Steady & Dynamic Simulation & Optimization of ADNOC/GASCO NGL Units: Work Progress

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Dr. Abdallah Berrouk (PI)

Project Team :

Dr. Yasser Al Wahedi (PI)

Dr. Abdallah Berrouk (PI)

Mr. Dara Satyadileep (PI)

Mr. Simon Leyland (PSE)

Mr. Artur Andrade (PSE)

مركز أبحاث الغاز | المعهد البترولي
Gas Research Center | The Petroleum Institute

Project Motivation

Optimization is no longer an option. It is now a commercial necessity.

The fluctuating marketplace for feedstock and energy prices means that the competitive advantage for petrochemical production is being squeezed.

It is then imperative to meet customer needs and be commercially profitable.

Oil and gas companies have many business challenges to overcome, including optimizing complex operations and efficiently designing facilities

The aim is to provide greater energy and capital cost savings.

To conquer complexity and drive efficiency measures across the operation, companies today are implementing flexible technology to achieve design and production optimization.

Cutting-edge technologies such as ***Process Modelling*** are to be extensively used to help bridge the skills gap and address operational challenges.

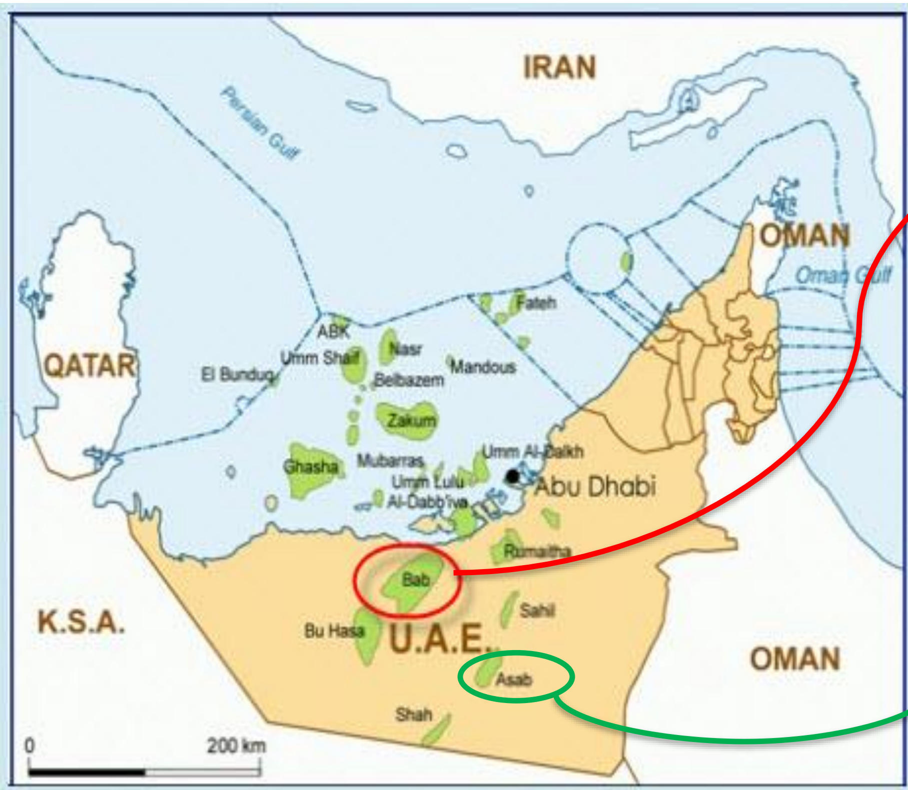
Project Motivation

Successful demonstration of the benefits of gas-plant modelling and optimization

Delivering fit-for-purpose steady-state and dynamic models for GASCO NGL units

Project Motivation

Products – Sales gas/Residue gas (C1+C2)
Natural gas liquids (C3+C4)
Condensate (C5+)



Project Objectives

- **Delivering a successful demonstration of the feasibility and benefits of gas-plant dynamic modelling and optimization**

- **Delivering fit-for-purpose steady-state and dynamic models that can be used and maintained in-house by GASCO personnel for future studies**

- **Transferring relevant knowledge and skills for this type of activity to both PI and GASCO team**

Project work plan

2 year project, started at end of 2016

Project phases:

