Towards a Green Future

Energy Efficiency & Carbon Footprint

An energy management project sponsored by TÜV SÜD PSB & German Investment & Development Corporation (DEG)

PSB Indonesia

February , 2015 Subramanian VAIRAVAN Singapore Certified Energy Manager (SCEM), Industry Services	February , 2015 Zainab, Energy & Carbon Products Auditing Centre	January, 2015 Name: Aprillia Anggasari Designation: PT Smelting

CHAPTER I

Introduction

1.1 LATAR BELAKANG / Back-Ground

a. PT Smelting has commitment to conserve energy

b. PT Smelting want to reduce the energy consumption

1.2 TUJUAN / Objective

1. To explore the condition of energy consumption in PT Smelting
2. To find the energy conservation opportunities

1.3 LINGKUP PEKERJAAN / Boundary (System)

1. Smelter Plant

1.4 METODOLOGI PELAKSANAAN / Implementation Method

1. Desk Review of 2013-2014 Energy Consumption and Production Historical Data
2. Smelter review to identify the area which has the highest power consumption
3. Prepare Audit Plan
4. Walk-through survey to identify potential Energy Conservation Opportunities (ECO)
5. Compile list of ECO
6. Data collection to support ECO
7. Analyze data collected and make recommendations

CHAPTER II

DESKRIPSI PERUSAHAAN/ Description about Company

2.1 GAMBARAN UMUM PABRIK / Overview of Company

PT. Smelting is constructed as the first copper smelter and refinery (Gresik Smelter and Refinery, GSR) in Indonesia between February 1996 and August 1998, and the operation was started from December 1998. The plant is constructed at Gresik, East Java, where located 20 km Northwest from Surabaya.

GSR is designed to produce 200,000 tpy of LME Grade A copper cathode from copper concentrate supplied from PT. Freeport Indonesia, Irian Jaya and PT Newmont Nusa Tenggara. Other products are 592,000 tpy of sulfuric acid; 31,000 tpy gypsum; 480 tpy of precious metals slime and 382,000 tpy of granulated slag. After the third expansion, the production of PT Smelting is increased become 300,000 tpy of copper cathode; 920,000 tpy of sulfuric acid; 35,000 tpy gypsum; 1,000 tpy of precious metals slime; and 655,000 tpy granulated slag.

Mitsubishi Continuous Copper Smelting Process, Mitsubishi Process (hereunder referred as "MI") and ISA permanent stainless steel cathode process were selected for smelter and refinery, respectively.

The Mitsubishi Process is using totally enclosed three furnaces and interconnected to each other using enclosed launder, so this process has truly continuous operation to convert copper concentrate to molten copper metal. And also completely eliminated all of undesirable emissions, and thereby has brought the smelting of copper into the category of Clean Industries.

The ISA Process is selected due to this process has some advantageous future compare to the conventional electrorefining process, more simple process, and copper cathode can be obtained with a high current efficiency even at a higher current density. And also in order to achieve good quality of cathode product, Continuous Anode Casting System is applied at anode casting stage. The Lurgi-Mitsubishi double contact and double absorption is installed to treat Smelter off-gas. Multistage water treatment plant is also constructed in order to treat all effluents from the plant.

- To be an optimum process for the environmental preservation.
- To be process that can be operated easily and assures high quality products can be obtained.

To be the most advanced, a state of art technology, the plant operation can be expected to continue for more than 20 years.

The electric power and oxygen are supplied from outsourcing company, which has long term experience of these operations. The power and oxygen plants are located in the adjacent site of the GSR plant and supply power exclusively and oxygen in first priority to the plant.

2.2 PROSES PRODUKSI / Production Process

Main Process

The Mitsubishi Process for smelting stage and ISA Process for refinery were selected for the main processes that were used in Gresik Copper Smelter and Refinery, and also continuous casting system is used at anode casting stage. The Lurgi-Mitsubishi double contact and double absorption is installed to treat Smelter off-gas which contain around 14-16% SO2. Multistage water treatment plant is also constructed in order to treat all effluents from the plant. The general flow sheet of the process at Gresik Smelter and Refinery is shown in figure 1.

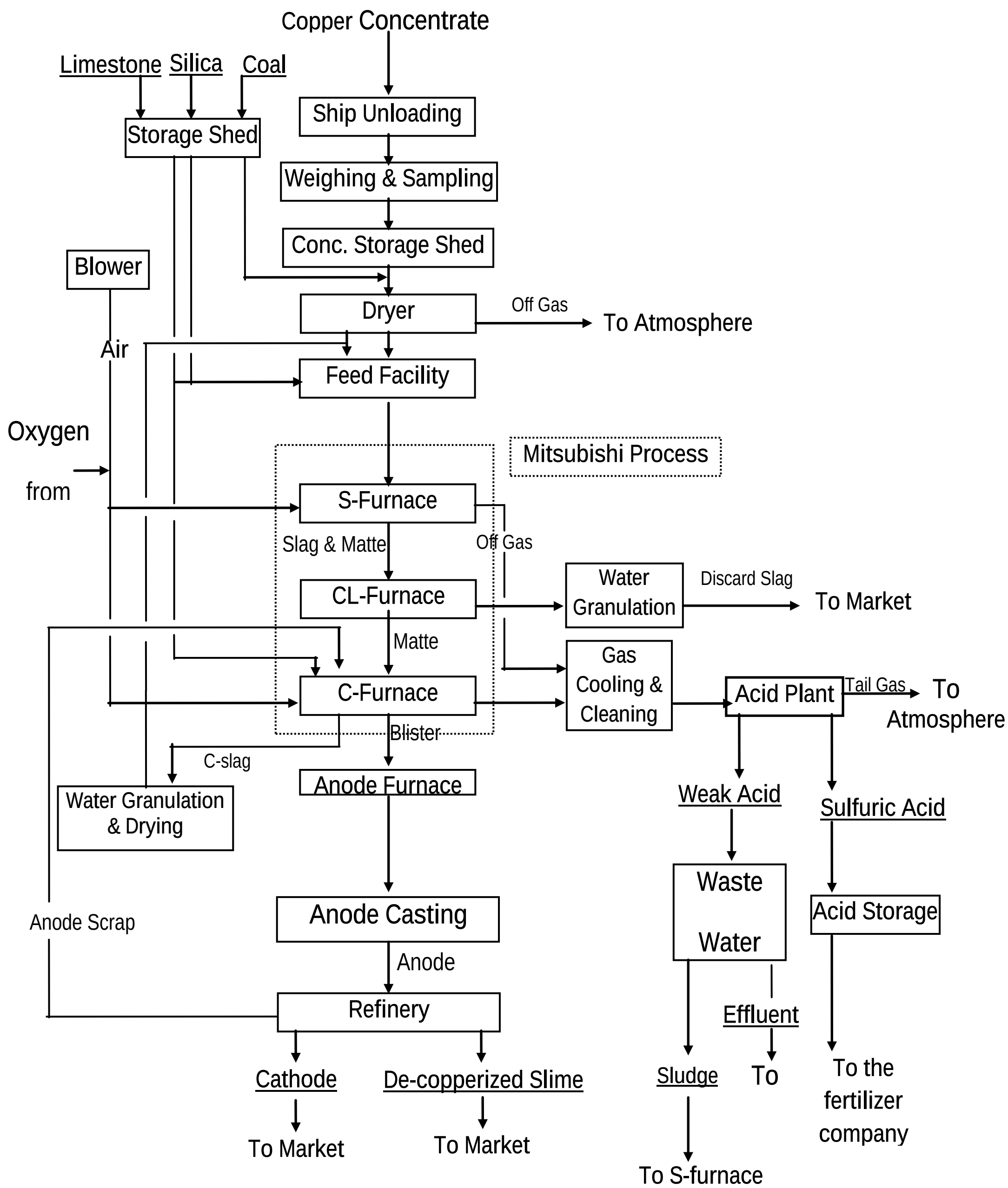

Figure 1. The general flow sheet of the process at Gresik Smelter and Refinery

Concentrate Handling

Copper concentrate from Irian Jaya is received by ship at a wharf which can accommodate concentrate ship carrying up to 35,000 tons. A jetty, 1.9 km in length is constructed to reach water of sufficient depth.

