplier, but USC itself does not belong to someone in the suppliers.

(Q) Does the government pay all the technical development costs of IGCC? (A)The government supports the cost, but the developers (e.g. JP) also bear the cost.

(Q) What is the coal type used for USC, calorie? (?) Indonesian coal is also burned. Generally, high quality coal of over 6,200 kcal/kg.

(Q) What happens if low quality coal is used for USC? The boiler size becomes larger, for example? (?) Exactly. Technically, it is no problem. The subbituminous coal is planned to be used for a 200 MW coal thermal plant project of JP proceeding now in the central Java.

(Q) How high is the operating rate of coal thermal power plant? (?)Depends on the situation, but possibly over 90%. The average operating rate of Takasago was about 80% in 40 years, but influenced by the power demand or law (frequency and duration of periodical checks).

(Q) What is SCR? It is not familiar in Indonesia. Is it related to Kyoto Protocol? FGD is the wet type. (A) It stands for Selective Catalytic (NOx) Reduction, familiar in Japan and other European countries and the US. Its contribution is the reduction of NOx, which is the reduction of influence to the regional environment, rather than to the global environment. The decision of SCR can be adopted or not will depend on the figures in the regulations. The wet type requires a large quantity of water for FGD, which would tell that Isogo would require twice as much water for twice as much output if the wet type were applied; for the purpose of saving the industrial water, the dry type was adopted.

(Q)Please explain about the combustion management system. (A) The explanation was provided on the combustion simulation in the presentation. This was applied for solving the problems in the boiler for the National Thermal Power Corporation Ltd/NTPC, and the suggestion was the re-arrangement of the boiler panel. This was a special example. As normal management of combustion, the central supervisory instrument for metal temperature and exhaust gas temperature, and the analyzed figures of non-combusted material in the ash, the burning condition observed through the inspection window during operation are watched for the overall judgment. The report will be found if the "JICA Study" is searched on the website.

(Q) How much was the cost for construction of Isogo? (A) Approximately JPY 0.2 mil/kW for 1 & 2

4. Seminar and workshop

(1) Date and Place

November 25, 2011 8:30 a.m. to 5:00 p.m.
Bidakara Hotel 3F Convention Hall

(2)Attendants: 80 persons

(3)Summary of Presentation

The chair of the seminar was Mr. Oscarlito C. Malvar/ACE. The opening address was made by Ms. Indarti, Chief of EEC, MEMR, New and Renewable Energy and Energy Conservation/NREEC, the greetings for holding a conference from Ms. Maureen/ACE, and Mr. Okamoto/ECCJ. In the greeting message by Mr. Okamoto/ECCJ, the gratitude was expressed to the support from various countries after the March 11. The summary of the presentation made by each presenter is listed below.

SESSION I: Policies, Programs and Initiatives on EE&C

(i) Overview of ASEAN EE&C Programs and APAEC 2010-2015: The introduction of ACE, the outlines of APAEC, in which the role of ACE, PROMEEC project and

MTPEC were introduced by Ms. Maureen/ACE. The material for this presentation was equivalent to that presented in Manila.

(ii) OVERVIEW OF ENERGY EFFICIENCY AND CONSERVATION ACTIVITIES IN INDONESIA: The introduction was made on the energy demand record of 2010 in Indonesia, demand prediction until 2025, history and plans of EC policies and the status of the overseas aid by Ms. Andria Feby Misna/ FP.

(iii) Japan’s Energy Conservation Policy and Measures and EE&C Experiences: The introduction was made on Japanese history of energy consumption, remedy to the energy conservation law, Top Runner Program and how to access the excellent examples in the website of AEEC by Mr. Okamoto/ECCJ

SESSION II: EE&C Best Practices in Industries

(iv) On the Job Training ENERGY AUDIT IN POWER PLANT: The introduction was made on the result of the assessment of energy conservation OJT conducted on the power generating plant by Dr. Tiva Winahyu/National Power Company/Research Institute. (Ref. Attachment-D)

(v) Case Study of Successful EE&C Countermeasures: The introduction was made on three examples of energy conservation conducted at a power plant in Japan by an expert Mr. Higaki/ECCJ.

(vi) Energy Conservation Successful Cases in Japanese Power Plants (Electrical Equipment): The introduction was made mainly on the twelve examples of the energy conservation conducted at thermal power generation plant in Japan, which got the prize for the excellent energy conservation in Japan by Mr. Takeda, an expert from ECCJ. These examples of power saving are the summary of the abstract from the presentation made at the national convention of energy conservation from 1999 to 2008 for the presentation of excellent examples by ECCJ. The following one question was asked.

