BUILD REFINERY MODELS QUICKLY AND EASILY TO SUPPORT YOUR LP MODEL!

RASOOL BAROUNI

Honeywell

AGENDA

- **UniSim Design**
- **UniSim Design EO Environment**
- **UniSim Refining**
- **Q&A**

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UNISIM DESIGN

UNISIM DESIGN SUITE

Applications

- **Dynamics & Steady State**
- **Operator Training Simulation (OTS)**

Vertical Solutions

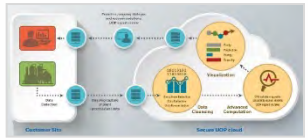
- **Upstream**
- **NGL / LNG**
- **Gas Processing**
- **Syngas**
- **EPC**
- **Refining (Next Generation Models)**

- **UniSim is the workhorse of many clients and also within Honeywell**

UniSim Design | Links with Performance Solutions

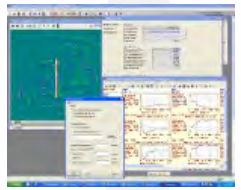
UOP CPS

Cloud-based service
to monitor, predict, and
improve plant performance



UniSim® Competency Suite

Process Operator
Training
Simulator

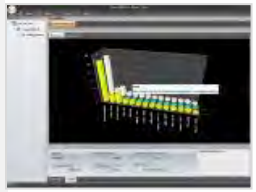


Profit® Controller

Embedded APC in UniSim
Direct link to Profit
Controller

Predict® Suite

Real Time
Corrosion
Management

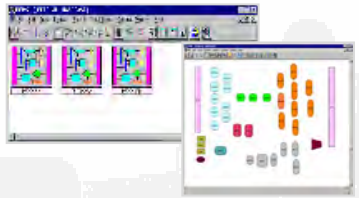


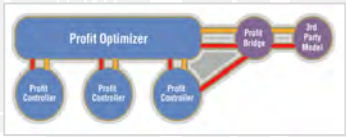
Uniformance® Asset Sentinel

Asset Performance
Calculation

Symphonite™ RPMS

Supply Chain
Optimization



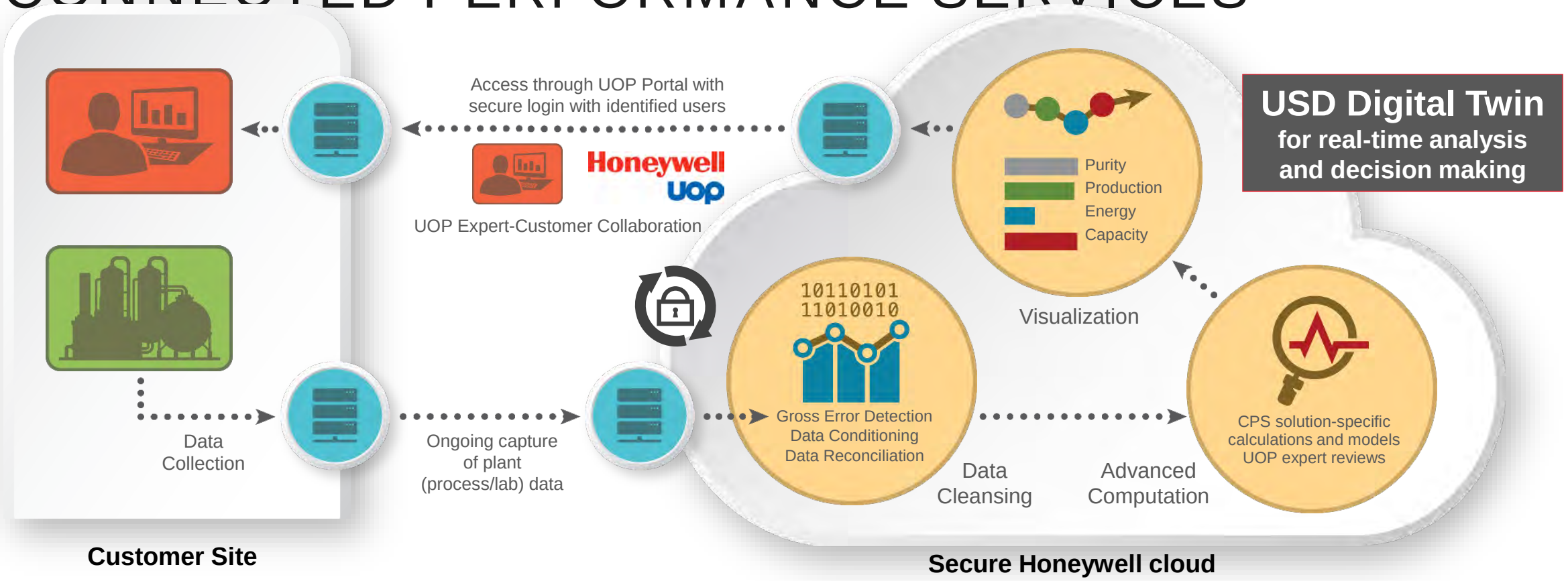


Profit® Optimization

Real Time Closed
Loop Optimization

UniSim Design is Pivotal to Many Applications

DEEPER DIVE | DIGITAL TWIN FOR CONNECTED PERFORMANCE SERVICES



Process Reliability	Process Optimization	Process Benchmarking	Predictive Maintenance
Customer Value (Incremental Operating Margin):		+$0.30-0.50/bbl. in Refining	+$10-20/MT in Petrochemicals

UNISIM DESIGN EO ENVIRONMENT

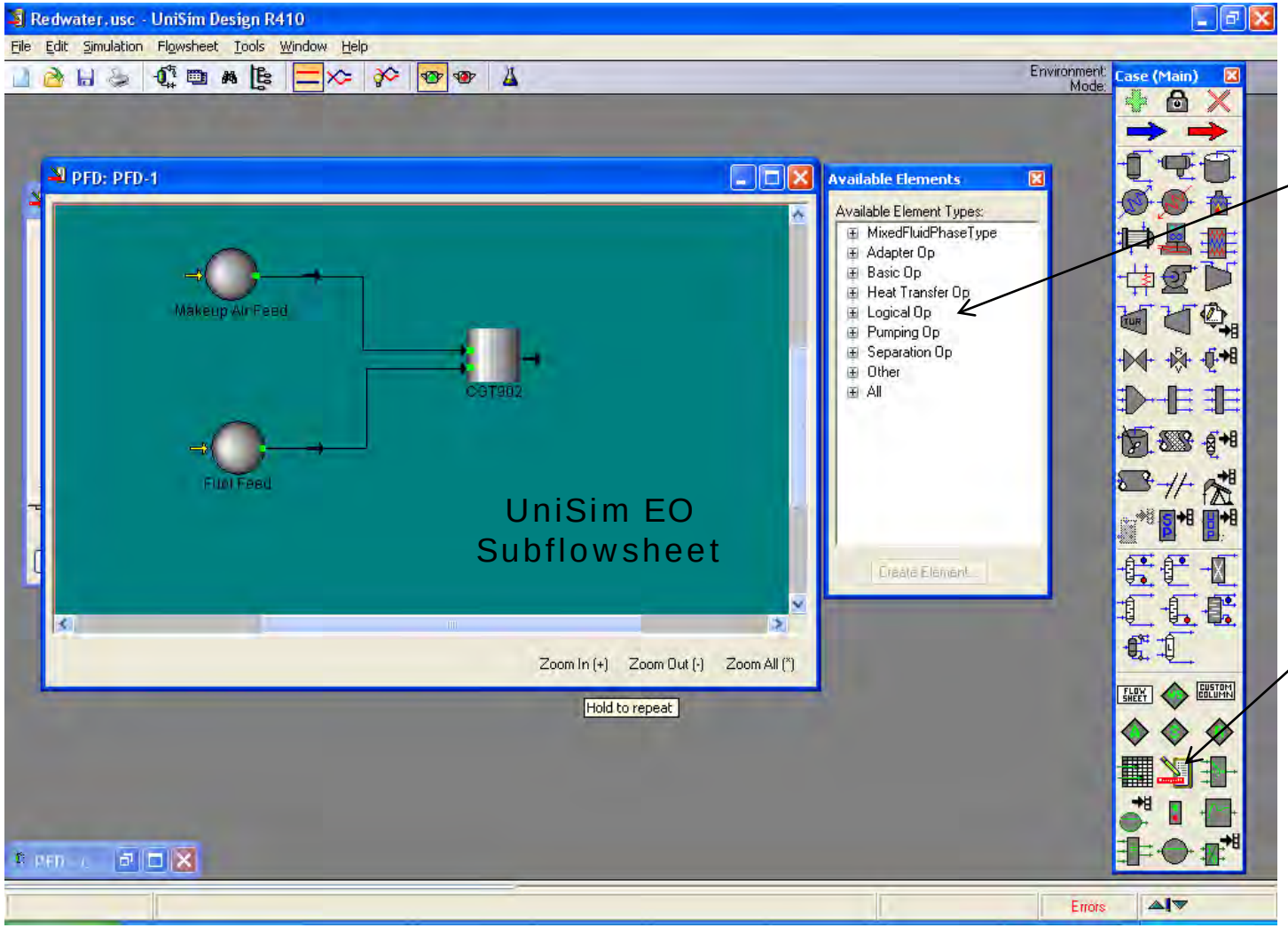
What is EO modeling?

- EO is short for “Equation Oriented”
  - Equations are written in residual format to define the behavior of the units on the flowsheet, and all of the equations can be solved simultaneously.

- Due to its superior performance over sequential modular approaches for optimization, in recent years there has been more interest in using EO to solve some specific problems that are challenging for the traditional (SM).