Figure 2. Jetty and Wharf Facility of PT Smelting

A wharf constructed at the head of the jetty. An unloader with a clam shell bucket, coverage capacity 300t/h, ship loader for slag, and reversible belt conveyors are installed. Unloaded concentrate is delivered to concentrate storage yard (capacity 50,000t) after weighing and sampling automatically on the way.

Other materials like silica, lime stone and coal are normally received by truck and stored in the flux storage building. Converting furnace slag (C-slag) is also stored in the flux building. Fluxes are then transferred by a belt conveyor to the each flux bin in the smelter and a belt scale weighs the fluxes on the way to the flux bins.

Smelting and Converting

Mitsubishi Continuous Smelting and Converting Process (Mitsubishi Process) is applied to Smelter. The major features of the smelting process are summarized as follows:

1. The Mitsubishi Process is the continuous copper smelting and converting process with a multi-furnace system, comprising three furnaces which are a Smelting furnace (S-furnace), a Slag Cleaning furnace (CL-furnace) and a Converting furnace (C-furnace). These three furnaces are linked with launders.
2. Concentrate, fluxes and other essential raw materials are melted rapidly as they are injected through top blowing lances with oxygen enriched air into the S-furnace. By using the top blowing lances higher oxygen utilization is attained and dust generation is minimized.

3. High-grade matte operation (65% Cu in matte) is performed at the S-furnace and a reaction heat of concentrate can be utilized at maximum extent.
4. In the C-furnace, matte is converted to blister copper continuously forming the Cu_2O-CaO-Fe_3O_4 ternary slag.
5. Since the furnaces are connected by sealed launders and off-gas from the furnaces are more stable and much higher in SO_2 concentration, the furnaces and the related facilities including the acid plant can be designed compactly.
6. From the environmental standpoint, the process is capable of preventing fugitive gas much lower than PS converter operation of conventional copper smelter because of the elimination of ladle transportation and batch-wise operation.

Schematic flow sheet of the Mitsubishi Process is shown in Figure 3. Concentrate blended with coal and in-plant recycled materials of which moisture is 7-10%, is dried to 0.5% moisture using a rotary kiln/flash dryer. Dried concentrate is transported to feeding tank system by conveyors. Fluxes are discharged to the same conveyors from the respective day bins and charging rate is controlled according to the concentrate feed rate to the S-furnace and concentrate composition based on metallurgical calculation.

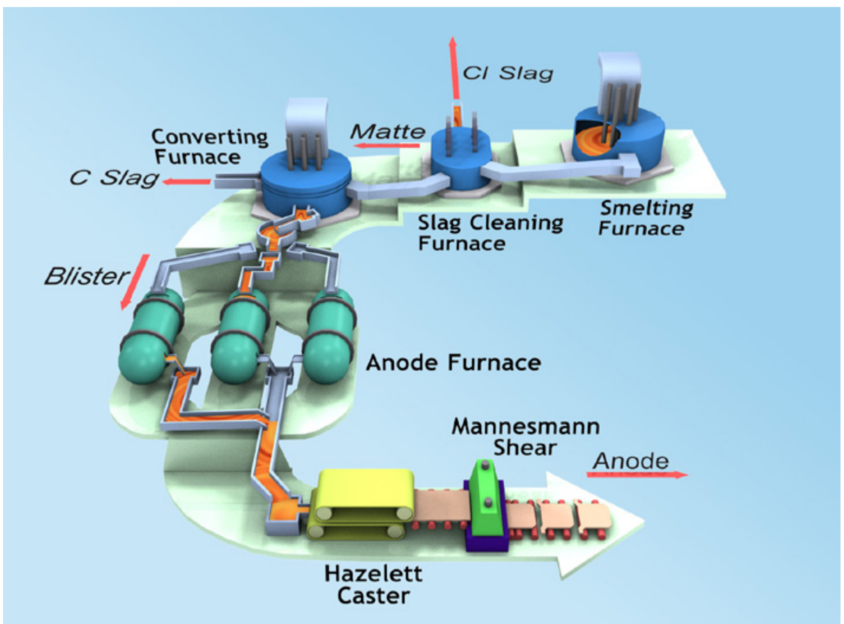

Figure 3. Schematic Diagram of the Mitsubishi Process

A flux-reverts-concentrates mixture is transported by pneumatic conveying air into a 2 inch inner pipe that is encircled by a larger 4 inch diameter lance pipe. Oxygen enriched air is introduced the annular region between pipes. The inner pipe ends at a short distance above the furnace roof and the final high velocity air-oxygen-concentrate mixture is introduced into the furnace through a rotating lance and impinges on the molten bath.

The S-furnace is refractory lined and circular in shape (10.0 m inside dia.). A tap hole for matte and slag mixture overflowing and uptake is installed on the side wall and roof respectively. Refractory of upper part of wall side and roof are equipped with water cooled copper jacket. 9 lances are installed on the roof.

Feed materials are smelted and form matte of 65% Cu and slag. Slag and matte mixture overflows from the furnace and flows via a natural gas heated launder to the CL-furnace.

The 3,600 KVA CL-furnace is elliptical in cross section and is heated by two sets of delta type electrode allocation, 16inch graphite electrodes. Matte and slag are separated by difference of specific gravity. Slag overflows from the CL-furnace and is water-granulated. Molten matte is constantly siphoned out to the C-furnace.

The C-furnace is circular in shape (9 m inside dia.) and 10 lances are equipped, which feed a limestone-coolant-oxygen enriched air mixture to the furnace bath. Anode scraps from refinery are fed to the C-furnace. Matte is oxidized and blister copper is produced. Blister copper is siphoned out from the C-furnace continuously and led to the anode furnace through launders. Formed C-slag, which is Fe_3O_4-CaO-Cu_2O, overflows from the furnace and is water-granulated. Granulated C-slag is returned to the S-furnace after drying and some amount of C-slag is fed to C-furnace as coolant.

Process of Gas Handling

Process gas from the S-furnace, at temperature of 1,250-1,300˚C, flows through the furnace uptake to waste heat boiler for cooling and partial cleaning. Process gas from the C-furnace is handled in a similar manner as that from the S-furnace. The steam generated from the waste boiler is delivered to steam turbine generators at power plant.