1. **Develop steady-state NGL plant models**
2. **Develop a dynamic *gPROMS ProcessBuilder* model for the natural gas dryers**
3. **Conduct steady state optimization**
4. **Develop dynamic natural gas dryers + NGL plant system model**
5. **Dynamic plant behavior and analysis (optimization)**

Project Outcomes

Upon successful project completion:

1. **Implement the optimal settings in a test run in the plant within 6 months of the project completion.**

2. **Test dynamic model predictions against plant results upon implementation of the optimal settings; perform final model tuning, if necessary**

3. **In collaboration with GASCO team, develop plan for implementation of Real-Time Optimization in the studied plants.**

Modelling Results

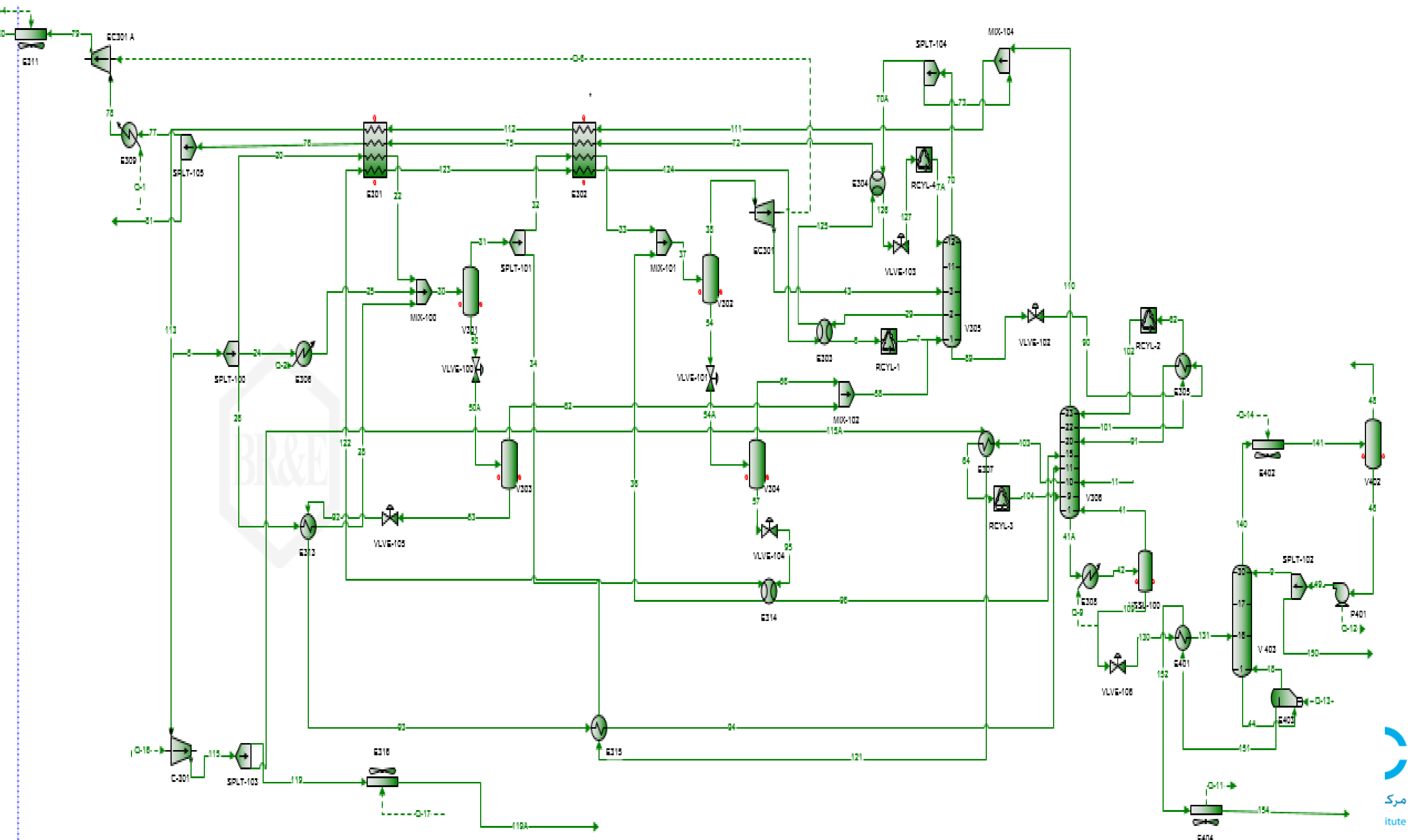
GASCO NGL unit
Design Data
Steady State Model
ProMax, Hysys, Aspen & gPROMS ProcessBuilder

