ISO 50001 Energy Management System
Case Study

Indonesia

PT Chandra Asri Petrochemical Tbk (CAP)

Implementation of Energy Management System at CAP resulted total energy cost saving of US$ 9.69 M since 2016.

PT Chandra Asri Petrochemical is leading and preferred Petrochemical Company in Indonesia

Organization Profile & Business Case

PT Chandra Asri Petrochemical Tbk (CAP) is one and the only Olefin producer in Indonesia. It is one of the Indonesia's vital industry and protected national assets by law which affected to macro market and economic sustainability. CAP supplied 35% of country's petrochemical demand (52% olefin, 24% polyethylene, and 29% polypropylene).

CAP started implementation of Energy Management System ISO 50001 officially in 2016 for Polymer Plant and got certification in 2017. Scope of implementation was extended to Naphtha Cracker Plant in 2017 and got extended certification in 2018. CAP has spent 3059 man-hours to develop the system and got fully support from Top Management since the beginning

Over 2 years of ISO 50001 implementation, average energy cost was brought down by 1.36 % or equivalent with US$ 6.36 M. The average energy consumption of CAP itself is 665 KTOE annually or equivalent with US$ 542.5 M.

Table 1 Case Study Snapshot

Case Study Snapshot	
Industry	Petrochemical
Product/Service	Olefin, Polypropylene, Polyethylene
Location	Cilegon, Banten, Indonesia
Energy Management System	ISO 50001
Energy performance improvement period	2 Years
Energy Performance Improvement (%) over improvement period	Polymer Plant: 2.44% Cracker Plant: 1.31% Overall 1.36%
Total energy cost savings over improvement period	US$ 6.36 M
Cost to implement EnMS	US$ 89,400
Total Energy Savings over improvement period	771,838 GJ
Total CO_2-e emission reduction over improvement period	55,697 Metric Ton

"As a manufacturing company, energy usage has always been one of our major production cost, and so it is natural for us to implement ISO 50001 in order to reduce our cost. In addition, this aligns with our current sustainability efforts as we believe that we need to contribute to saving the planet for our future generations."

—Erwin Ciputra, President Director (CEO)

The Driving Force

Implementation of Energy Management System ISO 50001 at CAP was driven by both internal and external factors:

A. Mandatory implementation of Energy Management System to comply with Government Regulation of Republic of Indonesia No. 70/2009
B. As a public and listed company CAP must issue Corporate Sustainability Report annually where energy concern is integrated part of this particular report.
C. Energy is the biggest opportunity to reduce CAP structure cost. Financial impact for every 1% energy reduction annually equivalent with US$ 5.4 M. Energy cost reduction is crucial to ensure business sustainability in the competitive market
D. Superiority of energy performance is a missing piece of the puzzle on CAP Roadmap to achieve highest rating (Gold) of Environmental Management Program from Indonesian Ministry of Environment (PROPER) in next 5 year
E. Highly commitment to take active part and support Indonesian Government to achieve country's CO_2 emission reduction by 29% in 2030

CAP Business Benefit

As part of Energy Management System implementation, CAP has developed multi variable regression baseline and Energy Performance Indicator (EnPI) based on ISO 50006. Energy performance is evaluated based on such baseline resulted 2.44% energy reduction at Polymer Plant and 1.31% at Cracker Plant.

Considering the nature of each plant CAP has 3 different baselines; Polyethylene plant with 2014-2015 base year, Polypropylene plant with 2014–2015 base year as well and Naphtha Cracker plant with 2017 base year.

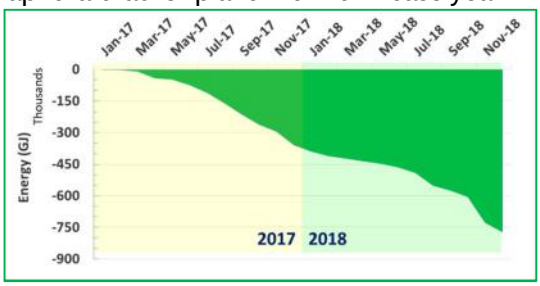

Figure 1 CAP CUSUM 2017-2018

Figure 1 showed total 771,838 GJ energy reductions or equivalent with US$ 6.36 M cost saving over 2 years of Energy Management System ISO 50001 implementation at CAP.

