PT PERTAMINA (PERSERO)
DIREKTORAT PENGOLAHAN

Pertamina Energy Management System (EMS)

Dhani Prasetyawan

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Energy Efficiency transformation for an oil refining company

- We are a National Oil Company in south east Asia with a refining capacity of 1 MBD i.e., **~1% of global refining capacity**
- For a refinery, energy cost forms ~60% of operating cost, hence the **opportunity for EE is immense**
- Set up **Energy Management System** (EMS)

Scope of EMS

Performance

- **Identify EE initiatives** to reach best-in-class performance
- **Implement 3** operational improvement initiatives as Value Accelerators
- **Set up** implementation for 2 Capex Initiatives

Process

- **Improve** equipment readiness to support energy efficiency
- **Identify and cascade** energy KPIs and KAIs from GM to Operators
- **Implement** performance monitoring and dialogues system

People

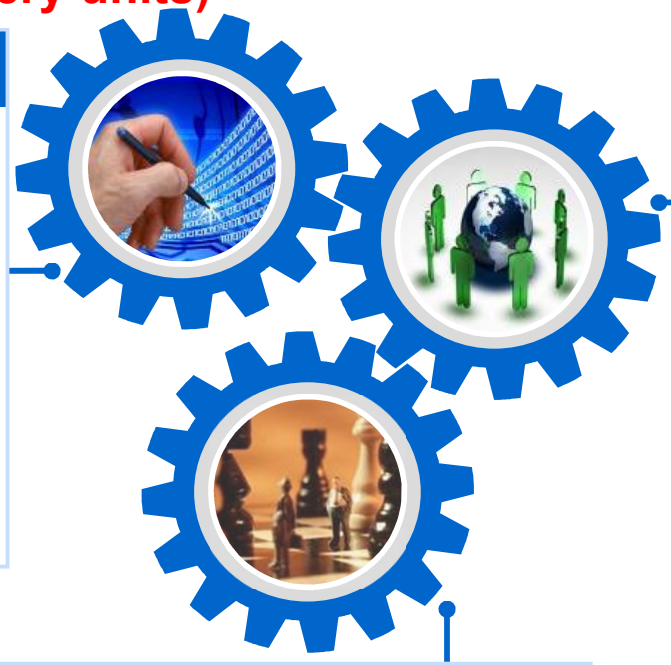
- **Build** capability to sustain program
- **Codify** technical and non-technical aspects of project in 'EMS Brick'
- **Set up** frontline engagement system

EMS has achieved impact across all 3 areas of the transformation framework (for 2 Refinery units)

