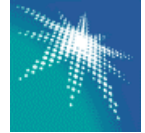




أرامكو السعودية
Saudi Aramco



Refinery Pre-heat Train Monitoring and Cleaning Tool

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OPTIMIZE™ 2013

Agenda

- Saudi Aramco
- Drivers for application and overall design.
- Overview of design.
- Challenges

Saudi Aramco Company Profile

- National oil company of Saudi Arabia.
- Almost 56,000 employees.
- One of the World's largest oil companies.
- A fully-integrated oil and gas company with affiliates, joint ventures and subsidiaries around the world.
- Owns and operates one of the largest oil tanker fleets.



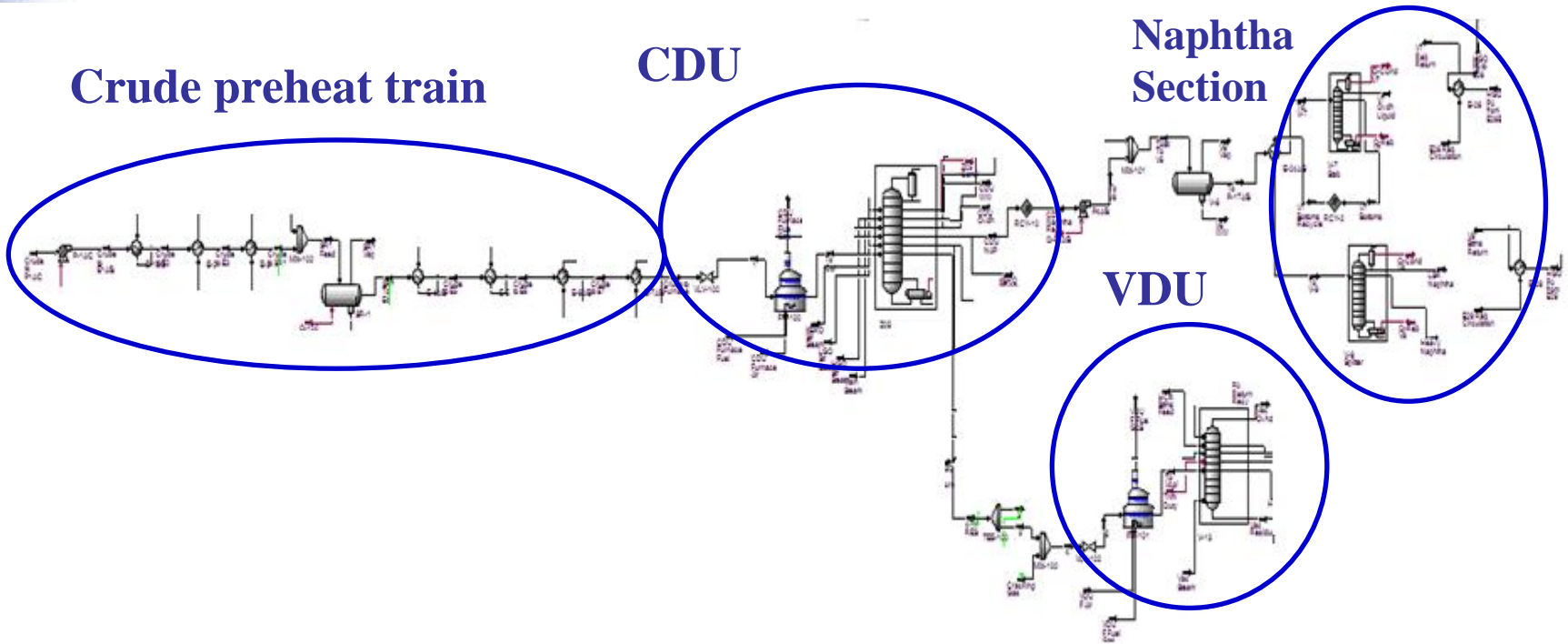
Crude Unit Overview

Crude preheat train

CDU

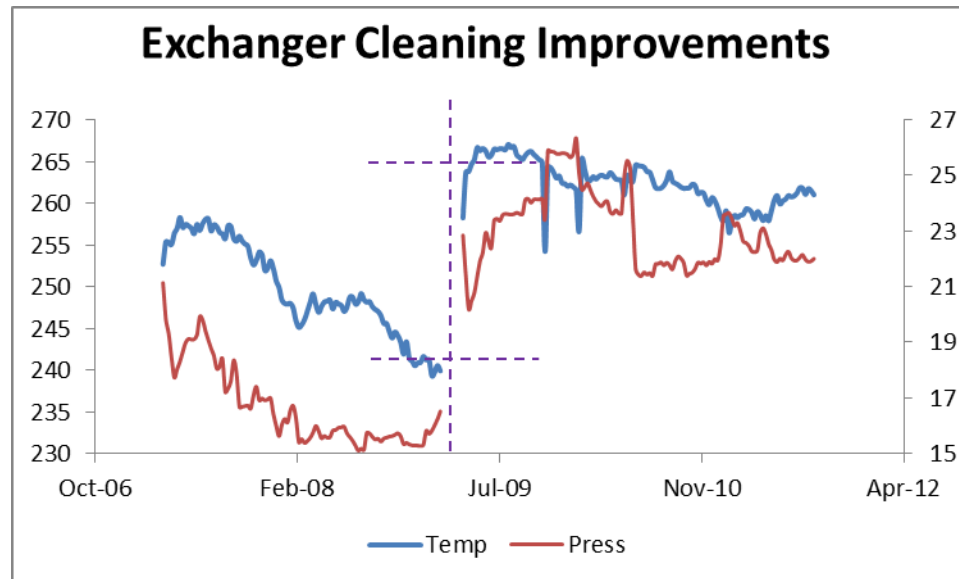
Naphtha Section

VDU



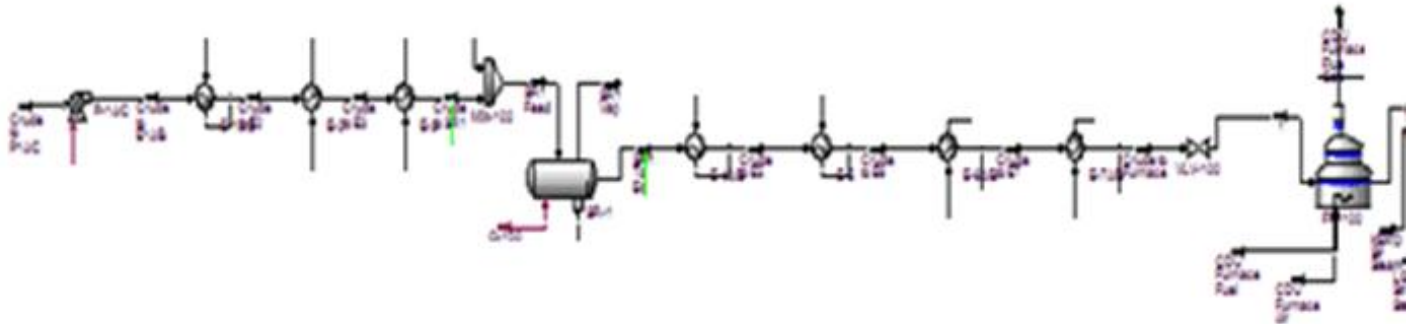
Operation Objectives

- Crude preheat exchanger fouling