MODEL Highlights

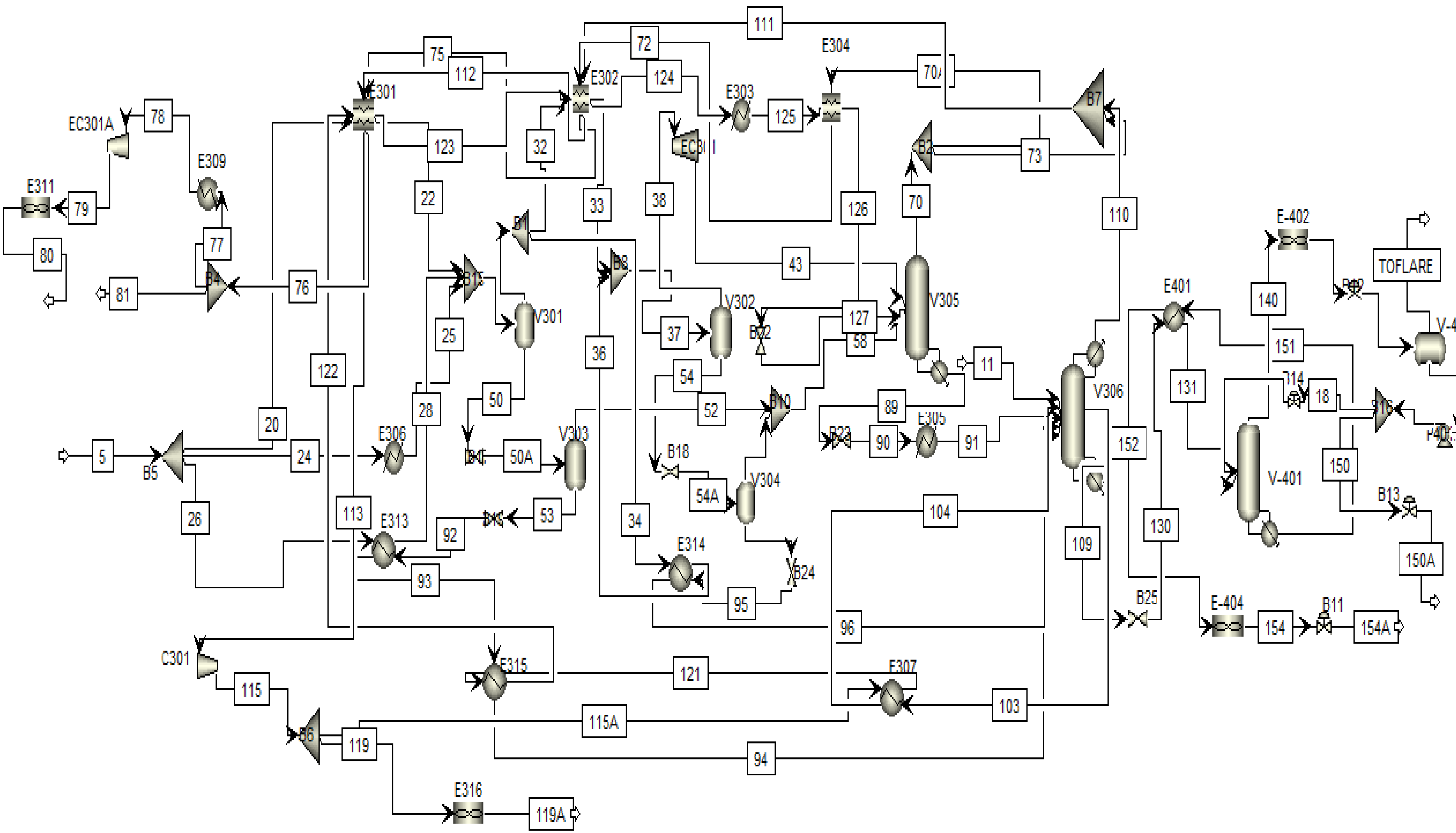
- Units
  - 3 distillation columns
  - 2 Multi-stream heat exchangers
  - ~10 additional heat exchangers
  - 2 compressors, 1 expander
  - + flash separators, valves

