Global Energy Management System Implementation: Case Study

Indonesia

PT Pembangkitan Jawa Bali Paiton

Business Case for Energy Management

Profile: PT PJB Paiton is a steam power plant with a capacity of 2 x 400 MW which contributes about 3.3 % to the electricity system in Java and Bali. The average energy consumption is about **56,03 million GJ** per year. This energy consumption is sourced from coal for its fuel and electricity for its auxiliary power as well as HSD (High Speed Diesel) during its start-up process. PT PJB Paiton is the one of the most efficient power plants, becoming a priority in Indonesia electricity production system. This is achieved by the implementation of sustainable energy management system, ISO 50001:2011 since 2013. Having principles in the management of ISO 50001, it also contributes in maintaining environmental sustainability. The success of the ISO 50001 implementation can be seen from the power plants efficiency, measured by the value of **NPHR** (Net Plant Heat Rate) which is the amount of energy consumption used to produce 1 kWh of electricity. It means that the smaller value of NPHR, the better efficiency and least energy consumption of the power plant. In the last 5 years, the **NPHR of PT PJB Paiton has been decreasing from 2754.1 kcal/kWh to 2577.13 kcal/kWh** or equivalent with **32.09 MillionUSD**.

"Energy is an inspiration. Conductingenergy efficiency is thus equal to inspire our people."
—Iwan Agung Firstantara, President Director of PT PJB

Case Study Snapshot	
Industry	Electric Power Generation
Product/Service	Electric Power
Location	Paiton, Probolinggo, Indonesia
Energy Management System	ISO 50001:2011
Energy Performance Improvement Period	5 years
Energy Performance Improvement (%) over improvement period	4,56 % every year
Total energy cost savings over improvement period	32,09 million USD
Cost to implement EnMS	8,17 million USD
Payback period (years) on EnMS implementation	< 3 months
Total Energy Savings over improvement period	13,11 million GJ
Total CO_2-e emission reduction over improvement period	3,32 million metric tons

Driver

As a state-owned enterprise, PT PJB Paiton must reach the target that has been given from the government of Indonesia related to the improvement of energy efficiency and the reduction of exhaust emissions, then implements the energy management system of ISO 50001. The indicator of an increased energy efficiency is seen from a good efficiency plant. With a good efficiency plans, the production cost of electrical energy becomes low. This will make the selling price of electricity from the government becomes cheaper so that the people in Indonesia can obtain a cheaper and more convenient source of electricity. Therefore, the grid will prioritize the electricity production that comes from PT PJB Paiton, which will make the company's

sustainability in the electricity system in Indonesia can be maintained.

Energy reduction approach

In its management system, PT PJB Paiton has always been sticked to the energy conservation since the power plant is operated in 1993. Every program planning has always done a feasibility study of operations, financial, and risk including energy reduction that will be pursued. With such a management pattern, the implementation of ISO 50001 will become easier.

Business Benefits Achieved

PT PJB Paiton has been implementing Energy Management System ISO 50001:2011 excellently. It is achieved due to the full support from the corporation which is always committed to conduct energy efficiency continually. By having energy efficiency management, PT PJB Paiton gains many benefits in conducting its business process. Since 2013, implementation of Energy Management System saves energy up to **13,11 million GJ** which is significantly equivalent to **3640 GWh** or **32,09 million USD.** This energy and financial saving are illustrated in the figure 1**.**

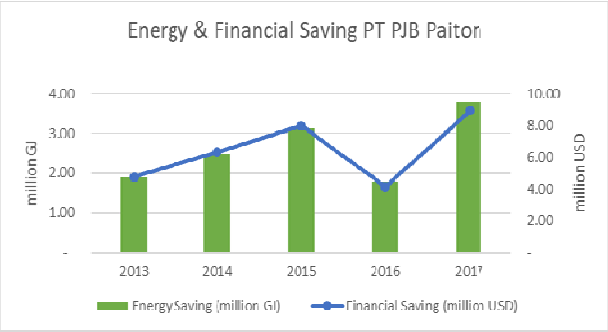

Figure 1. PT PJB Paiton Energy and Financial Saving

The energy saving activities have been reducing greenhouse effect emissions (CO_2), NO_2 and SO_2 pollution. The amount of pollution that has been reduced for the last 5 years is about **33,32 million Metric Tons** of CO_2, **2,63 Metric Tons of** NO_2, and **8,03 Metric Ton** of SO_2, and **90.151 Metric Tons** of B3 (fly ash) waste. The improvement of energy performance of PT PJB Paiton is seen from declining trend since 2012 (prior to the implementation ISO 50001:2011) of the NPHR (Net Plant Heat Rate). The bar chart at figure 2 signifies the success in execution the efficient electrical power production process.