 - Increased heater fuel load
 - Increased pressure drop
- Operating costs depend on fuel source



Operation Objectives

- Monitor heat exchanger performance.
- Identify which exchangers to clean and when.
- Demonstrate that overall cost of cleaning recovered



Modeling Objectives

- Utilize existing simulation technologies
- Evaluate technologies and methodology
 - Detailed exchanger models
 - Hysys EO
- Cautious approach to automation until benefits well understood.

Steps to Evaluate HX Network Scenarios

Establish Operating Conditions

- Eliminate individual energy imbalance:
 - Average data.
 - Reconcile data.
 - Improve measurements.

Estimate Exchanger Performance

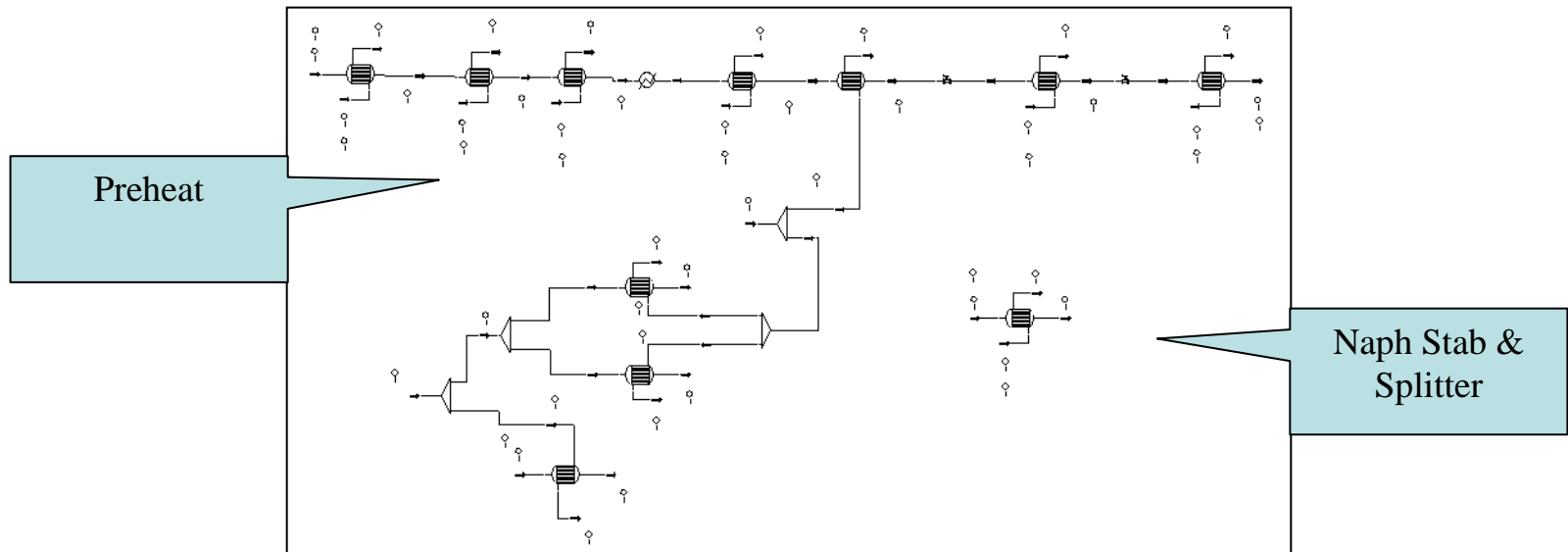
- Individual exchangers (U values, Fouling factors).
- Preheat exchanger network (normalized furnace inlet temperature).