Performance

135 Million USD in energy saving opportunity identified

19 Million USD saved through initiatives implemented



Process

121 KPIs cascaded to all functions

14 Areas where performance meetings are held

13% Improvement in Equipment readiness

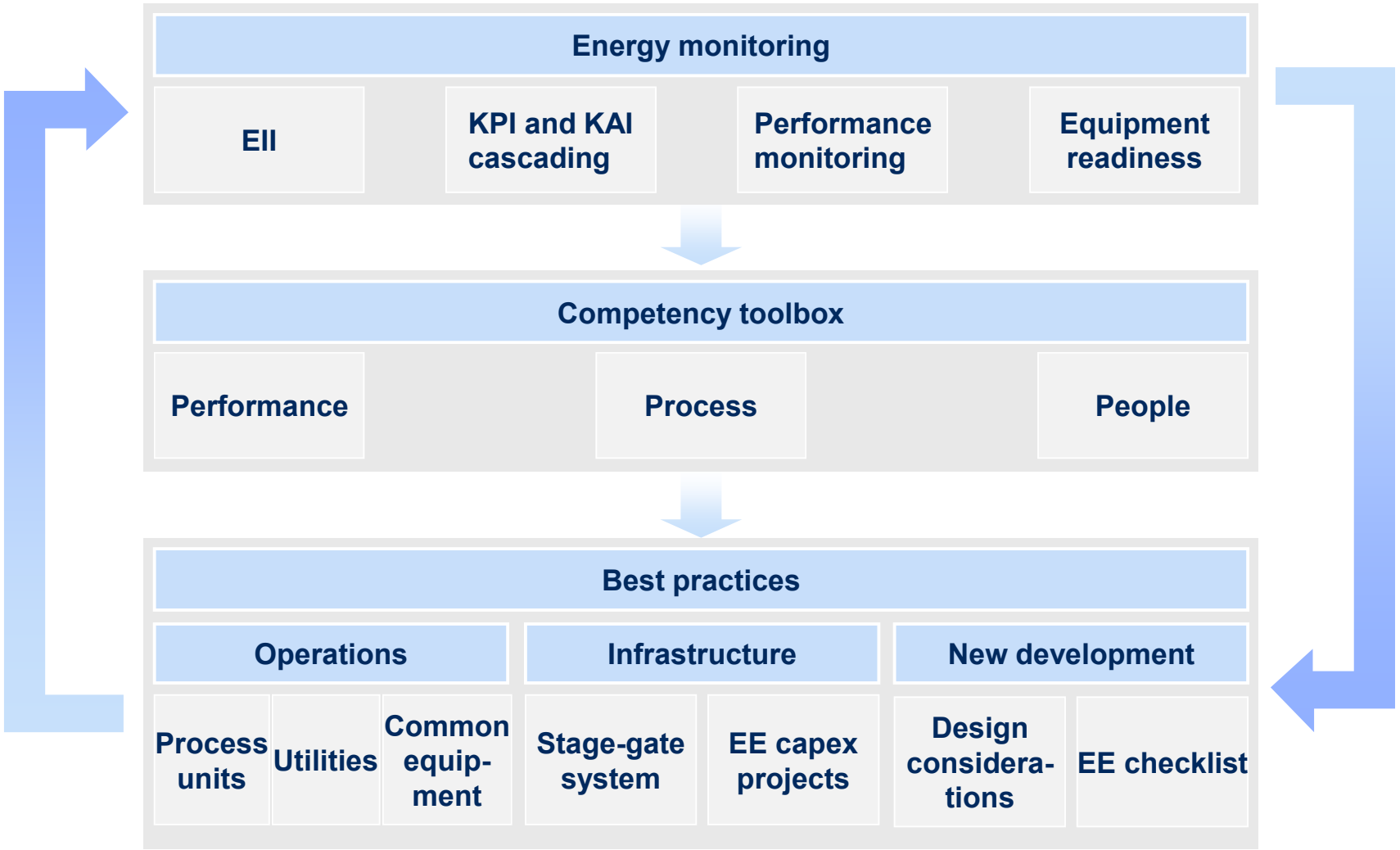
People

22 EMS Bootcamp modules delivered

48 Key stakeholders trained

>1000 Pages of energy best practices (EMS brick) codified

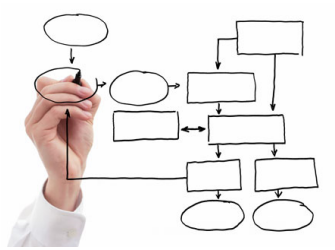
The end-to-end Energy Management System



Before and after of EMS program

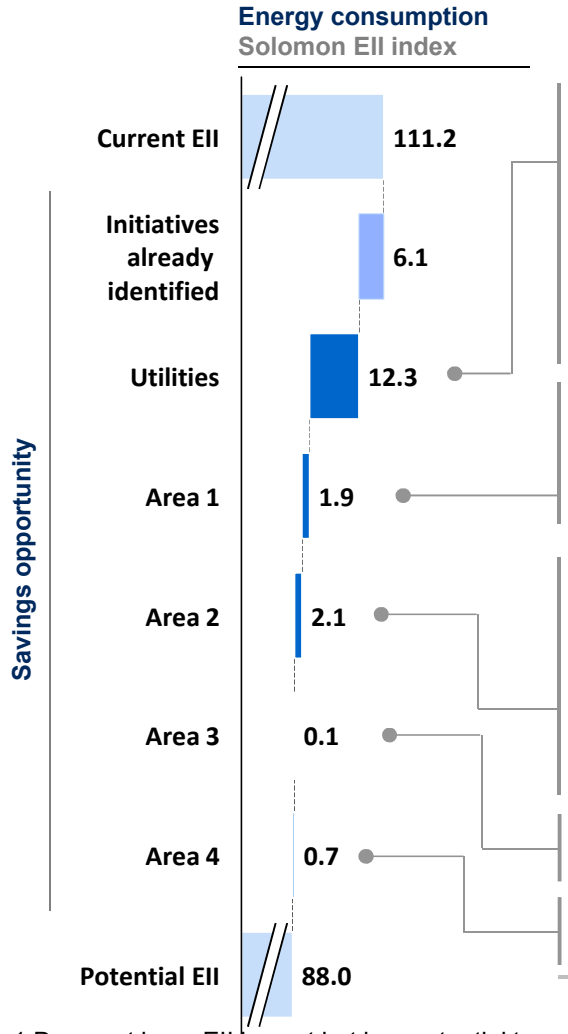
	Before	After
Overall	▪ Different energy practices across all sites	▪ Standardized energy management system across all sites
Performance 	▪ Year and year incremental improvement target ▪ Distributed initiatives not clearly linked to meet target	▪ 4 year target to reach top quartile performance ▪ Consolidated initiatives to meet target
Process 	▪ Energy KPIs for selected functions only e.g., production, engineering ▪ Energy discussed only in selected meeting e.g., hydrocarbon meeting	▪ Energy KPIs for all energy related functions incl. maintenance, procurement ▪ Energy discussed in all crucial meetings e.g., operations meeting, reliability meeting
People 	▪ No specific training on energy efficiency ▪ Only 1 unit level energy competition	▪ Comprehensive capability building toolkit incl. 22 modules ▪ 3 different energy competitions at individual and group levels

