Refinery Pre-heat Train Monitoring and Cleaning Tool

Stephen Wagner, Hiren Shethna (Saudi Aramco)
Manel Serra Rey, María Jesús Guerra (Inprocess)

OPTIMIZE™ 2013

Agenda

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

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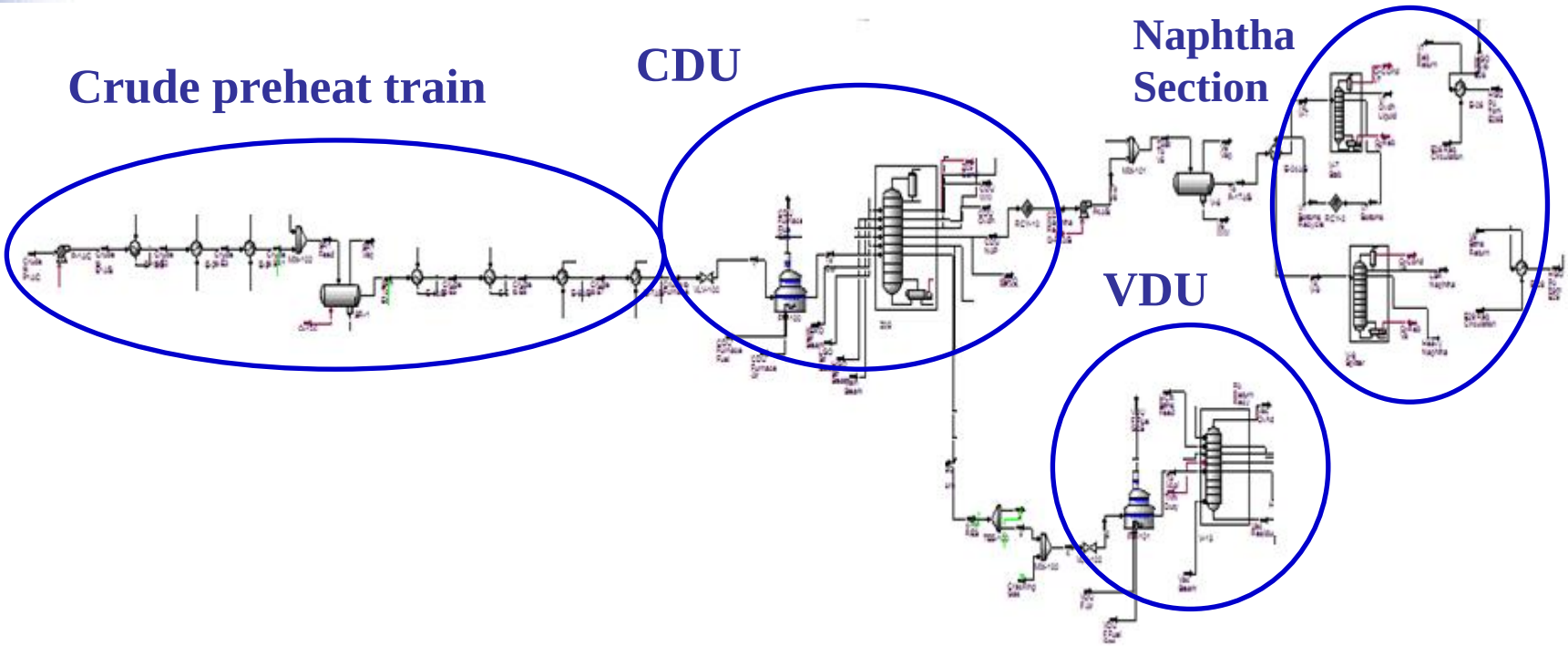
Saudi Aramco Company Profile

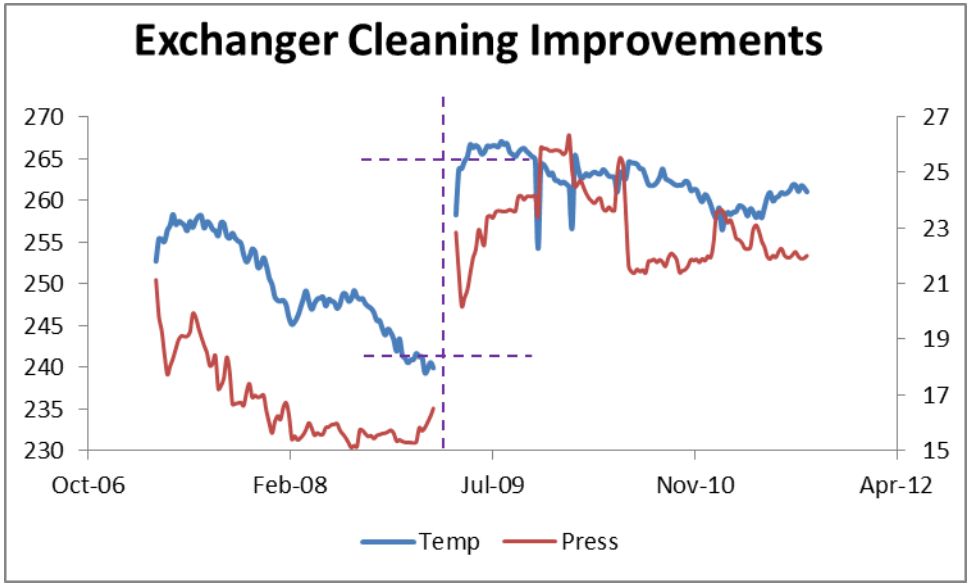
- National oil company of Saudi Arabia.
- Almost 56,000 employees.
- One of the World's largest oil companies.
- A fully-integrated oil and gas company with affiliates, joint ventures and subsidiaries around the world.
- Owns and operates one of the largest oil tanker fleets.