- UniSim Design offers an EO platform (Equation Oriented platform), seamlessly integrated within UniSim Design native environment

UniSim EO Environment Access in UniSim



UniSim EO Ops

UniSim EO Element

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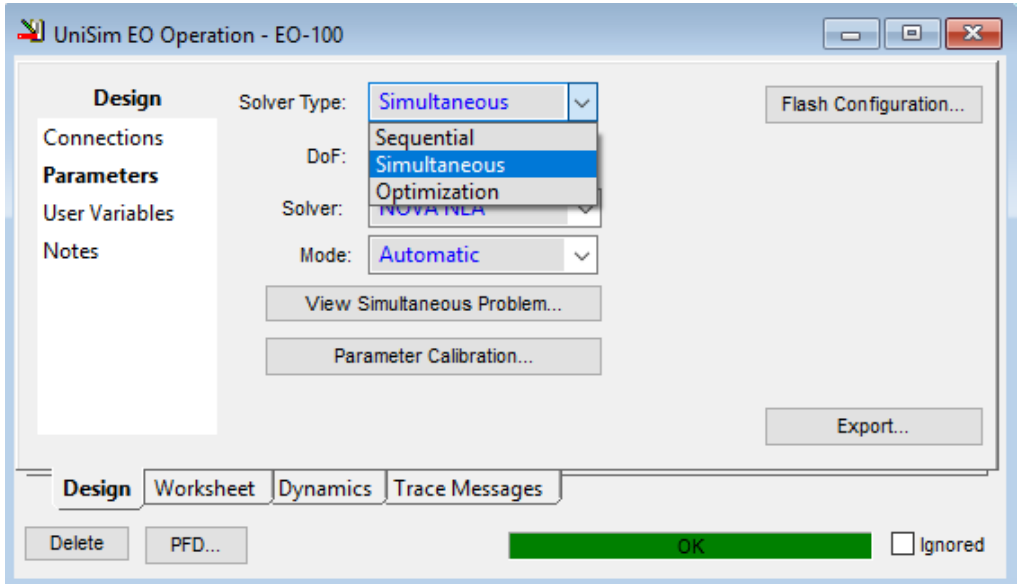
Motivation for Equation Oriented Modeling Development

- An Equation Oriented (EO) modeling capability is a great complement to a Sequential Modular (SM) capability
  - The strengths of EO are the weaknesses of SM and vise-versa
  - Combining the approaches broadens the potential for model based applications of the future
- EO Strengths/SM Weaknesses
  - Specification flexibility, lifecycle modeling, calculation parallelization potential, higher accuracy solutions, difficult recycle and highly interacting flowsheets, independent of solver technology, easier model code maintenance, analytical derivatives, online applications, optimization applications
- EO Weaknesses/SM Strengths
  - Ease of use
  - Difficult thermo
  - Diagnostics for solver failures



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Some Models in UniSim EO Model Library

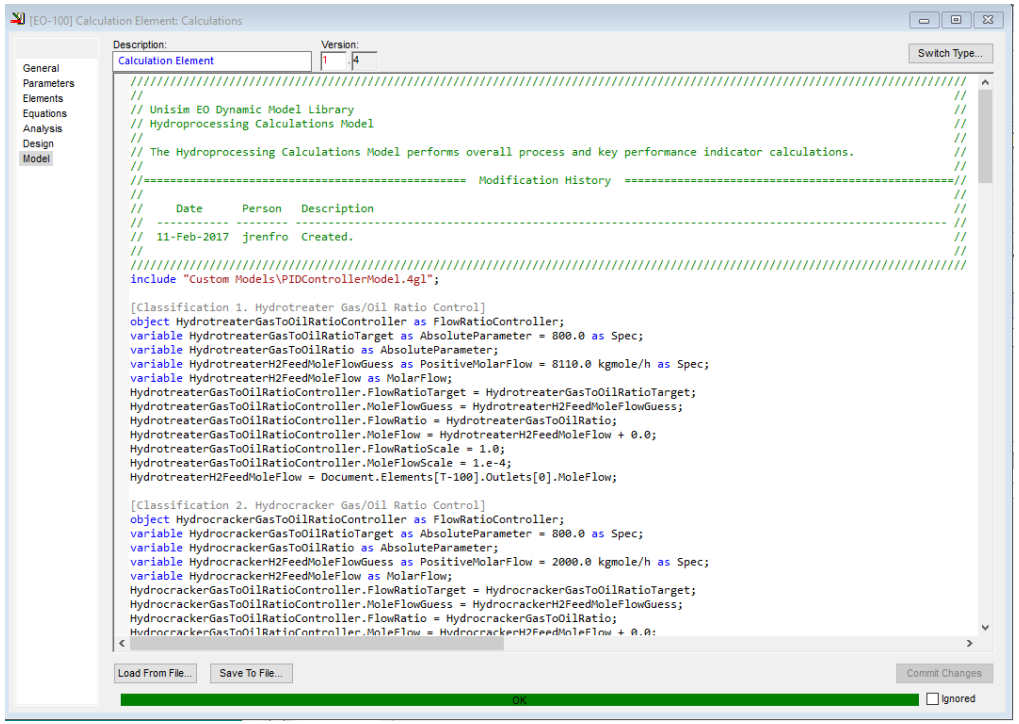
- **Streams**
  - Fluid Node
- **Heat Transfer Equipment**
  - Cooler
  - Heater
  - Heat Exchanger
  - Multistream Exchanger
- **Piping Equipment**
  - Pipe
  - Mixer
  - Tee
  - Valve
  - Orifice
  - Relief Orifice
  - Relief Valve
- **Rotating Equipment**
  - Centrifugal Compressor
  - Reciprocating Compressor
  - Expander
  - Centrifugal Pump
- **Separation Operations**
  - Separator
  - 3-phase separator
  - Phase Splitter
- **Column**
  - Tray Section
  - Pump Around
  - Reboiler
  - Partial Condenser
  - Total Condenser
  - Full Reflux Condenser
- **Reactors**
  - Alkylation
  - Catalytic Naphtha Reformer
  - Continuous Stirred Tank Reactor
  - Hydrocracker
  - Hydrotreater
  - Isomerization
  - Plug Flow Reactor
  - Fluid Catalytic Cracker
- **Electrical Network Operations**
- **Miscellaneous**
  - Adjust block
- **Custom Model**
  - 4GL Modeling Language

UniSim EO Integration in UniSim Design

- UniSim EO is actually a standalone environment with its own UI, but currently is integrated with UniSim Design and appears as a subflowsheet
- Users can select a UniSim EO subflowsheet operation and add that to their UniSim flowsheet
- Entering the UniSim EO subflowsheet, a new PFD environment can be accessed where an EO flowsheet model can be built from the EO model library
- The EO environment supports sequential and simultaneous solution modes
  - Sequential mode is useful for flowsheet model building and initialization
  - Simultaneous mode is useful for its specification flexibility and normally is the proper mode to work in for applications that require high performance
- The EO environment supports steady state and dynamic modes of UniSim
- Documentation is in the UniSim EO Environment PDF in the UniSim Design documentation directory

UniSim EO 4GL Modeling Language

- Process Modeling Domain Specific Language
  - Understands engineering units
- Can be used for simple or very complex models
- Supports object oriented class structures
- Integrated with UniSim Thermo
  - Can access UniSim Thermo fluid objects
  - Easy access to all fluid and component properties
- Models are checked for consistency
- Steady state and dynamic modes supported
- Default UI forms are configured for the model
- Can develop custom forms and icons for production models
- Great alternative to worksheets for overall model calculations that are readable and maintainable form



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UniSim EO 4GL Modeling Language

Cooler Model

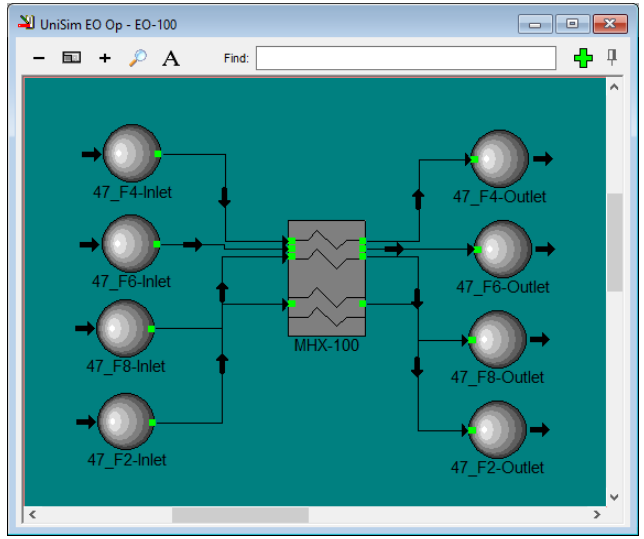
```
//
// Stream declarations.
//
inlet Inlet;
outlet Outlet;
//
// Variable declarations.
//
variable deltaP as DeltaPressure = 0.0 as Spec;
variable dutyPerMole as MolarEnthalpy = 0.0 as Spec;
//
// Cooler mass balance.
//
Outlet.MoleFlow = Inlet.MoleFlow;
//
// Cooler component mass balance.
//
Outlet.MoleFractions = Inlet.MoleFractions;
//
// Cooler energy balance.
//
Outlet.MolarEnthalpy = Inlet.MolarEnthalpy + dutyPerMole;
//
// Compute cooler pressure drop.
//
deltaP = Inlet.Pressure - Outlet.Pressure;
```

MULTISTREAM HEAT EXCHANGER MODEL

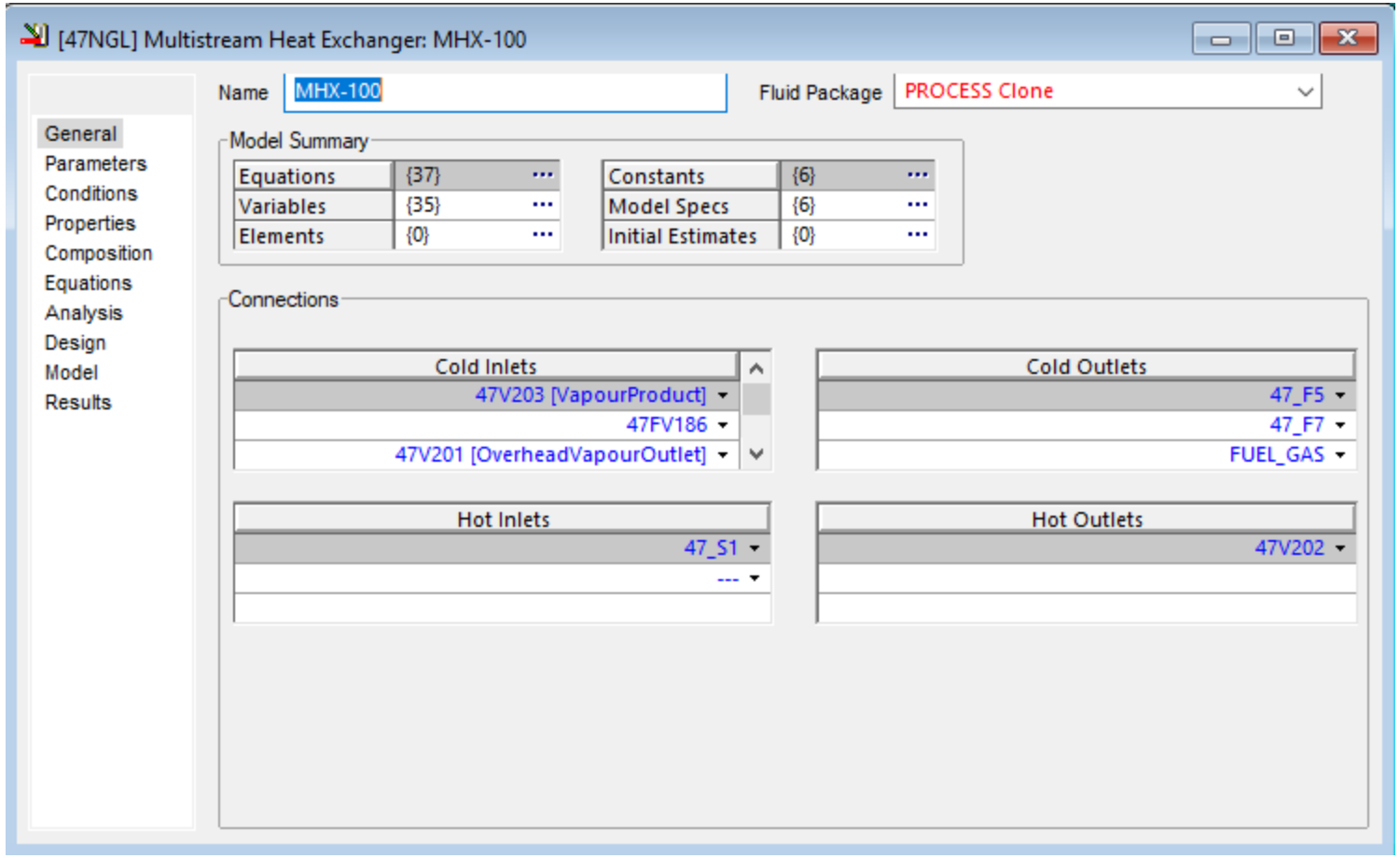
The Multistream Heat Exchanger model is used to simulate multistream counter-current heat transfer equipment, such as LNG and cold box heat exchanger equipment