Predict Future Performance

- Different operating scenarios (bypass, clean, etc.).
- Consider key time effects on unit performance.

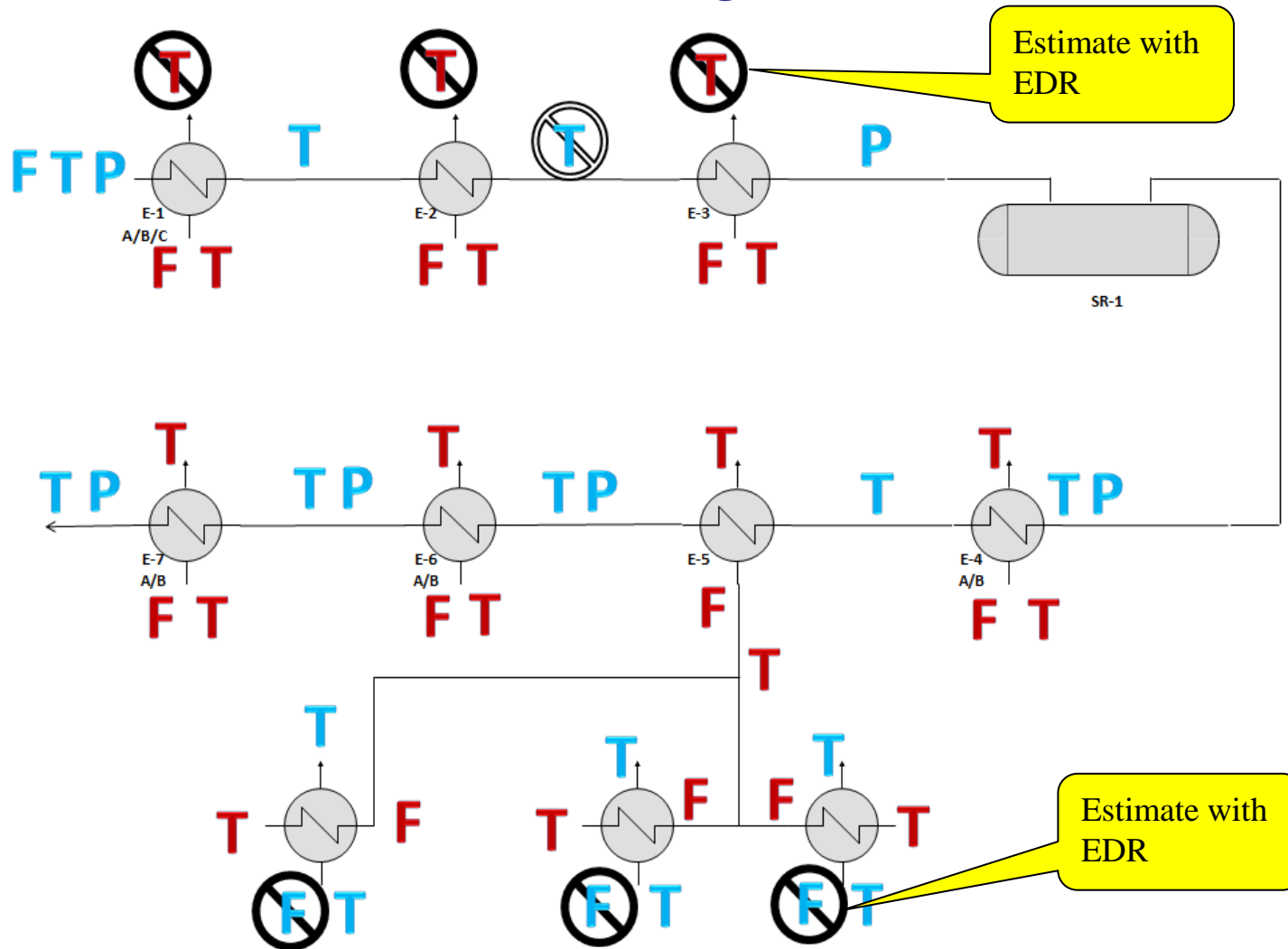
1. Establish Operating Conditions

- Heat and Material Balance reconciliation for selected Heat Exchangers.
- Using HYSYS EO
 - Easy interaction with performance, prediction models
 - Faster performance <1 min avg. solving time



1. Establish Operating Conditions

- EO: Available/missing instrumentation ...