Crude Unit Overview



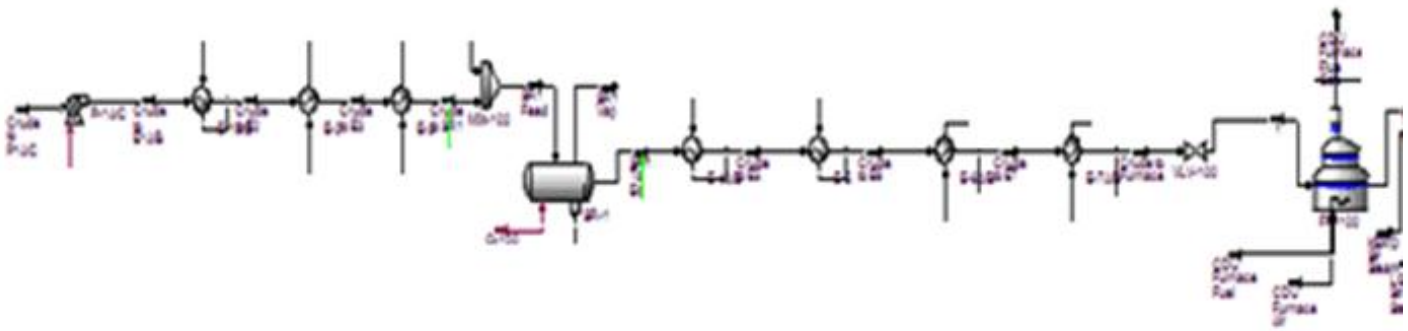
Operation Objectives

- 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

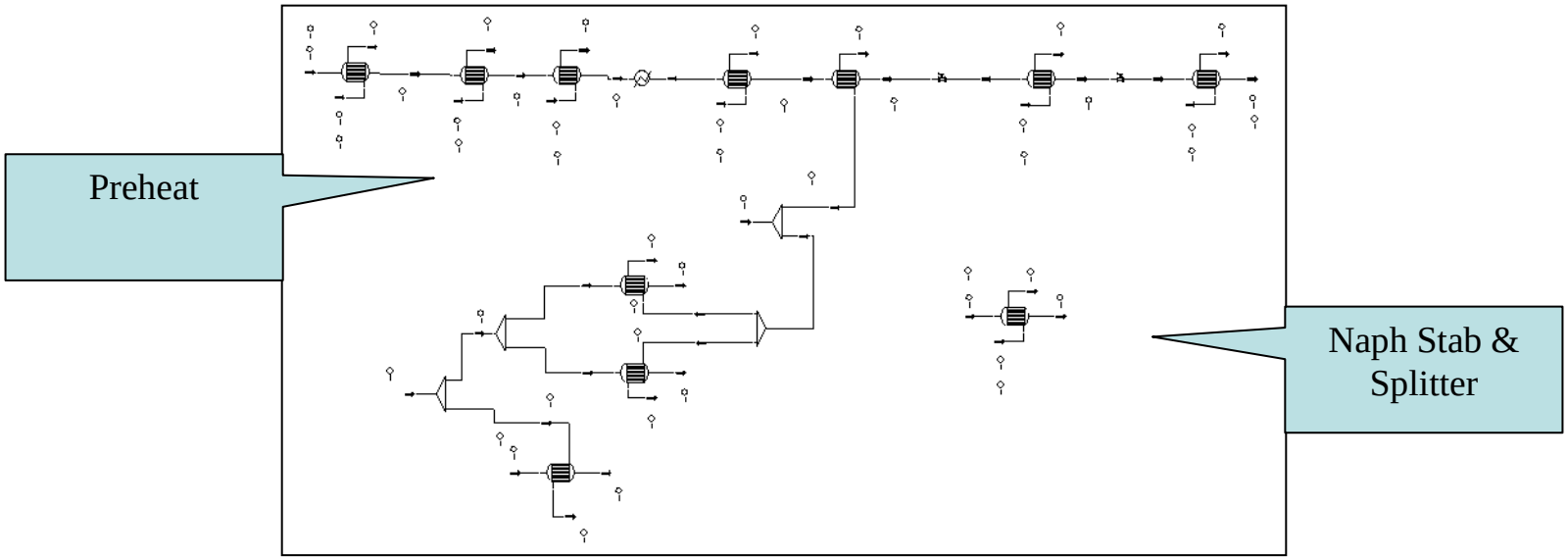
- Individual exchangers (U values, Fouling factors).
- Preheat exchanger network (normalized furnace inlet temperature).