This model is suitable for online model based applications

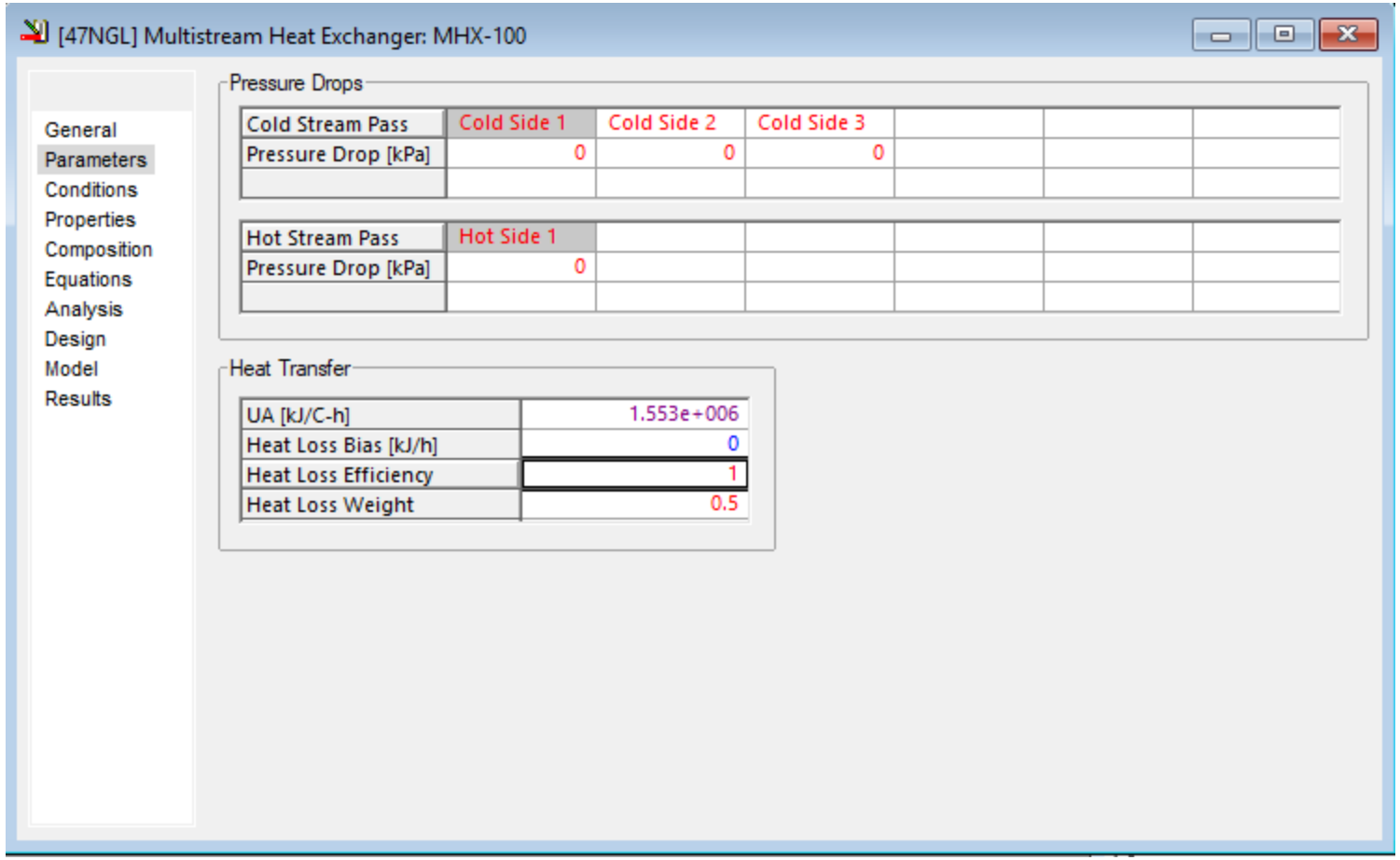
Variables for calibration are incorporated in relevant structural parts of the model to allow matching operating data and enable predictive capabilities in the face of unknown internal geometry and energy losses and efficiency



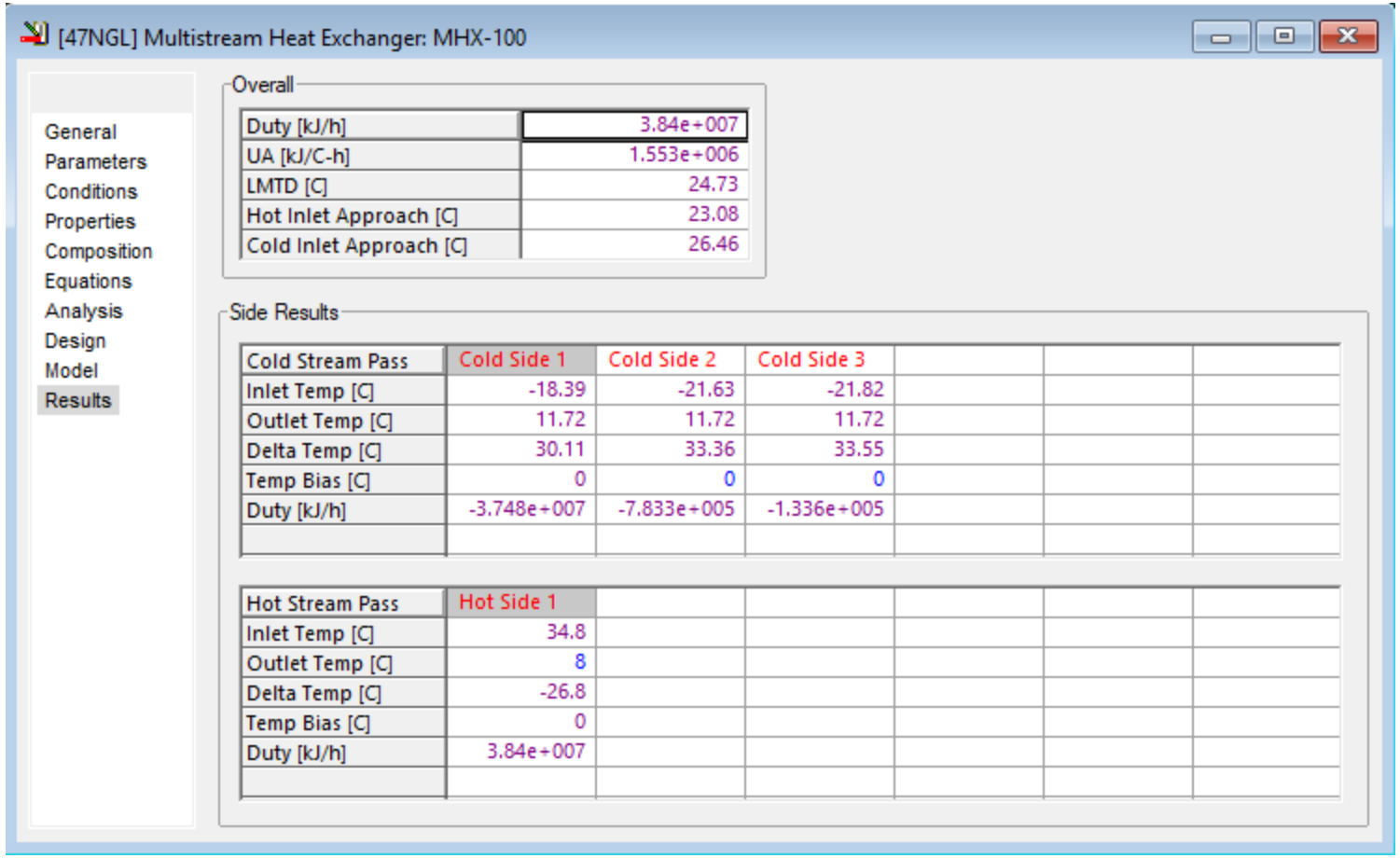
MULTISTREAM HEAT EXCHANGER MODEL – GENERAL VIEW



MULTISTREAM HEAT EXCHANGER MODEL – PARAMETERS VIEW



MULTISTREAM HEAT EXCHANGER MODEL – RESULTS VIEW



UNISIM REFINING

UNISIM DESIGN R470 REFINING

Reactor model development:

- Support from UOP experts
- Validated with UOP yield & pilot plant data
- Validated with customer data

Reactor Models Include:

- FCC
- Reformer (Gasoline and BTX)
- Hydrocracker
- Hydrotreater
- Isomerization
- Delayed Coker
- Alkylation