- Highly integrated
  - Multiple recycles
  - Heat integration via heat exchangers (inc. column reboilers and condensers)

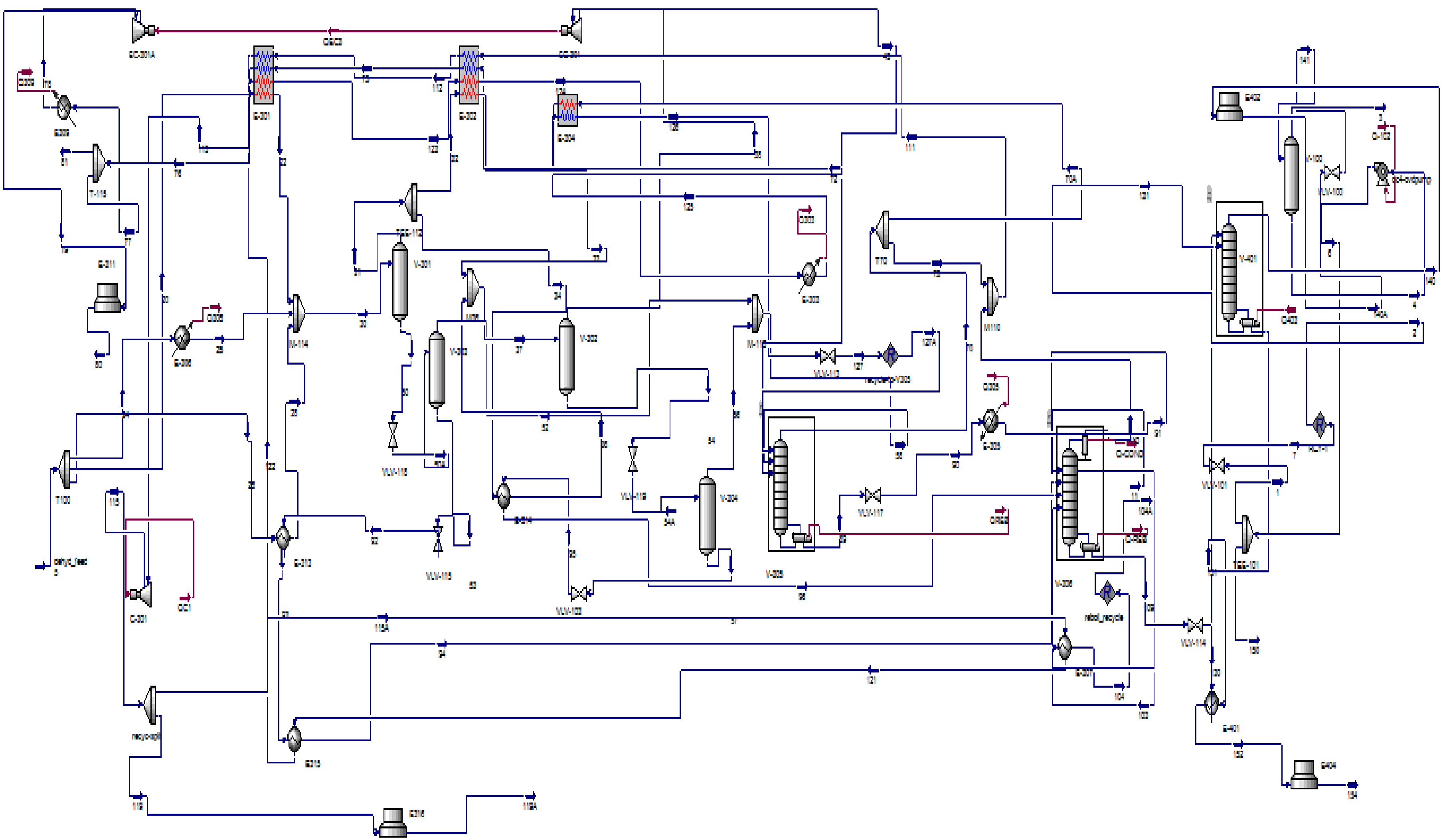
PROMAX model



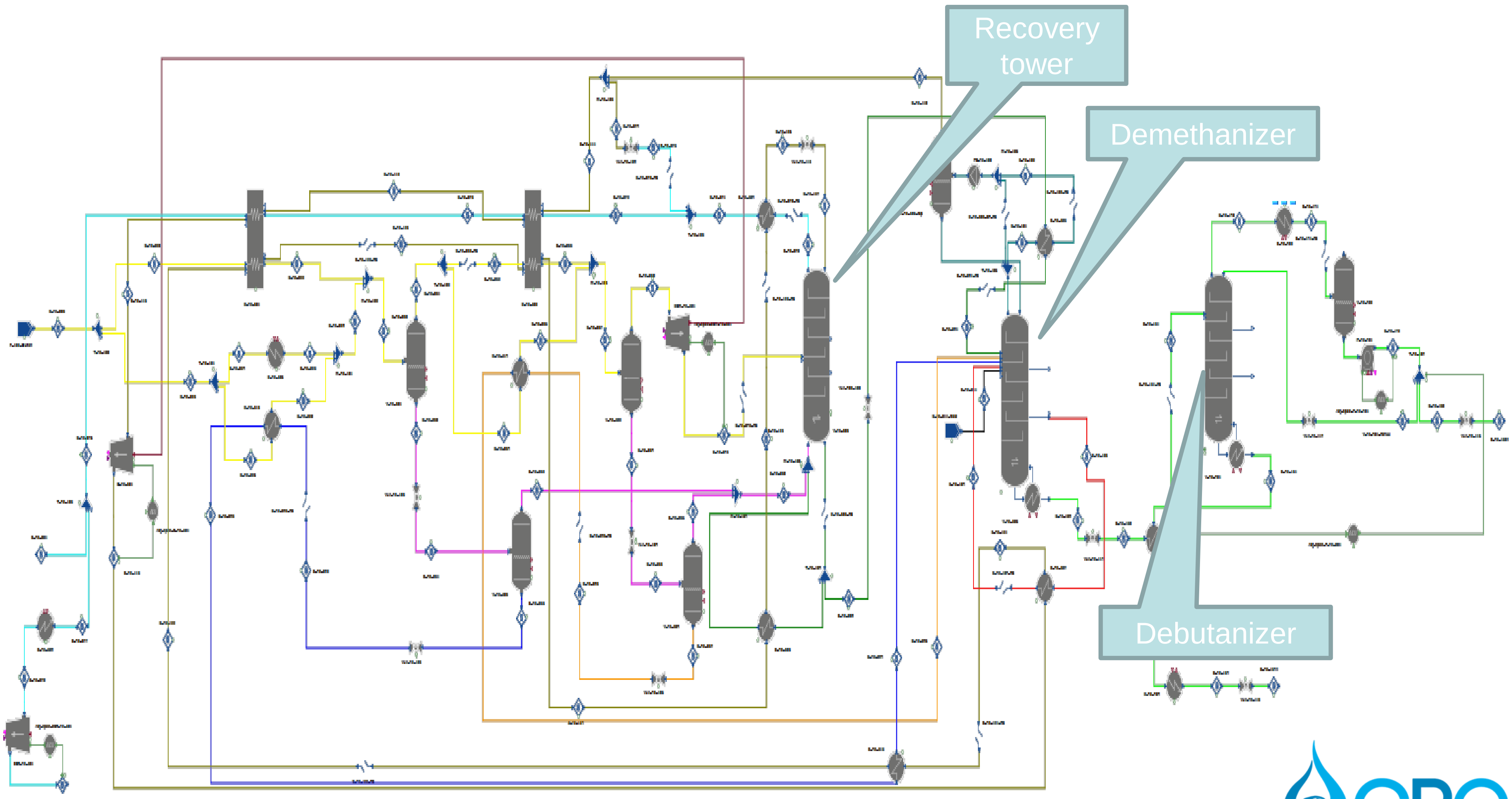
ASPEN PLUS model



ASPEN HYSYS model



gPROMS ProcessBuilder model



MODEL INPUTS

Equation of State: Peng-Robinson

Column Specifications

- **ProMax**:
  Recovery tower (bottoms rate only)
  De-C1 (side draw ratio, condenser temperature & bottom rate)
  For De-C4 (bottoms rate only)
- **Aspen Plus**:
  Recovery tower (bottoms rate only)
  De-C1(side draw rate, condenser temperature & bottom rate)
  For De-C4 (bottoms rate only)
- **Aspen Hysys**:
  Recover tower (bottoms rate only)
  De-C1 (side draw rate, condenser temperature & bottom rate)
  De-C4 (bottoms rate only)
- **gPROMS ProcessBuilder**:
  Recovery tower (bottoms rate only)
  De-C1 (side draw rate, condenser temperature & bottom rate)
  De-C4 (bottoms rate only)

