CHEMISTRY THAT MATTERS™

COMPREHENSIVE ASSESSMENT OF STEAM CRACKERS FOR ENERGY INTENSITY IMPROVEMENT

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Ethylene Middle East Technology Conference

EMET CONFERENCE

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MOTIVES FOR ENERGY INTENSITY IMPROVEMENTS

Comply to Government Regulations

Saudi Energy Efficiency Program

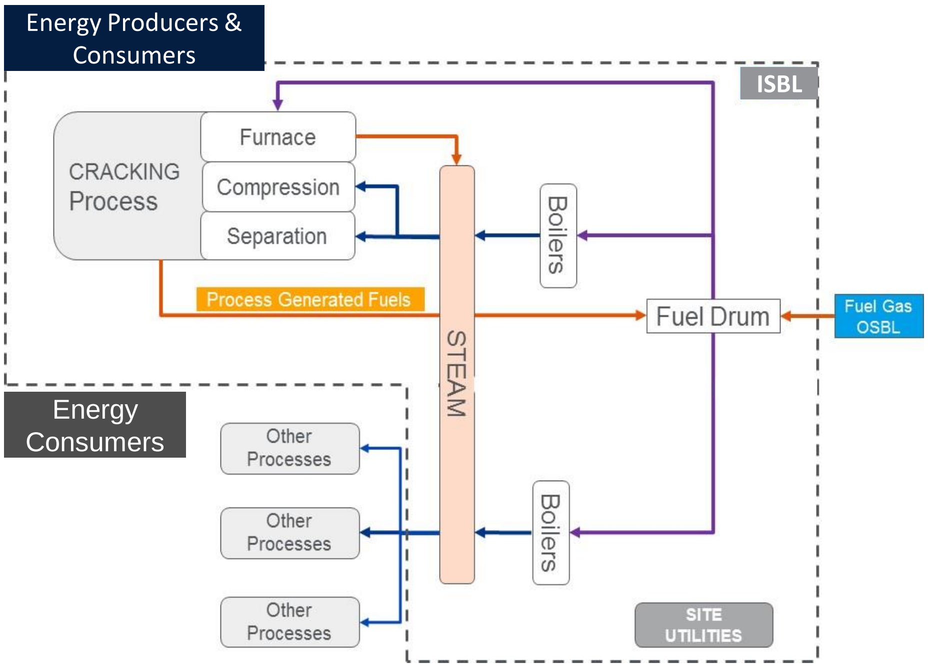
Increasing Cost Margin / Profit

Improving Sustainability Index

Non Availability of Fuel for Expansions

STEAM CRACKER ENERGY ASSESSMENT SCOPE

Crackers & Utilities formed Core of the Assessment in SABIC Integrated Petrochemical Complex



Measures for optimized Energy Consumption

- ❑ ***Optimization*** of process sequence
- ❑ ***Maximization*** of equipment efficiencies
- ❑ ***Reduction*** of dilution steam ratio
- ❑ Increased suction pressure CGC
- ❑ Increased ethane ***conversion***
- ❑ Boiler feed water preheating
- ❑ Reduced min. temperature differences
- ❑ ***Minimization*** of pressure drops
- ❑ Optimization of ***heat integration***

Comprehensive Assessment of Petrochemical Complex Provides Opportunities for Energy Saving by Integration of multiple Units

sabic

CRACKER ENERGY ASSESSMENT PROCESS

Energy Assessment Methodology

1 Understand Process Performance

2 Identify Process Gaps

3 Develop & Evaluate Opportunities

Site Data, Process Experience & Expertise

Affiliates + Project Team

- Benchmark & Gap Analysis
- Process & Utilities Review
- Operational Gap Analysis
- Detailed Pinch Analysis
- Total Site Analysis
- Yield / Energy Trade off
- Project Review
- Project Development
- Road Map