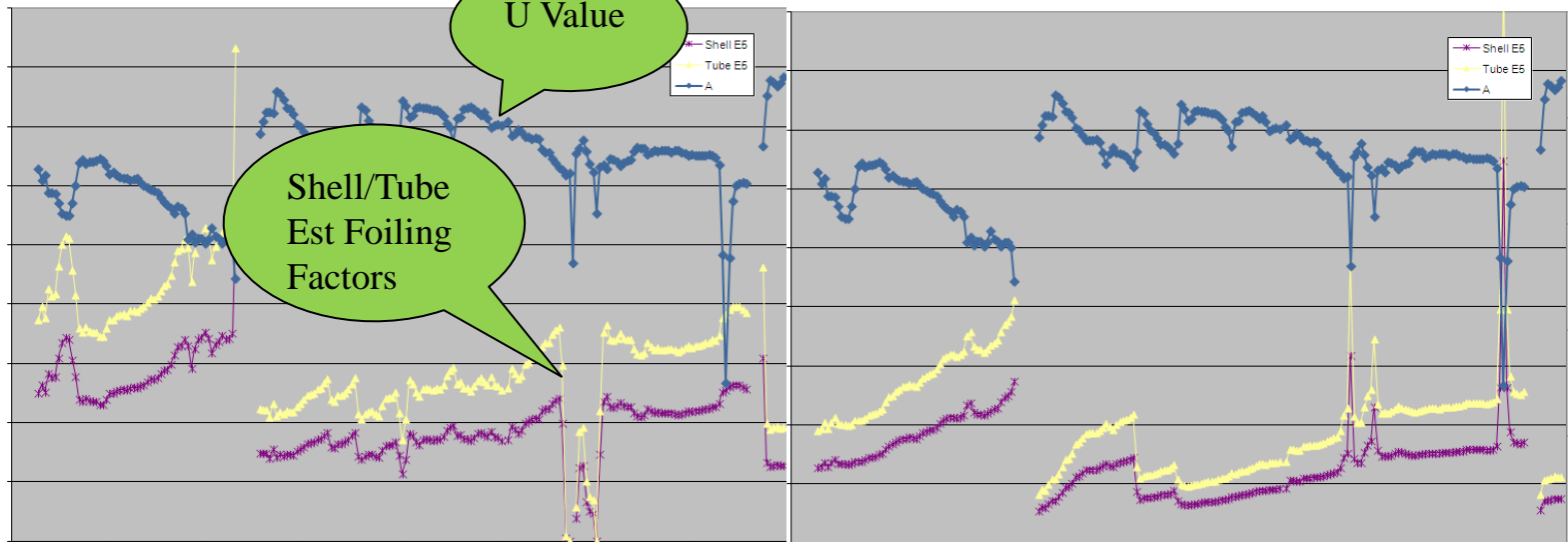


1. Establish Operating Conditions

- Reconciliation Improves results and helps identify trends
 - Smooths the trends.
 - Regression of fouling trends easier.
 - Helps automation of the tasks.

Non
reconciled
Data

Reconciled
Dara with EO
Mode



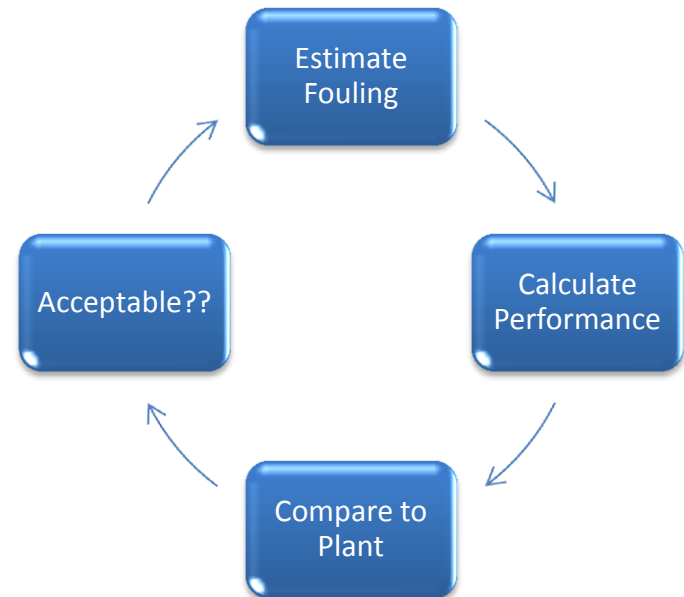
2. Estimate Exchanger Performance

- U ($U = Q / (A * LMTD * Ft)$)
 - FAST: Direct calculation from measurable variables.
 - INDIRECT: Varies with flows and properties.