From the waste heat boilers the gas enters to electrostatic precipitators to remove dust and then sent to the acid plant. Dust collected at boilers and electrostatic precipitators are normally returned to the S-furnace continuously.

Anode Furnace and Casting Machine

Three cylindrical anode furnaces are installed for refining blister copper (Figure 3). The blister copper from C-furnace is charged to either of the furnaces directly through launder while the other furnace is in refining and casting operation. At first stage, blister copper is oxidized by oxygen enriched air for elimination of remaining sulfur in the blister and at second stage, oil injection is used to reduce the excess oxygen in the blister. This refining controls sulfur and oxygen content in the blister, and the refined blister is then cast into anode by the Contilanod Process.

Casting facilities (Figure 4) consists of a holding furnace, a tundish, Hazelett twin belt caster, pinch roll, hydraulic shear, cooling tunnel and stacking device. Hazelett casting machine have been used in several smelters and it has been proven that flatness and uniformity in weight of the anode superior to an anode cast by a conventional casting machine. It is expected that these features will contribute to make the refinery operation much stables.

Figure 4. Hazelett Caster Machine

Refined copper is cast into continuous copper strip of 45mm thick with integral rug at 100tph through Hazelett caster. The continuous strip is cut into anode pieces by a hydraulic shear, which move together with the strip. Anodes are cooled with water spray in the cooling tunnel. The weight of anode is about 400kg.

Copper Refinery

The refinery has a capacity of producing LME Grade A quality copper cathode at 300,000 metric tons per year at current density of ±300 A/m2. It is the design concept of the refinery that the process and operation shall be as simple as possible to keep cathodes quality high. Major equipment and their features are summarized as follows:

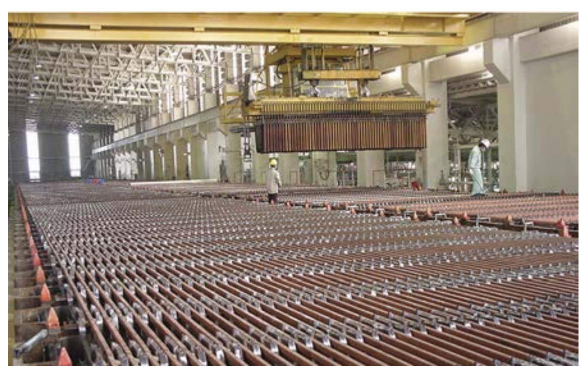

Figure 5. Refinery Plant

1. To make electrolysis operation stable and easy, anodes cast with Hazelett casting machine and stainless steel cathode of ISA Process are used. Both anodes and cathodes are much straighter and higher verticality in the cell than conventional ones. The inter-space between an anode and a cathode is much stable than conventional.
2. Each cell voltage is monitored on CRT of computer system in the control room.
3. Cathode washing and stripping machine can process a cathode up to 100kg copper deposit on each side.
4. Overhead traveling crane can transport both anodes and cathodes for a cell at one traveling. Positioning system (cone on the crane bale and pyramid on a cell and the electrode handling machines) are added to get quick and precise electrode alignment.
5. Liberator cells are divided into 3 stages to produce high quality electrowon cathodes in the first stage with removing impurities effectively in the third stage.
6. All the cells are made of polymer concrete without requirement for lining.
7. Autoclaves are used for anode slime treatment so that the treatment can be done rapidly and stable. High-pressure oxygen is used in the autoclaves.

Sulfuric Acid Plant

The process of sulfuric acid could be seen in figure 6. The off-gas from furnaces contains SO2 gas is pre-cooled, pre-cleaned and mixed in the smelter and then introduced to the gas cooling and cleaning section in the acid plant by main blower at the strong acid section. The off-gas from smelter contains around 14-16% SO2.

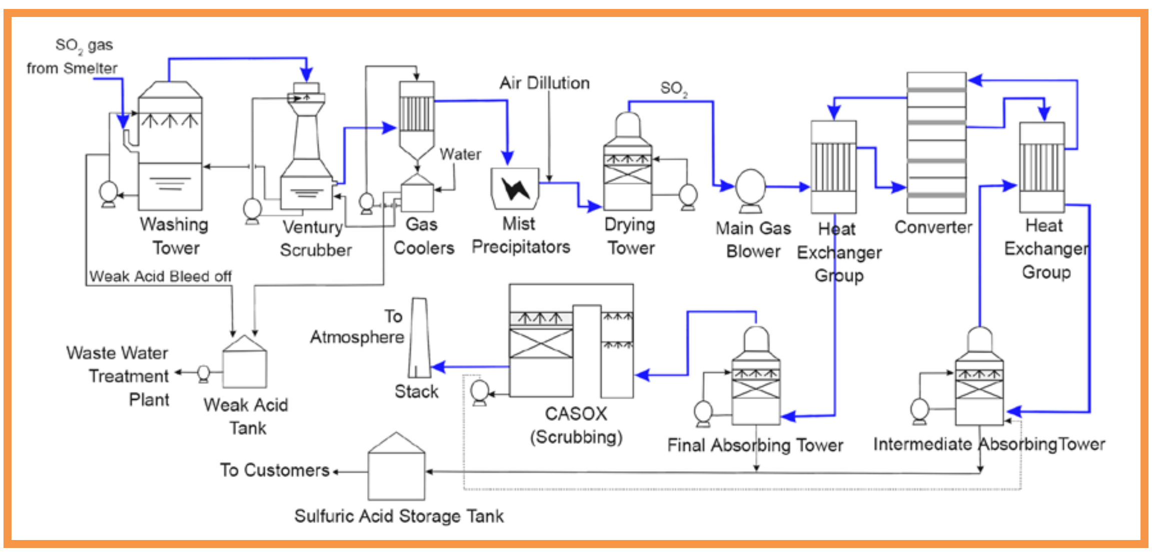

Figure 6. Acid Plant Process Diagram

A sulfuric acid plant is provided in order to recover sulfur dioxide (SO2) from the smelter and convert it into sulfuric acid as a product. The Lurgi-Mitsubishi Double Contact/Absorption is used in the sulfuric acid plant, so can be expected a high conversion ratio of SO2 to SO3 and a high recovery ratio of SO2 can be obtained.

A washing tower, a ventury scrubber and two steps of wet electrostatic precipitators are applied in gas cooling and cleaning section. The cleaned gas enters the drying tower, where gas is dried by contact in counter current flow with 95% sulfuric acid circulated.

The dried gas is then delivered to the converter via the main gas blower, and SO2 converted into SO3. Four catalyst bed converter is installed and the generated SO3 is then absorbed at Intermediate Absorption Tower and at Final Absorption Tower to produce 98.5% H2SO4. This product acid is sent to a fertilizer company through pipeline, stack emission is kept at less than 280ppm SO2.

Waste Water Treatment Plant

Multistage waste water treatment plant is designed to treat all effluents from the plant and surface water resulting from first 15mm of rainwater (storm water) by removing all impurities and adjusting the pH so that the effluent discharge from the plant meets with the Indonesia environmental standards.