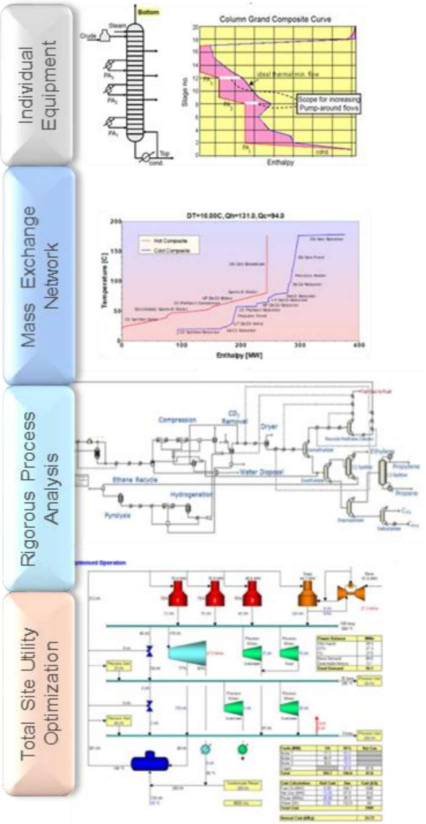
Utility System Modelling / Process Modelling / Pinch Analysis

50 Brainstorm Ideas

30 Screened Ideas

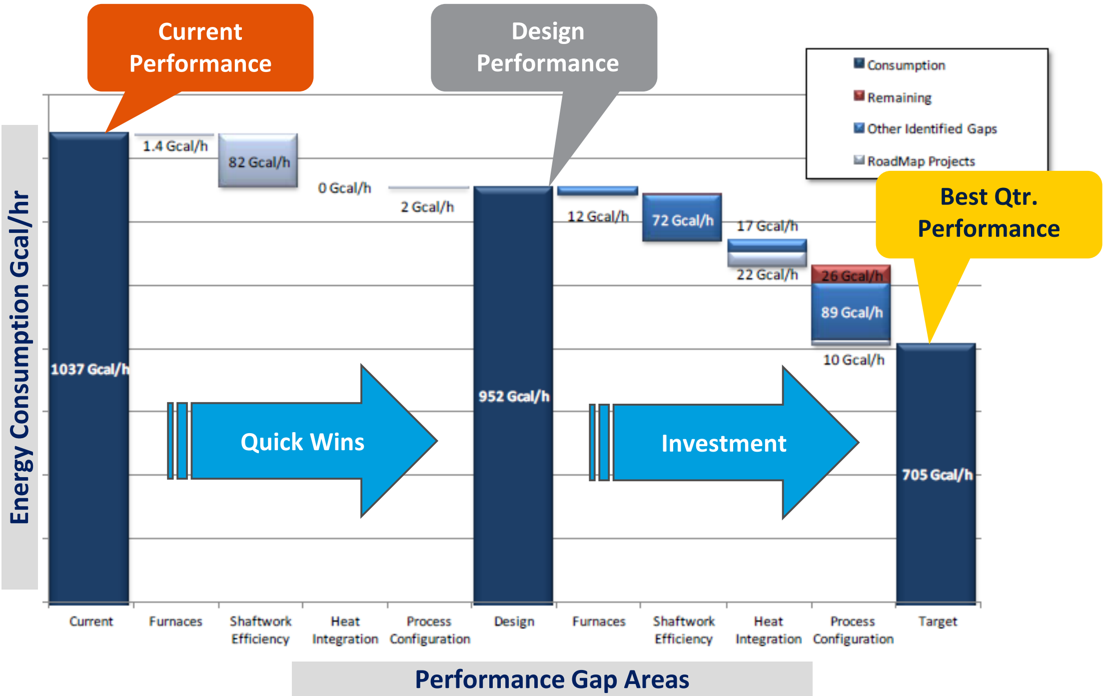
15 Road Map Projects

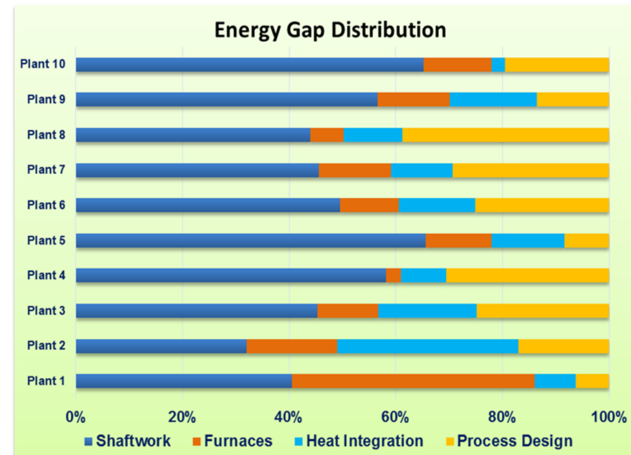
Evaluation Tools



Comprehensive Assessment of Cracker & Utilities for Opportunity Identification, Development and Implementation