Predict Future Performance

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

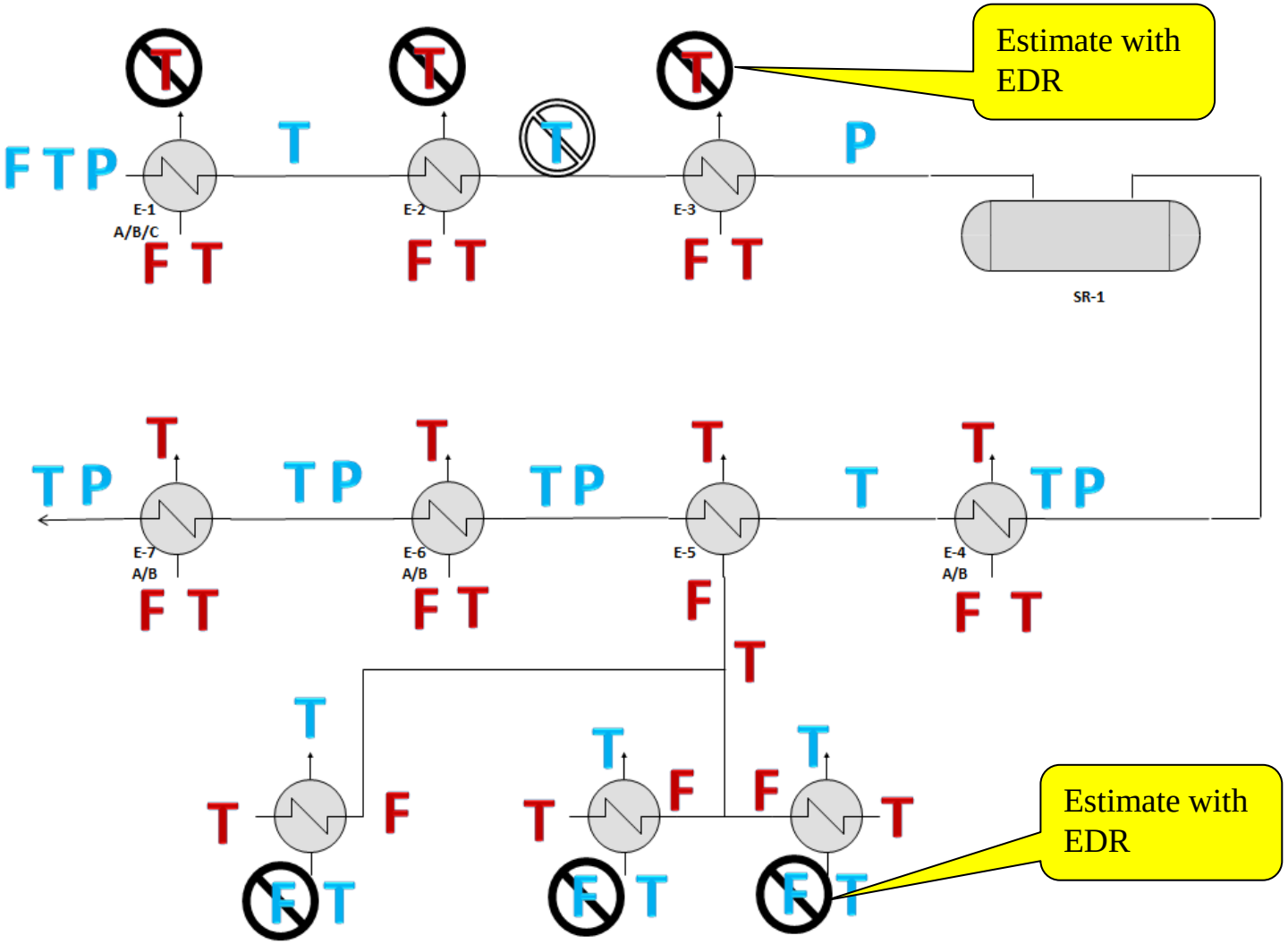
1. Establish Operating Conditions

- 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 …

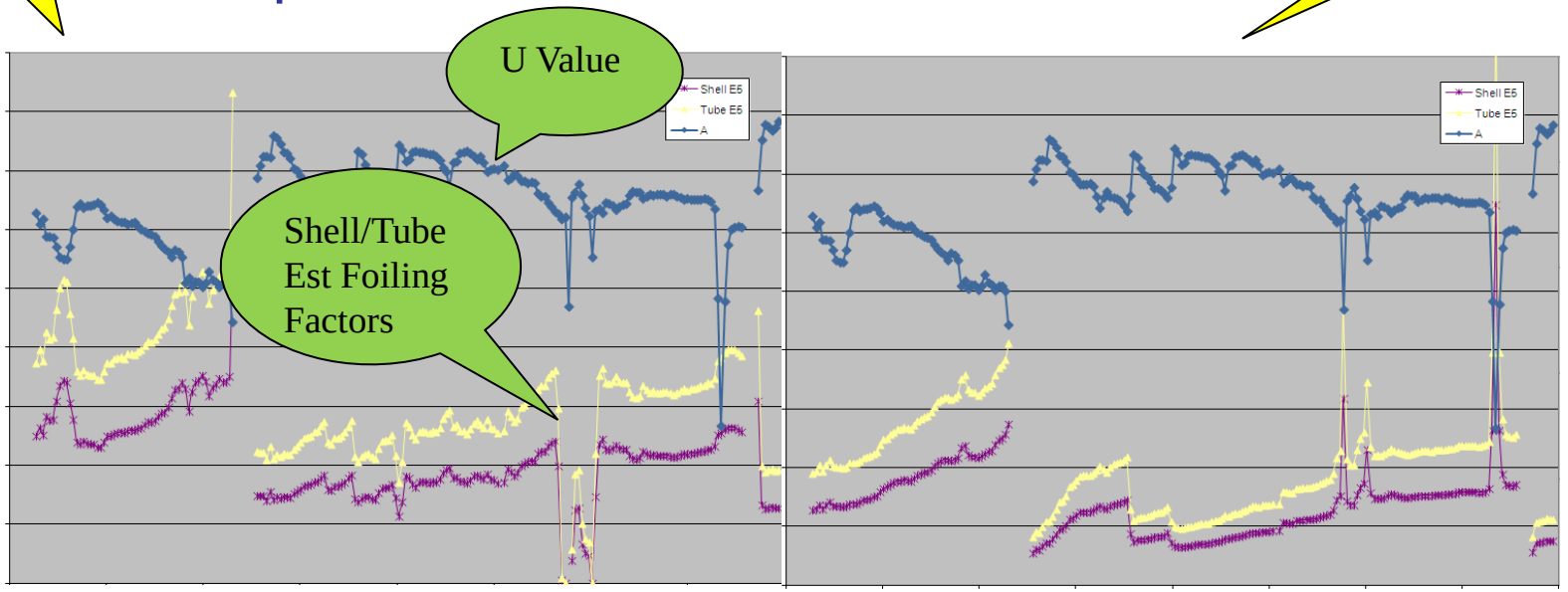


1. Establish Operating Conditions

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