Source of CAP energy demand is natural gas and electricity. As result of energy reduction during those periods, CAP also could reduce CO_2 emission of 55,697 metric tons. Standard calculation of CO_2 emission including emission are shown in **Table 2** below:

Table 2 CAP CO_2 Emission

Type Energy	Energy (GJ)	Emissoin Factor (kg CO_2/GJ)	CO_2 Emission (Metric Ton)
Fuel	708,366	56.15	39,776
Electricity	63,472	250.83	15,921
Total			55,697

CAP Worldwide Energy Benchmarking

CAP participate in benchmarking program provided by well-known benchmarking firm for mapping and positioning of plant performance among the peers both regional and worldwide as one of reference for company business strategic. The followings are two benchmarking providers hired by CAP:

A. Philip Townsend Associated (PTAI) Benchmarking for Polymer Plant (PP and PE) since 2010
B. Solomon's Benchmarking for Cracker Plant since 2013

Particularly for PP Plant is positioned among best efficiency plant in Asia Pacific & Middle East with specific energy consumption 340 kWh/T-PP in 2018 or down by 7.3% against base year of 2014-2015 as shown in **Figure 2**.

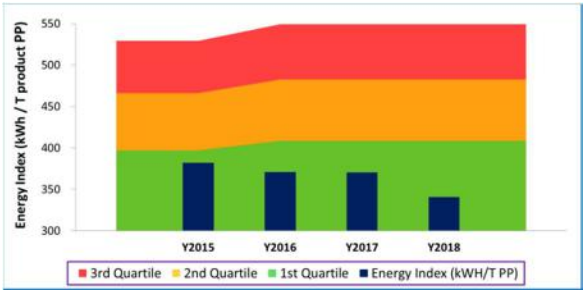

Figure 2 PP Plant Best Performance PTAI Benchmarking

Project Case Benefit

The followings are Top 3 of CAP Energy Projects which significantly reduces energy consumption in 2017-2018:

1. Optimization of Turbine Exhaust Gas (TEG) and Cracking Heater Integration at Naphtha Cracker

Plant. In this case TEG from GTG Unit is fully utilized as combustion air at 5 units of Cracking Heaters with total energy saving 374,710 GJ or equivalent with US$ 3.15 M.

2. Replacement of catalyst from dry to slurry type at Polyethylene Plant could save energy 3,859 GJ (1.11%) or equivalent with US$ 377K. This project also improve product quality and increase productivity from 28 t/h to 30 t/h
3. Upgrading of Cycle Water Pump at Polypropylene Plant could save energy 32,628 GJ or equivalent with US$ 708K. It also increased productivity from 40 ton/h to 44 t/h.

Intangible Benefit

ISO 50001 Energy Management System also leads to some non-financial benefits, such as:

- Successful implementation of ISO 50001 at CAP has inspired its subsidiary company (PT Styrindo Mono Indonesia) to implement it as well and got certification in 2018
- Polypropylene plant was honored among best energy performance plant in Asia & Middle East based on PTAI Benchmarking
- CAP was honored with Total Productive Maintenance (TPM) Excellence Award by Japan Institute of Plant Maintenance (JIPM) for Polymer Plant in 2017 and Naphtha Cracker Plant in 2018. One of TPM objective is Zero Loss including energy loss
- Highest Level (Level 5) Green Industry Award from Ministry of Industry in 2017 and 2018

Plan

CAP management has highly commitment to support implementation of Energy Management System which indicated by:

A. Giving priority for Energy Projects by differentiating of IRR criteria where minimum IRR for energy projects is 10% against 15% for other projects
B. Hiring reputable energy consultant (KBC Advanced Technology) to perform Investment Grade Energy Gap Analysis and develop Energy Improvement Roadmap until 2023 for Cracker Plant
C. Spending about US$ 89K to improve competency of Energy Team including certification of Energy Manager and certification of 10 Energy Auditors
D. Changing organization line where Energy Manager directly report to President Director for effective implementation of Energy Management System

Energy Review, Baseline, and EnPI

The assignments for Energy Team are to perform energy review, develop baseline and define EnPI as well:

- Collecting data from real time and online data system called Plant Information (PI) System to ensure data consistency and reliability
- The SEU and baseline has been developed based on energy consumption of each plant; Polyethylene Plant, Polypropylene Plant and Cracker Plant
- The calculation and analysis of energy baseline is based on monthly energy usage
- There are two Energy Performance Indicator (EnPI) used in CAP; CUSUM (cumulated energy saving) and Energy Intensity Index (EII) which defined as ratio of actual energy consumption against the baseline

Table 3 SEU, Energy Baseline and EnPI

Plant	Baseline	Driver	Adjusted R Square	EnPI
Polypropylene Plant 2014-2015	***y = 7,3456 +0.3408x1+0.5041x2+0.553x3+0.00036x4+0.00031x5***	*y = Energy (MWh)* *x1= Homo Prod. Volume (T)* *x2= Random Prod. Volume (T)* *x3= Impact Prod. Volume (T)* *x4= Nippon Sanso Nitrogen Prod. (Nm3)* *x5= Prax Air Nitrogen Prod. (Nm3)*	0.76	- CUSUM (MWh) - EII (lower than 1)
Polyethylene Plant 2014-2015	***y = 5,275 +0.3089x$_1$+0.2437x$_2$+0.4375x$_3$***	*y = Energy (MWh)* *x1= Film Prod. Volume (T)* *x2= Injection Prod. Volume (T)* *x3= HDPE Prod. Volume (T)*	0.86	- CUSUM (MWh) - EII (lower than 1)
Cracker Plant 2017	***y = 991,280 + 5.64*(C2+C3) + 31.61* (BD+BZ)***	*y = Energy (GJ)* *C2 + C3 = Prod. Ethylene and Propylene (T)* *BD+BZ = Prod. Butadiene and Pygass (T)*	0.94	- CUSUM (GJ) - EII (lower than 1)

ECO List, Objective, Target and Action Plan

CAP Energy Team has developed Energy Conservation Opportunity (ECO) list based on energy audit result and translated into ECO List Matrix for priority ranking of implementation (**Figure 3).**

ECO List Matrix					
IRR	10% < IRR < 15%	2			
	> 15%	3			
ECO Index = IRR x Project Duration			3	2	1
			< 1 year	1-2 year	> 3 year
			Project Duration		
ECO Index Level: High (>6) Medium (3-6) Low (<3)					

Figure 3 CAP ECO List Matrix

Particular for Cracker Plant, CAP also collaborate with reputable energy consultant (KBC Advanced Technology) to develop additional ECO list based on Best Technology (BT) benchmarking with targeted annual energy saving of 4,644,000 GJ/year or equivalent with US$ 42.8 M/year.

ECO list has been developed in line with CAP Midterm Objective to reduce energy consumption by 12% in 2023 and improve benchmarking position of CAP Energy Performance as below:

A. Cracker plant is targeted to move to 2nd quartile from 3rd quartile of Solomon Benchmarking
B. PE plant is targeted to move to 2nd quartile from 3rd quartile of PTAI Benchmarking
C. PP Plant is targeted to maintain 1st quartile of PTAI Benchmarking

Over the period of 2017-2018 Polymer Plant could achieve 2.44% of energy reduction again 2% target. On other side in same period of time, Cracker Plant could achieve 1.31% of energy reduction against 1% target. Financial analysis for Energy Improvement Projects during 2017-2018 period is shown at **Table 4.**

Table 4 Financial Analysis

Investment Cost	4,577,400	USD
Profit	6,359,607	USD
NPV (discount factor)	1,685,952	USD
IRR	43.2 %	

The Investment cost consist of project implementation, additional monitoring equipment, training, consultancy, certification and internal communications as well.