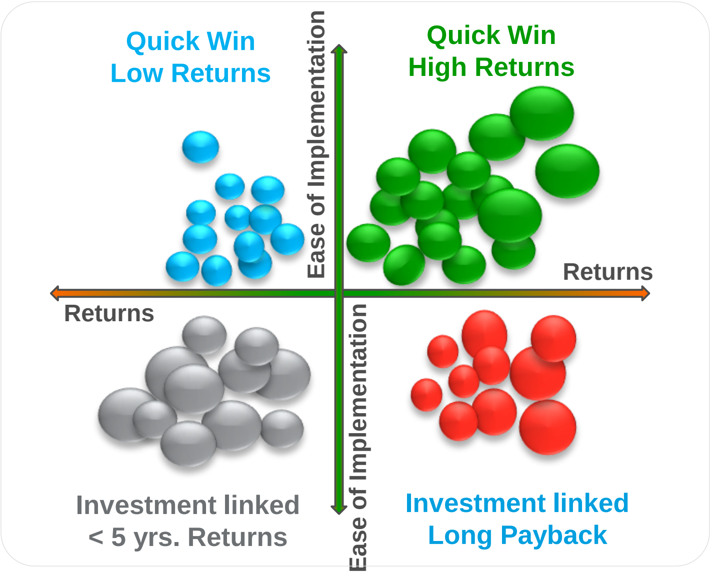
ENERGY GAP DISTRIBUTION FOR CRACKER PLANT

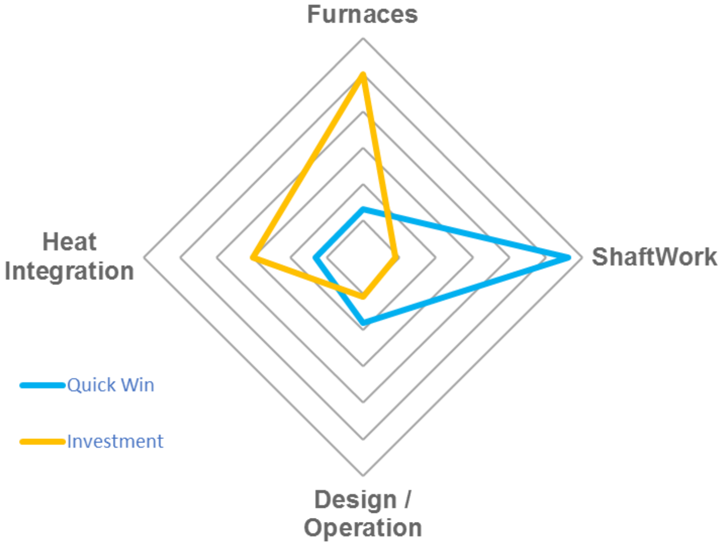




Categorization of Energy Gaps in Process would help in Focusing on Improvements in specific areas that results in High Impact

OPPORTUNITY SPREAD FOR >10 PLANTS





Investment Linked Opportunities do Exist
However very few are Economically Feasible due to low fuel cost scenario