Non reconciled Data

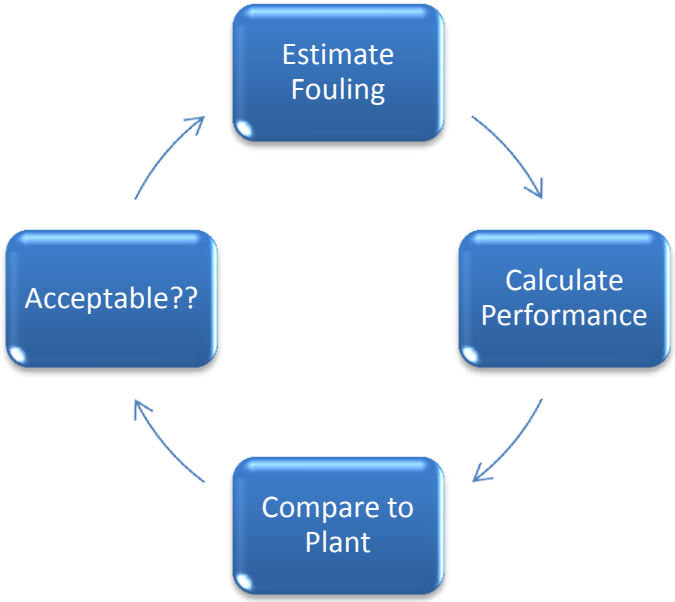
Reconciled Dara with EO Mode



2. Estimate Exchanger Performance

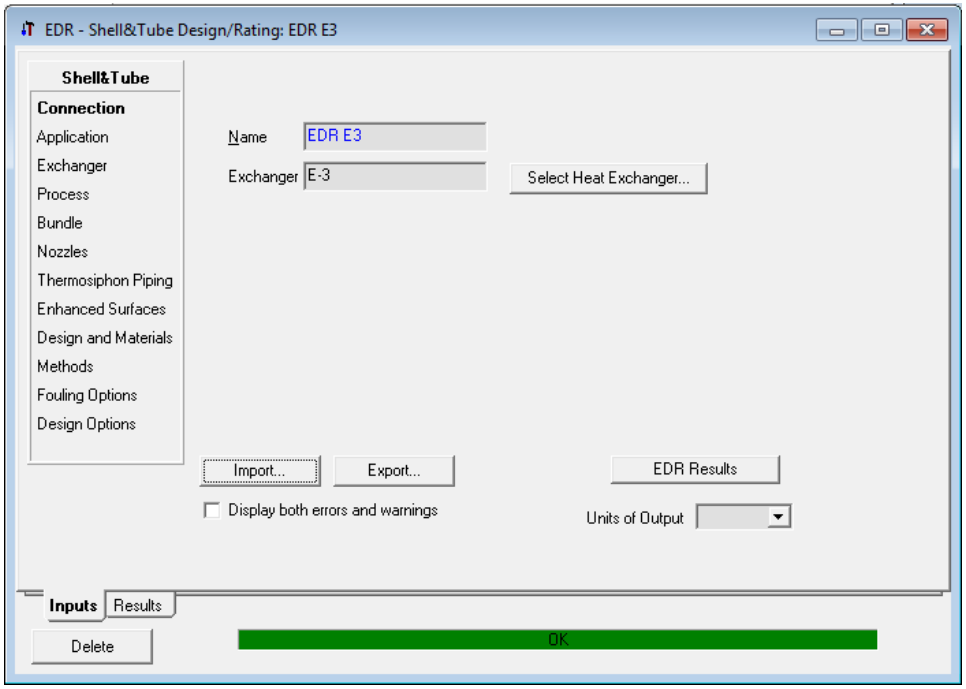
- U ($U = Q / (A * LMTD * Ft)$)
  - FAST: Direct calculation from measurable variables.
  - INDIRECT: Varies with flows and properties.
- Fouling factor $r_o + r_i (d_o/d_i)$