"We believe that adopting ISO 50001 and implementing continuous improvement in energy efficiency for our manufacturing process will reposition our cost curve and sustainably contribute to Profit, People and Planet."

—Terry Lim, Finance Director

Do, Check, Act

Action Plan

CAP has 42 action plans (projects) for 2017-2018 period. All of project has been approved by CAP Top Management based on minimum 10% IRR criteria. At the end of 2018, only 34 action plans (81%) were implemented. The problem arises in the implementation of the action plan is delay of project duration so that the action plan is carried over to the following year.

The top 5 energy reduction action plan in 2017-2018 as follows:

1) Cracker Plant optimization of Temperature Exhaust Gas (TEG) Integration between GTG and Cracker Heater with energy saving 374,710 GJ/Year equivalent with $3.15 M
2) Cracker Furnace efficiency improvement by cleaning convection coil and radiant box coating resulted energy saving 85,943 GJ equivalent with $722 K
3) Advance Process Control (APC) to optimize furnace oxygen excess and Column Reboiler heat optimization resulted 59,292 GJ equivalent with $498 K
4) Upgrading of PP Plant Cycle Water System with energy saving 32,628 GJ equivalent with $708 K
5) Optimization of PE Melt Pump Suction Pressure. This action plan changed critical operating parameter (COP) to optimum range with energy saving 4,894 GJ equivalent with $106 K.

Operational Control, Design & Procurement

Preventive maintenance has been managed well called "PM Check" and registered in Maintenance SAP System for all Critical Operating Parameter (COP) and all of them are connected to DCS System at Central Control Room. Any abnormality condition (out of range) directly acknowledged by Board Operator through Alarm System.

All of setting parameter in SOP, Working Instruction and Operator Log Sheet has been aligned with COP. CAP conducted socialization/familiarization program called "One Point Lesson Sheet (OPLS)" to ensure COP concern

is well delivered to all operators particularly for SEU operators.

CAP also adopted ISO 50001 guidelines for design and procurement, as follows:

- Energy review is part of design review for any modification or new equipment/unit which proposed through Management of Change System called "Engineering Change Request". For example, action plan for upgrading capacity of cycle water pumps at PP Plant has been reviewed with parameter energy consumption (**Table 5**)

Table 5 Energy Review Cycle Water Pump PP Plant

Modification Option	Head (m)	Flow (m3/h)	Velocity (m/s)	Power Consumption (kW)
Existing Pump	10.13	824	2.62	37
New higher capacity pump	10.94	1277	3.13	50
Parallel pump with additional smaller pump	10.53	824 + 524	3.25	37 + 20 = 57

- Life Cycle Cost (LCC) analysis is applied for any purchased equipment linked with SEU. Contract and Procurement Department has included LCC in their Commercial Evaluation.

Table 6 Life Cycle Cost of Mixer Motor PE Plant

Motor Brand	Price	Lifetime	Power Consumption	NPV	NPV Rank
	US$	Y	kWh	K US$	
Toshiba	502,890	15	6004	(37,247)	**2**
ABB	171,909	15	5955	(36,634)	**1**
Margin				**613**	

By applying of LCC for replacement of Extruder Motor (the largest SEU of PE Plant) could save procurement cost of US$ 613 K.

Communication and Training

CAP Management is committed to develop energy management system holistically, not only focus on energy projects but also on employee skill and all aspect of the system by providing certification and training as follows:

- Certification of Energy Manager and 10 Energy Auditors for each plant by HAKE as part of National Certification Professional Body
- Training of energy auditors for 20 person as junior auditor to assist energy auditors to evaluate plant energy performance

CAP communicates implementation of EnMS ISO 50001 through the following access:

- Communicate to all related vendors and contractors that CAP implement EnMS ISO 50001
- Communicate to all employee using monthly digital newspaper called "Energy Talk" as the tool to maintain awareness of energy saving.