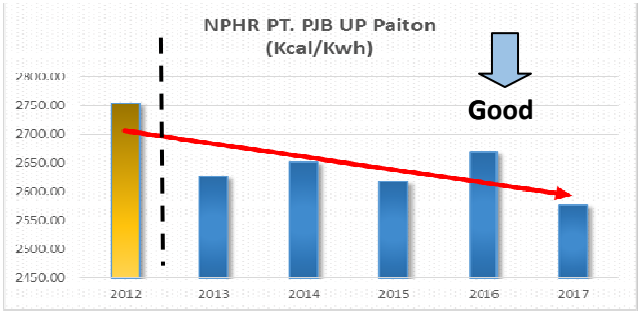

Figure 2. PT PJB Paiton heat rate (NPHR)

The greatest benefit with the existence of Energy Management System is creating awareness at the company and its employees towards the importance of energy efficiency in life. Energy savings and emission reductions are always made to improve the electricity production process. Without a continuous improvement, the goal of the energy management system will never be achieved. Another non-financial benefits obtained is PT PJB Paiton has won a highest award from the Ministry of Environment and Forestry called "**Proper Emas**", showing that PT PJB Paiton is compliant towards the conductions of environmental regulations. It includes energy efficiency, water conservation, emission reduction, and surrounding community empowerment. Furthermore, PT PJB Paiton has recently received an award at the national energy efficiency competition from the Ministry of Energy and Mineral Resources as "**Subroto Award 2017**" runner up in category for large industries.

EnMS Development and Implementation

As a corporation, the business management in PT PJB relies on "PJB IMS" (PJB Integrated Management System), an integration of overall management systems which are implemented in PT PJB. It is the best practice designed according to the process approach. The method of process approach is PDCA (plan-do-check-action) which is not only based on Indonesia standards but also international standards. The integration of management system is later referred as "PAS 99: 2012" which also consists ISO 50001. The clear figure is shown below.

Figure 3. PT PJB Paiton integration management system

Organizational

PT PJB as a leading electrical company in Indonesia commits to do good energy management system. Iwan Agung Firstantara, President Director of PT PJB, is committed to manage asset management efficiently and create eco friendly power plant with economical production cost. As one of the power plant assets, PT PJB varies its steps to achieve an excellent energy management system. In order to achieve that, both PT PJB as a corporation and PT PJB Paiton as one of its units have been implementing ISO 50001, certified in 2014 and recently renew it. The first step taken by PT PJB Paiton formed an 'energy team'. The organizational structure of this energy team falls under General Manager who assigned Operations Manager to act as the Energy Manager. The energy management team consists of various sections such as operation, maintenance, engineering, and logistics. It intends to provide a sense of responsibility and awareness for energy saving activities comprehensively. The 'energy team' was eventually formed as a special and competent team to manage the energy system. The members of the team must be equipped with personal skills and knowledges. Moreover, they also must meet professional certification according national standards. The national standard itself adopts international standard ISO 50001: 2011. Certified professionals from special team members are Dwi Juli Harsono as Energy Manager and Wisnu C. Kurniawan as Energy Auditor. To be precise, the Energy Manager is in charge on planning and controlling energy efficiency programs, ensuring the effectiveness of the programs, and also reporting the implementation of the programs to General Manager. Meanwhile, Energy Auditor is responsible in establishing a baseline of energy consumption data and measuring the energy consumption in the power plant. It is followed with issuing recommendations for preventive actions in order to improve energy performance. The energy team works are driven by the NPHR target that has been determined and stated by the top management. Furthermore, Key Performance Indicators (KPI) are given and cascaded to the Energy Manager along with the Energy Team. Afterwards, it will be monitored and evaluated periodically. During the process, the energy team will conduct a performance test that held monthly to analyze and give recommendations to the energy Manager. After that, the energy manager and the energy team hold regular peer group discussion also once in a month to review program implementation and its result, whether it is already in accordance to the target or need more improvement. During the implementation of the system, PT PJB Paiton collaborates with BPPT, a national agency for assessment and application of technology. The agency is specifically a non-ministerial government institution, falling under Ministry of Research, Technology and Higher Education. Other party that also involved is as Institut Teknologi Sepuluh Nopember (ITS), a technology-public institution