However, there are some challenges that we faced in rolling out EMS

Issue	How it was addressed
 **Adherence to new processes and procedures**	▪ **Communication** cascade about the program and what each member is required to do ▪ **Coaching** through 3 bootcamps to ensure employees feel confident that they can implement change ▪ **Role modeling** by senior management to get involved in project ▪ **Formal mechanisms** such as KPIs
 **Ownership in senior management**	▪ In monthly steering committee meetings **refinery General Managers presented the progress of EMS** in their refineries, which put them under pressure to show progress
 **Roll out to other refineries**	▪ **Pull forward program** – training sessions conducted by change agents of the pilot sites for change agents from other sites

We identified initiatives to take us to EII Quartile 1

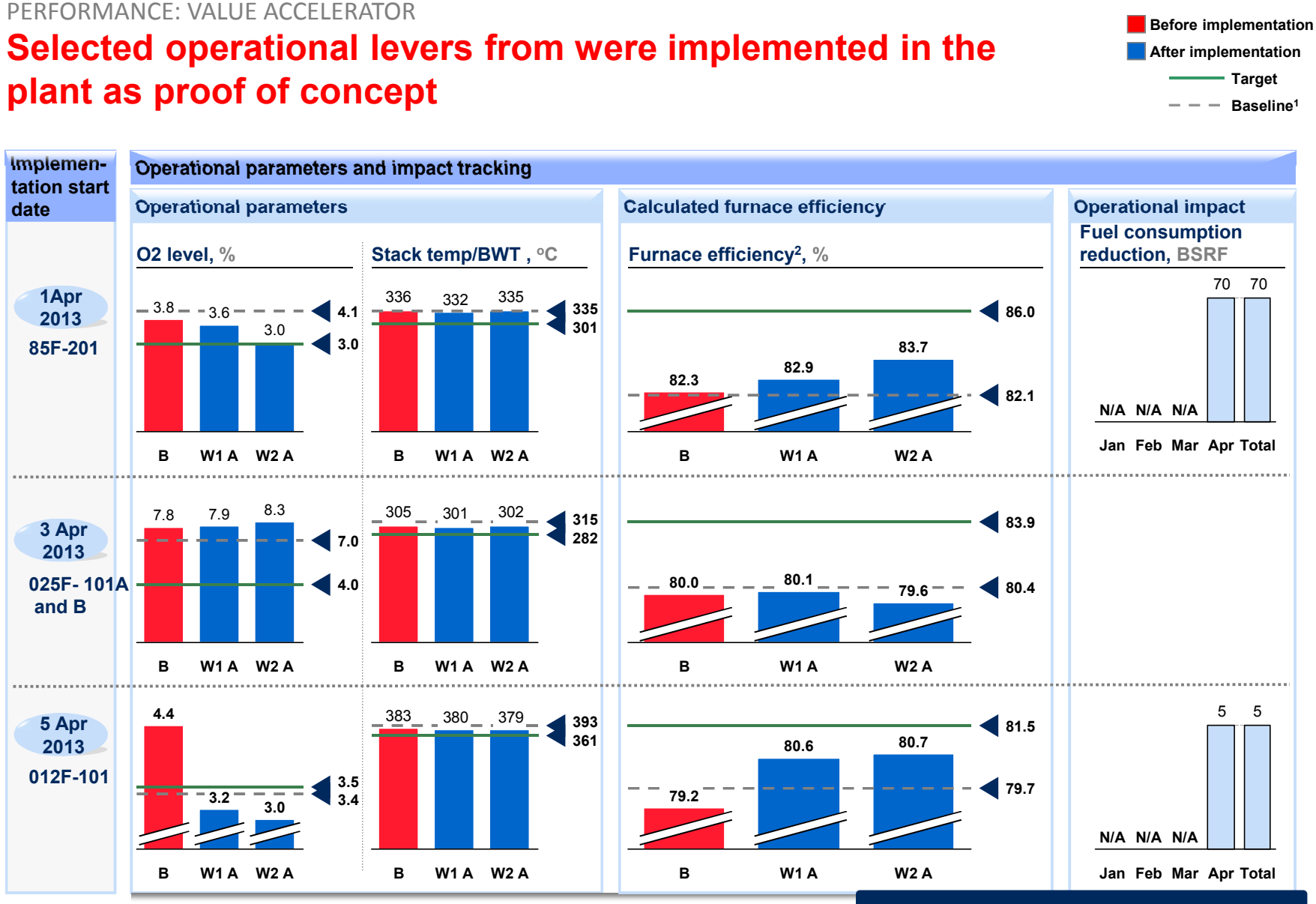
x.x Day to day operation
x.x Minor capex[2]
x.x Heavy capex[3]