Other refining features developed and validated

- Product Blender
- Assay Synthesis
- LP Vector
- SRU
- Fired Heater model in EO

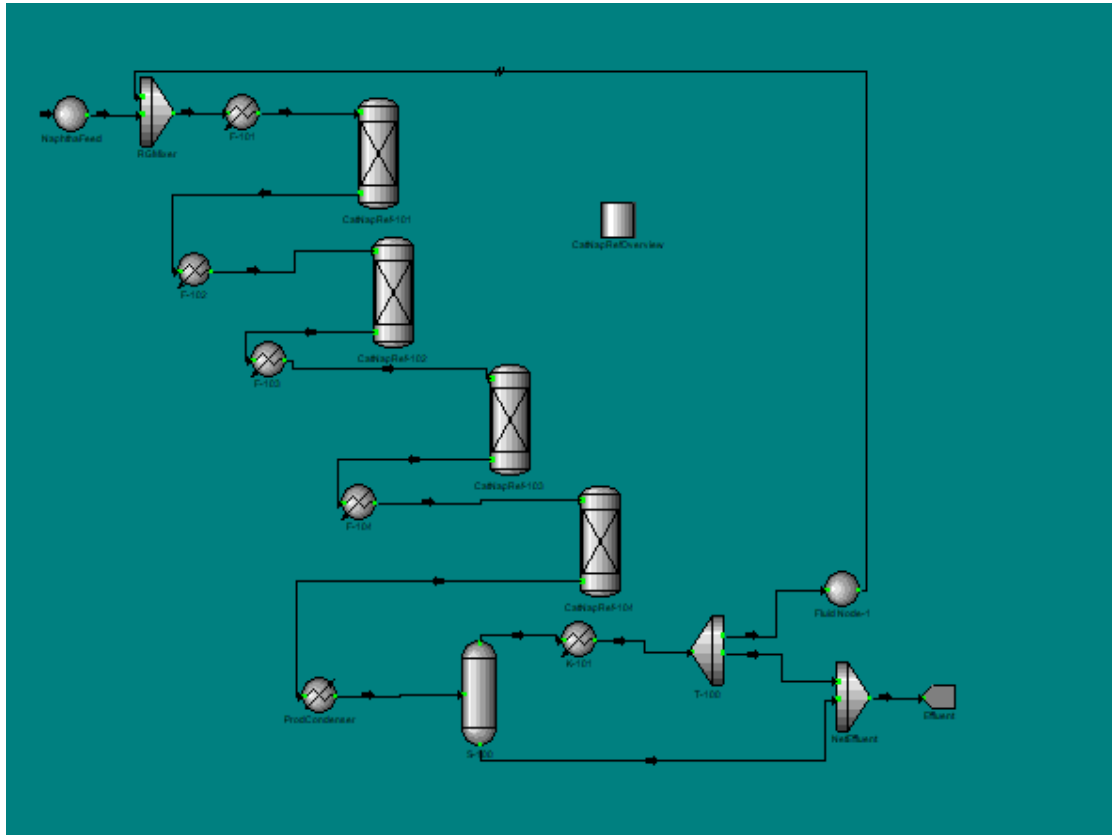
Refinery-wide Simulation Capability

UniSim Refinery Simulation Applications

- Crude Assay Management
- LP Data Generation
- Unit Performance Monitoring
- Profit Improvement (Refinery Wide)
- Refinery-Petrochemical Integration
- Area Target Setting/Process Optimisation
- Process Engineering Studies
- Process Engineering Training & OTS
- Capex Studies (Feasibility, Configuration)

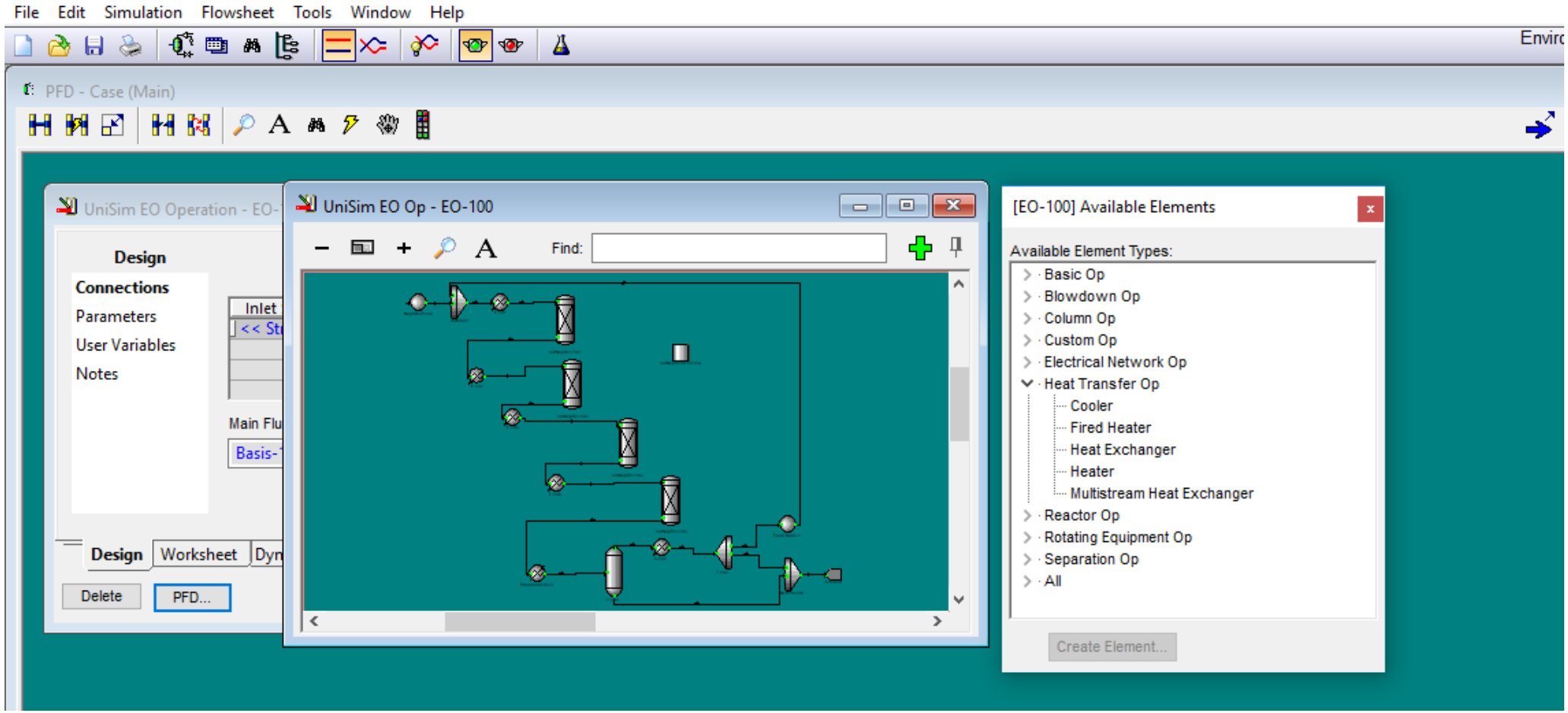
Refinery Conversion Unit Models

- UniSim Design offers all major refinery conversion unit models
- All models cover most used configurations and UniSim Design provides a template for them
  - Catalyst Deactivation functionality is available for all catalytic unit models. This allows catalyst life prediction and refineries can save millions US$ using it
- Models cover all operation modes of conversion units
  - For example Catalytic Naphtha Reforming model for Gasoline or BTX production



A flexible Flowsheeting Capability

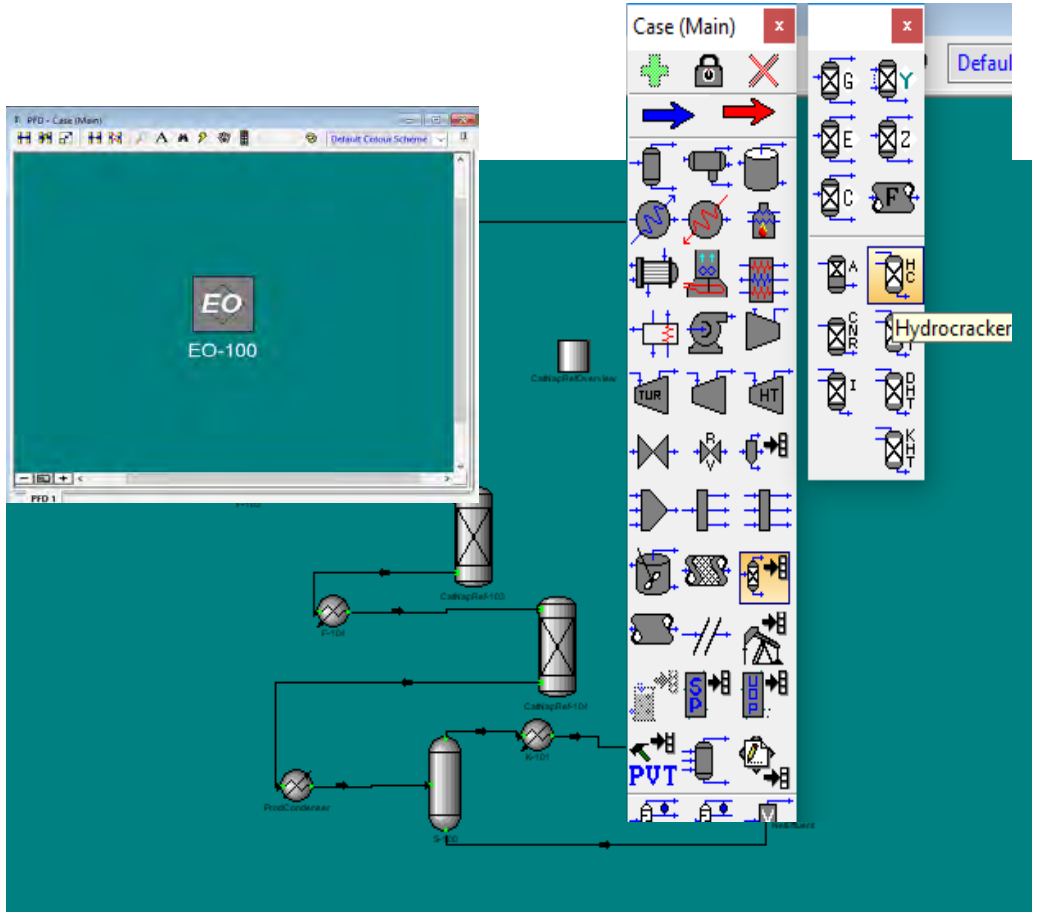
- Access to individual reactors and unit operations is possible in UniSim Design - not like other packages which define the conversion unit model as a block



UNISIM R470 – NEW REFINERY REACTORS

Refinery Reactor Models

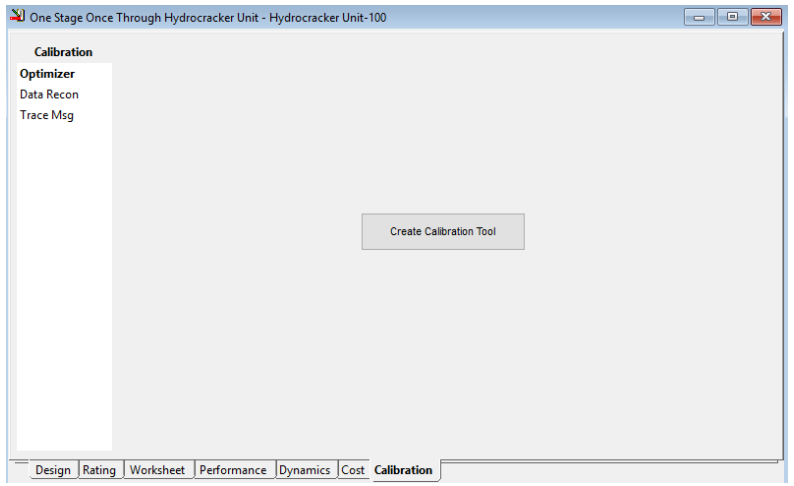
- Simple model creation with templates
  - ‘Drag & Drop’ a reactor block into your flowsheet
- Simple Tuning Parameters
  - Connects to operational data for tuning
- All include catalyst deactivation
- Built on the EO platform for model speed
  - Useful for optimization
- Simplified workflow easily links with multiple tools
  - Easily import crude assays
  - Export equations for planning optimization
  - Connected process & assets with Honeywell Forge integration

