

## Parasitic Load Efficiency Program Kamojang Generation Business Unit Pt. Indonesia Power, Indonesia

Pelitabar Pakpahan, Ruly Husnie Ridwan, and Irwan Edi S. Lubis

Keywords: Parasitic load efficiency program

### ABSTRACT

The existence of an electricity energy crisis in Indonesia has continued to drive UBP Kamojang efforts to lessen parasitic load at each geothermal power generation unit. The aging of the equipment combined with the increasing demand has forced UBP Kamojang management to decrease the parasitic load as soon as possible (parasitic load efficiency program). This paper will explain the strategy which has and will be applied by UBP Kamojang management to implement this program. Execution of this program has a cost benefit ratio which is relatively large, that is  $\pm$  IRD 1.38 Milliard per year.

### 1. INTRODUCTION

Generation Business Unit (GBU) of Kamojang (UBP Kamojang) is one of eight GBUs under PT Indonesia Power using geothermal as its primary energy. It is the biggest one of its kind in Indonesia. There three sub GBUs: Kamojang (1 x 30 MW and 2 x 55 MW), Darajat (1 x 55 MW), and Gunung Salak (3x 60 MW).

The Kamojang geothermal power plant has operated since the Unit 1 (30 MW) was declared open by the former President Soeharto on 7 February 1983. The operation of Unit 2 (55 MW) and Unit 3 (55 MW) followed in July and November of that year. The formal opening was extended by a new project of the Darajat geothermal power plant (55 MW) that was completed in 1993, while the Gunung Salak plants were completed as follows: Unit 1 (55 MW) in 1994, Unit 2 (55 MW) in 1995, and Unit 3 (55 MW) in 1997, and a later renovation increased the capacities of Gunung Salak geothermal power plants to 3 x 60 MW. With its producing capacity of some 375 MW, the GBU of Kamojang supplies some 3.98 % of Indonesia Power's overall energy production.

Study of the Parasitic Load, usually called PL, in Kamojang Generation Business Unit, usually called UBP Kamojang, had been done several times. The spirit of this is to improve upon these due to the existing national electrical energy crisis.

The PL is defined as the amount of electrical energy required by a power generation unit to guarantee operation from or self usage of electrical energy for power generation unit operation. The PL reflects the energy needed for principal electrical energy producer and also for requirement of the auxiliary unit.

During the development of this paper the calculation methodology for this terminology, PL has experienced some transformations. If in the year 2006 rearward, the process calculation of PL is by the way of lessening generator output electric energy with kWh meter which as described at line before PL transformer for every unit. Hence after the year 2006, calculation method for PL have included loss factor at PL transformer and main unit transformer. Transformation of this calculation method has a large effect on the summary of PL in UBP Kamojang.

The Life Cycle from a power generation unit always started from the Engineering Procurement Construction (EPC) phase which is generally done by a contractor, then continued to Operating & Maintenance (O&M) phase which is done by the owner of a power generation unit. The illustration in Figure 1 explains each step in a life cycle for the power generation unit.

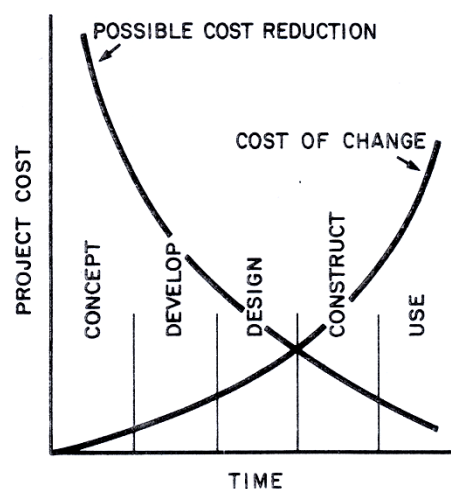


Figure 1. Project cost vs. time (phase)

In fact, the step for PL efficiency from a power generation unit can give the maximum benefit if done in the engineering phase from an EPC project. It is based on the capability of the engineer at this phase to optimize an efficiency which will give big impact with relatively less effort because the specification of equipment is not yet determined. While at the phase O&M, where specification of equipments has been attached with certain specifications, it will of course limit the engineers in O&M phase in their ability to do PL efficiency. But it is important to know this, because the phase of engineering in EPC projects is relatively short (less than 3 month for a EPC project of 24 month duration) and hence there are limitations on time and man hour engineering at this phase. This gives an opportunity of inefficiency over design in power generation unit design. This opportunity then will try to be exploited by engineering at O&M phase.