- Fouling factor $r_o + r_i (d_o/d_i)$

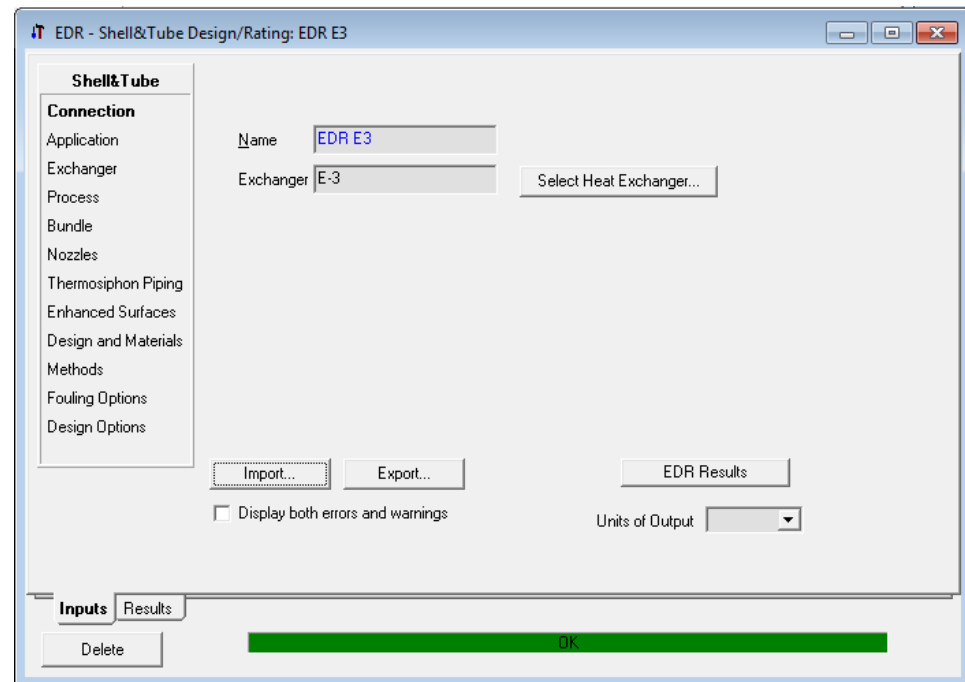
$$(1/U = 1/h_o + r_o + e/K(d_o/d_w) + (1/h_i + r_i) d_o/d_i)$$

- SLOW: Traditionally iterative.
- DIRECT: Only dependent on amount of fouling.
- Requires individual coefficient correlations.



2. Estimate Exchanger Performance

- New EDR utility in HYSYS
 - FAST: Directly calculates fouling factor - no iterations.
 - ACCURATE: dependent on fouling, not on process variables.



2. Estimate Exchanger Performance

- Using EDR to estimate fouling factor KPI is realizable objective.
- Beneficial for historical fouling trends analysis.
 - Two years of weekly datasets (7 exchangers / dataset).
 - Trial and error
 - 30 to 60 seconds per heat exchanger per dataset.
 - 6 - 12 hours for all datasets
 - EDR
 - 10 - 20 minutes for all datasets.

3. Predict Future Performance

- Fractionators in pumparound rating mode.
- EDR to calculate the performance of heat exchangers.
- Include effect of online time on unit performance.
 - Fouling factor trends extrapolated as desired.
- Decision and adjust variables :

Decision	Adjust
Fractionator heat balance	Heat exchanger cleaning
Furnace preheat temperature	Bypasses
Furnace fuel consumption	Pumparound flows

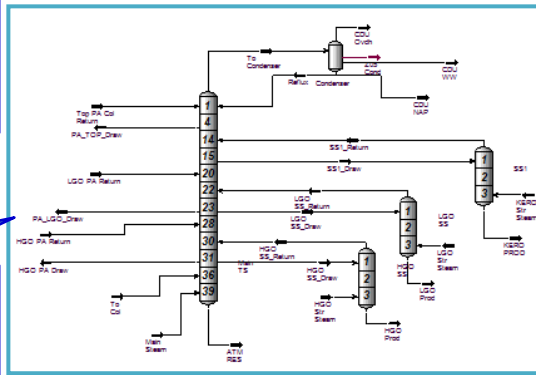
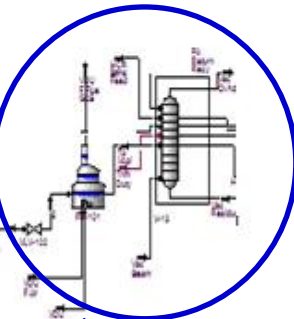
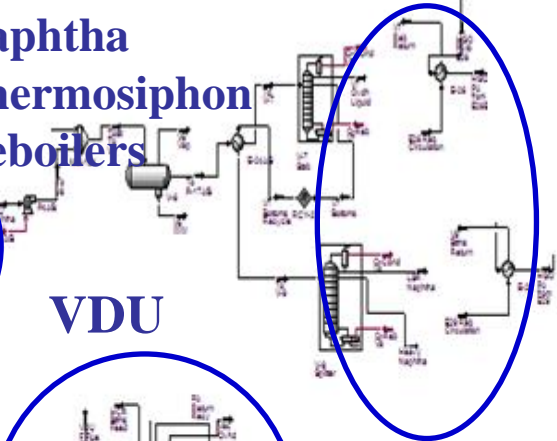
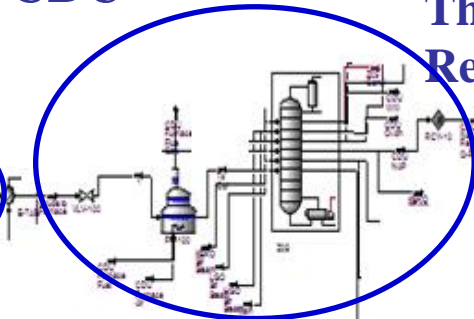
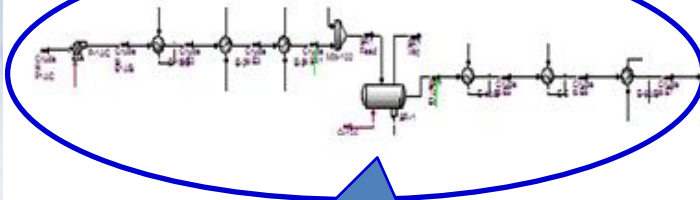
3. Predict Future Performance