	Top initiatives quantified	EII reduction	Savings $mn/yr	Capex
U.1	Reduce let down of MP to LP steam	0.28	2.06	▪ Negligible
U.2	Maximize steam turbine inlet temperature[4]	0.27[4]	2.01[4]	▪ Negligible
U.3	Improve STG condenser performance[4]	0.24[4]	1.81[4]	▪ 0.5
U.4	Install air pre heaters	0.14	0.57	▪ 0.5
U.7	Reduce O2 level of boilers	0.14	0.55	▪ Negligible
U.8	Replace STGs with Cogeneration	11.54	45.61	▪ 50-100
U.9	Reduce steam leaks	0.20	1.45	▪ Negligible
F1.1	Increase coil inlet temperature	0.46	1.83	▪ 0.15
F1.3	Reduce excess O2 level in furnaces	0.22	0.85	▪ Negligible
F1.4	Reduce radiation loss from furnaces	0.23	0.90	▪ 0.1
F1.8	Install air pre heaters	0.40	1.60	▪ 1
F2.1	Reduce flaring[1]	n/a	7.42	▪ Negligible
F2.2	Increase coil inlet temperature	0.98	3.87	▪ 0.15
F2.3	Reduce spillback on platformer compressors	0.10	0.60	▪ TBD
F2.4	Reduce excess O2 level in furnaces	0.51	2.02	▪ Negligible
F2.5	Reduce radiation loss from furnaces	0.51	2.03	▪ 0.1
F2.9	Install air pre heaters	0.62	2.44	▪ 0.5
L.1.1	Reduce excess O2 level in furnaces in unit I	0.03	0.13	▪ Negligible
L.2.1	Reduce excess O2 level in furnaces in unit II	0.08	0.32	▪ Negligible
P.1	Reduce excess O2 level in furnaces	0.34	1.36	▪ Negligible
P.2	Reduce radiation loss from furnaces	0.34	1.36	▪ 0.1
	Total	17.1	77.0	

1 Does not have EII impact but has potential to reduce energy cost 2 Does not require procurement and investment decision 3 Long lead times
4 Impact is not counted in the long term EII and cost reduction because of future CoG replacement

Selected operational levers from were implemented in the plant as proof of concept

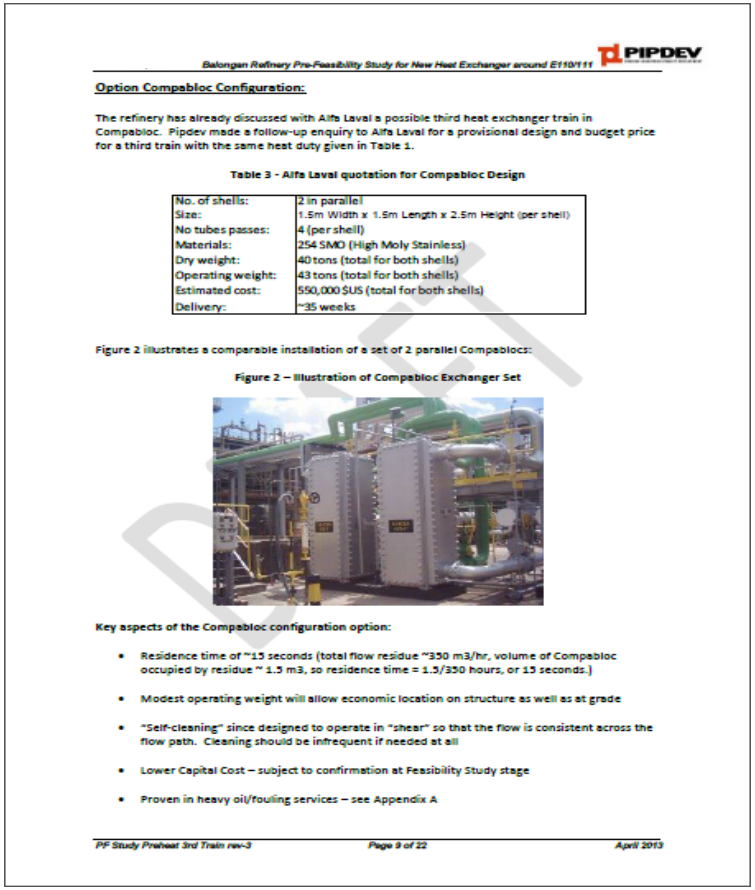


1 Baseline period is from Jan – Dec 2012, with abnormal data removed

More than USD 0.2 million/year of projected annualized impact from the 3 fired heaters

We engaged an engineering firm to provide expertise for Capex Initiatives

Snapshot of Compabloc PFS report



Balongan Refinery Pre-Feasibility Study for New Heat Exchanger around E110/111 — PIPDEV

Option Compabloc Configuration:

The refinery has already discussed with Alfa Laval a possible third heat exchanger train in Compabloc. Pipdev made a follow-up enquiry to Alfa Laval for a provisional design and budget price for a third train with the same heat duty given in Table 1.

Table 3 - Alfa Laval quotation for Compabloc Design

No. of shells:	2 in parallel
Size:	1.5m Width x 1.5m Length x 2.5m Height (per shell)
No tubes passes:	4 (per shell)
Materials:	254 SMO (High Moly Stainless)
Dry weight:	40 tons (total for both shells)
Operating weight:	43 tons (total for both shells)
Estimated cost:	550,000 $US (total for both shells)
Delivery:	~35 weeks

Figure 2 illustrates a comparable installation of a set of 2 parallel Compablocs:

Figure 2 – Illustration of Compabloc Exchanger Set

Key aspects of the Compabloc configuration option:

- Residence time of ~15 seconds (total flow residue ~350 m3/hr, volume of Compabloc occupied by residue ~ 1.5 m3, so residence time = 1.5/350 hours, or 15 seconds.)
- Modest operating weight will allow economic location on structure as well as at grade
- "Self-cleaning" since designed to operate in "shear" so that the flow is consistent across the flow path. Cleaning should be infrequent if needed at all
- Lower Capital Cost – subject to confirmation at Feasibility Study stage
- Proven in heavy oil/fouling services – see Appendix A

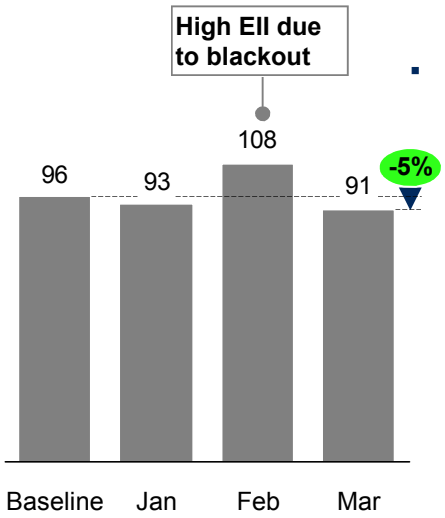
PF Study Preheat 3rd Train rev-3 — Page 9 of 22 — April 2013

Highlights of report

Root cause analysis	▪ Loss in CIT due to fouling in HEX E110/E111
Investment package	▪ Welded plate HEX (e.g., combabloc) 2 parallel sets ▪ Project cost = $4.7mn
Impact analysis	▪ $21mn/yr from debottlenecking of CDU ▪ $4.3mn/yr from reduced energy consumption due to higher CIT
Business case	▪ 1 yr counting only energy impact ▪ 3 months including process impact
Action plan and project tracking template	▪ Estimated 1 years of project duration ▪ However, significant increase possible due to approval and contracting process

We set up a KPI based system to track normalized energy efficiency for each refinery…

EII achievements



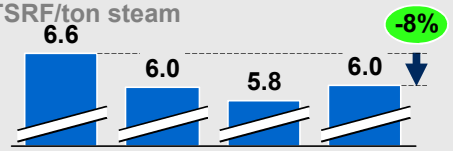
Reasons for change

- Lower coke production in RCC due to low MCRT
- Catalyst problem in PLF

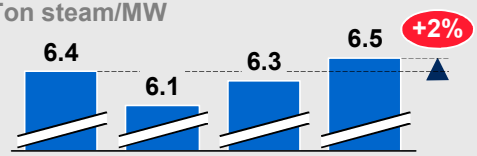
Energy KPI breakdown by EE areas

Utilities

TSRF/ton steam



Ton steam/MW



Reasons for change

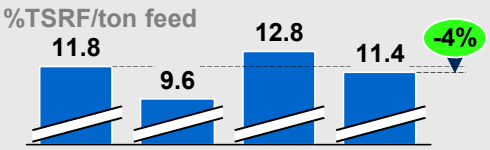
- Efficiency increase due to increase in share of fuel gas
- STG B & E operating in extraction mode to satisfy increase in MPS demand

% of total energy cons.

24%

Area 1

%TSRF/ton feed

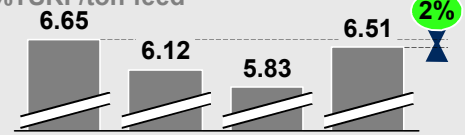


- While lower MCRT reduces TSRF/ton feed, it also reduces the standard energy, thereby increasing EII

35%

Area 2

%TSRF/ton feed

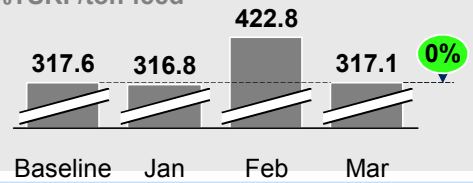


- TSRF/ton feed has reduced, but due to catalyst problem in PLF, the std energy has reduced, thereby increasing EII

21%

Area 3

%TSRF/ton feed



20%

Equipment readiness was tracked on a weekly basis and action taken for low readiness areas

- 100%
- 90%-100%
- >90%
- >75%

	Boilers	Furnaces
Firing	100	100
Combustion air supply	100	95
Temperature indicator	100	100
Sootblowing	73	83
Drafting	100	83
Flow and pressure measuring	100	95
Others	100	100
Total	99	96