It is undeniable that the units in UBP Kamojang have average age of more than 15 years. It means that the equipment was designed at least 15 years ago. Are there developments in equipment designs to improve efficiency in the last 15 years? Yes there are. Do we adopt the new design of equipments? If we do so, we will be able to reduce parasitic load.

### 2. THE PL EFFICIENCY PROGRAMS

The application process of PL efficiency programs always started at the step of surveying the power consumption requirements of each piece of equipment in a power generation unit. After the surveying, it is clear which equipment is relatively more and less efficient. The small

nominal of efficiency from large power consumption equipment, has a larger impact than the same nominal efficiency of small power consumption equipment. Therefore, the steps of PL efficiency program have focused on big power consumption equipment for UBP Kamojang.

The improvement strategy of PL efficiency that must and will be done by UBP Kamojang for the agenda of PL efficiency program covers the following:

### 2.1 Review Existing Design and Modification at Systems

At this approach, the part done is reviewing an existing design for a system in power generation unit. If the study concludes there is an opportunity to make the unit more efficient. Hence, there will be a transformation of the system that is either the specification of equipment in the system, amount of the equipment, etc. This approach was carried out in UBP Kamojang, which is the modification of reinjection system at PLTP Kamojang power generation unit which has been executed in the year 2006. (PLTP is an abbreviation from Geothermal Power Generation Unit). UBP Kamojang is consisted of PLTP Kamojang (1x30 MW and 2x55 MW), PLTP Darajat (1x55 MW), and PLTP Gunung Salak (3x60 MW).

### 2.2 Review Existing Design and Modification at Equipments

At this approach, the part done is reviewing an existing design for equipments in system of power generation unit. If the study produces an opportunity to make the system more efficient, it will be carried out. Hence, there will be transformation of the parts at the equipments either that is form, number of part, material type, etc. In fact, this approach is step to do PL efficient program at smaller linkage compared to the approach as explained before. This

approach has been carried out in UBP Kamojang; there is modification of the fan blade cooling tower at PLTP Kamojang & modification of main transformer at PLTP Gunung Salak.

### 2.3 Review & Modification the Sequence of System & Equipments Operations

This approach is aimed at reviewing the sequence of system & equipment operation in power generation units. If the review produces an opportunity to make the unit more efficient, hence the transformation will be completed by either changing the sequence operation of the system, equipment, or with no changing of equipment or part specifications but rather the number of equipment or part, etc. This approach is not product transformation like two approaches before. This approach has been done in UBP Kamojang, which is transformation of the operation sequence for the cooling tower when 4 monthly maintenance works and transformation of the operation sequence for the auxiliary unit.

## 3. THE PL EFFICIENCY PROGRAM REALIZATION

Table 2 and Figure 2 provide data about the portion of the power consumption of the equipment that shows the largest contributions of PL in UBP Kamojang. The following illustration shows some steps of the PL efficiency program which has been implemented in UBP Kamojang.

### 3.1 Modification of Re-Injection System at PLTP Kamojang

PLTP Kamojang with capacities (attached) is 140 MW consisting of 3 units with capacities 1 x 30 MW and 2 x 55 MW.

**Table 2. List main equipment that contributing PL in UBP Kamojang**

EQUIP. LIST	UNIT	KMJ #1 (30 MW)	KMJ #2 (55 MW)	KMJ #3 (55 MW)	DRJ #1 (55 MW)	GSL #1 (60 MW)	GSL #2 (60 MW)	GSL #3 (60 MW)
MCWP	kW	880	1600	1600	1340	2400	2400	2400
LRVP	kW	-	-	-	350	-	-	-
CT FAN	kW	300	600	600	440	750	750	640
1RY PUMP	kW	45	85	85	55	75	75	75
2RY PUMP	kW	55	55	55	55	45	45	45
RE-INJECTION PUMP	kW	150	-	-	75	-	-	-
COMPREPLOR UNIT	kW	55	55	-	45	-	-	-
VENT COMPREPLOR	kW	1.1	11	-	-	-	-	-