STEAM CRACKER ENERGY SAVING OPPORTUNITIES

Process Optimization

- ❑ Fired Heater Optimization
- ❑ Steam Header Balance
- ❑ Cond. / Extr. Optimization
- ❑ Column Targeting
- ❑ Heat Integration
- ❑ Fouling Control / Mitigation

Process Intensification

- ❑ Anticoking Coils
- ❑ High Emissivity Coatings
- ❑ Swirl Flow Tubes
- ❑ Heat Pumps

Opportunities do exists to Improve Energy Intensity of Plants,
but "Is it Economical Considering Fuel Cost in Oil rich Economies"

STRATEGIES TO PURSUE ENERGY SAVING OPPORTUNITIES

How to Justify Energy Savings if the Marginal Cost for Fuel Savings is low - 1.75 $/MMBTU?

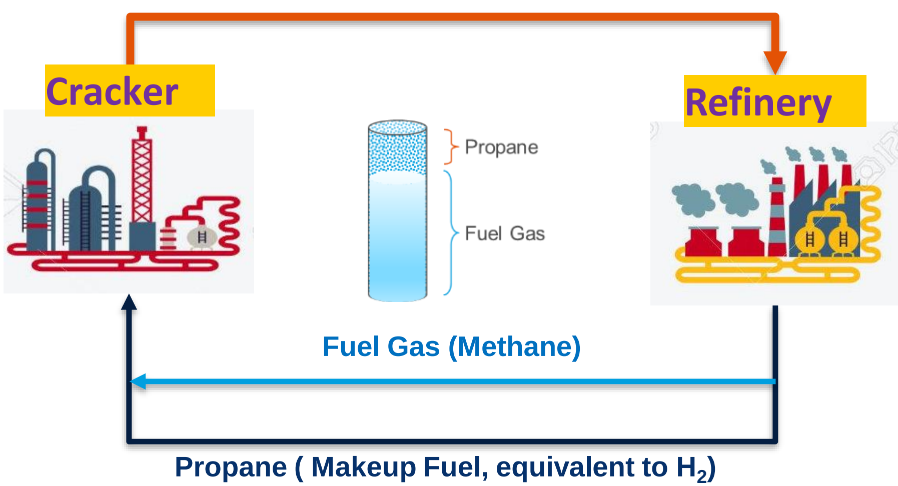
- What's really Impacted
- What process are affected if there is low Fuel
- What can I do if I get some additional Fuel
- Improving Sustainability helps in Improving Brand Value

Redefining Marginal Fuel Cost will Improve Investment linked Energy Saving Opportunity

REDEFINING MARGINAL FUEL COST : RECOVERY OF VALUABLE COMPONENTS FROM FUEL

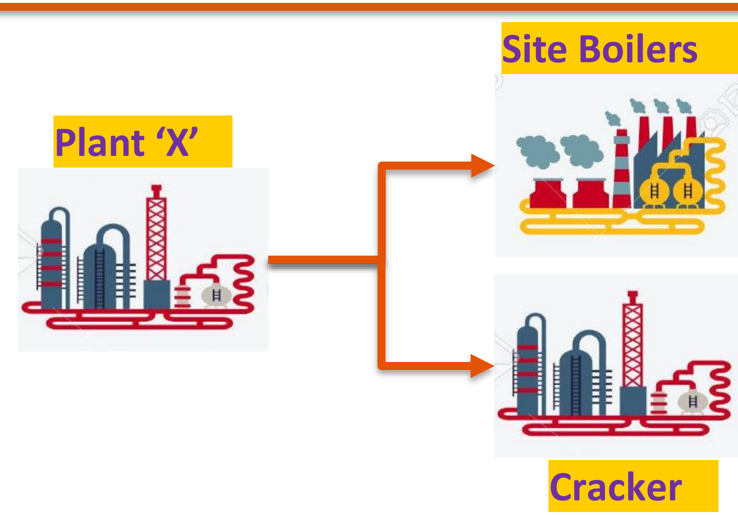
- Fuel Grid Integration with adjacent refineries / chemical plants
- Export / Recovery of High Value Chemicals e.g, H_2 / Propane
- Every Kj of energy saved in cracker is evaluated against additional revenue by either selling H2 to refineries or recovering valuable paraffin's from offgas