Energy Review and Planning

Energy review and planning is a strategy implemented by PT PJB Paiton in the context of energy management system ISO 50001. Precisely, our energy consumption uses coal as fuel to produce electricity, HSD oil as fuel in the start-up process, and electricity for auxiliary power to function equipments. In the consumption list, the biggest amount of consumption is coal, showing an average 2429,34 kilo tons annually. Turning to average electric power, the consumption of auxiliary power is approximately 375,96 GWH per year while oil consumption is around 1799,29 kL per year. From those energy consumptions, PT PJB Paiton SEU (Significant Energy Use) is coal consumption as shown in figure 4 and SEU of auxiliary power usage for BFP (Boiler Feed Pump) equipment. Thus the efficiency program focuses on fuel savings by lowering the NPHR and improving BFP operation.

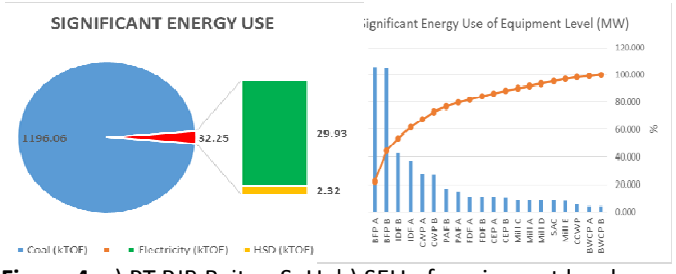

Figure 4. a) PT PJB Paiton SeU; b) SEU of equipment level

Due to the great number of energy consumption, PT PJB Paiton should pay attention to the management of ISO 50006. This ISO emphasizes on a determined baseline and energy performance indicators. PT PJB Paiton eventually sets NPHR value of all units as its Energy Performance Indicator (EnPI). NPHR measurement is performed on daily basis using input/output method data sourced from netto kWh production record and coal volume measured by gravimetric feeder for 24 hours. On the other hand, the coal calorific is measured from proximate analysis conducted by independent surveyor. The daily record is reported as monthly business report to the PT PJB Head Office. The baseline used in the report is the data implementation of NPHR 2016 (the previous year), numbered **2646.77 kCal/kWh**. The baseline is eventually used by PT PJB Head Office to set a higher target or challenge for PT PJB Paiton. It is expected that PT PJB Paiton can achieve better NPHR than the baseline. The NPHR target for PT PJB Paiton performance contract in 2017 is **2642 kCal/kWh**. The baseline, target, and achievement of PT PJB Paiton NPHR in 2017 are illustrated in figure 5.

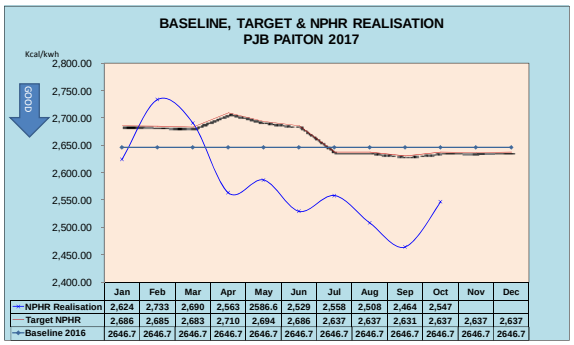

Figure 5. PT PJB Paiton heat rate data in 2017

The energy review is conducted monthly using Performance Test applying ASME PTC 4 and 6 standards by certified energy auditors. The certified auditor adopts ISO 50002. The results are eventually discussed with other sectionss to determine the recommendations for efficiency improvement of the power plant. In addition, there is also a routine energy audit performed by independent external experts. The final results show the losses occured related the power plants. Thus, pareto is made to prioritize an action plan. This can be seen in figure 6.

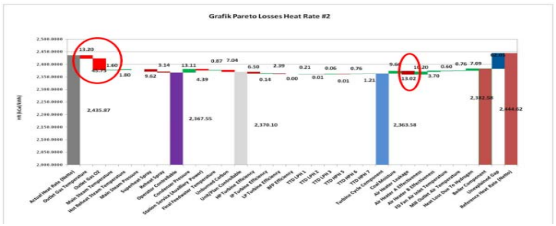

Figure 6. PT PJB Paiton pareto heat rate loss

Energy efficiency is the main attention in determining the performance of power plants and strategic planningas well as reference set forth for company road map. The strategic steps in energy efficiency are later divided into two which are long-term plans and short-term plans. **The short-term and long-term plans are arranged referring to the Heat Rate Pareto Losses Graph**. Programs arranged are envisioned to reduce the Heat Rate Losses. In fact, PT PJB Paiton is a state-owned enterprises aligning its principle to good corporate governance. Thus, budgeting should be accorded with the government regulations. Consequently, program plannings must be detailed including feasibility studies (operations, financial, and risk) and term of reference. When those criteria have been met, new programs can be proposed in 'RKAU' (budgeting workplans). Several short-term and long-term energy efficiency plans can be seen in table 1 and table 2 below.