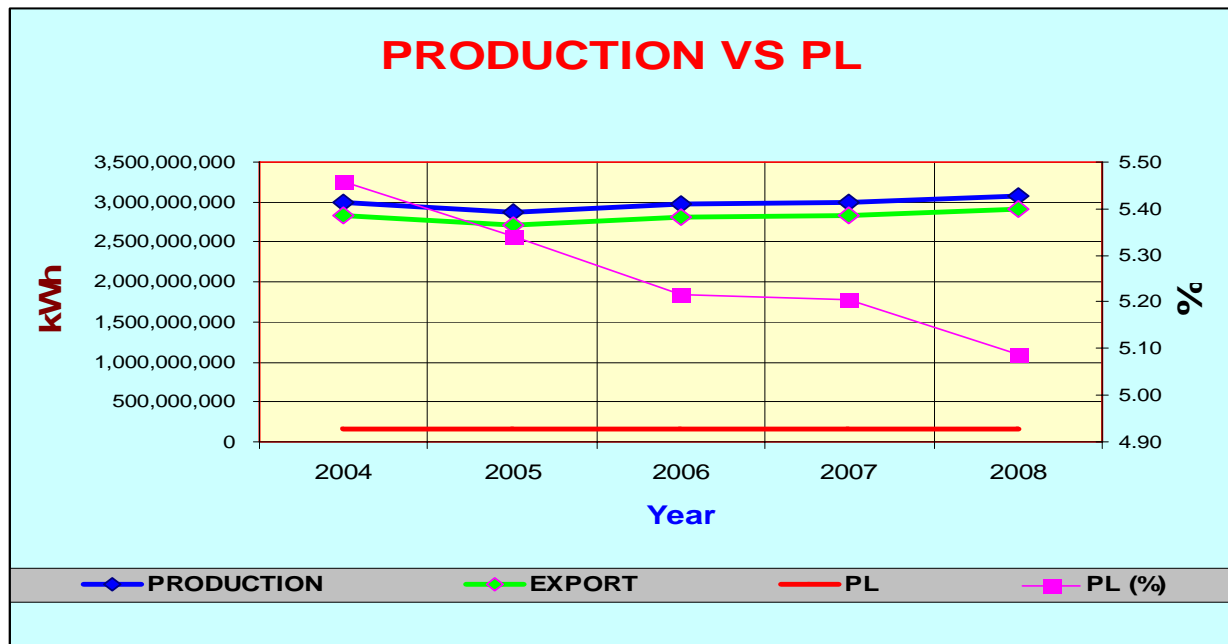


Figure 4. UBP Kamojang PL (PS) Realization data recording

The exhaust of the steam turbine is condensed in the condenser to become condensate water and is then pumped to cooling tower for cooling process, where the excess of the condensate water from all units will be accommodated for sump reinjection. Hereinafter the condensate is pumped to the reinjection pit to lessen the pollution of the power plant, lessen ground subsidence, and also recharge water for the reservoirs property of Pertamina (as steam supplier company at Kamojang geothermal area) with the aim to make this energy renewable and take care to replace the required amount of steam continually withdrawn for power generation.

The existing reinjection system operation is plagued by problems, the problems increase for spare part replacement cost & usage of Caustic Soda (NaOH).

To overcome the problems, the study calculates the potential of existing equipment, and then after got the potential for PL efficiency from result of the calculation and enabled by modification. The modification involves exploiting Hot Water Discharge of Main Cooling Water Pump (MCWP) jointed directly with existing reinjection piping system, with the result that the overflow from condensate water didn't enter reinjection sump and reinjection pump becomes inoperable again.

With existence of this modification the PL efficiency of electrical energy, the usage of caustic soda is closer to optimal and maintenance cost can be lowered, so that modification results in the cost benefit for UBP Kamojang of about. 891,486,584 Rp/year. Illustration of this modification can be seen in the appendix.

### 3.2 Modification of Operation Sequence for the Cooling Tower When Preventive Maintenance Work at PLTP Kamojang

PLTP Kamojang unit #2 & unit #3 have 5 fan cooling towers, the fans assist the heat transfer process between hot water fluids from the condenser and atmosphere air. The fan must be working for optimum conditions. The

preventive maintenance for fan cooling tower based on Inspection and Maintenance Interval (Document No. CM - 04), execute when the fan to experience operation during more or less 720 hours (2 monthly).

At the time of preventive maintenance will be executed, based on Operation Manual, operator will reduce the load beforehand by about 10 MW. The preventive maintenance usually needs about 30 minutes for each fan. The derivation load (10 MW) comes to de-rating for PLTP Kamojang. If there are 5 fans to be maintained, the time required for de-rating is more than 2.5 hours every period of preventive maintenance. By changing the operation sequence for the shut down, each fan which during the time to preventive maintenance is done, operator hopes can lessen the de-rating that occurs.