CASE 1 : Export of H_2 from Fuel Stream



Energy Saved → Reduced Import of Expensive Fuel

Case 2 : Recovery of Paraffin's



Energy Saved → Recovery of Valuable Chemicals (H_2)

OPERATION FLEXIBILITY (EXAMPLE CRACKER OPERATION)

Low Fuel

- Adhering to quota will require Cracker to Increase cracking severity
- Increasing severity decreases the selectivity to HVC
- This has negative impact on plant economics

Additional Fuel

- Any Fuel gas saved provides opportunity to Operate cracker at desired severity (high HVC)
- Operating at lower conversion
- Fuel gas saved → Marginal cost of additional HVC produced

Fuel Gas Savings

Operation Flexibility Low Severity High Profitability	Less Fuel Gas formation More imports / minimize consumption

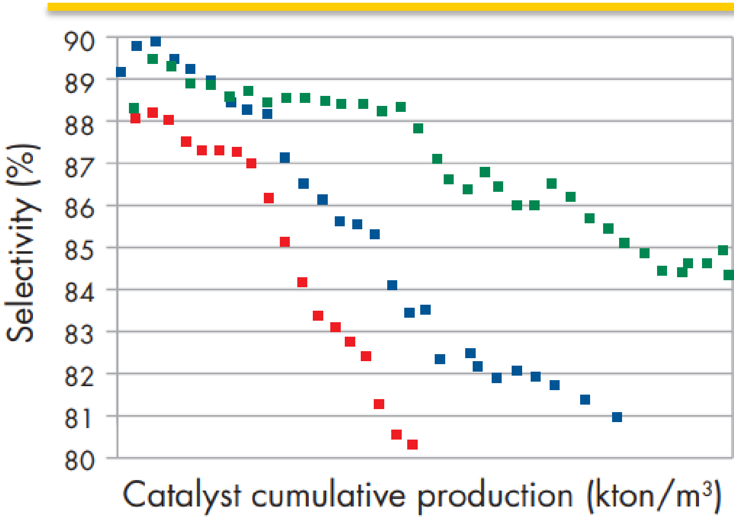
Low Severity

Energy Saved → Improving Operation Flexibility → Prod. of High Value Chemicals

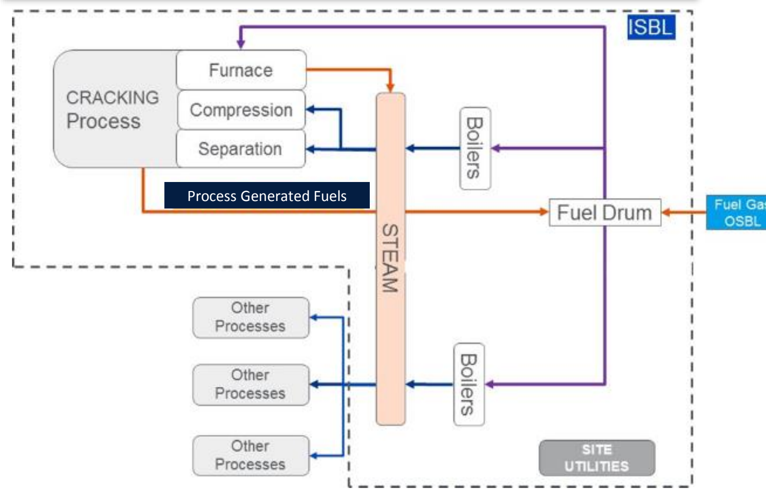
INCREASING CATALYST SELECTIVITY

- Current Catalyst has low selectivity, part of feed is burnt and the energy is converted to Steam. Steam thus produced is used in the process elsewhere.
- High selective catalyst provides better production & minimizes reactant requirement.
- Steam Savings in other parts of the complex provides an opportunity to implement high selective catalyst