(Q)Regarding the prevention of accident of transformer (A) The tendency management using the analysis of the gas in the oil of the transformer has been conducted in Japan since more than 30 years ago. The standard for the diagnosis is defined by each company. (e.g., Oita Works has the standard for the judgment of transformer deterioration established in 1973.) For example, if acetylene is detected, the burn out of the insulator inside is suspected. (Furfural, CO + CO_2, etc. are adopted for lifetime diagnosis) Regarding the details of the gas analysis, it was recommended to consult a power company in

Indonesia who is probably conducting it.

SESSION III: The Way Forward

(vii)Updates on the Development of PROMEEC EM Tools: The explanation was provided regarding the status of development on the Technical Directory, In-house Database, and ASEAN Energy Management Service and System by Mr. Pham/ACE.

SESSION IV: EE&C TECHNOLOGIES

(viii)Japanese State-of-the-Art Smart Energy Products & Technologies: As the introduction of high efficiency product in Japan, the introduction of JASE-World was made, and as an example of technical database, instruction was provided for accessing the Centrifugal Chiller of Mitsubishi Heavy Industries, and the acquired information was displayed and explained by Mr. Okamoto/ECCJ.

(ix)The Latest and High Performance Coal-fired Power Generation: Asked Mr. Shimizu/J-Power to make a similar presentation made at the thermal power plant yesterday. (Ref. Attachment-E) The active questions and answers are listed below:

(Q)Do not know the details about IGCC/IGFC, but they seem to be the combination power plant. Probably they are different from the conventional coal thermal power plant, but how high is their efficiency? (A) IGCC/IGFC does not have a combustion furnace; they have a gasification furnace. IGCC is the dual combined cycle system in which the generated gas burns in GT, then its exhaust gas generates the steam in HRSG, and then power is generated at ST. On the other hand, IGFC is a triple combined cycle system in which part of the generated gas goes through the FC for power generation, and then generates power together with the remaining generated gas in GT⇒HRSG⇒ST. The power generation efficiency of IGCC 1500-degree class GT is 51% to 53%. That of IGFC is over 60%, Isogo is 43%.

(Q)How is the quality of coal for IGCC/IGFC(?)The high quality imported coal of over 6200 kcal/kg is used in Japan. It seems IGCC/IGFC also uses this type of coal. The gasification furnace has the structure in which the molten ash drops to the bottom, therefore suitable for the coal with ash with low melting point; however, the test is made also on the coal with high melting point ash for widening the range of coal type.

(Q)Is IGCC a commercially operated?(?)It is now under verification test, not a commercial operation.

(Q) Surprised at the cut down of NOx at Isogo. 159 ppm ⇒ 13 ppm. It was explained that it was achieved by SCR, but is there another way for a cut down?

(A) Previously Isogo was using the Low NOx burner and the two stage combustion for a cut down of Nox. However, by adopting SCR, NOx can be significantly cut down. This method is to pour in the ammonia to reduce the NOx to N_2 gas and water (steam) by catalyzers.

(Q): A question to Mr. Takeda/Experts of ECCJ, regarding the judgment criteria on the efficiency (soundness) of the transformer / Sometimes the transformer will breathe fire when the operation is continued not knowing the condition of the transformer.) (A: The supplementary explanation by an engineer of J-Power) The explanation was provided regarding JICA Study in this presentation; in it, RLA (Remaining Life Assessment) was conducted for transformers. By searching a Study Title in the JICA website, information can be acquired at no charge, such as CO/CO_2 analysis, Furfural Analysis, DP (Degree of Polymerization) for insulation paper important for soundness assessment.

The seminar was closed with the address made by Ms. Indarti, Director of Conservation of NREEC, MEMR.

(4) Personal Comment

The attendants to the OJT were asked to make a presentation, on the result of the assessment of energy conservation OJT, similarly as the activities in the Philippines. The material and the presentation was a sophisticated one. It was difficult to say that the contents of the diagnosis was sufficient due to the limited time; however, we hope those materials handed over to them and the explanation during OJT will be fully utilized, and used for the assessment of energy conservation in the future. As a first trial, asked to make a presentation by a similar thermal power plant regarding the status of Japanese high efficiency operation etc. at the last day in the shop and during the seminar. It was easily guessed that it was a good chance to listen to the very meaningful presentation, for Indonesia side, as it appeared like in the hot discussion at the presentation.

The schedule of this activity became different from the one decided at the Inspection Workshop. From this year, planned to invite the experts from outside ECCJ to join, for supplying the meaningful information for the ASEAN nations, and enforced it. Therefore, I would like FP to more closely exchange information regarding the schedule etc.