From the calculated results data that is obtained, effectivity cooling tower PLTP Kamojang unit 2 before preventive maintenance of fan is 62.55% , with inlet water temperature is 30°C, exit water temperature from cooling tower is 48°C and dry bulb temperature is 18.2°C and wet bulb temperature is 20.7 C. With a tolerance of increased exit water temperature from the cooling tower of 3°C the temperature 29°C becomes 32°C (alarm for exit water temperature is 33°C) the time required by cooling tower before the alarm reached is 10.28 minutes.

Transformation principle of this operation sequence is by following transformation of inlet water temperature and exit water at the cooling tower and the load is degraded by 5 MW (before this modification the load is downwards to 10 MW) when the parameter has shown transformation. The result of its modification was time de-rating of only 10 minutes, as compared to 30 minutes of preventive maintenance for each fan. Energy loss because of de-rating for preventive maintenance each fan with change operation sequence is 4167 kWh. It is more efficient, compared to the energy loss before changing the operation sequence saved almost 25,000 kWh for each fan.

So the cost benefit for one round of preventive maintenance for the fan cooling tower at PLTP Kamojang Unit #2 is Rp. 12,133,140 with total annual savings Rp. 72,798,840 for six preventive maintenance services per year.

### **3.3 Modification of Operation Sequence for Auxiliary Unit at PLTP Kamojang**

Transformation of operation sequence auxiliary unit, with existing overchange every 2 weeks becoming once per month. The cost benefit is claimed from an electric current start which it is big (more than 2-3 times the rating current for each piece of equipment). It will give contribution in PL efficient program which enough means.

### **3.4 The Addition of Turbine Washing System at PLTP Kamojang**

Existence of this system unconsciously is a breakthrough in PL efficiency program. Existence of this system always related to the extension of operating hour and acceleration of overhaul duration, but it has never been seen that in each sequence of operation when shutdown and start up a power generation unit (at time table start up & shutdown, it will be seen that the operating sequence all auxiliary equipment that running when start-up & shut down) will give more PL power consumption. It is coming from PL power consumption for each auxiliary equipment which on the wane with existence of extension of operation hour. At single line diagram/data equipment, it can be seen that auxiliary equipment relating to main cooling water pump, cooling tower fan, jacking oil pump, aux. oil pump and barring gear (this equipment is operating at shutdown or start up) is equipment with big power consumptions. The value of this efficiency has proven based on PL Power Consumption realization data before and after usage of turbine washing system at the year 1993. Before to execute turbine washing, PLTP KAMOJANG must stop the unit every 4 months just for anticipation of scaling phenomenon (solid deposition), but after executor turbine washing the unit can be operated up to 8 months without planned shutdown (preventive maintenance).

### **3.5 The Decrement of Losses at Main Transformer at PLTP Gunung Salak**

Main transformer of PLTP GUNUNG SALAK has capacities 70 MVA with coolant system ONAN (Oil Natural Air Natural) that is only by exploiting air at atmosphere (ambient) as a coolant media.

With up-rating at PLTP GUNUNG SALAK unit #3, from 55 MW to 60 MW, there is indication existence of increase of winding temperature at main transformer. This is because of increase of current yielded by generator after the load is boosted up.

Increase of temperature happened in main transformer of PLTP GUNUNG SALAK unit #3 has reached alarm, that is reaching 100 C (with setting alarm at 100 C and setting trip at 115 C). If this thing were to happen it would be very dangerous because it can destroy the insulation/winding of the transformer. To overcome the problem a fan is attached to the main transformer.

If PS Unit 3 is assumed constant, it is inferred that there is derivation of losses from condition of before and after attached fan (PL power consumption data in October 2004 to April 2005).

If fan attached in main transformer of PLTP GUNUNG SALAK unit #3 is 10 pieces, with the power consumption

of each fan at 120 W, hence the power requirement of all fans is 1200 W or 1.2 kW. This means a gain from derivation losses or power saving each day of about 888.2 kWh/day.

## **4. THE PL EFFICIENCY PLAN PROGRAM**

The following illustration shows some steps of the PL efficiency program which will be implemented in UBP Kamojang.

### **4.1 Change of Operation Sequence & Modification of Gas Removing System (Grs) at PLTP Darajat**

The design manual explains that design of GRS PLTP Darajat apply Liquid Ring Vacuum Pump (LRVP) and 2nd stage Ejector at the same function. To date PLTP Darajat is the only operating LRVP for this function. This study will examine changing the operation sequence (it is meant to only apply to ejector 2nd stage to replace LRVP) or modification nozzle ejector (change comparison of diameter in-out of nozzle) can mean that LRVP may not need to be operated. Parasitic load efficiency from not operating the LRVP will give significant value, because it has a large power consumption relative to other equipment.