There are two categories of waste water into waste water treatment plant, contain large concentrations of sulfuric acid and the other contain small concentration of sulfuric acid, neutral or bases.

The waste acid coming from the acid plant typically contains large amount of sulfuric acid. Wastewater containing small concentration of sulfuric acid comes from smelter, such as blow down of the granulation circuits (C and Cl-slag), and also wastewater came from storm water pond.

The treatment of wastewater water consists of three stages. The first stage (gypsum separation stage), solid particles in wastewater containing large concentrations of sulfuric acid is removed and then partially neutralized using limestone (CaCO3) to produce gypsum as by product. The clarified solution out of this stage thickener is delivered to the second stage in order to precipitate the trace metals using slaked lime (Ca(OH)2) to produced sludge. This sludge is then recycled to smelter (S-furnace). The last stage is polishing to remove remaining trace metals especially arsenic. In this stage, the trace metals are precipitated by sodium hydrogen sulfide and ferric chloride respectively. Sludge, which is produced at this stage is recycled to second stage. Some of the treated water out of the clarifier is reused as water for diluting waste water in the gypsum separation stage, dissolving and diluting chemicals in the WWTP.

2.3 PERALATAN UTAMA / Main Energy Users

1. Main Gas Blower
2. Ventilation Fan
3. Concentrate Dryer Off Gas Fan

2.4 SUMBER DAN DISTRIBUSI ENERGI / SOURCE AND ENERGY DISTRIBUTION

Energy Source:
1. Electricity
2. Natural Gas
3. HSD
4. Coal

Energy Consumption:

1. Electricity

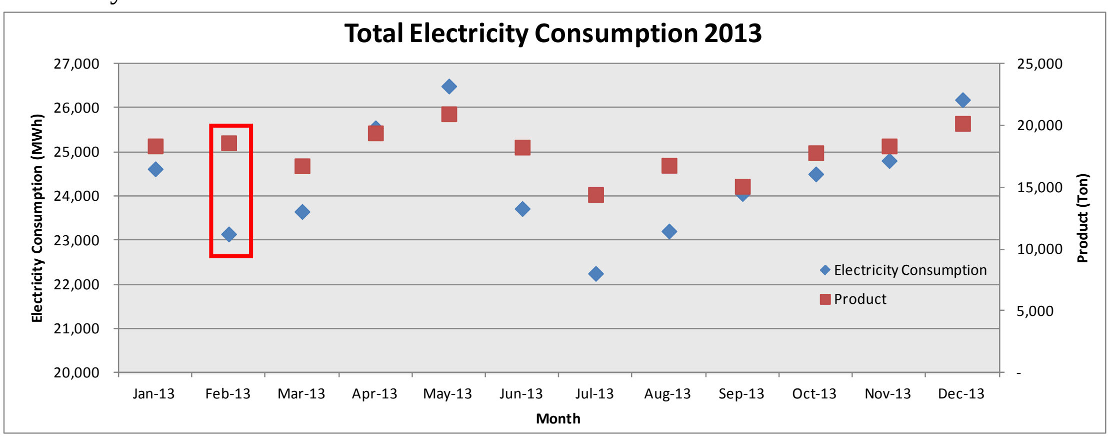

Figure 7. Total Electricity Consumption 2013

The graph of electricity consumption against total production mostly shows linear movement. When the production increased the consumption of electricity also increased, except February because many activities of engine repair in smelter and acid plant. So, the usage of electricity in those places is decreased due to stop operation. Production is stabile because refinery operation is stabile.

2. Natural Gas

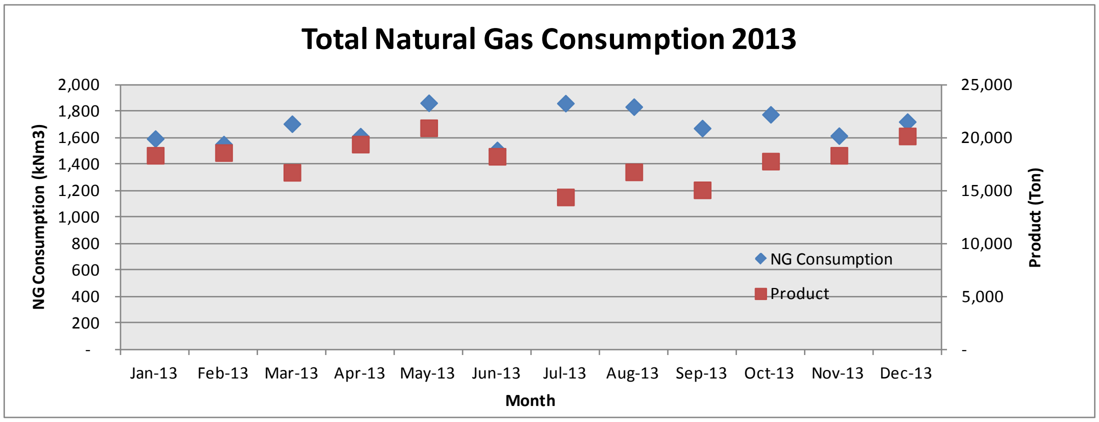

Figure 8. Total Natural Gas Consumption 2013

From the figure 8, total consumption of natural gas has irregular plot graph. Most of the graph has different pattern with production graph. It means that natural gas has Energy Conservation Opportunity because usually the energy consumption which has not correlation with production amount means it has not usage standard. To make it stabile, it should be standardized by making Operational Standard Procedure or making automatic operational system.

3. HSD

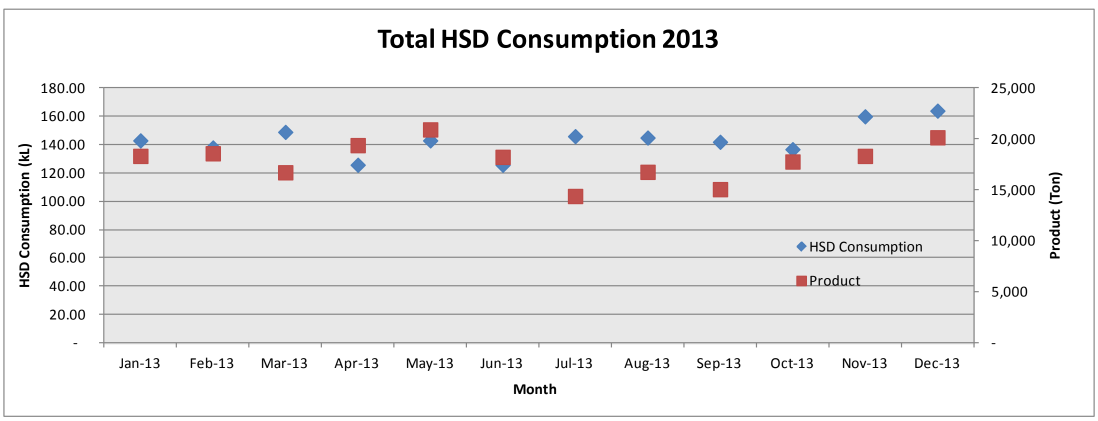

Figure 9. Total HSD Consumption 2013

The plot graph of HSD consumption and production in figure 9 is almost the same with natural gas plot graph which is not linear with production plot. But, in this case HSD consumption is depend on concentrate content. The more sulfur content the more oxygen needed to bind sulfur means the more HSD needed to pick up the oxygen from the molten metal.