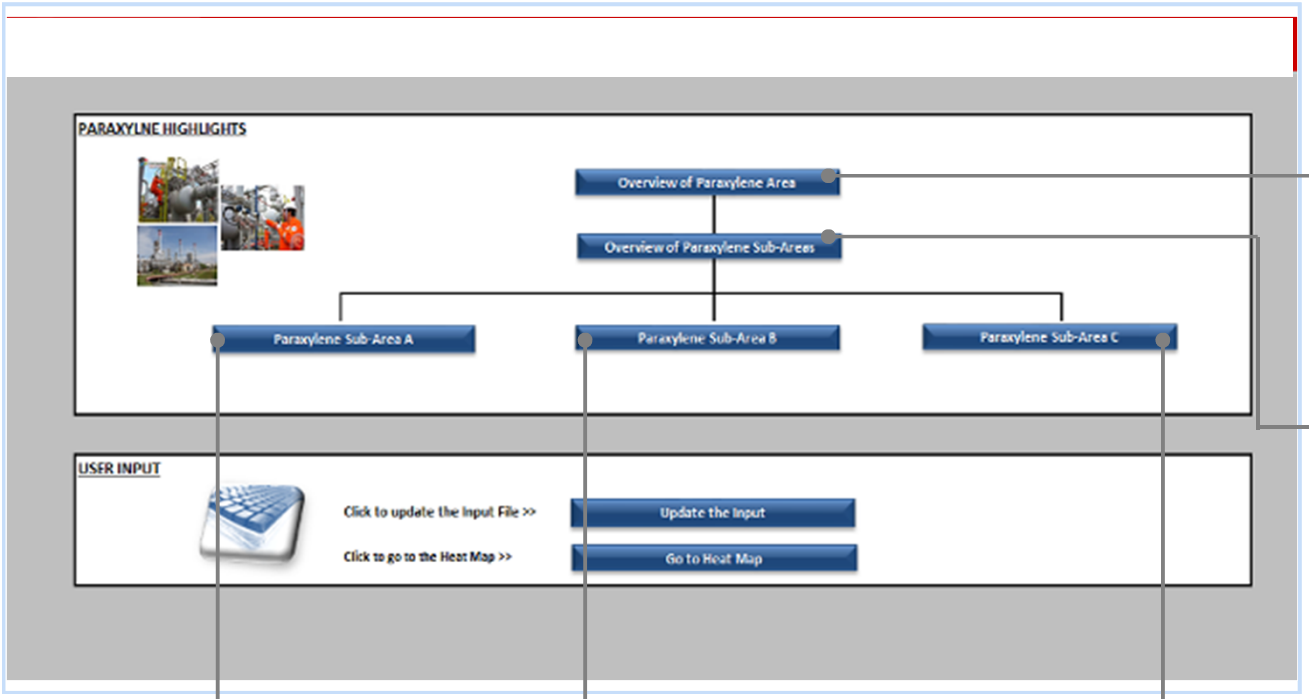
	Low readiness units	Readiness
Air registers	11-F-101	81
	12-F-101	80
	13-F-101	80
FDF / IDF	11-F-101	50
Soot-blowing	52B-101A	60
	52B-101B	60
	52B-101C	90
	52B-101D	90
	52B-101E	70
	52B-101F	67
	15B-101	48
Stack damper	14F-101	75
Draft gauge	15B-101	50
	31F-101	67
	31F-102	67
	31F-103	67
	32F-101	0
	32F-102	0
	32F-103	0
	32F-104	0

… which was cascaded down to every related position of the organization

	Recommendations
General Manager	▪ EII
Senior Manager	▪ EII
Production I manager	▪ EII in Production I area
Production II manager	▪ TSRF/feed[1]
RPO manager	▪ None
Turnaround manager	▪ % completion of energy-related initiatives recommended for TA
MPS manager	▪ Equipment & accessories readiness for energy-related equipment[2]
ME manager	▪ Lead time in energy-related repair/replacement work
Procurement manager	▪ Service level of accessories/equipment/ service/catalyst for EE-critical equipment[2]
Reliability manager	▪ % of EE-related program improvement based on Master Plan
Eng & Dev manager	▪ EII improvement gained from supporting programs based on EII roadmap; EII
OPI manager	▪ EII improvement gained from supporting programs based on EII roadmap

1 Only for units of which EII cannot be calculated 2 Details to be added in equipment readiness addendum

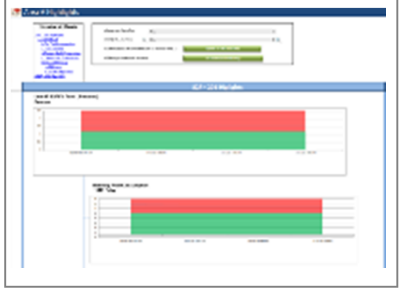
We created performance dashboards to ensure effective performance dialogues…