Pictures of Activity: PROMEEC Industrial Entreprixe @Indonesia

2011-11-21 First day of the assessment of energy conservation/ Explanation of outlines of the facility

2011-11-23 Inspection of the function of the steam trap

2011-11-23 Instruction of Group 1 by the specialist

2011-11-22 Instruction of Group 2 by the specialist

2011-11-25 Meeting place for seminar

2011-11-25 Scene from the seminar (last presentation)

Attached Materials(omitted)

1: Outlines of Muara Karang Power Plant

2: Company Organization Chart

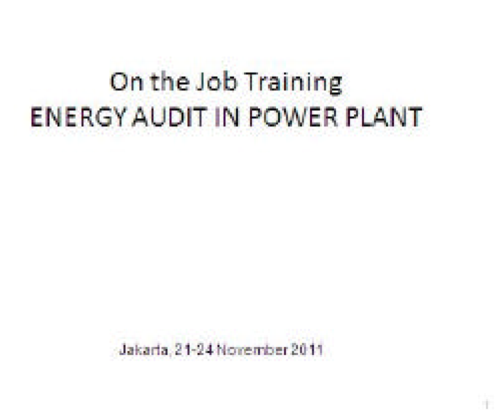
3: Questionnaire

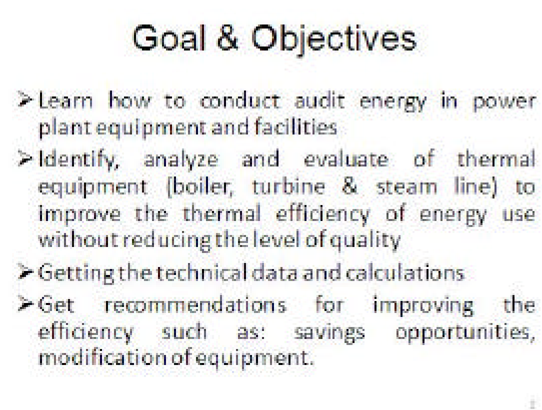
4: Report of Expert Mr. Higaki: Report of OJT Assessment of energy conservation of

Muara Karang Thermal Power Plant

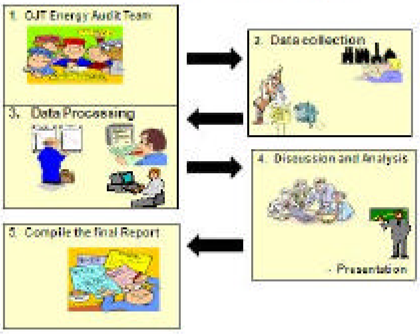
5. Report of Specialist Mr. Takeda: Report of Electrical Energy Conservation Regarding Thermal Power Plant in Indonesia/ Site Visit
6. Energy Audit Plan of Facilities Related to Thermal Energy
7. Briefing of Energy Audit for Air Compressor
8. Instruments for Energy Audit
9. On the Job Training ENERGY AUDIT IN POWER PLANT
10. Presentation by J-Power: The Latest and High Performance Coal-fired Power Genera.
11: Report of Business Trip by Mr. Shimizu/J-Power: The Energy Conservation Survey of Muara Karang Thermal Power Plant of Indonesia National Power Company PT. PLN(Persero), etc.
12. SEMINAR AGENDA
13. Overview of ASEAN EE&C Programs and APAEC 2010-2015
14. OVERVIEW OF ENERGY EFFICIENCY AND CONSERVATION ACTIVITIES IN INDONESIA
15. Japan's EC Policy and Measures and EE&C Experiences
16. Case Study of Successful EE&C Countermeasures
17. Energy Conservation Successful Cases in Japanese Power Plants (Electrical Equipments)
18. Updates on the Development of PROMEEC EM Tools
19. Japanese State-of-the-Art Smart Energy Products & Technologies

Material? D: Results of Energy Audit OJT at B Power Plant





Activities Scope



1	Air Compressor	Recommendation
2	Lighting Facility	Recommendation
3	Thermal Energy	Recommendation

1	Air Compressor	Recommendation

Aircompressor list

Air compressor name	Number (set)	Air Compressor					Motor ___[V]		
		Type	Capacity control	[m³/min]	[MPa]	Maker / year	[kW]	[A]	[rpm]
Atlas Capco 1	AII076120	ZR 132	612	15	10	2002	121	215.6	2980
Atlas Capco 2	AII076121	ZR 132	612	15	10	2002	121	215.6	2980
EcoAir 3		12202	18.9		10			252	2980
IR 1	153460007022	SIERRASH132A		18.8	10.2				2980

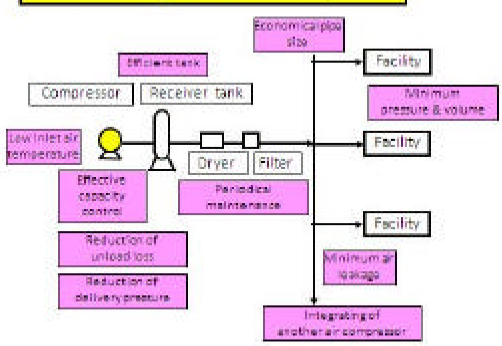
Check sheet of Air Compressor

Air Compressor name	Type	Capacity control	[m³/min]	[MPa]	[kW]	Maker / year	Motor [kW]	[A] / [rpm]	Inverter type	PT [m³]
Atlas No.1, No.2	oil free screw	On load/unload			121				(yes, no)	2/12