A study about this change of Gas Removing System PLTP Darajat operation sequence was completed, with the conclusion that an alternative operation sequence of GRS PLTP Darajat by exploiting 1st Stage Ejector as 2nd Stage Ejector will replace the function of the LRVP.

Approximation of parasitic load efficiency gained is around 525 kW. Illustration of this modification can be seen in the enclosure.

### **4.2 Modification of Fan Stack Cooling Tower**

This modification is based on trends in fan stack cooling tower design, where the newest design is believed able to make the flow of air at cooling tower more effective and easier. If this modification can prove that with new design of fan stack will give sufficient flow of air to atmosphere, hence lower the fan motor load either by the way of reducing revolution (rpm) and or changes operation sequence of cooling tower.

### **4.3 Modification of Main Cooling Water System**

Modification will be aimed at the possibility to reduce parasitic load of MCWP by the way of adopting the development from newest pump with the same rating with MCWP that is attached? Besides that, another approach is by doing function of accurate control to obtain higher efficiency level system. Simulation program of Process at PLTP which will be developed can show these possibilities. Is circulation water quantity at main cooling water system reduced? If yes, lowering MCWP parasitic load can be increased.

### **4.4 Modification of Automatic Temperature Control (ATC) Cooling Tower**

Existence Automatic Temperature Control (ATC) at existing facility cooling tower is evidence of manufacturer willingness to make more accurate controls in order to improve efficiency at cooling tower. Unhappily, this ATC has not operated for a long time. Basically the controller concept for this ATC is an arranged fan speed configuration for all cell adapted based on condition of ambient temperature (wet/dry bulb temperature or humidity of the atmosphere). Ambient conditions have fluctuations all day long (night/ daylight period) and also on an annual basis.

The reason the operation of this ATC stopped, besides existence of part damage of control equipment, is the fact that with full speed fan cooling tower the units power production is derated. This extra loss in efficiency is avoidable and by modifying ATC by mapping performance cooling tower to actual condition, hence it is believed that ATC will now be able to give more efficient operation with the cooling tower.

#### 4.5 Modification of Re-Injection System at PLTP Darajat

A study about the modification of reinjection system at PLTP Darajat was conducted, with the conclusion that the reinjection cannot be completed with DRJ-1 reinjection well, as this pit cannot be exploited to become reinjection well. This is because the injectivity rate is too small and the condition of injection pipe from power generation unit to casing at pit DRJ-1 which has a wall thickness that is increasingly thin, and therefore it will cause water pollution of condensate into the geothermal area.

However, a continuation study proposes doing the same thing on reinjection system at PLTP Kamojang, by exploiting the discharge MCWP.

#### 4.6 Decrement of Losses at Transformer in PLTP Kamojang

In general, losses at Transformer PLTP Kamojang are bigger than losses at Transformer in PLTP Darajat or PLTP Gunung Salak, as seen at Table 1.

By paying attention to Table 1, it can be seen that it is important to study losses at Transformer in PLTP Kamojang, so that this loss can be measured and investigated, and a more efficient transformer can be installed.

### 5. CONCLUSIONS

The existence of the parasitic load efficiency program has yielded cost benefit of more than 1,382,452,478 IRD/year in just PLTP Kamojang compared to initial design of each unit. The strategy applied for the parasitic load efficiency

program in UBP Kamojang is to: Review Existing Design and Modification at Systems, Review Existing Design and Modification at Equipments, and Review & Modification The Sequence Of System & Equipments Operations.

The realization of parasitic load efficiency program which has been done: Modification Of Re-Injection System At PLTP Kamojang, Modification Of Operation Sequence For The Cooling Tower When Preventive Maintenance Scheduled At PLTP Kamojang, Modification Of Operation Sequence For Auxiliary Unit At PLTP Kamojang, The Addition Of Turbine Washing System At PLTP Kamojang, and The Decrement Of Losses At Main Transformer At PLTP Gunung Salak.

**Table 1. List of estimates Losses Transformer Kamojang GBU**

No	Power Generation unit in Kamojang GBU	Losses Transformer (%)
1	PLTP Kamojang 1	1 - 2
2	PLTP Kamojang 2	0,7 - 0,9
3	PLTP Kamojang 3	0,9 - 1,1
4	PLTP Gunung Salak 1	0,2 - 0,4
5	PLTP Gunung Salak 2	0,4 - 0,5
6	PLTP Gunung Salak 3	1
7	PLTP Darajat 1	0,7