Change in Catalyst Selectivity with Productivity*



SABICs, Integrated Petrochemical Complex



Energy Saved → Opportunity for High Selective Catalyst
Low reactant consumption → Higher Productivity

** Enhancements in EO/EG Manufacturing technology White paper*

OPTIMIZATION OF FIRED HEATERS

- **Gross Energy Consumption ~ 97 %**
- **Net Energy Consumption ~ 45 %**

SABIC Experience

- More than 150+ High Capacity Fired heaters
- Furnaces from all ages, 1980s to 2010s
- Thermal Efficiency : 88% - 94%

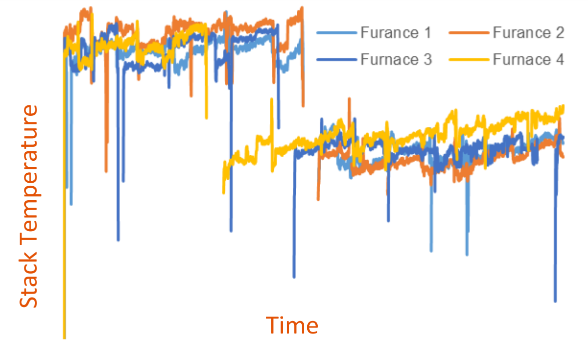
Old Furnace

- Stack O2
- Stack Temp.
- Casing Losses
- Burner Maintenance

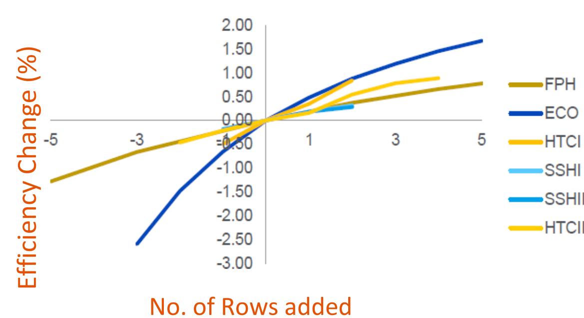
New Furnace

- Stack O2

Convection section Cleaning

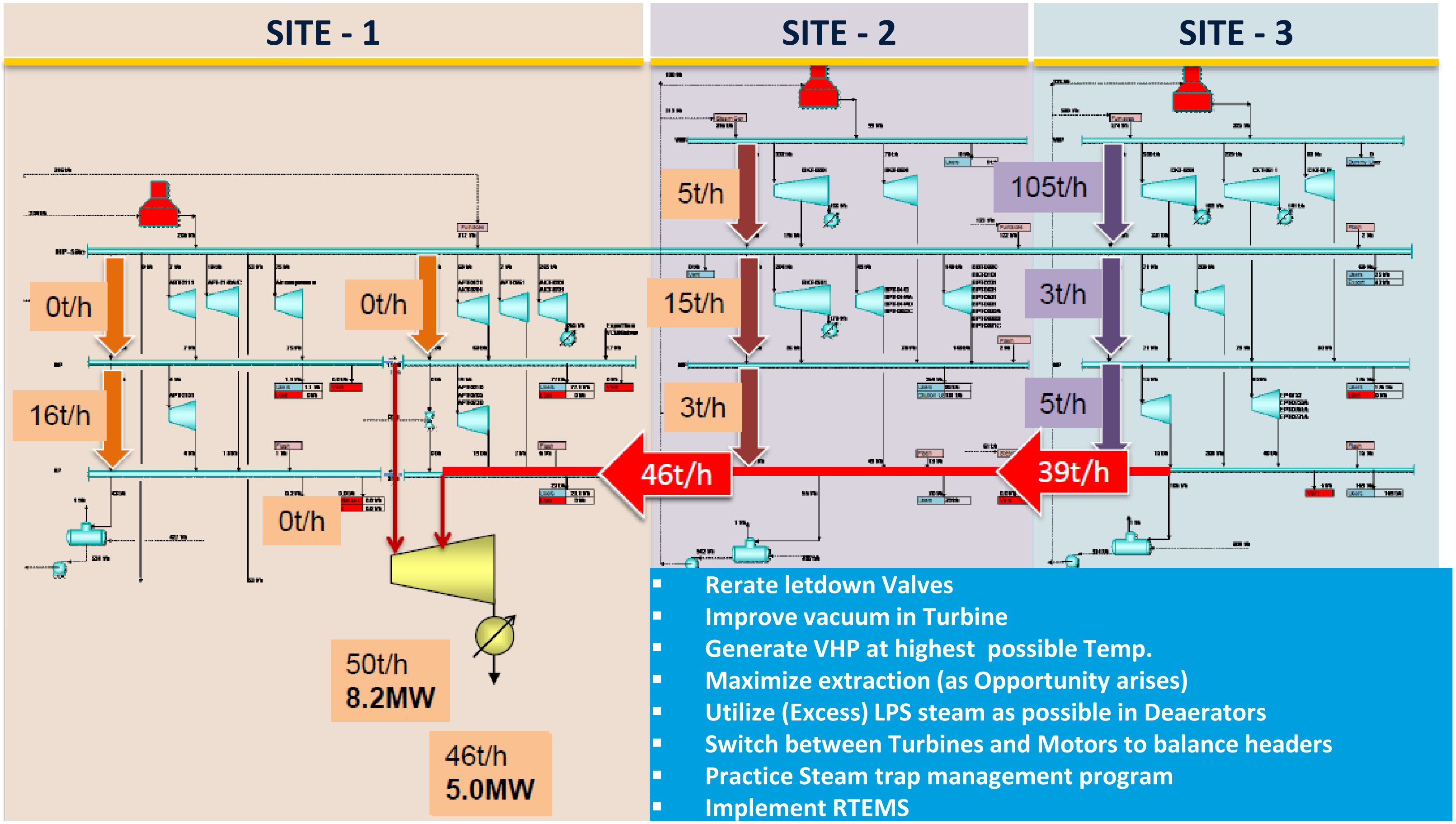


Model based evaluation for Revamping Furnaces