4. Coal

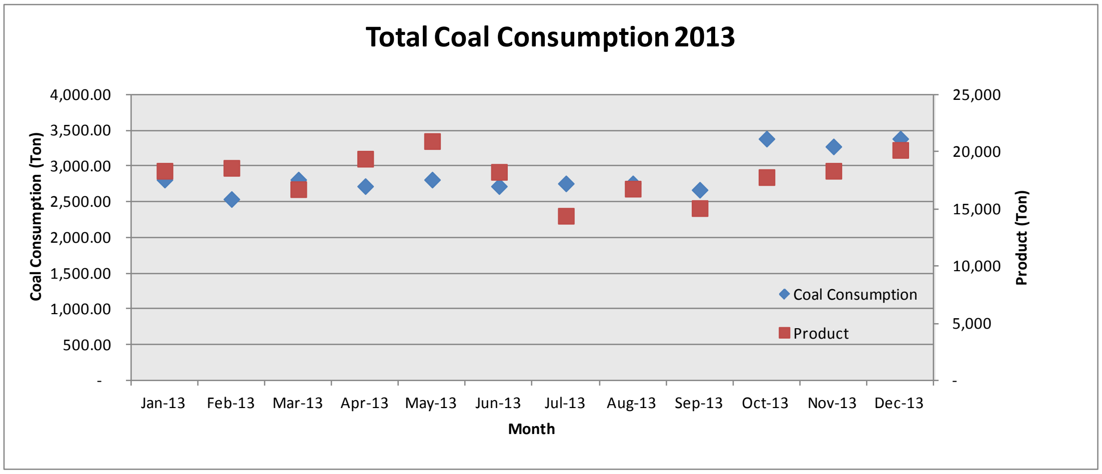

Figure 10. Total Coal Consumption 2013

Figure 10 describes the plot of coal consumption graph almost linier with production graph. But actually the main factor which influence the usage of coal in sulfur content in concentrate. The more sulfur content in concentrate, the less usage of coal. I happens because sulfur could cause exothermic reaction by itself. Coal is used to increase the heat if sulfur content in concentrate is low.

Total Energy Consumption:

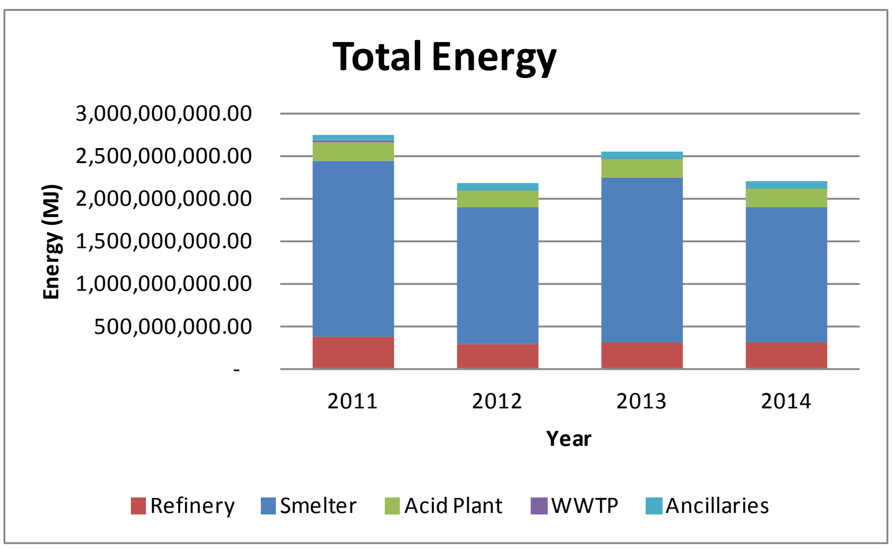

Figure 11. Total Energy Consumption 2011-2014

From 2011 to 2014, the average yearly total energy consumption is 2,400 TJ.

2.5 MANAJEMEN ENERGI / ENERGY MANAGEMENT TEAM

Below is the chart of PT Smelting Organization of Efficiency and Conservation of Natural Resources and Waste Management (Figure12). There is a manager of Water and Energy who has authority to give instruction to each of section's representative. Besides, he also assisted by Internal Auditor to conduct investigation, monitoring of water and energy programs and also audit.

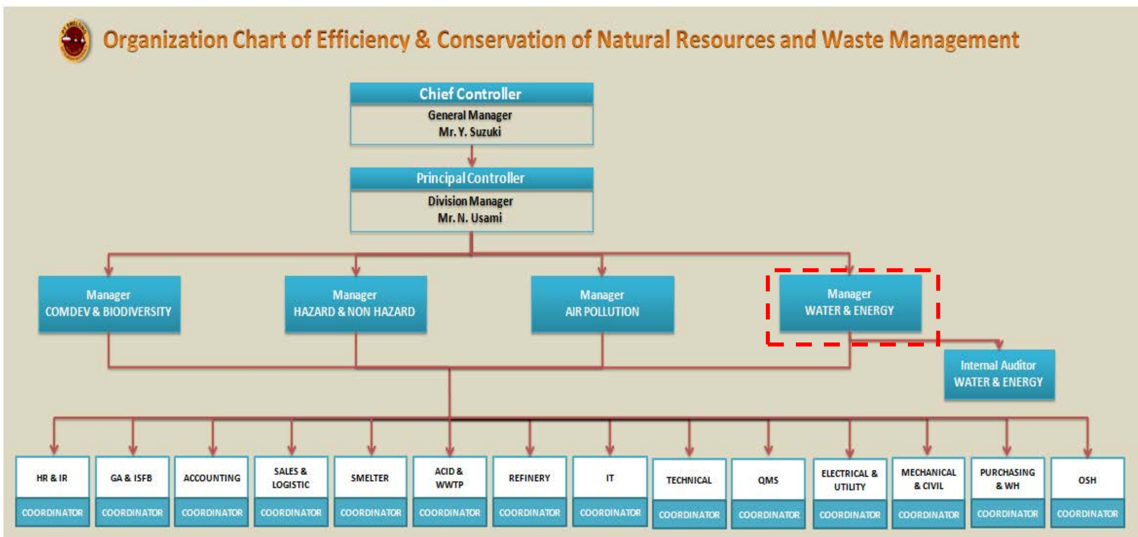

Figure 12. PT Smelting Organization of Efficiency and Conservation of Natural Resources and Waste Management Chart

CHAPTER III

FAKTA DAN TEMUAN / FACTS & FINDINGS

Based on the energy distribution data (Figure 11), the highest consumer of energy in PT Smelting is Smelter Plant. About 74% of the total energy is consumed by Smelter Plant. From the fact of energy data, finally the auditors decide to choose smelter plant as the energy audit area.