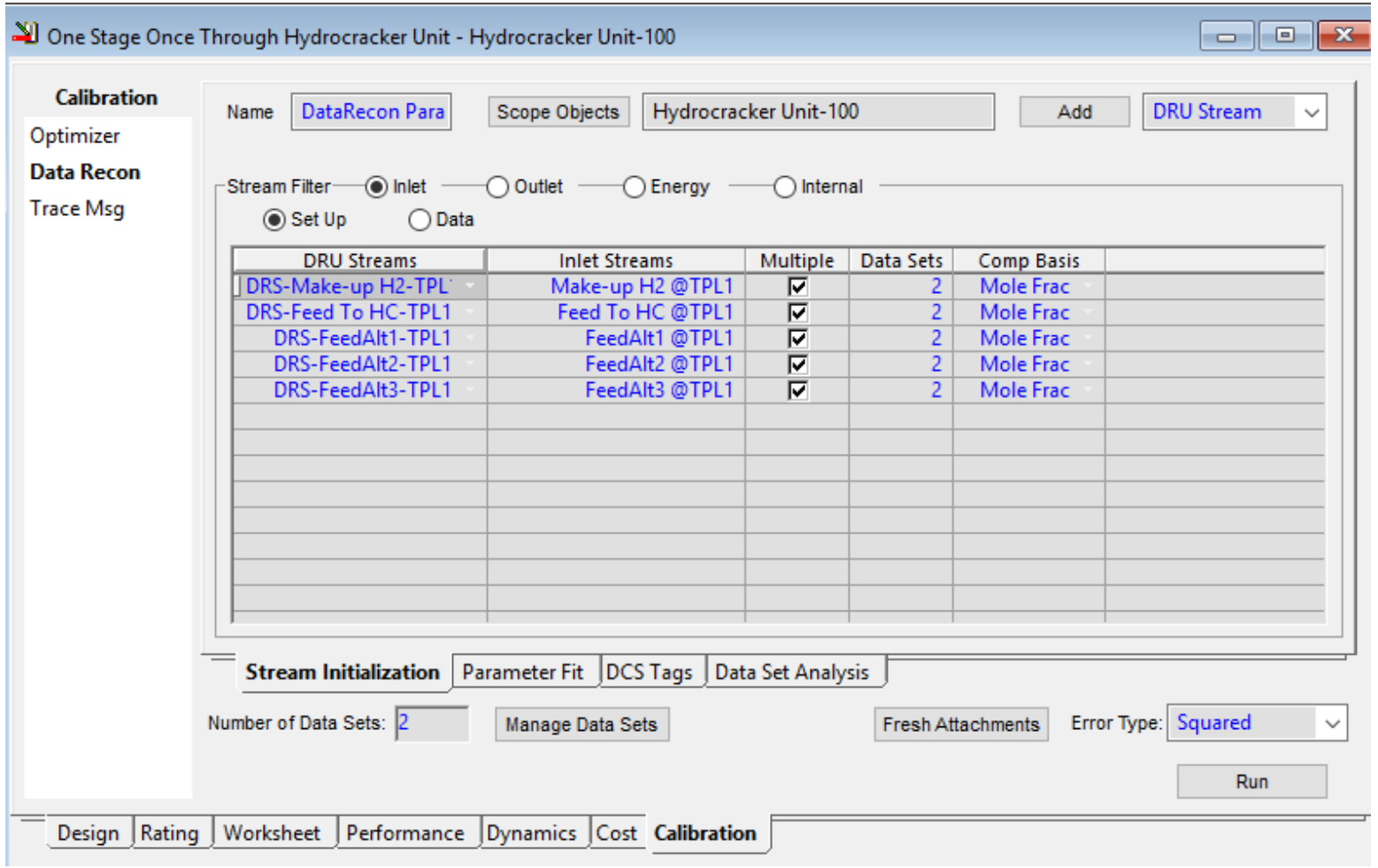


New models allow full plant optimization

USD R470 – PARAMETER CALIBRATION

Automatic Calibration



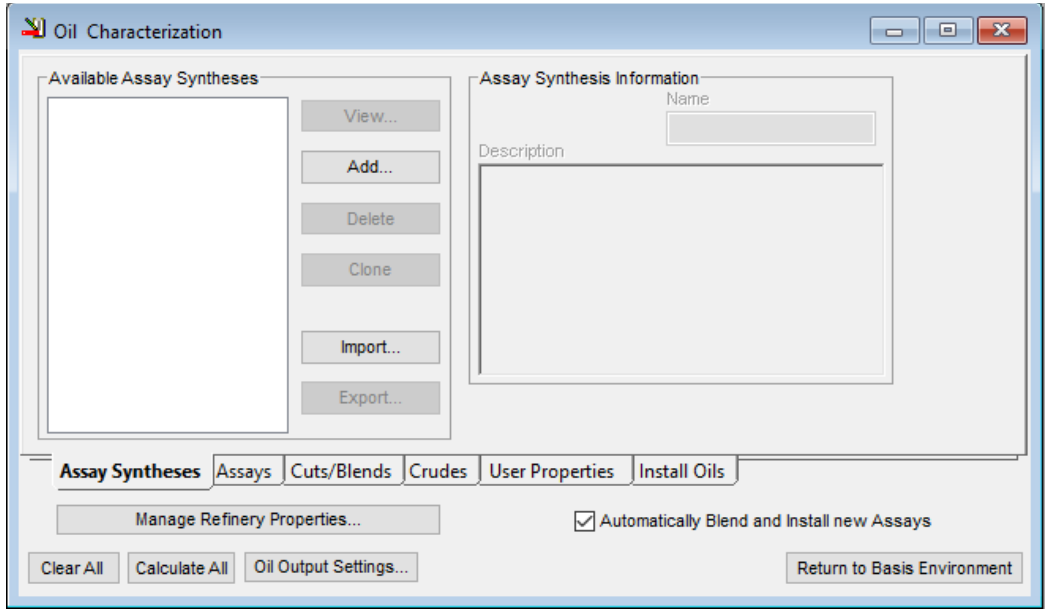


Calibration made easy and fast

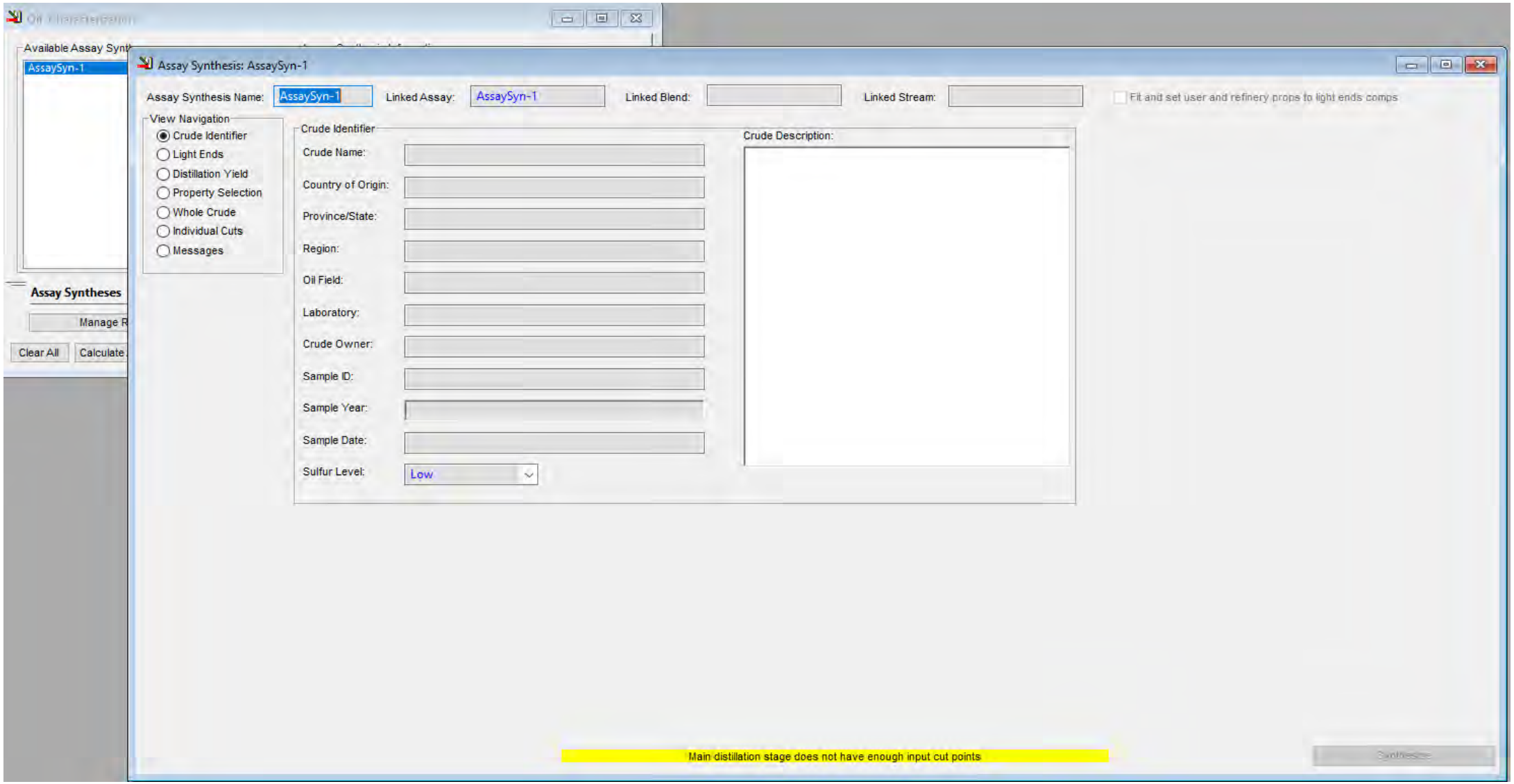
ASSAY SYNTHESIS MODEL

UniSim Assay Management

- A New Assay Synthesis Model in UniSim Design
  - Improves the assay management in UniSim Design greatly
  - UniSim Design offers both Assay Importing and Synthesis
  - Add Crude Oils, Condensates, or any Oil Cut to a Case
  - Offers better functionalities than any other similar tool
  - Kept the legacy synthesis method of HYSYS
  - Applications:
    - Crude and Condensate Evaluation
    - Yield and Property studies
    - LP Vector for Assays
    - Etc.