Table 1. PT PJB Paiton Short Term Programs

No	Programs	Year	PIC	Target
1	Boiler Overhaul	2018	Mtc. M.	Increasingboiler efficiency up to>1%
2	Burner tilting calibration	2018	Mtc. M.	Decreasing unburned carbon 0,5%
3	Superheater spray valve replacement	2018	Mtc. M	Decrease losses 10 Kcal/Kwh
4	Cleaning condenser tube	2018	Mtc. M	Increasing thermal efficiency up to 0,25%

Table 2. PT PJB Paiton Long Term Programs

No	Programs	Year	PIC	Target
1	Sealing air heater brush replacement	2019	Mtc. M	Decreasing air heater leakage 5%
2	Hot air gate sealing air fan upgrading	2019	Mtc. M	increasing mill outlet temperature 3^0C
2	Boiler combustion tuning	2020	Mtc. M	Increasing boiler efficiency 2%
4	Coal burner replacement	2020	Mtc. M	Increasing boiler efficiency1%

*Mtc. M : Maintenance Manager

" Energy efficiency is for a better life "
—MustofaAbdillah, General Manager of PT PJB Paiton

Cost – Benefit Analysis

The table 3 depicts energy saving by PT PJB Paiton since 2013.

Table 3. PT PJB Paiton energy efficiency program

No	Energy Efficiency Program	Investment (USD)	Saving (USD/ Year)	Payback Periode (Year)	NPV (USD)	IRR
1	Redesain reheater tube boiler	148	301	0.49	719.20	104%
2	Online cleaning condensor	98	946	0.10	4,691.99	864%
3	Rehabilitation of turbine	10,207,852	20,340,741	0.50	47,045,230.77	99%
4	Install dynamic classifier	2,576,963	7,737,037	0.33	26,578,605.94	200%
5	Overhoul Boiler	1,565,481	5,131,111	0.31	18,581,123.74	228%
6	Fin tube boiler modification	1,963	26,067	0.08	134,229.98	1228%
7	Burner tilting calibration	431,778	3,056,296	0.14	14,397,334.04	608%
8	Re-Engineering Deaerator	1,064,741	1,193,037	0.89	5,676,184.13	112%

PT PJB Paiton has been contributing to company's energy savings for approximately **32.09 million USD** with only capital investment for about **8.17 Million USD**. Hence, as number showed, the payback period is estimated for 3 months.

Approach used to determine whether energy performance improved

The energy saving monitoring uses EnPI utilizing heat rate and plant efficiency. In order to perform energy efficiency, PT PJB Paiton employs heat rate gap analysis method. *Heat rate gap analysis* is a method used to compare *heat rate reference* with *current heat rate* at a particular equipment level. The bigger gap means the greater losses degradation of power plant. As the heat rate losses are known in the equipment level, analysis, recommendation and follow up steps are planned to solve the problem based on EPRI "Heat Rate Improvement Reference Manual". Systematic energy approach is illustrated below.

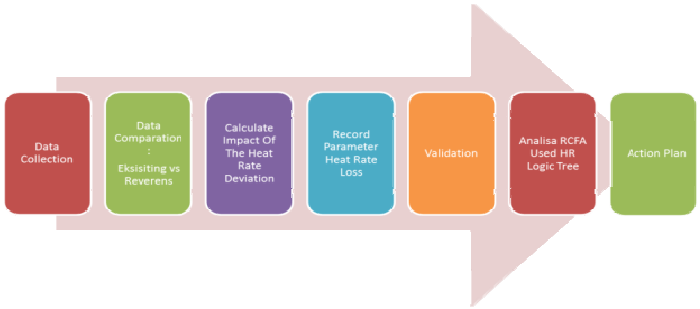

Figure 8. PT PJB Paiton Systematic Energy Approach

Heat rate monitoring is performed by 'planning and operation control section'. The result is analyzed by 'engineering system owner section' to find a required improvement. These all steps are certainly verified by internal energy auditor which finally reported to energy manager.