Overview of Area

Overview of Area

Area A

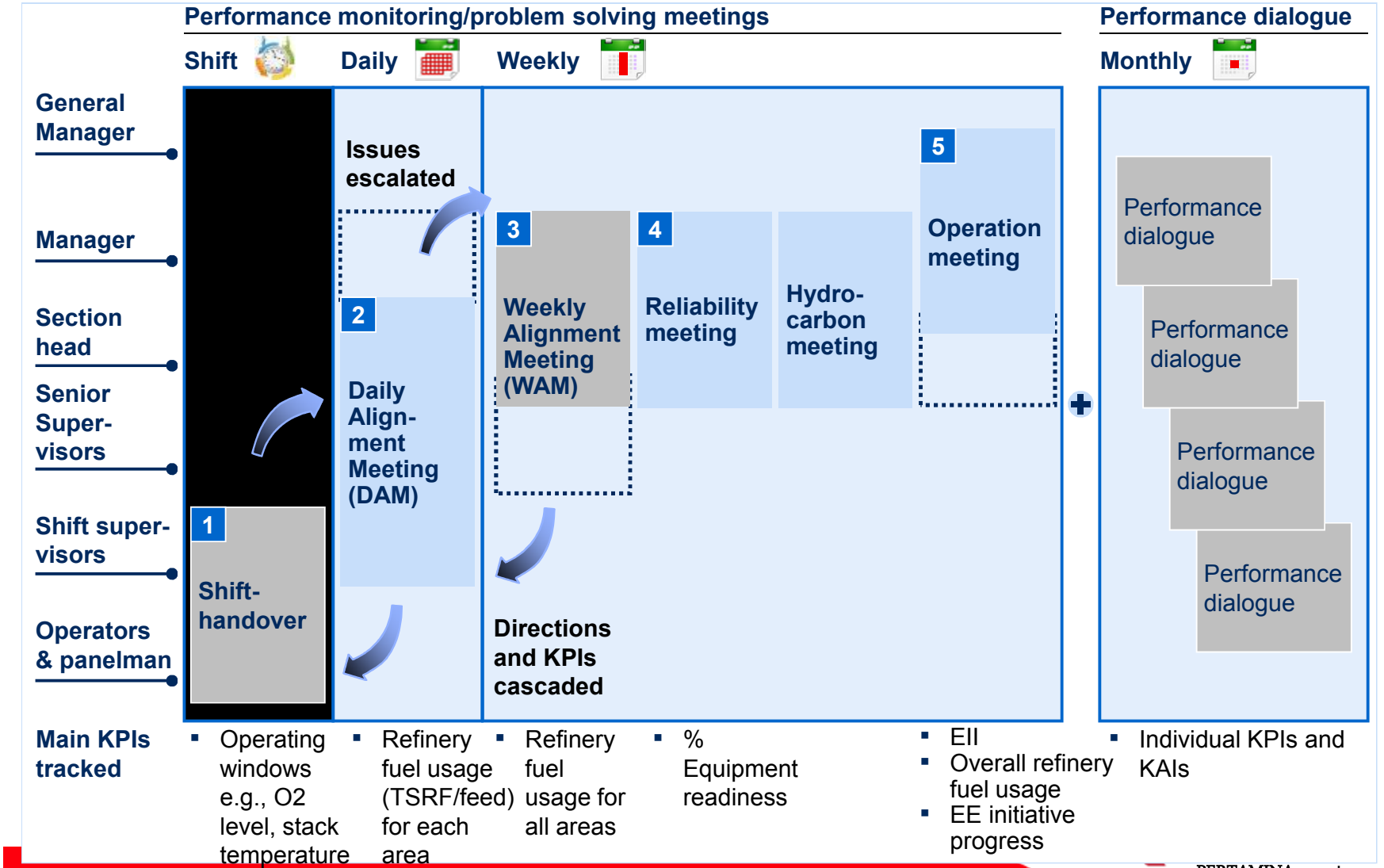


Area B

Area C

Each production area can leverage electronic dashboard as a tool to track energy-related KPI performance

… which were conducted at every level of the refinery



3 bootcamps were conducted to upskill employees

	Bootcamp 1: *"Basics of EMS"*	Bootcamp 2: *"Leading change"*	Bootcamp 3: *"Sustaining impact"*
Performance 	Energy value chain EMS-PF1 Theoretical limit EMS-PF2 Energy loss framework EMS-PF3 EII EMS-PF4	Load curve EMS-PF5 Pinch analysis EMS-PF6	Cost curve EMS-PF8 Energy and product quality EMS-PF9 Rotating equipment analysis EMS-PF7
Process 	EMS brick architecture EMS-PR1 Equipment readiness I EMS-PR2 KPI & KAI cascading EMS-PR3 Performance monitoring EMS-PR4	Equipment readiness II EMS-PR5 Transformation design & implementation roadmap EMS-PR6 Capex stage gate system EMS-PR7	Equipment readiness III EMS-PR8
People 		Frontline engagement EMS-PE1 Stakeholder ownership EMS-PE2	Skill assessment system EMS-PE3 Continuous improvement EMS-PE4 Innovative learning mechanisms EMS-PE5

Energy related competitions were conducted to keep frontline motivated

120+ ideas have been submitted

10 different areas involved in the competition, from manager to operator level

> Reduce ammonium salt deposit in NHT unit by injecting wash water to inlet 31-E-104

> Increase vacuum condition in STG to reduce steam consumption

We have selected winners for best ideas based on impact and creativity

Best Ideas:

1. Manager – Production 1
2. Operator - RCC
3. Junior Engineer - Process Engineering

Next step is to add ideas into initiatives roadmap

Actions:

- Insert realistic ideas into roadmap for future implementation

30+ pivotal positions across seven functions have been coached to drive change and ensure EMS sustainability

People

"Pivotal positions" is an initiative under "People" to …

- Drive positive change to improve EE mindset
- Lead key initiatives to drive implementation and realize impact
- Provide guidance and inputs to shape EMS brick codification
- Enable sustainability by acting as EMS role models for the rest