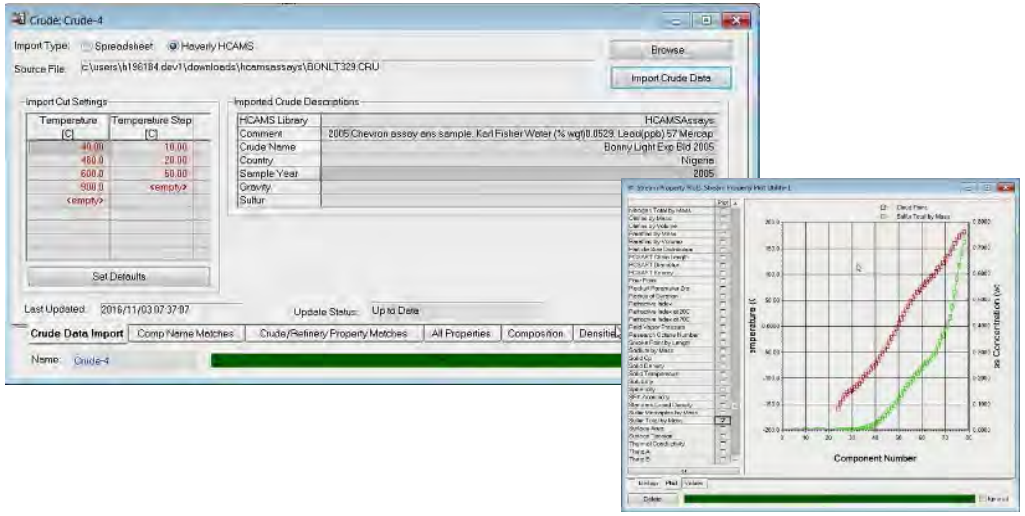


ASSAY SYNTHESIS MODEL ONE VIEW



Crude Assay Management

- UniSim Design links to Crude Assay Databases
- Haverly H/CAMS
- Spiral
- Other Databases
  - Possible to also include proprietary assays
- Assays are imported under the UniSim Crude Manager environment
- Assay Synthesis

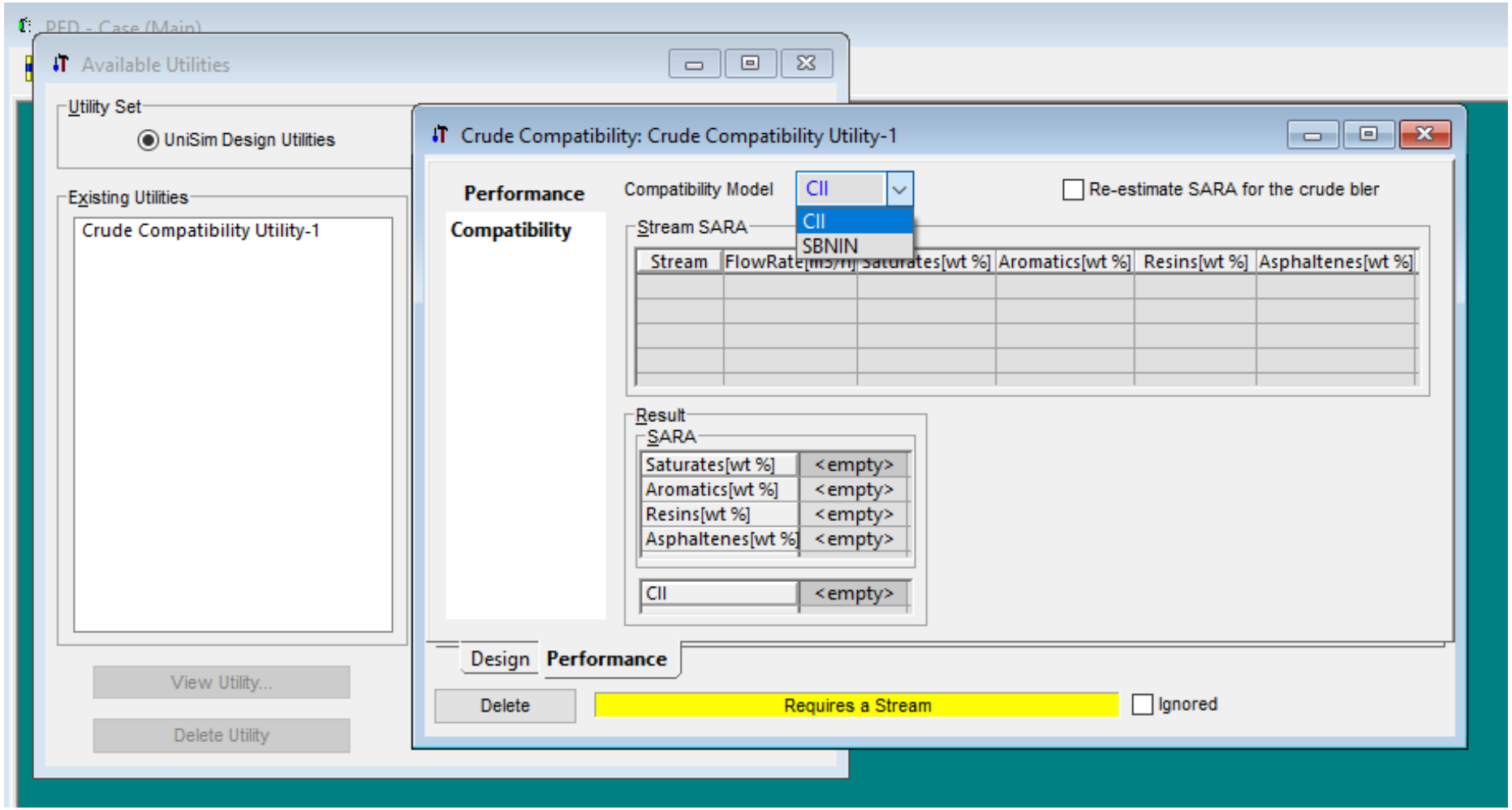


- The crude assay import facility makes it easy to import and manage crude assays.
- This functionality increases engineering effectiveness, eliminates room for manual data entry, and makes it easier to model crude storage facilities and refining processes.