No.	Check items	Examination result	Judgment or comment
1-1	Classification of load	(Constant, Variable, Intermittent)	
1-2	Measured data (average)	128 [kW] [m³/min] 8.0 [MPa]	[kW]: input power
1-3	Unload factor [%]	50	Little data
1-4	Air leakage [%]		No check
1-5	Intake air & ambient temperature	Intake air [℃], ambient [℃]	No measurement
1-6	Inspection & maintenance	(daily inspection, BDM, PM, CBM, TBM)	
2-1	Start / stop operation	(machine side operation, remote, automatic)	
2-2	Capacity control method	(suction valve, etc., inverter type, turbo type)	On load/unload control
3-1	Reduction of compressed air consumption	(implementation, non-implementation)	
3-2	Reduction of delivery pressure	(implementation, non-implementation)	High delivery pressure
3-3	Changing to small capacity air compressor	(implementation, non-implementation)	
3-4	Lowering of inlet air temperature	(implementation, non-implementation)	Unnecessary
3-5	Converting to inverter type air compressor	(implementation, non-implementation)	
3-6	Number control in operation	(implementation, non-implementation)	
3-7	Integrating air compressors	(implementation, non-implementation)	
3-?	Others counter measure(dryer and so on)	(implementation, non-implementation)	

Audit result and/or recommendation items	1) Reduction of unload loss 2) Reduction of delivery pressure 3) Implementation of periodical air leakage test and air leakage parts repair 4) Integration air compressor and introduction of number control in operation

Viewpoint of Energy Conservation on Air Compressor



Reduction of unload loss

< measured data >
on load : 127.7 [kW], 50 [%], unload : 27.3 [kW], 50 [%]
* Input power [kW] = √3 × __[kV] × __[A] × ____(cosΦ)
on load : √3 × 0.38[kV] × 216.6[A] × 0.9 = 128.3 [kW]
unload : √3 × 0.38[kV] × 63.8[A] × 0.65 = 27.3 [kW]

a) Example case 1: converting to inverter type air compressor
(a) Power-saving by electric power consumption decrease
power-saving ΔkWh1
= [(128.3 [kW] (on load) × 0.5 (on load factor) + 27.3 [kW] (unload) × 0.5 (unload factor)
− (128.3 [kW] (on load) × 0.5 (on load factor) / 0.96 (inverter efficiency)] × 8760 [h/y]
= 10.27 × 8760 [h/y] = **89,965 [kWh/y]**

(c) Reduction effect of delivery pressure
* 0.7846 ⇒ 0.7257 [MPa]* (8.0 ⇒ 7.4 [kg/cm²])
electric power consumption ratio :
P_1/P_2 = [(0.7257+0.1013)/0.1013]^(...) −1] / [(0.7846+0.1013)/0.1013]^(...) −1]
= 0.7231 / 0.7546 = 0.9589
(b) power-saving
ΔkWh2 = 128.3 [kW] (on load) × (1 − 0.9589) × 8760 [h/y] × 0.5 (on load factor)
= **23,096 [kWh/y]**

total power-saving
ΔkWh1 + ΔkWh2 = 89,965 + 23,096 = **113,061 [kWh/y]**

Recommendation EC items of Air compressor

1) Reduction of unload loss
Large unload factor (change to frequent on load / unload) in now operation, but little measured data in this audit, therefore long term measurement is necessary.
Implementation of counter measure to large unload factor
(1) Sudgesst to inverter type air compressor
(2) Sudgesst to small capacity air compressor

2) Reduction of delivery pressure with to keep end pressure
High delivery pressure in now operation, therefore examination of pressure drop & adjustment to best delivery pressure is necessary.
(delivery pressure ≧ required use pressure + piping loss + safety margin)
Ex.) power-saving by delivery pressure reduction
* 0.7845 ➡ 0.6865 [MPa]* (8 ➡ 7 [kg/cm²]) : power-saving abt. 7[%]
* 0.7845 ➡ 0.6374 [MPa]* (8 ➡ 6.5 [kg/cm²]) : power-saving abt. 11[%]

3) Implementation of periodical air leakage check & air leakage parts repair

4) Integration air compressor & introduction of number control in operation
(1) Integration air compressor of each plant use
(2) Introduction of number control in operation
Use of installed PT of receiver tank

2 Lighting Facility

Recommendation

Room name	Place	Time zone	Condition (*1)	Lux Std	Illumination [lx]		
Turbine Floor	3rd floor	13:00	Ceiling	75-150	67	38	67
Control Room	3rd floor	13:15	Ceiling	300-750	528	491	509
MCC Room	2nd floor	10:30	Ceiling	150-300	55	112	115
Switch Gear	2nd floor	11:00	Ceiling	150-300	28	73	148
BFP (Boiler feed pump)	2nd floor	11:15	Ceiling	75-150	280	234	213
CP (Condensate Pump)	1 floor	11:30	Ceiling	75-150	30	278	20
Relay House	2nd floor	12:00	Ceiling	150-300	300	689	414
AUX Cooling Water	1 floor	11:45	Ceiling	75-150	191	178	117