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

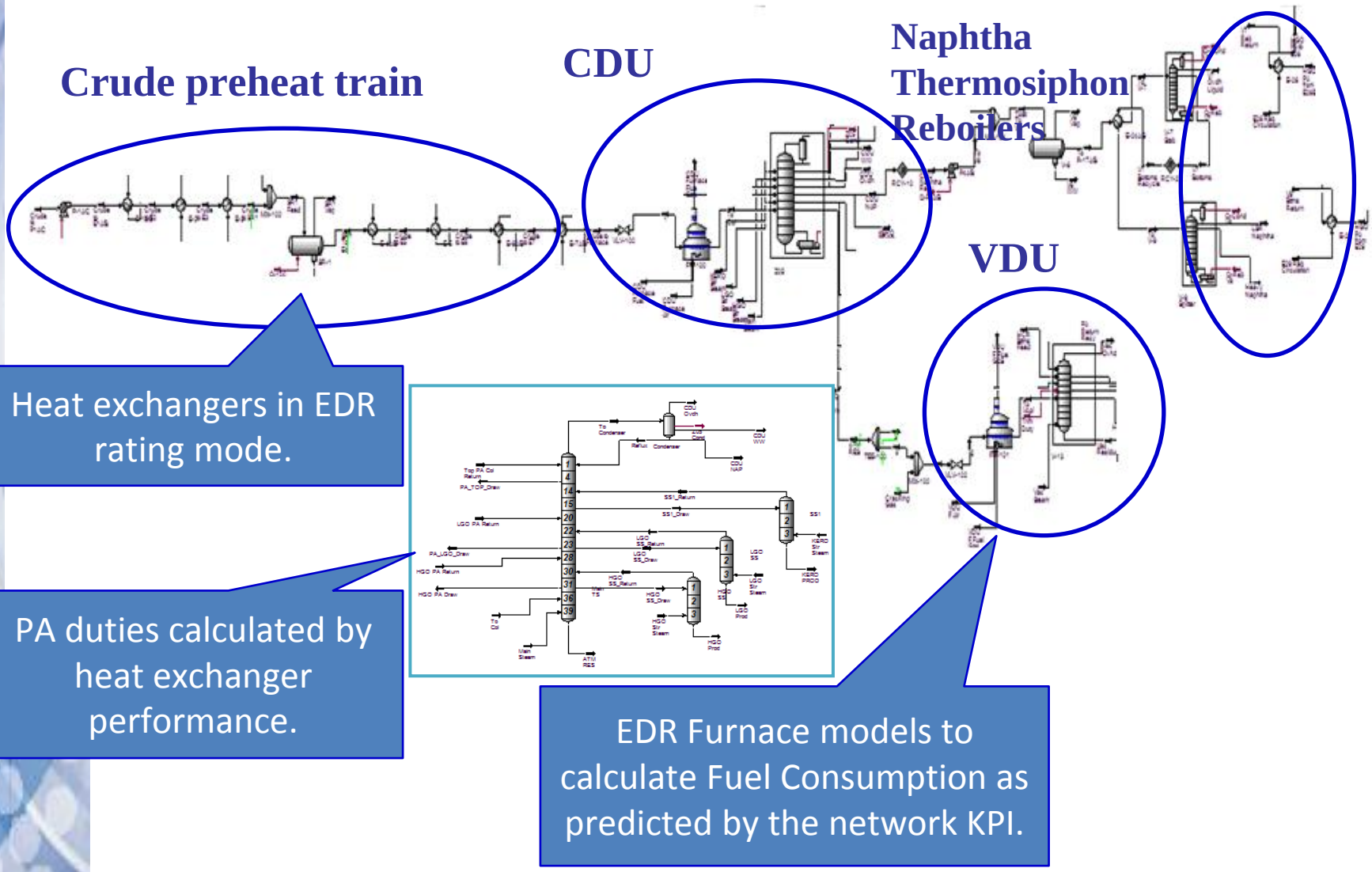
3. Predict Future Performance

- 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 :