Easy Assay Import Into Unisim Design

Crude Compatibility Utility

- A New Utility to Evaluate the Compatibility of Crude Oil Blends

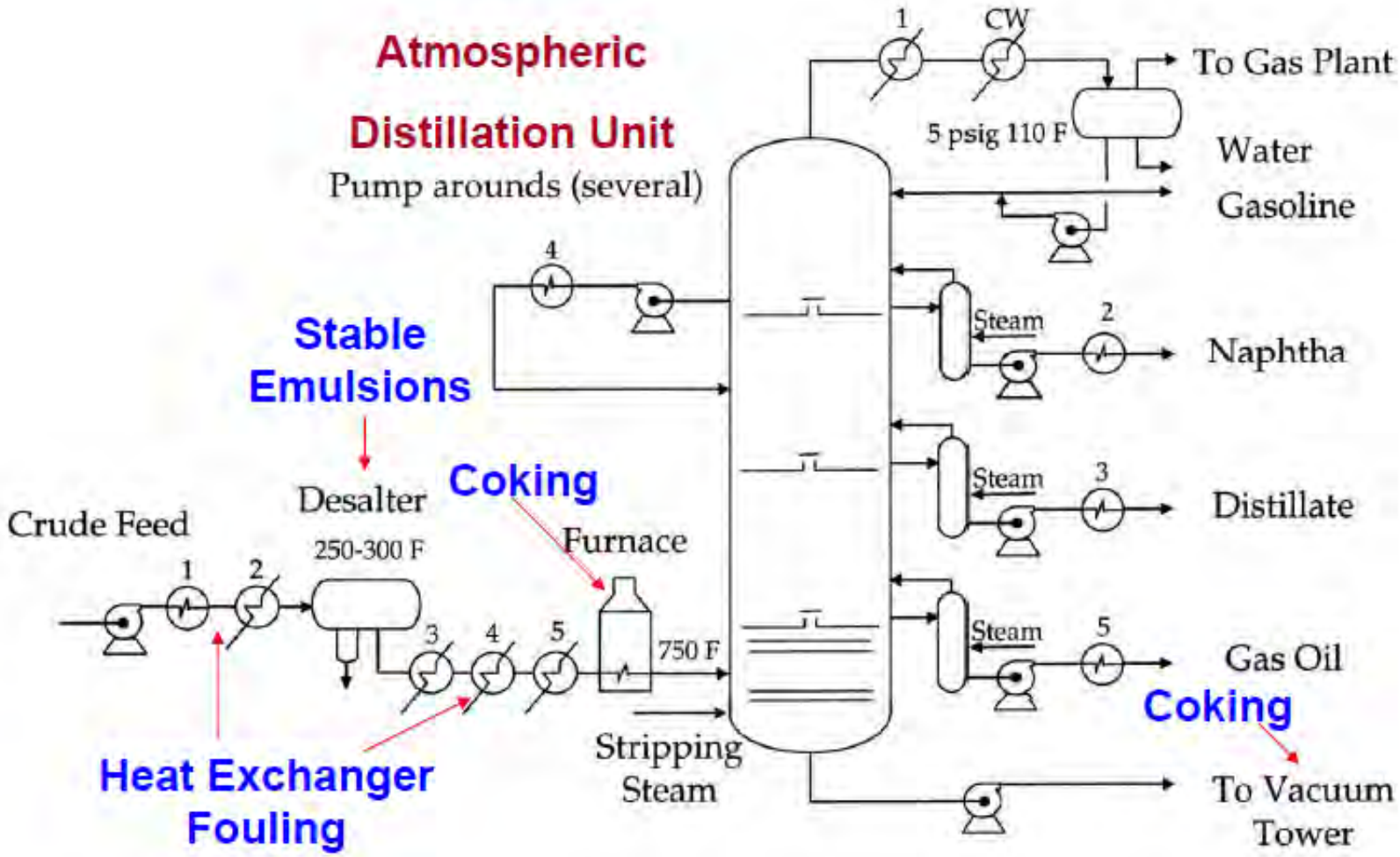


Crude Compatibility Utility

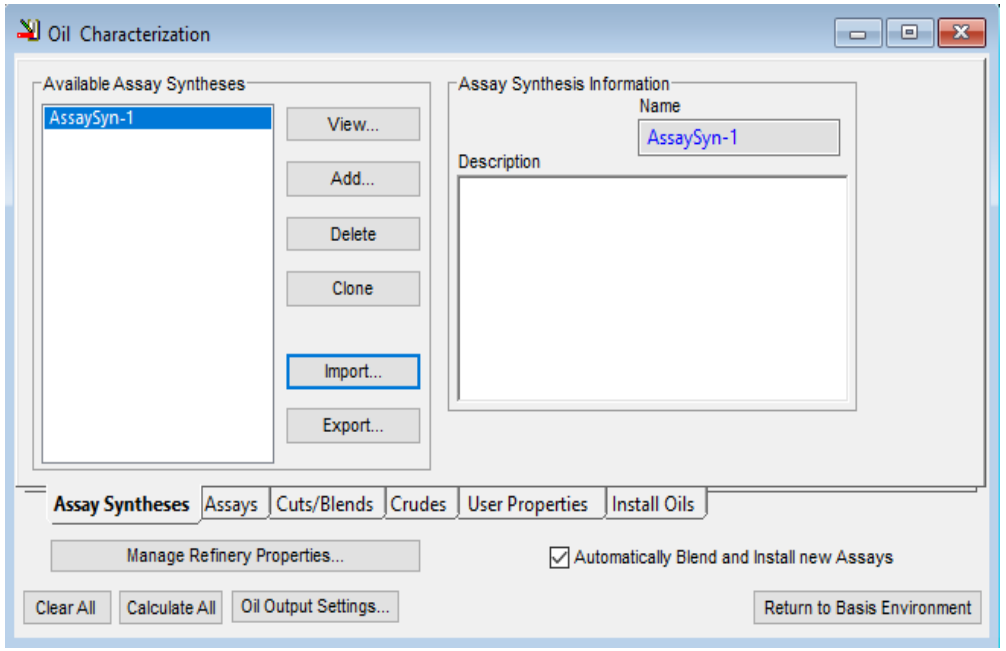
Benefits

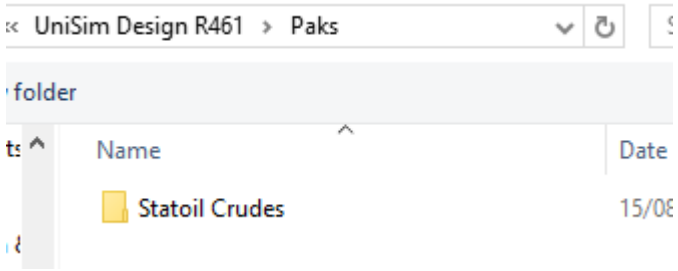
- Allows evaluation of opportunity crude oils and condensates for processing by the refinery
  - Shale Oil, Tight Oil, etc.
- Makes it possible to evaluate and minimize risk of damage by non compatible feedstock
- Supports better crude blending practices
  - Adjusting the ratio of incompatible crude oils

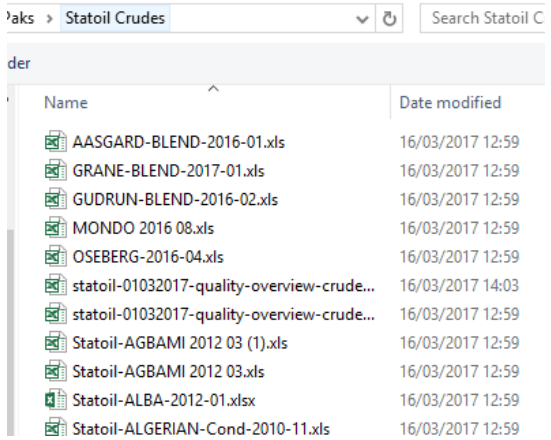
Where it can happen?



Refinery Modelling Made Easy



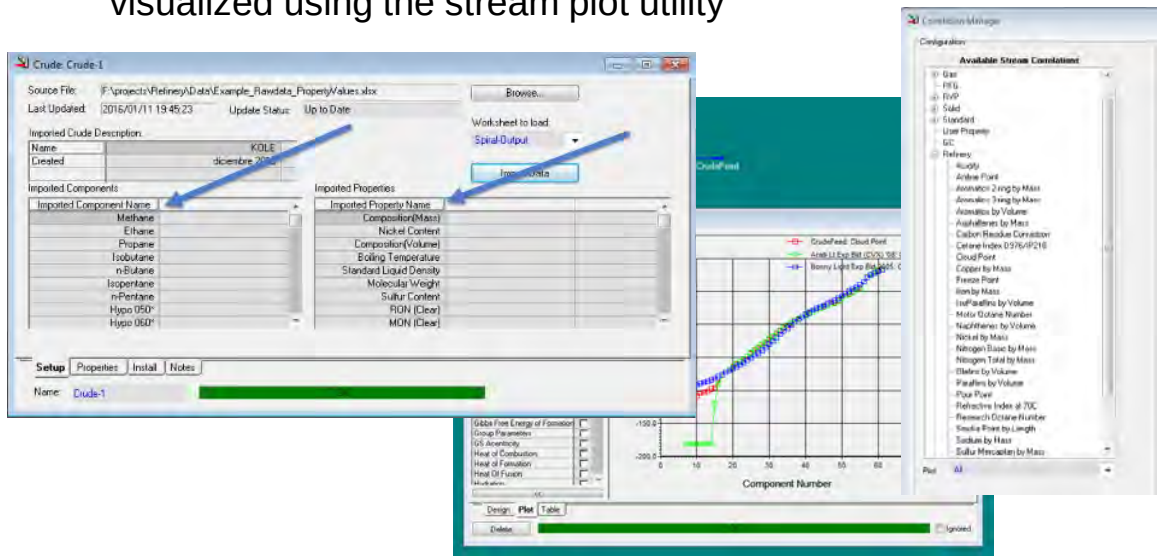




Refining Infrastructure

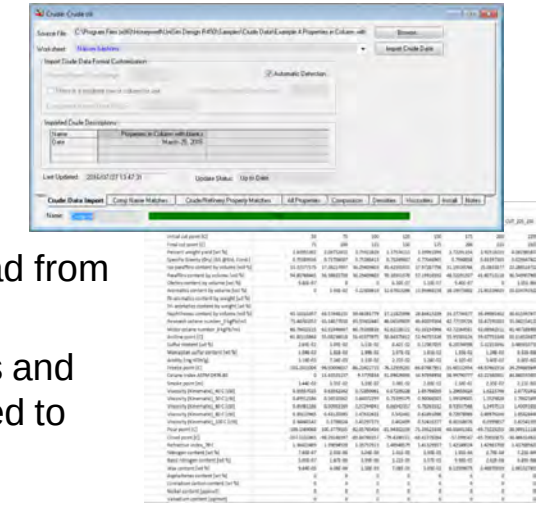
Refining Properties

- Base environment stream properties required to support Refining Flowsheet and Crude Environment
- RON, MON, RVP, conradson carbon rate, carbon to hydrogen ratio, cetane index, refractive index, yield, Aniline, cloud, freeze, pour, smoke, softening, wax congealing and flash points, X-ring UV and IP391 Aromatics, Cx Asphaltenes, olefins, naphthalenes, naphthenes, n-paraffins, paraffins, polynaphthenes, mercaptans...
- Individual stream properties or multiple stream properties can be visualized using the stream plot utility



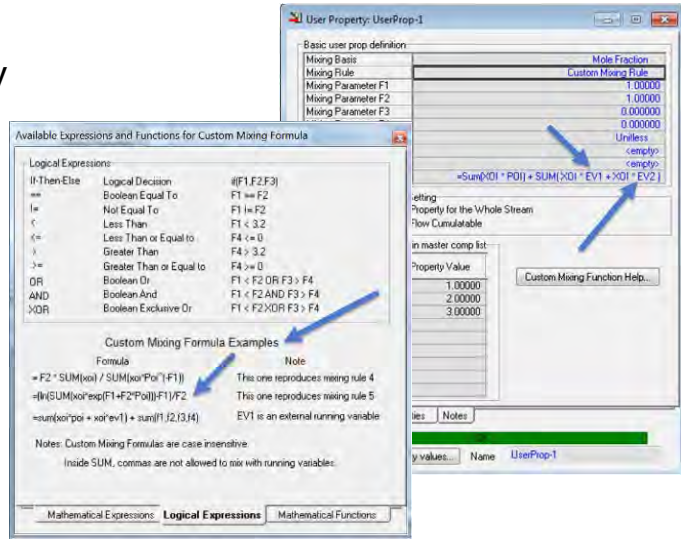
Crude Environment

- Environment for managing Crude Assay properties
- Direct link to Haverly H/CAMS crude assay library, can also be read from MS Excel files or manually entered
- Assays are mapped to components and pseudo components and propagated to flowsheet environment



Blending Rules

- Pre-defined non proprietary blending rules included
- Fully customizable



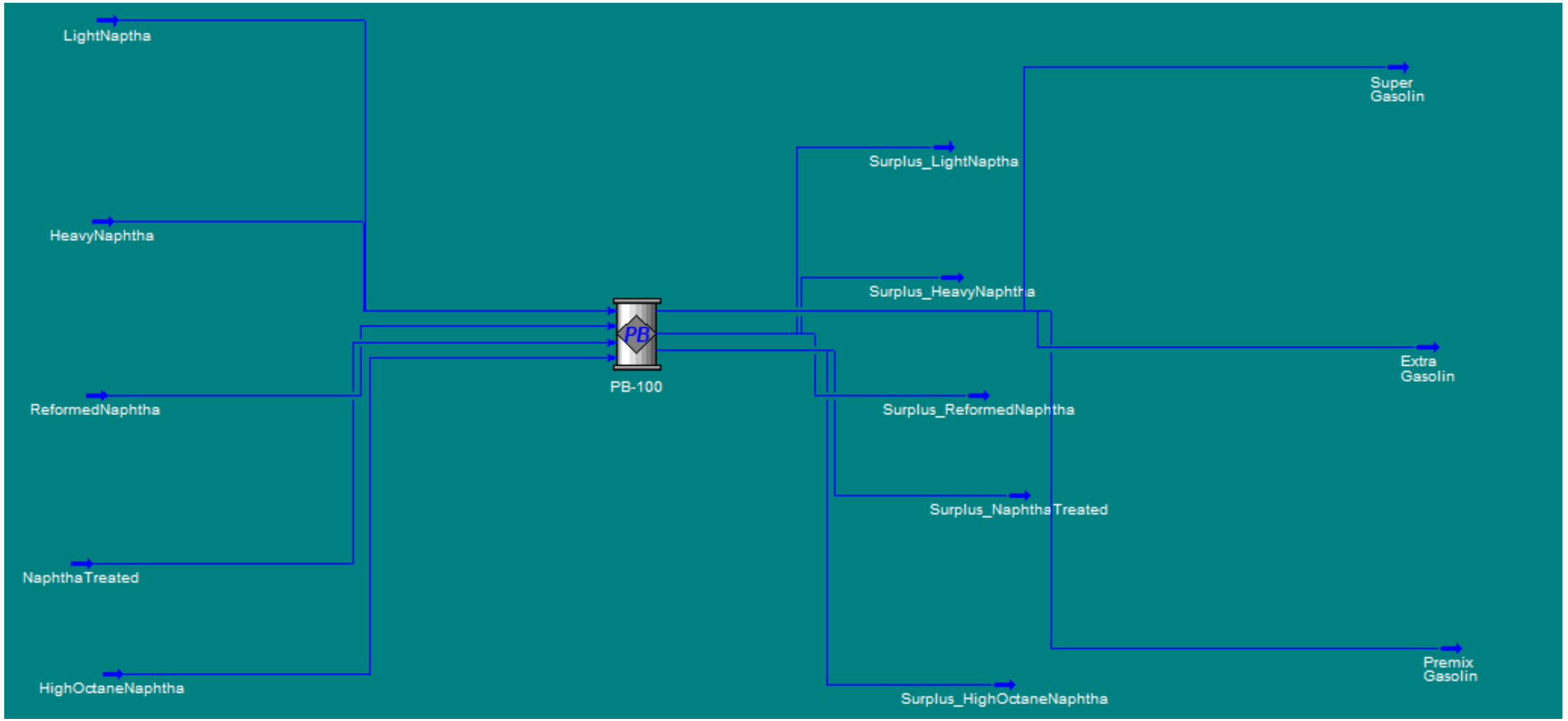
Infrastructure & Unit Operations to Efficiently Create Complete Refining Flowsheet