Crude preheat train

CDU

**Naphtha
Thermosiphon
Reboilers**

VDU



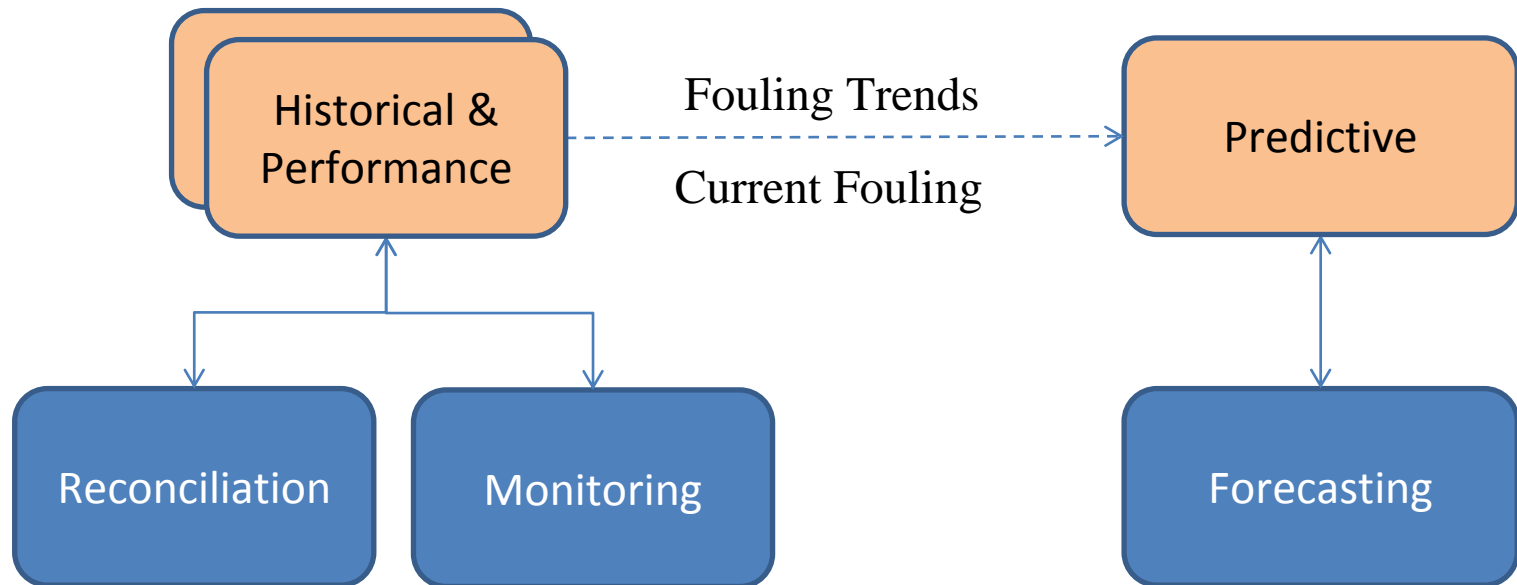
Heat exchangers in EDR rating mode.

PA duties calculated by heat exchanger performance.

EDR Furnace models to calculate Fuel Consumption as predicted by the network KPI.

Architecture Overview

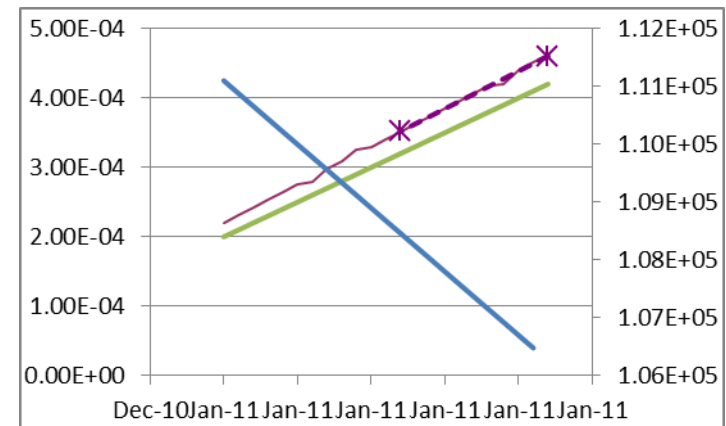
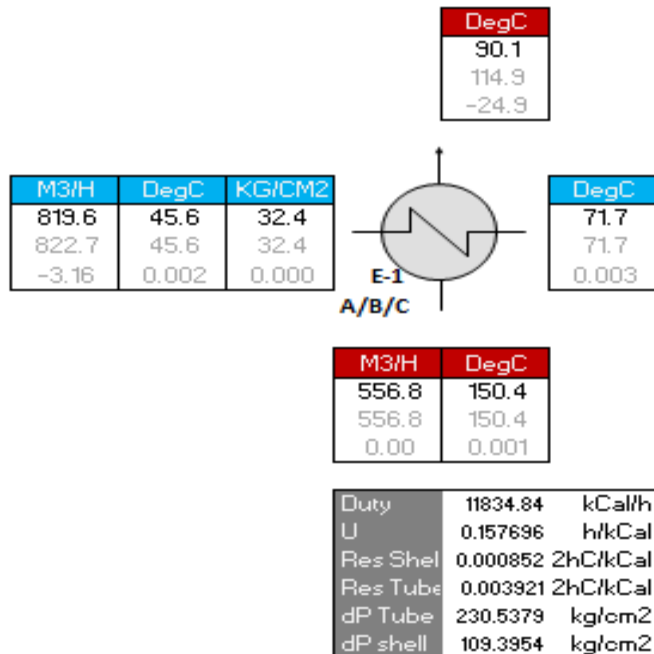
- Two (2) simulation-based applications.
 - Performance – Historical & Current
 - Predictive
- Three (3) simulation blocks.