30+ pivotal position from GM to managers and section heads have been identified and coached in Wave 1

7 different functions are involved to drive change and ensure EMS sustainability

~300 coaching sessions (formal and informal) have been conducted in the last 8 months

A comprehensive guidebook on energy efficiency was created to codify all related information

Topic

Snapshots of EMS bricks

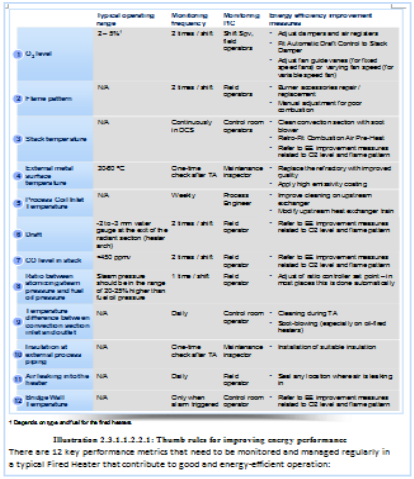
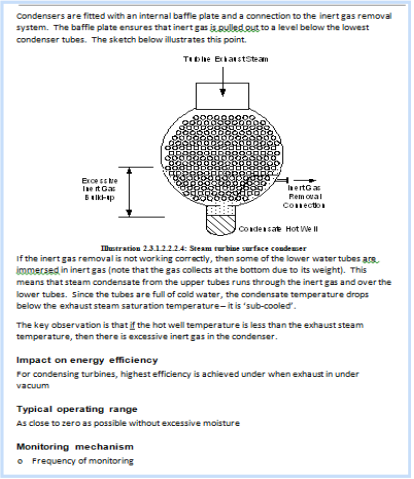


Illustration 2.3.1.2.2.1: Thumb rules for improving energy performance

There are 12 key performance metrics that need to be monitored and managed regularly in a typical Fired Heater that contribute to good and energy-efficient operation:



Condensers are fitted with an internal baffle plate and a connection to the inert gas removal system. The baffle plate ensures that inert gas is pulled out to a level below the lowest condenser tubes. The sketch below illustrates this point.

Illustration 2.3.1.2.2.4: Steam turbine surface condenser

If the inert gas removal is not working correctly, then some of the lower water tubes are immersed in inert gas (note that the gas collects at the bottom due to its weight). This means that steam condensate from the upper tubes runs through the inert gas and over the lower tubes. Since the tubes are full of cold water, the condensate temperature drops below the exhaust steam saturation temperature – it is 'sub-cooled'.

The key observation is that if the hot well temperature is less than the exhaust steam temperature, then there is excessive inert gas in the condenser.

Impact on energy efficiency

For condensing turbines, highest efficiency is achieved under when exhaust in under vacuum

Typical operating range

As close to zero as possible without excessive moisture

Monitoring mechanism

- Frequency of monitoring

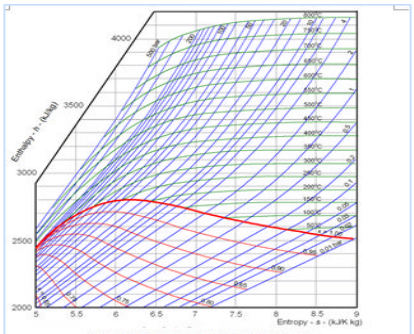


Illustration 2.3.1.2.2.7: Steam turbine Mollier diagram

It is a fact that increasing a steam turbine inlet temperature either increases output power or allows a reduction in steam flow while maintaining the original power, and so the temperature should be the maximum that is safe for the turbine. The Mollier Diagram clearly shows that increasing temperature has a far greater impact on steam enthalpy than increasing pressure.

If the temperature is too low, then there is a serious risk to the LP Blades of a condensing turbine due to erosion from the droplets of condensate that form in the exhaust.

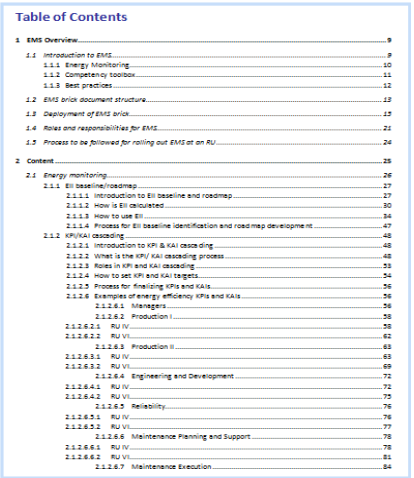


Table of Contents

EMS activities documentary .....

"Month of energy" kicked off by GM: is a good start to encourage energy initiatives, but more sustained collaborative effort required

Boiler & Furnace optimization upskilling address operators capability needs

RCPS methodology was applied on energy performance dialog

Boiler & Furnace competition : periodically rotating cross-audits will be performed to evaluate team performance and promote learning

EMS activities documentary .....

Energy Patrol to build energy awareness for all .....

Steam leak recovery competition : effectively reducing loss of energy

Energy campaign design: is an integral part of the EMS

Cross functional meeting can enable regular performance reviews

Thank you