Cheek sheet of Lighting facility

Room name	Category of Lamp	[W]×[N]	[set]	[W]	Illumination standard [lx]
(Sampling audit implementation)	Fluorescent lamp	40×2			
	Mercury-vapor lamp				
	Sodium lamp				

NO.	Check items	Examination result	Judgment or comment
1-1	Measured illumination data [lx]		Sampling measurement
1-2	Unnecessary lamps	[W/set] × [set] = [W]	No check
1-3	Thorough light out management	(enough, indifferent, insufficiency)	Many unnecessary lighting
1-4	Light out non operation place	(manual in room, site, remote, auto)	
1-5	Dirty lamp & reflector	(nothing, little, many)	
1-6	Periodical inspection & maintenance	(daily inspection, SDM, PM (TBM, CBM))	
2-1	Task ambient lighting	(implementation, non-implementation)	
2-2	Natural lighting	(implementation, non-implementation)	
2-3	Automatic lighting control	(implementation, non-implementation)	
3-1	More management of light out	(implementation, non-implementation)	
3-2	Reduction of illumination	(implementation, non-implementation)	
3-3	Introduction of high efficiency lighting facilities (lamp & floor reflector)	(implementation, non-implementation)	
3-4	Others counter measure	(implementation, non-implementation)	

Audit result and/or recommendation items	1) Implementation of strict light out management 2) Reduction of illumination 3) Converting to high efficiency light sources and

Recommendation EC items of lighting facilities

1) Implementation of strict light out management
(1) To light out at unnecessary time, in uninhabited places
(Ex. Relay panel room etc.)
(2) Automatic on / off control by motion sensor lighting, illumination sensor etc.
(3) Improvement from integrated switch to individual switch

2) Reduction of illumination
(1) Adequacy of illumination standard
(2) Removal of useless lighting
(3) Improvement of layout of illuminator

3) Converting to high efficiency light sources and fitting
(1) Introduction of mirror surface reflector
Ex.) fluorescent lamp 40W×2 ⇒ 40W×1
(2) Changing to Hf fluorescent lamp and ballast
Ex.) fluorescent lamp 40W ⇒ 32W
(3) Changing to metal halide lamp and/or sodium lamp from mercury lamp
(4) Changing fluorescent lamp to LED lamp (50 percent more efficient)

3 Thermal Energy

Recommendation

Instruments

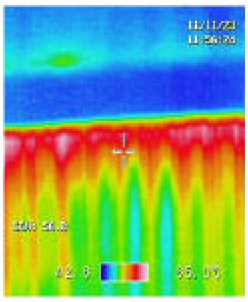

Acoustic Rod


Infra Red Camera

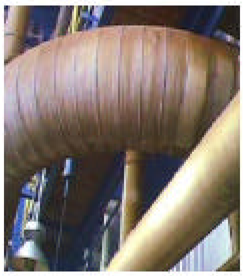

Portable Infrared Thermometer

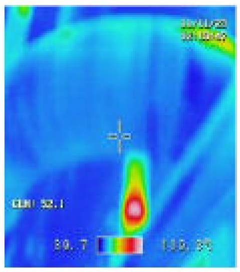
Spot Checking by using Thermograph camera


Normal mode Boiler surface of right side


Thermo mode Boiler surface of right, side

Spot Checking by using Thermograph camera - con'd


Normal mode of main steam pipe line


Thermo mode of main steam pipe line

Checking Result of Insulation & Refractory by using Thermograph Camera

1. The condition of insulation & refractory are relatively good.
2. There are some hot parts where the temperature is high
3. It's very convenient to find out the hot parts by using thermograph camera
4. It's required to repair the insulation of the hot parts to reduce the the radiation and convection losses

Checking of Steam Traps

1) As a result of site survey, there would be about 30 steam traps in this power plant.
2) One steam trap was checked using an acoustic rod.
   - The action of steam trap was normal.
   - The bypass valve of steam trap was a little bit leaking.
3) it is recommendable to implement the periodical checking (such as every one year) of all steam traps and the maintenance.