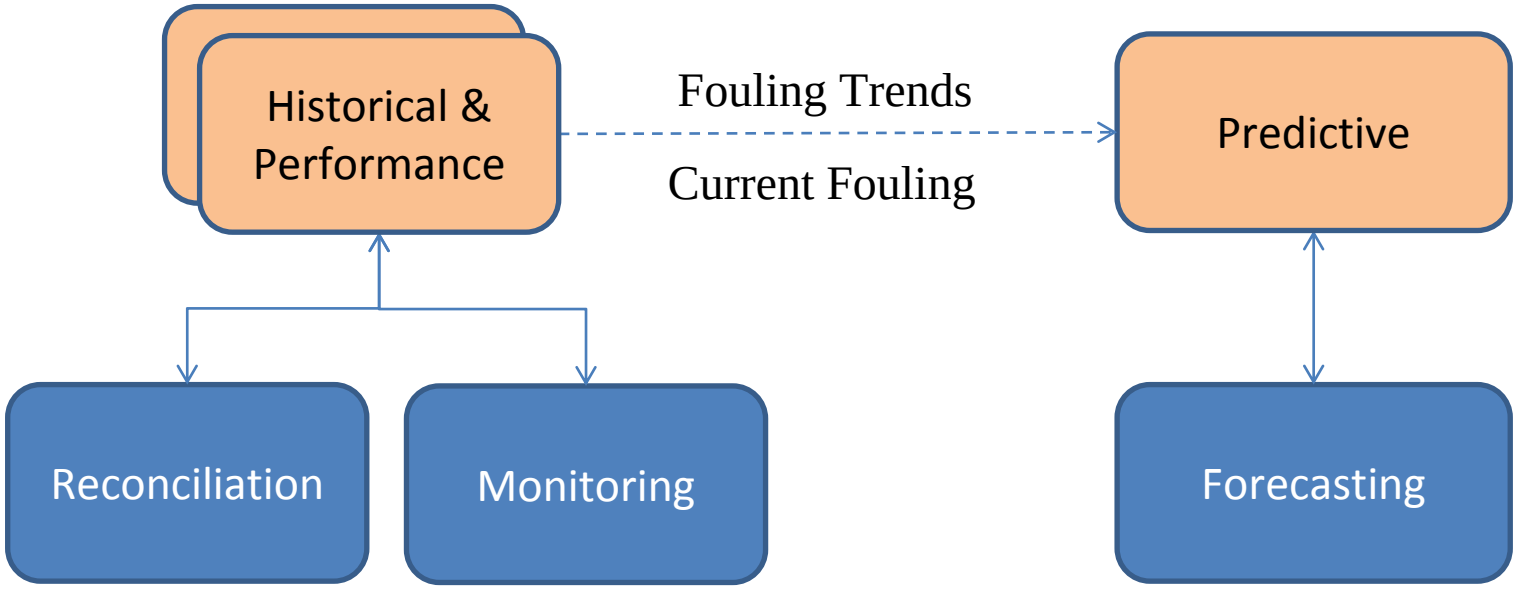
Decision	Adjust
Fractionator heat balance	Heat exchanger cleaning
Furnace preheat temperature	Bypasses
Furnace fuel consumption	Pumparound flows

3. Predict Future Performance



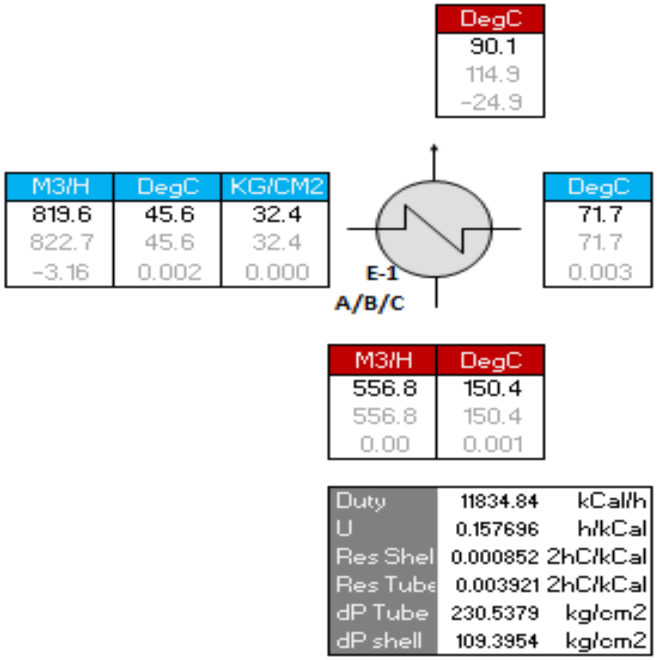
Architecture Overview

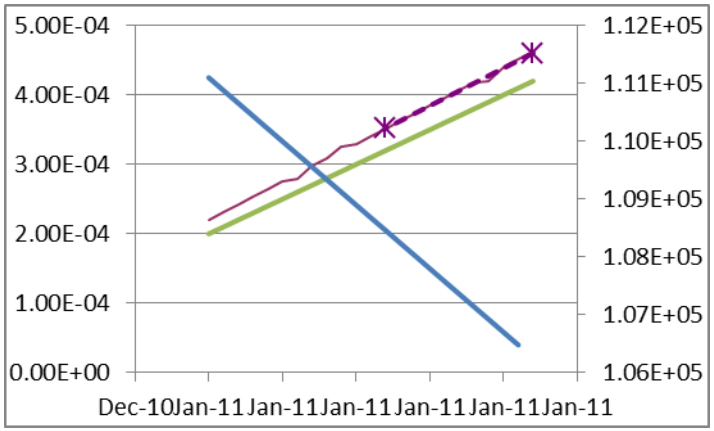
- Two (2) simulation-based applications.
  - Performance – Historical & Current
  - Predictive
- Three (3) simulation blocks.