Energy Check and Monitoring

CAP monitors the Energy Management System through layer by layer. CAP has real time online monitoring for Critical Operating Parameters (COP). If the COP exceed allowable range, alert system convey the information to Board Operator to take immediate action. Moreover, CAP has invested US$1.4 M for newest monitoring technology to optimize controlling and monitoring through Advanced Process Control (APC) for critical process units and SEU. APC also provides prediction of COP condition in 3 hours later. It allows the board operator to directly take action before abnormality happen. Optimum COP range has been set to achieve maximum energy efficiency. (**Figure 4**).

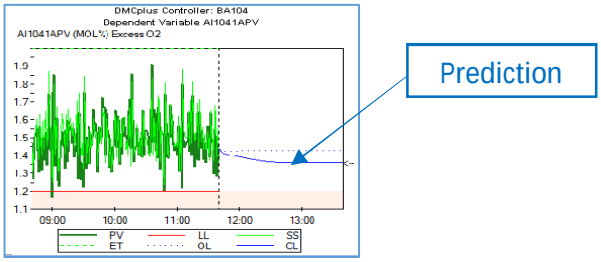

Figure 4 APC Oxygen Excess of Furnace at Cracker Plant

For daily monitoring, CAP has Daily Energy Performance Dashboard to monitor SEU and Energy Benchmarking Performance (**Figure 5**). The persistent and repeated problem is managed through abnormality reports and discussed in monthly review meeting attended by Energy Team and Energy Manager. The abnormality report is submitted to CAP internal portal system called "ESS" for further elaborate and investigate by related party to take corrective action. Any unsolved chronic problems are raised up by Energy Manager through GM monthly meeting.

The strategic planning, future energy projection and budget request is discussed during the Management Review Meeting (MRM) which attended by Manufacturing Director and all General Managers.

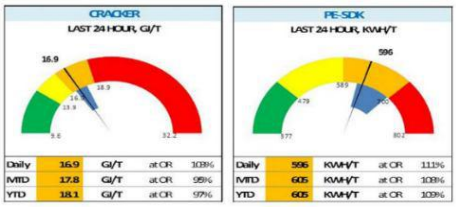

Figure 5 SEU & Plant Energy Dashboard Monitoring

Annual Energy Cost Saving report shall pass Verification Team called "Factory Cost Analysis" to check data validity and calculation for each energy action plan. The energy reduction which has been verified by national certified energy auditor and Energy Manager is reported to Ministry Energy and Natural Resources through Online Reporting of Energy Management (POME). CAP is waiting for government confirmation for assessment and verification which is scheduled at end of February 2019.

Transparency

CAP has officially published EnMS ISO 50001 implementation through various channels:

- Online Reporting System (POME) of Ministry of Energy & Natural Resources
- CAP Sustainability Report based on GRI Standard
- Worldwide Energy Performance Benchmarking
- Annual performance report as a mandatory report for public and listed company
- Annual corporate performance rating program in Environmental Management Program (PROPER) of Environmental Ministry
- Green Industry Program of Industrial Ministry

Lessons Learned

A. CAP has real time online monitoring system called Plant Information (PI) but it would be better to have real time optimization (RTO) system to ensure all of COP to be automatically adjusted back to its optimum range

B. Applying of newest technology Advanced Process Control System (APC) will be more effective if it can be extended to all COP of SEU

C. CAP has 10 thermal energy auditors but additional energy auditors with electrical competency will help CAP to find out more opportunities of energy saving at electrical system

Key to Success

- Highly Management commitment and support to prioritize energy project with IRR >10% while another project with IRR >15%
- Hiring of reputable consultant has helped CAP to have Investment Grade Energy Gap Analysis by using Best Technology Benchmarking
- Availability and data integrity is supported with high quality of instrumentation
- CAP has real time optimization called advanced process control technology (APC) to monitor COP of some SEUs
- CAP has daily monitoring tools called "Energy Performance Dashboard" to monitor Energy Benchmarking Position where all abnormalities can be acknowledged and solved promptly