Two Model User Interface(s)

- 1 : Performance Monitoring

- Data validation & reconciliation.
- Calculation of fouling factors.
- Fouling trend calculation from reconciled historical plant data.
- Current fouling from reconciled plant data.



Two Model User Interface(s)

- 2 : Prediction/Scenarios
 - forecasting operation to assess changes.
 - using fouling from historical analysis.

Events		
1	<input type="text" value="1 / 20 / 2013"/>	<input type="text" value="Start"/>
2	<input type="text" value="3 / 20 / 2013"/>	<input type="text" value="Clean E1 B"/>
3	<input type="text" value="3 / 29 / 2013"/>	<input type="text" value="E4 A clean, in service"/>
4	<input type="text" value="6 / 1 / 2013"/>	<input type="text" value="Reduce Feed - TPA Pump repair"/>
+		
5	<input type="text" value="12 / 31 / 2013"/>	<input type="text" value="End"/>

<input type="button" value="Save"/>					
Description: <input type="text"/>					
Start: <input type="text" value="7 / 25 / 2013"/> <input type="button" value="Calendar"/>					
Exchangers					
	<u>Shell</u>	<u>Status</u>		<u>Fouling Rate</u>	
		Offline	Cleaned	Tube	Shell
Top PA	E1A	<input type="checkbox"/>	<input type="checkbox"/>	<input type="text" value="6.9E-06"/>	<input type="text" value="1.02E-06"/>
	E1B	<input checked="" type="checkbox"/>	<input type="checkbox"/>		
	E1C	<input type="checkbox"/>	<input type="checkbox"/>		
LGO PA	E2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
HGO PA	E3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
LGO	E4A	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="text"/>	<input type="text"/>
	E4B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
HGO	E5	<input type="checkbox"/>	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
HVGO	E6A	<input type="checkbox"/>	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
	E6B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
Resid	E7A	<input type="checkbox"/>	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
	E7B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>

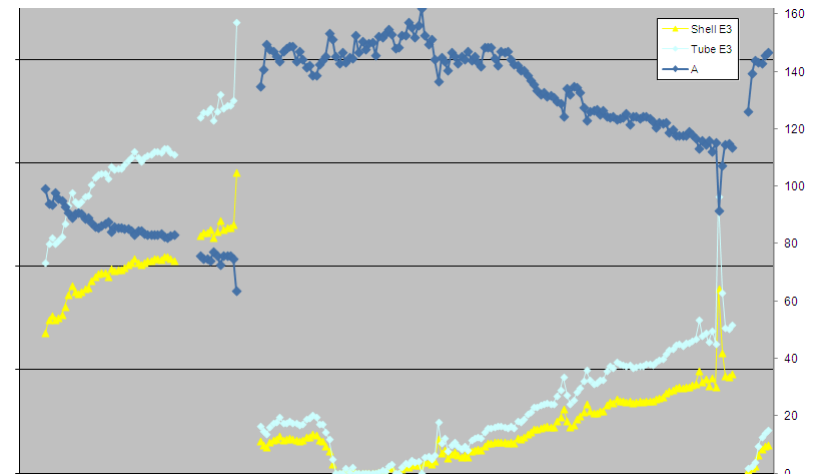
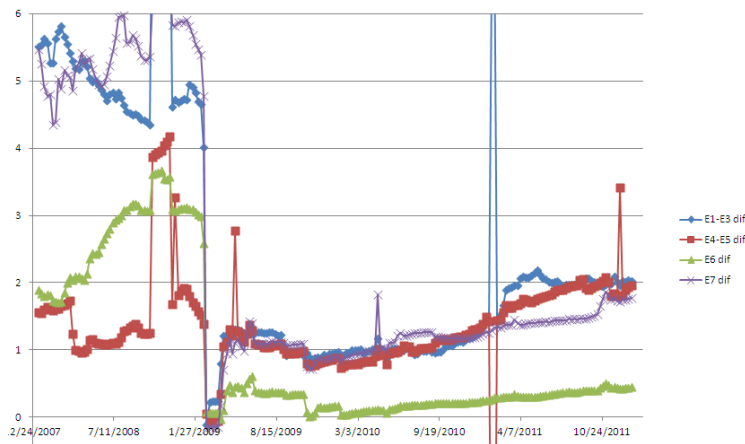
Challenges

- Variable vs. constant Fluid properties
 - For changing crude slate it may be necessary to run distillation columns.