Two Model User Interface(s)

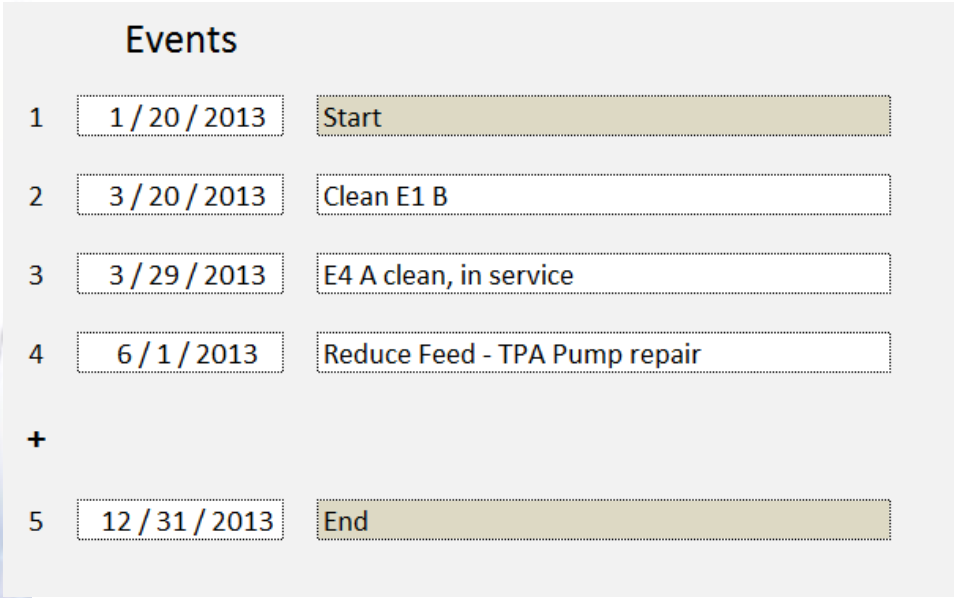
- 1 : Performance Monitoring
  - Data validation & reconciliation.
  - Calculation of fouling factors.
  - Fouling trend calculation from reconciled historical plant data.
  - Current fouling from reconciled plant data.

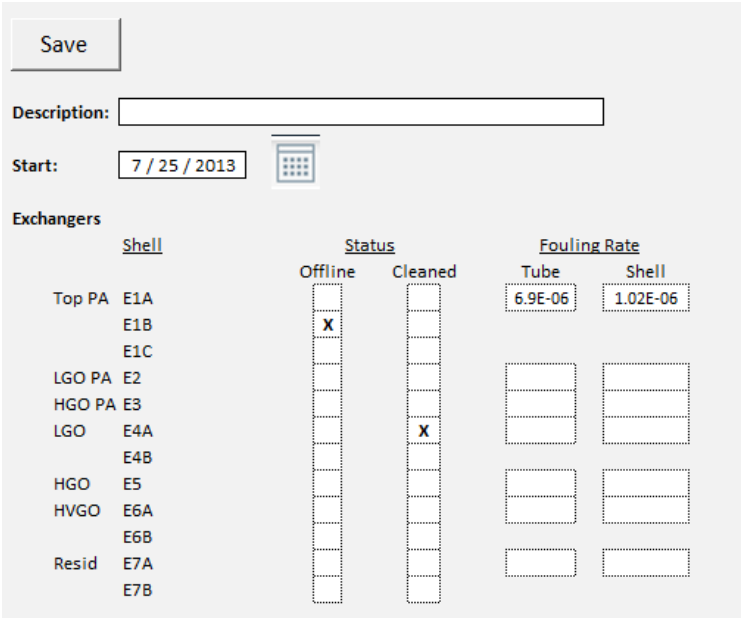




Two Model User Interface(s)