Here is the group auditors which conducted walk-through audit on 20th Oct 2014:

Group I (Utility)

1. Review the energy consumption of smelter plant in 2013
2. Review the energy portion of smelter plant in 2013
3. Review the main energy user in smelter plant

Group II (Electrical)

1. Investigate electrical quality of Smelter equipment in Smelter Substation

Group III (Mechanical)

1. Investigate mechanical performance of main energy user in smelter plant

Group IV (GHG Management)

2. Investigate mechanical performance of main energy user in smelter plant

Facts and finding of walk through audit:

I. Utility System

2.1. Review the energy consumption of smelter plant in 2013

There are four energy sources that are used in Smelter Plant:

1. Electricity
2. Natural Gas
3. HSD
4. Coal

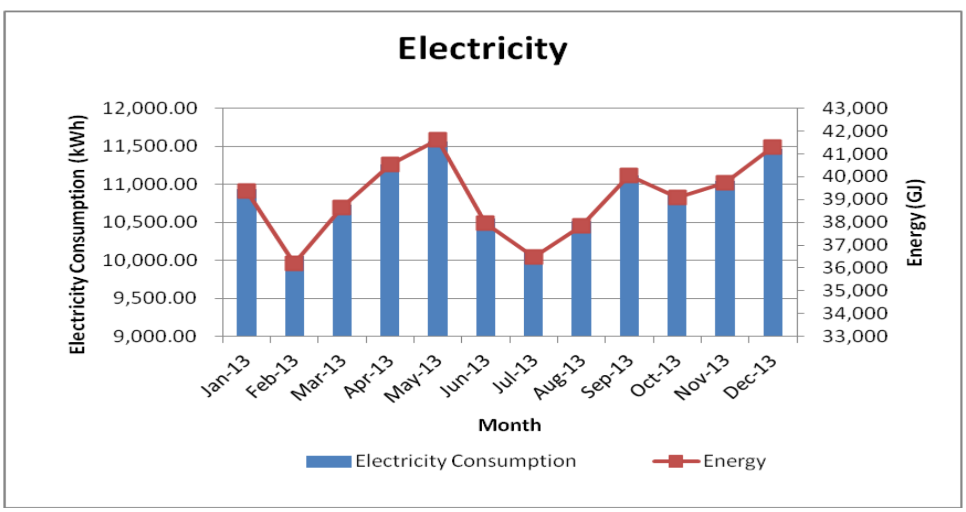

Figure 13. Electricity consumption of Smelter Plant 2013

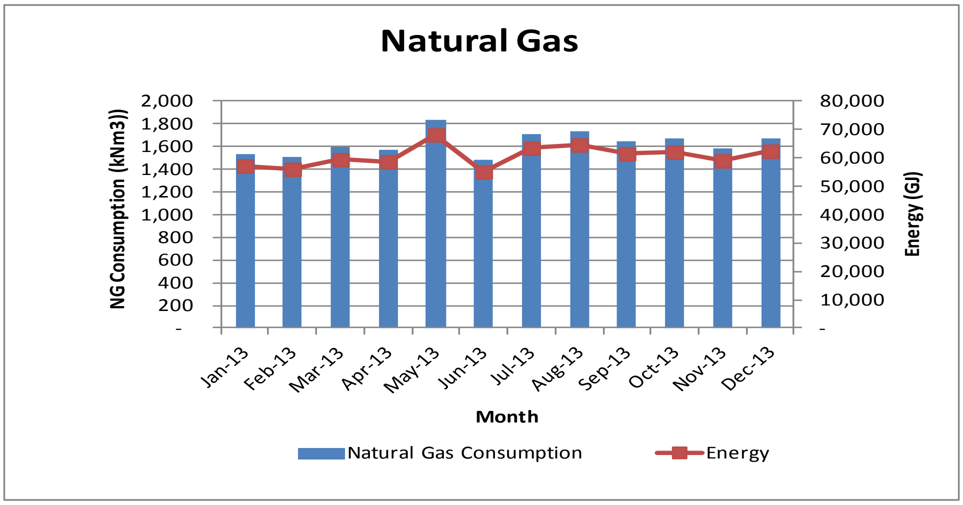

Figure 14. Natural gas consumption of Smelter Plant 2013

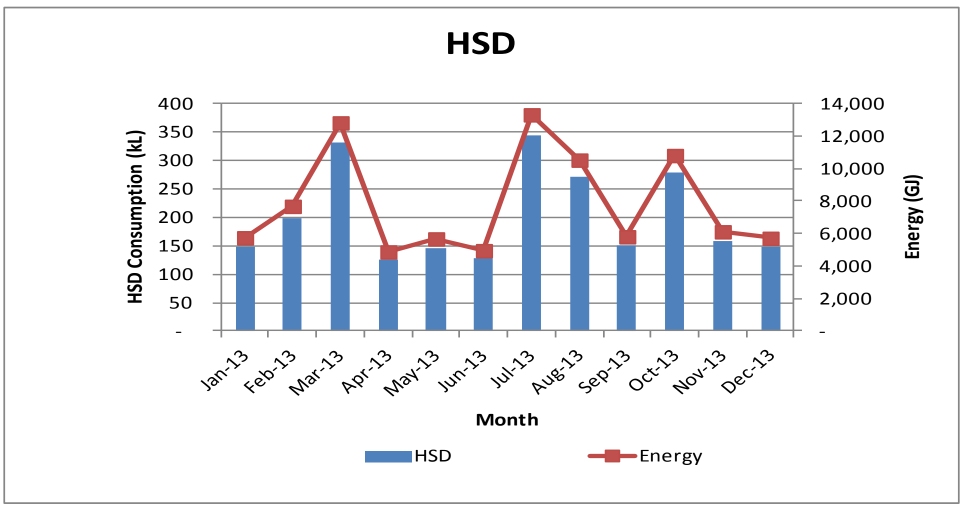

Figure 15. HSD consumption of Smelter Plant 2013

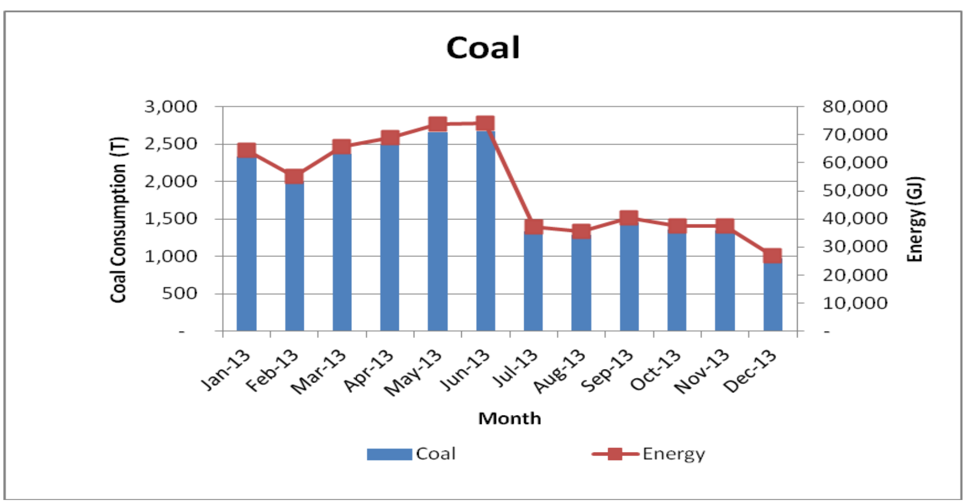

Figure 16. HSD consumption of Smelter Plant 2013

Each energy source has been influence by their own parameter. Electricity is influenced by operation. The higher operation, the higher electricity needed to support the process.