Comprehensive assessment helps in Identifying specific issues, developing tailor fit solutions for Increasing throughput & decreasing energy intensity

SHAFT WORK OPTIMIZATION



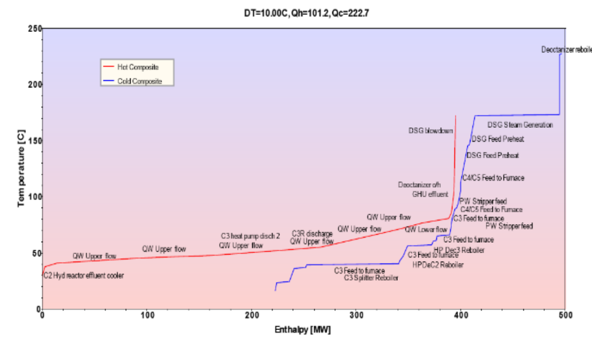
- Rerate letdown Valves
- Improve vacuum in Turbine
- Generate VHP at highest possible Temp.
- Maximize extraction (as Opportunity arises)
- Utilize (Excess) LPS steam as possible in Deaerators
- Switch between Turbines and Motors to balance headers
- Practice Steam trap management program
- Implement RTEMS

Shaft Work, often overlooked, provides the largest Opportunity for Energy Saving in New and Old petrochemical Complex

HEAT INTEGRATION OPPORTUNITIES IN OLEFINS

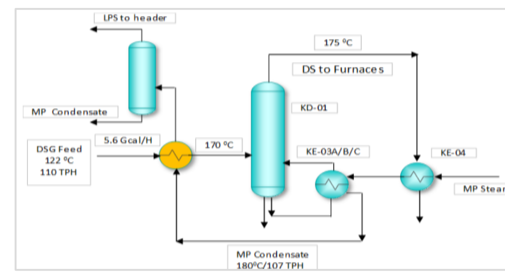
Modern day Plants are heat integrated within their ISBL.