Steam Trap for Fuel Oil Heater (TLV-made, 2-1/2" Free Float Type)

Steam Trap for LP Steam Transfer Line (Refox-made, 1" Free Float Type)

Effect of Periodical Maintenance of Steam Traps

Empirical malfunction rate of steam traps without any periodical maintenance: 20～30%

- Maintenance of whole steam traps based on periodical inspection including bypass valves
- Replacement or overhauling of following malfunctioned steam traps
  - Steam blowing
  - Blocking up
  - Chattering (Disc type), etc.
- Replacement of inefficient steam traps with energy-saving ones

Large Amount of Energy Saving

Empirical malfunction rate of steam traps with periodical and correct maintenance: lower than 10%

Steps to calculate Plant Efficiency

- Choose the proper methods
- Define system boundary
- Data collection & analysis
- Calculation
- Results Validation
- Reporting

Boiler Efficiency Calculation - Results

Energy output		
Live steam output	kJ/s	416,870.72
Reheat output	kJ/s	66,091.90
Auxiliary steam	kJ/s	-
Blowdown steam	kJ/s	-
Total energy output (QnO)	kJ/s	482,962.62
Energy Input		
HHV	kJ/kg	43,324.10
Fuel mass flow	kg/s	12.83
Heat input	kJ/s	555,992.62
Boiler efficiency based on HHV	%	**86.86**

Calculation of Steam Turbine Generator Efficiency - Results

Energy output		
Generation Power	kWh	200,200
	GJ/h	720.72
Energy input		
Main steam input	GJ/h	1,500.73
Reheatsteam intput	GJ/h	237.93
Total energy input	GJ/h	1,738.67
Steam turbine generator efficiency	%	41.45

CALCULATION OF OVERALL POWER PLANT EFFICIENCY

- Overall Plant Efficiency can be calculated

$$\eta = \frac{Q_{el}}{Q_{in}}$$

- Qel is generator output (kWe)
- Qin is useful heat input proportional to fuel burned (kJ/s)

CALCULATION OF OVERALL POWER PLANT EFFICIENCY

- Yields

$$\eta = \frac{200,000}{555,992.62} = 0.3597$$

- Then the overall power plant efficiency is 35.97%

Material? E: J-Power Presentation Document

Promotion for Energy Efficiency and Conservation (PROMEEC)-Industries in Indonesia

The Latest and High Performance Coal-fired Power Generation

Noriyuki SHIMIZU

J-POWER

Presentation at PT. PJB Up Muara Karang PP 24 Nov, 2011 ACE Seminar in Jakarta 25 Nov, 2011

Discussion Points

1. What is J-Power?
2. Historical trend of thermal efficiency improvement
3. The latest and high efficiency coal-fired thermal power station – Isogo TPS
4. Efficiency management and improvement for existing coal-fired TPSs

What is J-Power?

- Electric Power Development Company, Ltd.
- The largest wholesale electric power company in Japan
- Initially founded by the Japanese Government in 1952 and fully privatized in 2004
- Domestic wholesale installed capacity: 16,993MW
  - ✓ Coal: 8,412 (7 TPSs), Geo-thermal: 15, Hydro: 8,566
- Other power business installed capacity: 1,149MW
- Global power business
  - ✓ Consulting service: 320 projects in 63 countries, 1962 - Indonesia; Keramasan CCGT 80MW (PT. PLN), 2008 -
  - ✓ IPP: 3,708MW(share eq.) by 29 projects in 6 countries

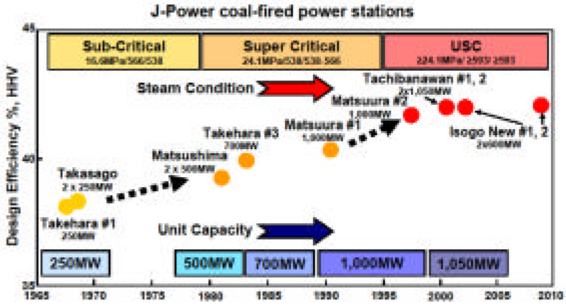
What is J-Power? (cont'd)

Trend of Efficiency Improvement

Coal-fired thermal power stations in Japan

1. Upgrade of steam condition
   - sub critical < 22.1MPa
   - super critical ≥22.1MPa, ≤ 566°C
   - ultra super critical ≥22.1MPa, >566°C
2. Size up of unit capacity
   - ~200MW to 1,000MW+
3. R&D of new technologies
   - IGCC
   - IGFC