2.2. Review the energy portion of smelter plant in 2013

Smelter is divided into four areas, they are:

1. MI (Mitsubishi Process Area)
2. Anode Furnace
3. Anode Casting
4. RMH (Raw Material Handling)

Each area has different energy consumption. Here is the portion of energy consumption in Smelter area (Figure 17).

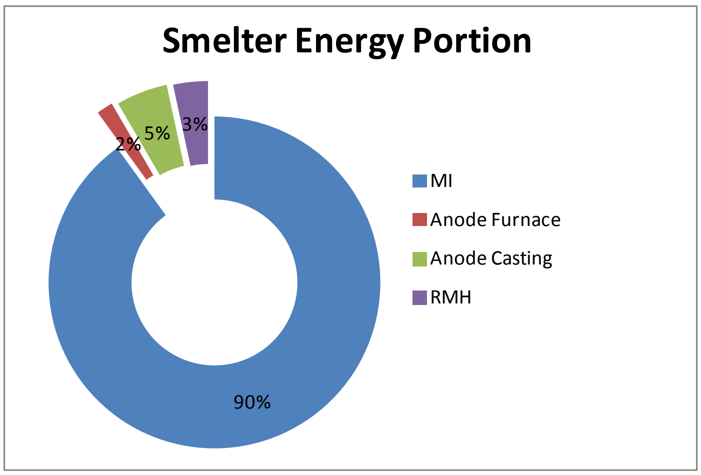

Figure 17. Energy Portion of Smelter Area

Mitsubishi process area has the highest energy consumption. About 90% of energy in smelter plant is consumed by this area. Therefore, energy audit is potentially conducted in this area.

2.3. Review the energy consumption of smelter plant in 2013

Based on equipment data of smelter plant, there are two main energy users in Smelter plant. Those main energy users are :

1. Concentrate dryer off gas fan (Power 650kW)
2. Ventilation fan (Power 520kW)

II. Electrical System

Auditors have conducted quality measurement of electricity using power quality analyzer. There are several analysis of electrical parameters, such as: power factor, voltage unbalance, frequency, THD voltage and THD current. Measurement is done at substation which has voltage 11 kV, 6kV, and 0.4 kV. Here are the objects of measurement in smelter substation:

1. 52F1 Smelter No.1 (11 kV)
2. 52F3 Smelter No.2 (11 kV)
3. Compressor House No.1 (6 kV)
4. Compressor House No.2 (6 kV)
5. Electromotor 135-BL-001 (6 kV)
6. Furnace Jacket Cooling Pump 135-PP-001 (6 kV)
7. Compressor 170-CP-052 (6 kV)
8. Electromotor 105-RM-001 (0.4 kV)

Based on measurement result of power quality analyzer, all of the equipment has good electrical system quality because they are still fulfil the standard of electrical parameters.

III. Mechanical System

Object of mechanical system assessment is concentrate dryer off gas fan and ventilation fan.

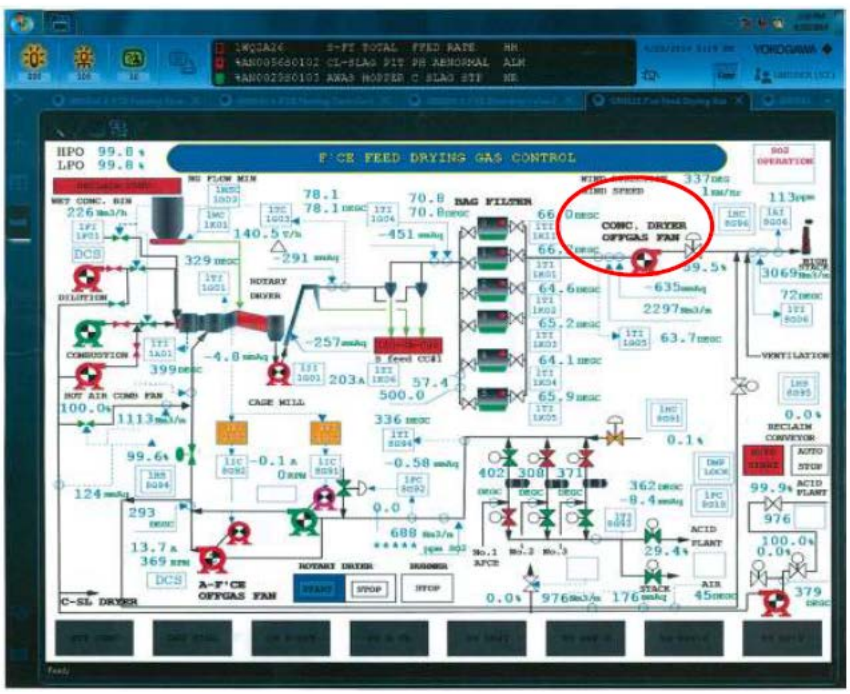

Figure 18. DCS Furnace Drying Gas Control

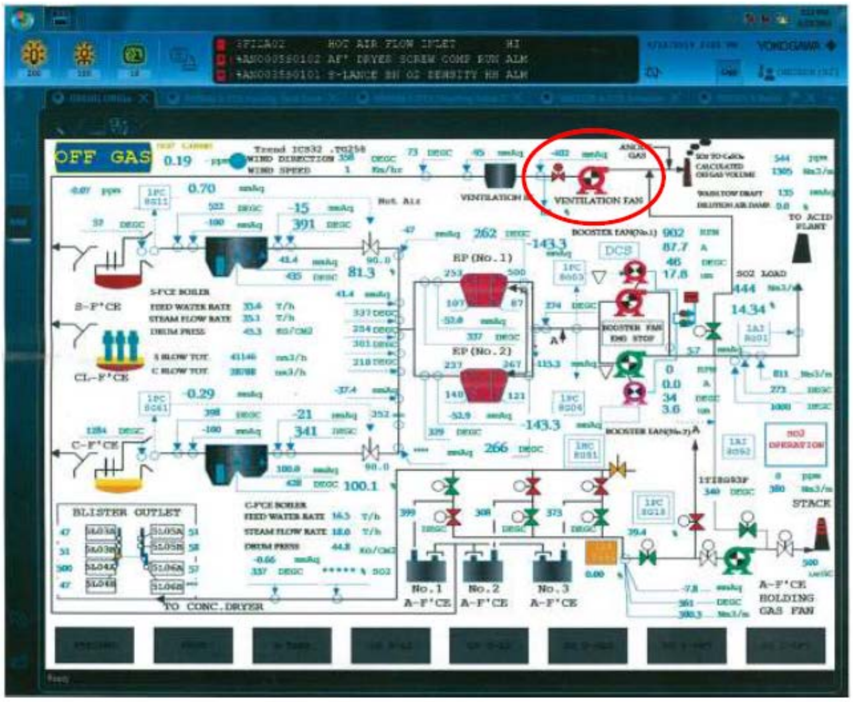

Figure 19. DCS Off Gas Handling

The DCS Furnace Drying Gas Control shows the process of off gas handling in smelter plant. Look at the concentrate dryer off gas fan which has been circled. From the observation, the valve of concentrate dryer off gas fan was opened 60%, while the power always running 100%. It means that not all of the energy is used in this system, because the valve only 60% opened. This situation also happened to ventilation fan (Figure 19). Its valve also opened 60% while the power is 100%. From these conditions, it can be predicted that there is any ECO that can be applied.