PHYSICAL COMPARISON TABLE		Selection criteria: Crude API most different				
DATE	TOP PA	Std Id	Mass Dens	Mass Heat Capacity	Thermal Cond	Viscosity @T
			Kg/m3	Kj/kgC	W/mK	cP
			735.701	2.562	0.098	0.194
			733.848	2.557	0.098	0.195
			720.133	2.533	0.098	0.192
			736.163	2.565	0.098	0.194
			735.702	2.560	0.098	0.195
			734.591	2.556	0.098	0.195

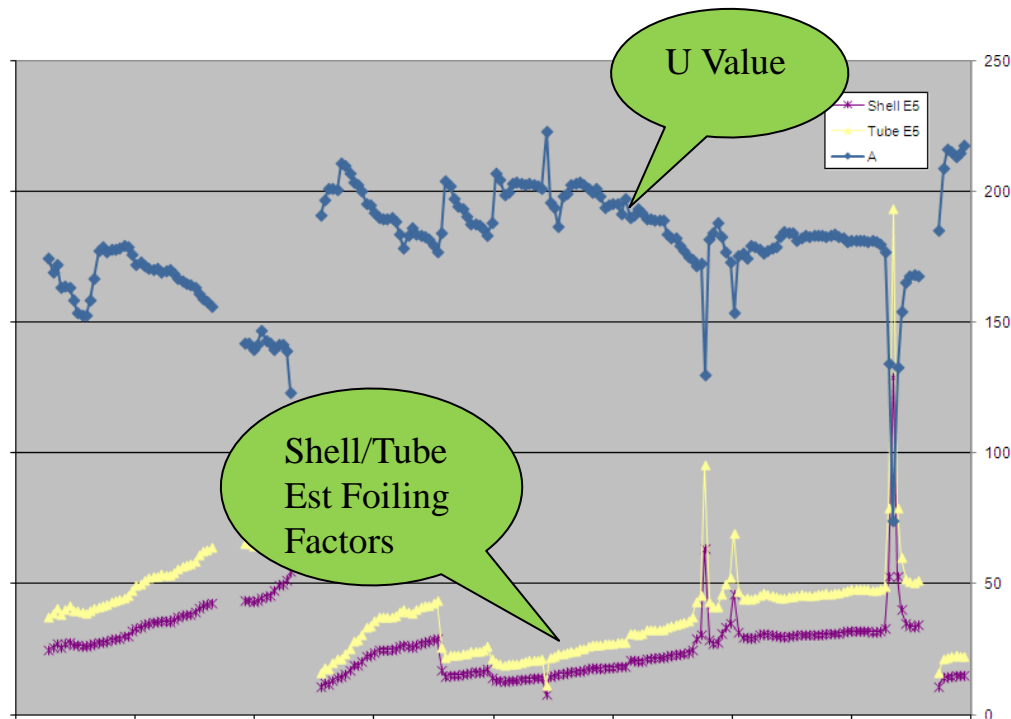
Challenges

- Pressure drop (dP) as a fouling indicator.
 - Fouling factor calculations seem to be more stable and reliable as a source for identifying fouling than a difference between measured and model (theoretical) pressure drop.



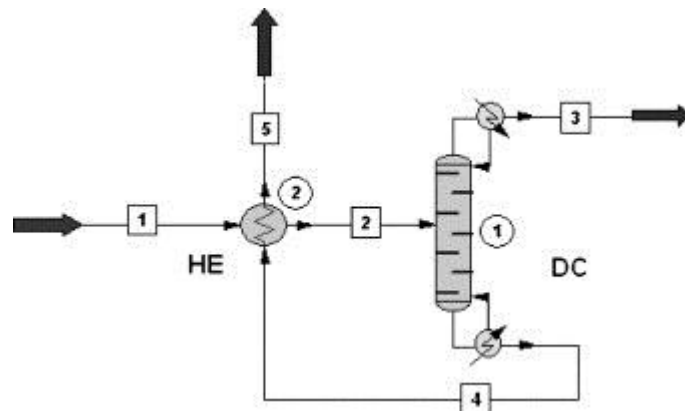
Challenges

- Simple UA/A as indicator.
 - Again, fouling factor calculated results are more stable and reliable in predicting exchanger fouling.



Challenges

- Model scope in reconciliation.
 - A decision was made to use a reduced scope model, fixing some relationships between fluids instead of modeling the actual dependence.
 - The decision was made based on the model of a splitter with a pre-heater reusing some heat from the bottoms stream.



Conclusion

- Using EDR to estimate fouling factor KPI is a realizable objective.
- Data reconciliation benefits limited by missing process data.
- Improved Hysys EO desired
 - EDR not linked to EO exchangers: extra SM model required
 - Direct EO automation not available: ASW & EO synchronization issues
- Work in progress
 - Main benefit expected from fouling trends



Thank you