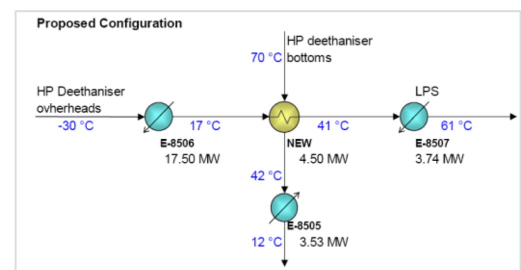
Opportunities arises by integrating with adjoining plants.



Typical Pinch Opportunities

- ❑ Rerouting Stream
- ❑ Addition of New exchangers
- ❑ Increasing Area in Existing exchangers
- ❑ Replacing MPS with LPS
- ❑ Shift cryogenic utility levels from C2R to C3R





All Heat Integration opportunities needs investments & have low impact.
Most of these are economically infeasible due to low Fuel Cost

SUSTAINABILITY STRATEGY

- Corporate Sustainability KPI’s
- Special Sr. Management sponsored programs in every affiliates /subsidiaries
- Continuous monitoring and reporting system to ensuring sustaining the benefits

SABIC Sustainability Targets

2010
Base Year

25 %

2025
Assessment Year

GHG Emissions Intensity

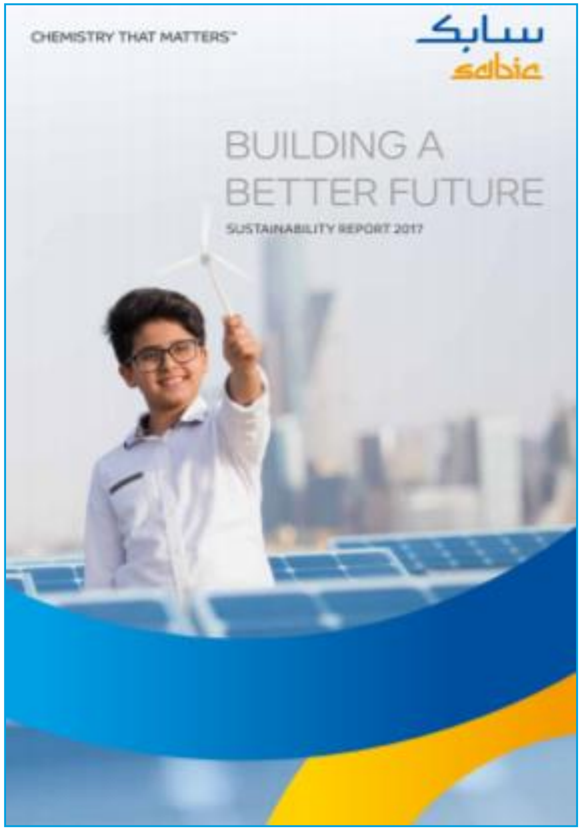
Energy Intensity

Water Intensity

Material Loss Intensity

Energy Saved = Achieving SABIC’s Sustainability Goals (KPI’s)
Improving Brand Value; Meeting Regulatory Targets ; Social Responsibilities

SABIC SUSTAINABILITY PERFORMANCE 2017



OPERATIONAL KPI PERFORMANCE

- ↓ **9.3%** GHG EMISSIONS INTENSITY
- ↓ **7.6%** ENERGY INTENSITY
- ↓ **8.8%** WATER INTENSITY
- ↓ **35.2%** MATERIAL-LOSS INTENSITY
- ↓ **43%** REDUCTION IN FLARING EMISSIONS[1]
- **3.5 mmt** TOTAL CURRENT CO_2 UTILIZATION