Product Blender

Benefits

- Allows economic optimization of recipes and Refinery-wide modelling
- Avoid quality give away
- Provides refinery-wide modelling capability
- Can use it as a stand-alone blender model or as part of a flowsheet

Product Blender Model in UniSim Design



Product Blender

Benefits

- Produce on-spec finished products
- Enables calculation of bio component requirements
- The same model can be used for gasoline, gasoil or fuel oil blending
- Evaluate options for IMO 2020 compliance

Product Blender View in UniSim Design

SRU Model

Benefits

- SRU model allows to comply with strict environmental regulations to avoid:
  - Paying penalties
  - Forced refinery shut-down
- Avoid production loss and fines
- SRU model is part of UniSim Design Platform

SRU Model

Benefits

- Readily available to be integrated within your full Upstream, Gas Processing, or Refining flowsheet

- Sulfur recovery model can also be used as a standalone model

- Ease of use
  - Simple configuration & calibration
  - Templates available
  - Configuration flexible

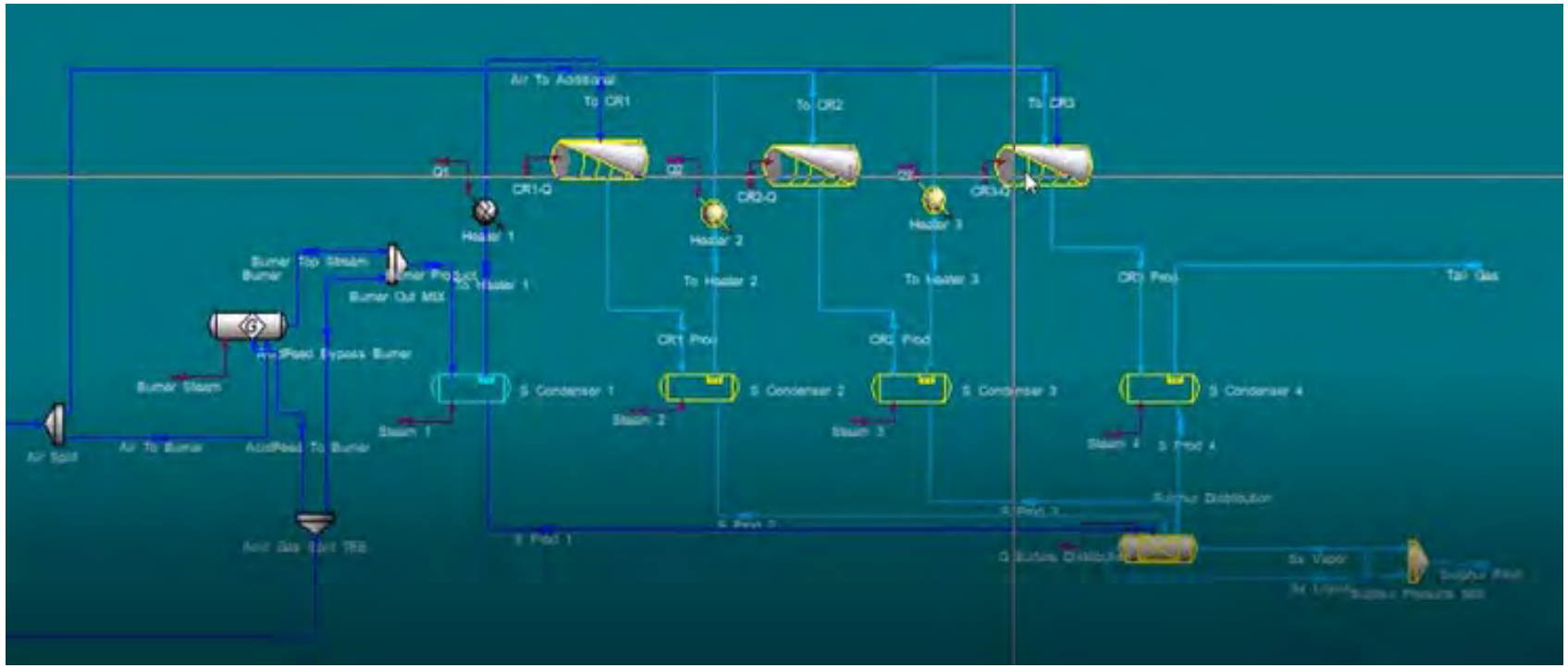
SRU Model

- Makes evaluation of additional sulfur recovery requirements possible
  - Need for additional SRU capacity
- Validated by Honeywell subject matter experts
  - Ortloff Engineers
- Evaluation of unit revamps
- Available at no additional cost within UniSim Design R470

USD R470 – SULFUR RECOVERY MODEL

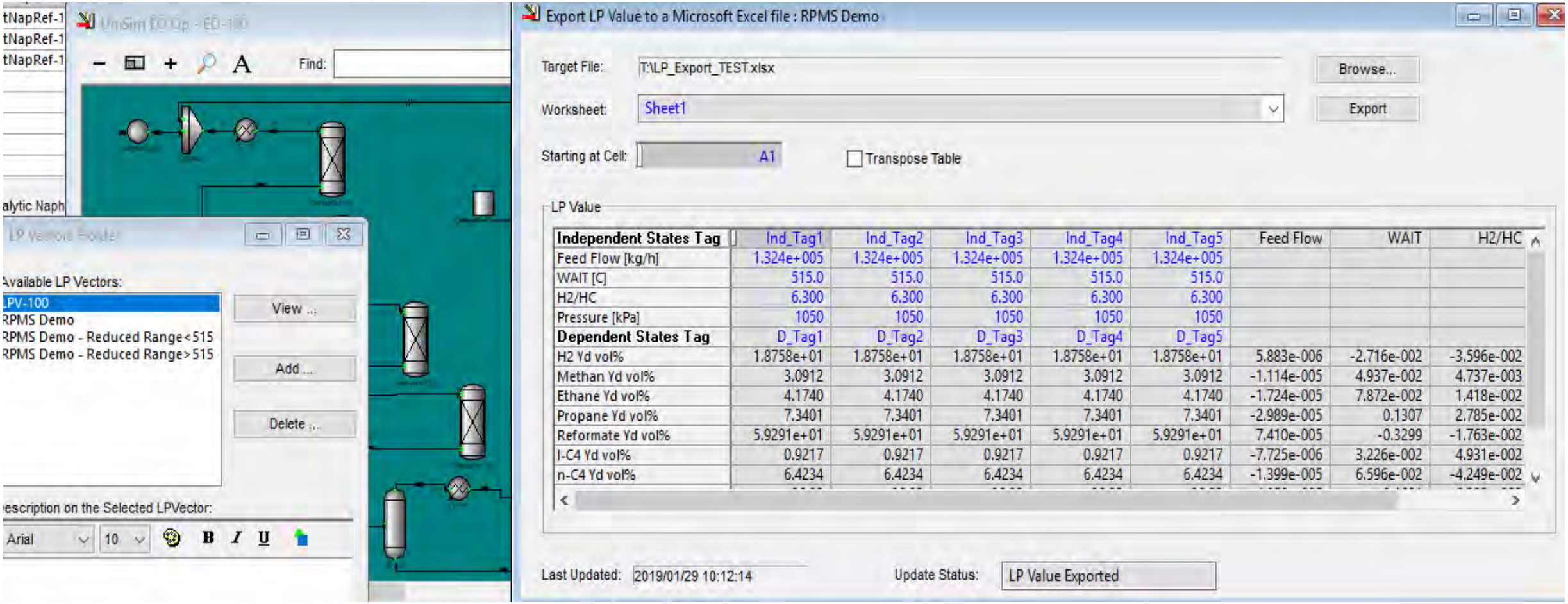
Sulfur Recovery Model

- Claus, Super Claus, …
- For Upstream, Downstream



LP Vector Generation

- This is now automated to export data to templates for RPMS, GRTMPS, PIMS, etc.



Independent States Tag	Ind_Tag1	Ind_Tag2	Ind_Tag3	Ind_Tag4	Ind_Tag5	Feed Flow	WAIT	H2/HC
Feed Flow [kg/h]	1.324e+005	1.324e+005	1.324e+005	1.324e+005	1.324e+005			
WAIT [C]	515.0	515.0	515.0	515.0	515.0			
H2/HC	6.300	6.300	6.300	6.300	6.300			
Pressure [kPa]	1050	1050	1050	1050	1050			
Dependent States Tag	D_Tag1	D_Tag2	D_Tag3	D_Tag4	D_Tag5			
H2 Yd vol%	1.8758e+01	1.8758e+01	1.8758e+01	1.8758e+01	1.8758e+01	5.883e-006	-2.716e-002	-3.596e-002
Methan Yd vol%	3.0912	3.0912	3.0912	3.0912	3.0912	-1.114e-005	4.937e-002	4.737e-003
Ethane Yd vol%	4.1740	4.1740	4.1740	4.1740	4.1740	-1.724e-005	7.872e-002	1.418e-002
Propane Yd vol%	7.3401	7.3401	7.3401	7.3401	7.3401	-2.989e-005	0.1307	2.785e-002
Reformate Yd vol%	5.9291e+01	5.9291e+01	5.9291e+01	5.9291e+01	5.9291e+01	7.410e-005	-0.3299	-1.763e-002
I-C4 Yd vol%	0.9217	0.9217	0.9217	0.9217	0.9217	-7.725e-006	3.226e-002	4.931e-002
n-C4 Yd vol%	6.4234	6.4234	6.4234	6.4234	6.4234	-1.399e-005	6.596e-002	-4.249e-002

Q & A

THANK YOU FOR ATTENDING

Honeywell