Approach used to validate results

PT PJB Paiton has verified the result of energy saving and benchmark so that the successful accomplishment is known. It mainly involves '*PT ITS Kemitraan*' as an independent company for the benchmark. Specifically, the benchmark applies the comparison with other coal-fired power plants in Indonesia. Impressively, PTPJB Paiton is ranked as the top energy saving benchmark in Indonesia. Besides that, the energy saving will be reported to the Cost Management Division of PT PJB Head Office to see whether it's still better than the target or not. If the NPHR realization is better than the target, PT PJB Paiton will be given a financial incentive. In the opposite, if the NPHR realization is worse than the the target, PT PJB Paiton will be given a financial penalty.

Steps taken to maintain operational control

In the energy management implementation, PT PJB Paiton refers to ISO 50001: 2011, specifically PDCA system (Plan-Do-Check-Action). This system is fully supported by Top Management through the implementation of every aspects involved. To ensure continual energy efficiency activities, working instructions as efficient management guide for power plant are legalized by Top Management. The Energy Team with the experts support, determine the critical operating parameters of the power plants based on the SEU and set the boiler performance as a critical parameter that is monitored online by the power plant operators (see fig. 7).

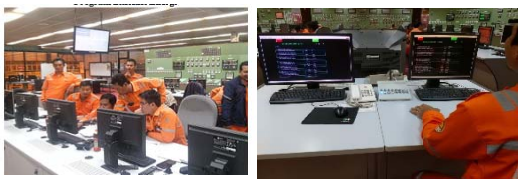

Figure 7. Boiler Performance Online Monitoring

Then, from these critical operating parameters, several Standard Operation Procedures (SOP) will be made and will be used by operators that have been trained and certified according to that SOP.

Development and use of professional expertise, training, and communications

PT PJB Paiton has been equipping professionals with knowledge and competency by providing several programs such as

- ✓ Conducting energy auditor and energy manager training & certification
- ✓ Conducting routine knowledge sharing
- ✓ Creating a creative idea contest focusing on energy savings for all employees

In addition, discussions and technical studies related to efficiency management is held in collaboration with external experts such as 'BPPT', academicians, other power plant companies and related manufactures.

Tools & resources

PT PJB Paiton has several management systems such as

- ✓ Energy Management System ISO 50001:2011
- ✓ Quality Management System ISO 9001:2008
- ✓ Environmental Management System ISO 14001
- ✓ Health, Safety and Environment Management System OHSAS 18001:2007
- ✓ Asset Management System ISO 55001:2008
- ✓ Business Continuity Management System ISO 22301
- ✓ Testing and Calibration Laboratory Accreditation Standard ISO 17025
- ✓ Security Management System SMP.

All of the management systems are integrated to determine energy efficiency. Moreover, PT PJB Paiton has Six Sigma as a tool to its quality management. Furthermore, the energy team has been certified with ***"green belt six sigma"*** for energy efficiency improvement analysis. To examine the power plant efficiency level, a gate cycle is used (see fig. 9). In addition,to go towards "***Industry 4.0***" company, an Asset Performance Management (APM) and boiler optimization are used as tools on daily basis to do online monitoring system that will be conducted by REMDO (Remote Engineering, Monitoring, Diagnostic, and Optimization) which is a Digital Real Time Expert based in PT PJB Head Office (see figure 10)

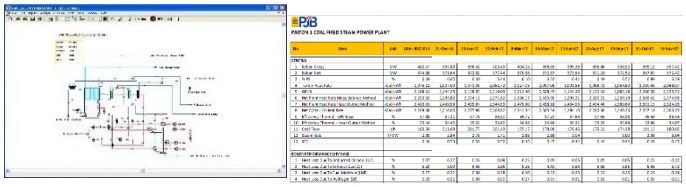

Figure 9. Modelling & calculation by gate cycle

Figure 10. Digital expert real time REMDO (asset performance management & boiler optimization)

Lessons Learned

Presently, Energy Efficiency Team in PT PJB Paiton is able to execute implementation of Energy Management System ISO 50001:2011 systematically and accordingly. The Energy Efficiency Team strive their best to solve all energy problems happening in power plant. It all aims to accomplish goals and targets. In the implementation, several obstacles are encountered. One of them is the lack of energy efficiency awareness. However, the Energy Efficiency Team works together with various sectionss to give understanding for employees and stake holders to play active role for energy efficiency. The successful key role for Energy Management System ISO 50001: 2011 implementation are

- ✓ Integrity and persistence in its implementation
- ✓ Solid teamworks and clear responsibilities
- ✓ The involvement of all employees and management in supporting the programs
- ✓ Accurate monitoring and improvement systems