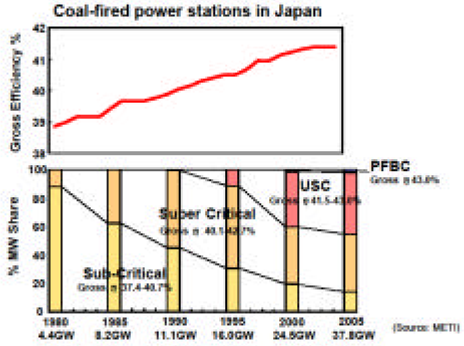
Efficiency Improvement



USC Coal-fired TPSs in Japan

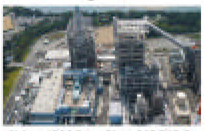
Major EPCos	Power Station	MW	MPa/MST/RST	COD
Chubu	Hekinan #3	700	24.1/538/593	1993
Tohoku	Noshiro #2	600	24.1/566/593	1994
Hokuriku	Nanao Ota #1	500	24.1/566/593	1995
Tohoku	Haramachi #1	1,000	24.5/566/593	1997
J-Power	Matsuura #2	1,000	24.1/593/593	1997
Chugoku	Misumi #1	1,000	24.5/600/600	1998
Hokuriku	Nanao Ota #2	700	24.1/593/593	1998
Tohoku	Haramachi #2	1,000	24.5/600/600	1998
Shikoku	Tachibanawan	700	24.1/566/593	2000
J-Power	Tachibanawan #1	1,050	25.0/600/600	2000
Hokuriku	Turuga #2	700	24.1/593/593	2000
J-Power	Tachibanawan #2	1,050	25.0/600/600	2000
Chubu	Hekinan #4	1,000	24.1/566/593	2001
J-Power	Isogo New #1	600	25.0/600/610	2002
Hokkaido	Tomatoh Atsuma #4	700	25.0/600/600	2002
Chubu	Hekinan #5	1,000	24.1/566/593	2002
Kyushu	Reihoku #2	700	24.1/593/593	2003
Tokyo	Hitachinaka #1	1,000	24.5/600/600	2003
Tokyo	Hirono #5	600	24.5/600/600	2004
Kansai	Maizuru #1	900	24.5/595/595	2004
J-Power	Isogo New #2	600	25.0/600/620	2009

Historical Efficiency Improvement



R&D of New Technology

IGCC Demo Plant	IGFC Pilot Plant EAGLE
• Output: 250MWe • Coal feed rate: 1,700t/d • Test Period: 2007-2013 • Developer: CCP R&D Co. (10 EPCos & CRIEPI) • Air-blown gasifier	• Output: 8MWe • Coal feed rate: 150t/d • Test Period: 2001-2014 • Developer: J-Power • Oxygen-blown gasifier


Nakoso IGCC Demo Plant, CCP R&D Co.


Wakamatsu Research Institute, J-Power

Isogo TPS

- Initially commissioned in 1969 (2x265MW) in urban area of Yokohama City
- Replaced/repowered in 2009 (2x600MW)
- Replacement under operation of old units
  - ✓ in the same area of 12 ha
  - ✓ Build (New #1), Scrap (Old #1&2) and Build (New #2)
  - ✓ replacement work 1996 – 2009
- Why replaced?
  - ✓ to meet Yokohama City Environmental Improvement 21st Century Plan
  - ✓ to meet increasing power demand in metropolitan area
  - ✓ to cope with aged facilities
- Apply the latest USC/environmental technology

Technical Features of Isogo TPS

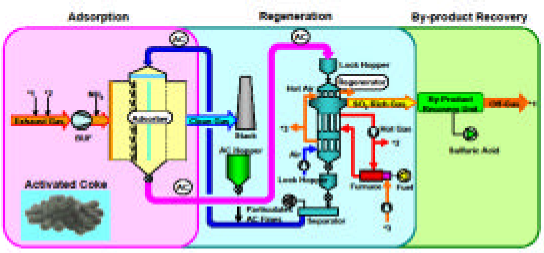
- USC
  - ✓ New #1; 25MPa/600/610
  - ✓ New #2; 25MPa/600/620
- Environmental control
  - ✓ Flue gas treatment;
    Dust: ESP
    SOx: Activated coke dry type FGD
    NOx: SCR
  - ✓ Waste water treatment system
  - ✓ Coal/ash scattering control;
    Coal: Indoor type silo & air-floating belt conveyor
    Ash: Indoor type silo
- Measures for small area of 12 ha
  - ✓ Tower type boiler and tall silos/tanks

Emission Regulation

- Close to the level of gas-fired TPS

		New Units		Old Units
		#1	#2	#1, #2
Dust	mg/m³N	10	5	50
SOx	ppm	20	10	60
NOx	ppm	20	13	159

Activated Coke Dry Type FGD



Replacement Milestone

Old 2x265MW

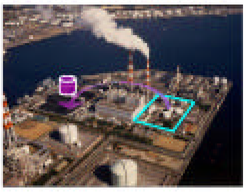
1996

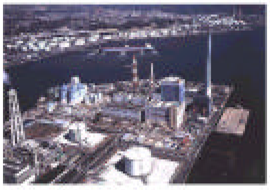
New 2x600MW


2009

Replacement Milestone (cont'd)

- Sep 1996: Start replacement work
  (reduce coal storage area → remove existing outdoor BOP and construct coal silo there)
- Jul 1998: Start construction, New #1





Replacement Milestone (cont'd)

- Nov 2001: Start demolition, Old #1&2
- Apr 2002: COD, New #1
- Mar 2004: Complete demolition, Old #1&2

Replacement Milestone (cont'd)