IV. GHG Management

The Green House Gases of overall PT Smelting is calculated using TUV SUD calculator and the result is like the table below (Figure 20):

PSB Indonesia

Carbon Footprint Emissions for PT Prima Elektrik Power

DEG PPP Project

9/15/2014

Total Emissions from process		
Source	**kg CO2**	**tons CO2**
Electricity	216,494,398.38	216,494.40
Solar	7,751,459.65	7,751.46
Coal	37,011,630.06	37,011.63
Natural Gas	42,432,905.62	42,432.91
Total Emissions	**303,690,393.71**	**303,690.39**

Total Emission from operation is **303,690.39** **tons of CO2 emission equivalent**

Figure 20. PTS GHG

From the table above, Smelter plan is estimated has contribution about 74% of emission equivalent due to its energy portion (Figure 21). It is means smelter plant emitted about 224,730.89 Tons CO2 emission equivalent.

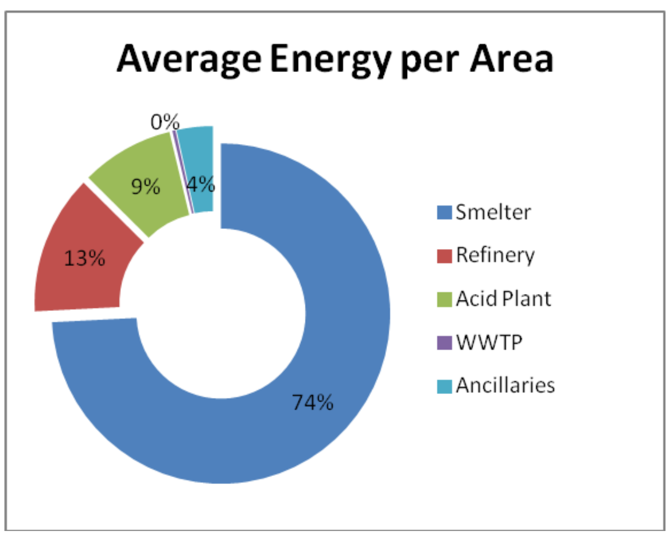

Figure 21. Average energy per area in PT Smelting

CHAPTER IV

ANALISIS POTENSI PENGHEMATAN ENERGI / ANALYSIS FOR ENERGY CONSERVATION OPPORTUNITIES

4.1 Utility System

Each energy source has been influence by their own parameter. Electricity is influenced by operation. The higher operation, the higher electricity needed to support the process. It is also happen to diesel and coal. But Natural gas is stabile although the operation is not stabile. It is means that there is any energy user which always using natural gas every time. After walk through audit, the auditors found that burner of furnace launder is running every time and operated without any operational procedure. There is the possibility of energy wastage happen.

ECO

1. Make operational procedure of natural gas utilization of launder burner
2. Make trial test to measure the optimal usage of launder burner

4.2 Electrical System

NO problem.

4.3 Mechanical System

Concentrate dryer off gas fan and ventilation fan have un-optimum operation due to their opening valve. Their valves were open 60% while the power is transferred 100%. It means that energy wastage happened about 40%.

ECO

1. Use Variable Speed Drive (VSD) to control the valves performance

4.3 GHG Management

PT Smelting consumed huge source of energy and emitted huge amount of GHG. It is necessary to conduct energy management system to manage the energy usage well. The energy management also helped PT Smelting to be more environmentally friendly by reducing their emission.

ECO

1. Conduct energy monitoring regularly (once a month)
2. Conduct energy audit regularly (once a year)
3. Conduct energy retrofit to improve energy utilization

CHAPTER V

REKOMENDASI PENGHEMATAN ENERGI / RECOMMENDATIONS FOR ENERGY CONSERVATION

5.1 RINGKASAN POTENSI PENGHEMATAN / SUMMARY OF POTENTIAL ENERGY SAVING

The summary of potential energy saving from this audit result is:

1. **Improve launder burner operation system**
2. **Improve concentrate dryer off gas fan**
3. **Improve ventilation fan**

5.2 RENCANA AKSI IMPLEMENTASI / SUMMARY OF OUTCOME FROM ACTION PLAN

The summary outcome from action plan is:

1. **Optimization trial test of launder burner**
2. **Install VSD in concentrate dryer off gas fan**
3. **Install VSD in ventilation fan**

CHAPTER VI

HASIL AKSI IMPLEMENTASI / RESULT OF IMPLEMENTATION ACTION

1. Optimization trial test of launder burner

Burner running

Burner closed

Launder is the gutter of molten metal between the furnaces. Along the launder is installed several burner to keep the molten metal in liquid condition. We tried to know how many burner is should be used to keep the operation stable by closing several of them and analyze what happen with them. Previously, natural gas average consumption of this launder is 233.3 kNm^3/month and in January 2014 the consumption was decreased up to 218.30 kNm^3/month after two burners were closed. If price of natural gas is 345 US$/kNm3, by assuming 1 US$ equal to 13,127 rupiah, decreasing in natural gas consumption by 15 kNm3/month means that PT Smelting can save the natural gas cost up to 67,932,225.00- rupiah/month. The reduction of launder burner did not reduce the quality of molten metal heating in launder. Hence, PT

Smelting will continue to try reducing this burner until we find the optimum number of burner used in burner utilization.

2. Install VSD in concentrate dryer off gas fan and ventilation fan

VSD of concentrate dryer off gas fan and ventilation fan

VSD finally installed as energy retrofit in PT Smelting. After one month installation, it can reduce the energy usage of concentrate off gas fan dryer from average 309,067 kWh to 274,113 kWh and ventilation fan from average 423,256 kWh to 330,223 kWh. Comparing the estimation and actual, we can figure:

	Without VFD	With VFD	
		Estimation	Actual
Conc. Dryer Offgas Fan 105-FA-003	Shaft power = 605 kW	Shaft power = 455 kW	Shaft power = 447 kW
		Cost reduction = $177,600/year	Cost reduction = $184,800/year
Ventilation Fan 155-FA-001	Shaft power = 562 kW	Shaft power = 371 kW	Shaft power = 376 kW
		Cost reduction = $220,800/year	Cost reduction = $216,000/year

And the gain that we get is:

	Procurement & Installation cost	Cost gain	R.O.I
Conc. Dryer Offgas Fan 105-FA-003	$187,700	$184,800/year	12 months
Ventilation Fan 155-FA-001	$123,400	$216,000/year	7 months

And based on actual figure of energy consumption, the Return On Investment (ROI) could be estimated around 12 months for Concentrate Dryer Offgas Fan 105-FA-003, and 7 months for Ventilation Fan 155-FA-001 (based on payable electrical power by considering Power Factor of motors and Power Factor of PT. Smelting - Linde agreement). This actual figure is as we expected. That is big saving and we will conduct maintenance and monitoring to keep this VSDs run well.