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





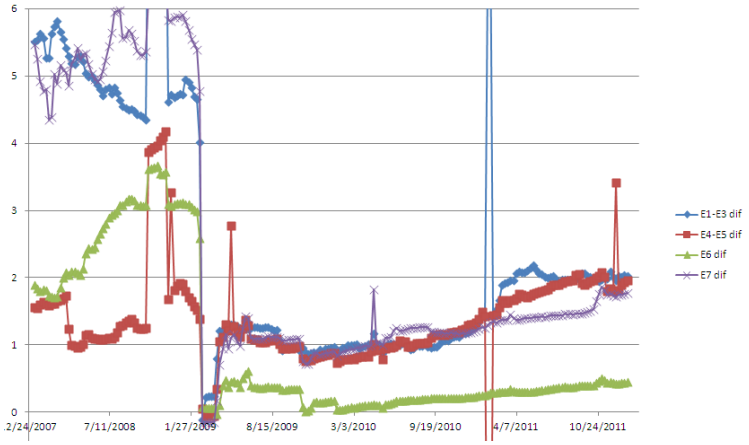
Challenges

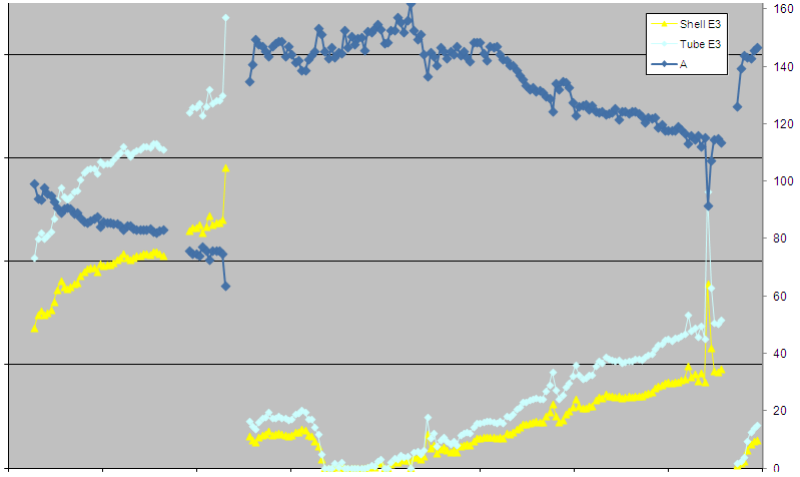
- Variable vs. constant Fluid properties
  - For changing crude slate it may be necessary to run distillation columns.

PHYSICAL COMPARISON TABLE	Selection criteria: Crude API most different			
	TOP PA			
DATE	Std Id Mass Dens Kg/m3	Mass Heat Capacity Kj/kgC	Thermal Cond W/mK	Viscosity @T 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

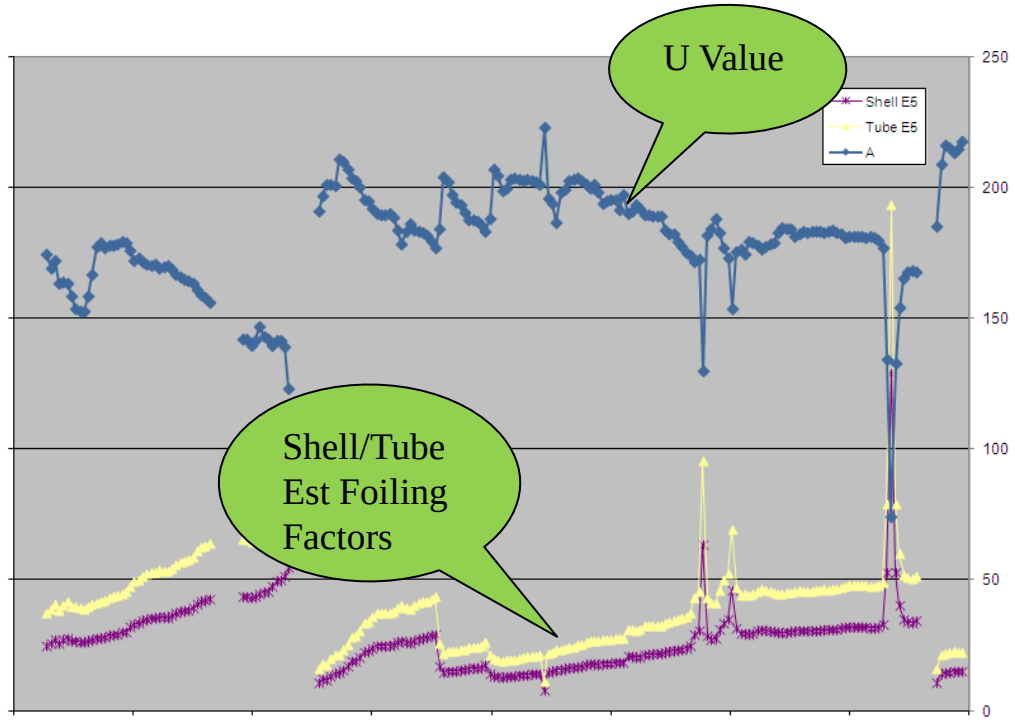
- Pressure drop (dP) as a fouling indicator.
  - Fouling factor calculations seem to be more stable and reliable as a source for identifying fouling than a difference between measured and model (theoretical) pressure drop.





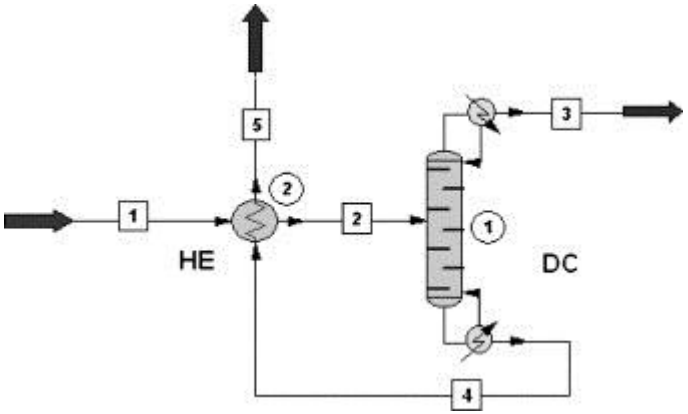
Challenges

- 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