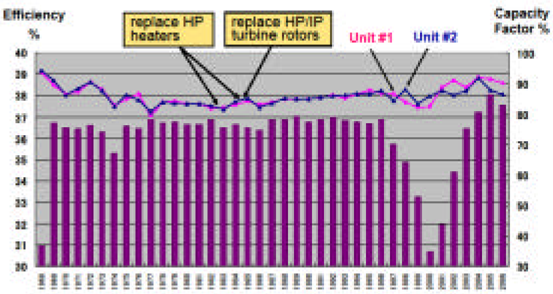
- Oct 2005: Start construction, New #2
- Jul 2009: COD, New #2

Efficiency Management

1. Efficiency of coal-fired power stations in Japan has been improved by upgrading of steam condition and size-up of unit capacity.
2. However, basis of efficiency management activities is same regardless of steam condition and unit size.
3. Such a basis can be applied to coal-fired power stations in Indonesia, where sub-critical and 300-600MW class units are dominant.

Typical Efficiency Management Record

J-Power Takasago coal fired power station, 2x250MW



Activities in Takasago during 40years

1. Shut-down Maintenance
   Boiler: Biannually, Turbine: once every 4 years
2. Major Replacements of Facility
   - Boiler Tubes & SH/RH: 1985, 86, 89, 90, 91, 93, 94, 95, 96, 97 & 98
   - ESP Electrodes: 1987 & 88
   - Turbine Rotors: 1984 & 1985
   - FGD Absorbers: 1985 & 1986
   - Control System: 1985 & 1996
3. Daily Efficiency Management
4. CMMS (Computerized Maintenance Management System): 2002-
5. PdM (Predictive Maintenance by thermograph, vibration, oil analysis): 2002-

Typical Efficiency Management

1. Proper operation and maintenance to keep the efficiency at the level of the design efficiency
2. Active performance improvement by applying new technologies and/or replacing with high efficient equipment

Proper O&M

1. Monitor efficiency trend periodically
2. Analyze the deviation between current efficiency and the design efficiency to get the root cause, if any
3. Take countermeasures both during operation and /or periodical inspection shut-down

Typical O&M Activities

1. Operation
   - proper combustion management to reduce unburned carbon loss
   - proper soot blowing to prevent increase of flue gas temperature
   - proper management of feed water quality to prevent boiler tube corrosion and heat loss through boiler drum water blow
   - monitoring of air ingress into condenser

Typical O&M Activities (cont'd)

2. Maintenance
   - gap adjustment and replacement of turbine labyrinth seal
   - gap adjustment and replacement of AH seal
   - water washing and replacement of AH element
   - scale removal from turbine nozzle
   - boiler chemical washing
   - replacement of plugged condenser tubes

Active Performance Improvement

1. Gross heat rate improvement
   - AH leakage control system
   - high performance AH element
   - optimization of soot blowing
   - low flue gas O2 operation
   - high performance turbine blade and anti-erosive turbine nozzle
2. Net heat rate improvement (reduce in-house power consumption)
   - variable speed/pitch fans
   - partial in-service of aux. equipment

JICA Study in India

- JICA Study on Enhancing Efficiency of Operating Thermal Power Plants in NTPC-India
- Dec 2008 – Jan 2011
- JV of J-Power, Kyushu and Chugoku EPCos
- Objectives
  - ✓ Improve the efficiency of coal-fired TPSs sustainably
  - ✓ Transfer the technologies for the above objective
- for 9 units of 5 coal-fired TPSs, NTPC
- Study incl. economic/financial evaluation and CDM
  - ✓ Efficiency: AH, Condenser, Pump, BFP-T, C&I, BT
  - ✓ RLA: Boiler, Turbine, Generator/Transformer
  - ✓ O&M Procedure
  - ✓ Boiler diagnosis and Combustion simulation

Result of JICA Study

- Efficiency improvement
  - ✓ Various proposals were made; AH new seal system, Boiler furnace modification, O&M procedure, etc.
  - ✓ Some of them were implemented; Condenser air ingress improvement, Turbine seal fin treatment, etc.
  - ✓ The others are under progress for implementation including detail study/design by NTPC/OEMs, cost-effectiveness and timing adjustment.
- Technology transfer
  - ✓ A lot of technologies/information/exercises were introduced.
  - ✓ They were transferred through in-situ demonstration, trainings in Japan and Seminars/Workshops.
- Details: http://lvzopac.jica.go.jp/library/indexeng.html

Conclusion

- For newly planned coal-fired power stations;
  - ✓ New technologies such as USC can be applied to get better thermal efficiency.
  - ✓ This is also effective against Global Warming.
  - ✓ The latest environmental control technologies can also be applied to reduce pollution in local environment.
- For existing coal-fired power stations;
  - ✓ Proper management shall be conducted to keep the thermal efficiency at the design level.
  - ✓ Measures for efficiency improvement beyond the original design level can be considered through justification of related technologies.
- J-Power can provide assistance upon request.