Results comparison - Notes

- **All 4 models compared to design data***
  - **% deviations shown in tables in comparison to this**
- **Design data previously generated in HYSIM with PR Equation of state in 1990's**

Ultimate aim is to compare to actual plant data when available

Results comparison

Recovery Tower Top

	Promax	Hysys	Aspen Plus	gPROMS ProcessBuilder
% deviations in Temp	6.72	0.33	1.45	0.150
% deviations in Flow	0.52	0.0122	0.0099	0.010

De-Methanizer C1 top

	Promax	Hysys	Aspen Plus	
% deviations in Temp	5.58	0.0259	14.43	8.113
% deviations in Flow	4.23	0.4021	0.040	3.480

De-Butanizer C4 top

	Promax	Hysys	Aspen Plus	
% deviations in Temp	0.063	0.0158	0.54	0.908
% deviations in Flow	5.24	0.7776	0.0	0.000

Percent deviations of Stream X (Recovery Tower top)

	Promax	Hysys	Aspen Plus	gPROMS ProcessBuilder
Temp	6.71	0.326	1.45	0.150
Flow	0.51	0.012	0.0099	0.010
Composition				
N2	0.007	0.001	0.0014	0.47
C1	0.011	0.005	0.0070	0.01
C2	1.47	0.046	2.56	0.12
C3	101.55	3.82	32.91	0.64
IC4	226.93	46.36	43.90	0.00
NC4	565.38	60.35	246.59	0.00
IC5	-	-	-	-
NC5	-	-	-	-
NC6	-	-	-	-
NC7	-	-	-	-
NC8	-	-	-	-
NC9	-	-	-	-
NC10	-	-	-	-
H2S	2.00	0.44	3.44	0.81
CO2	0.0021	0.041	0.013	0.00
COS	58.56	5.94	4.68	-
CS2	-	-	-	-

Percent deviations of Stream XX(De-C1 top)

	Promax	Hysys	Aspen Plus	gPROMS ProcessBuilder
Temp	5.57	0.025	14.43	8.113
Flow	4.23	0.402	0.040	3.480
Composition				
N2	11.64	4.31	16.67	9.63
C1	10.14	0.98	9.11	1.35
C2	8.43	1.65	25.45	0.89
C3	2.46	3.79	16.35	20.87
IC4	126.05	33.11	21.78	65.39
NC4	297.46	53.53	44.53	77.23
IC5	-	-	-	-
NC5	-	-	-	-
NC6	-	-	-	-
NC7	-	-	-	-
NC8	-	-	-	-
NC9	-	-	-	-
NC10	-	-	-	-
H2S	4.07	2.40	40.43	0.60
CO2	8.33	1.19	12.20	1.56
COS	10.91	3.20	113.32	-

Percent deviations of Stream XXX (De-C4 top)

	Promax	Hysys	Aspen Plus	gPROMS ProcessBuilder
Temp	0.063	0.0158	0.53	0.908
Flow	5.24	0.777	0.0001	0.000
Compositon				
N2	-	-	-	
C1	99.02	95.61	98.70	81.00
C2	50.40	2.19	86.01	1.69
C3	22.53	1.03	4.99	0.01
IC4	12.03	0.30	0.59	0.77
NC4	32.47	2.09	2.23	2.41
IC5	45.12	25.10	29.13	22.96
NC5	48.79	48.64	21.85	48.04
NC6	97.90	97.81	98.21	97.24
H2S	45.97	5.68	82.81	10.55
CO2	91.49	80.70	95.58	54.98
COS	29.39	2.42	4.86	*
CS2	84.52	962.57	211.24	*
METHYL-M	100	0.28	0.26	0.46
ETHYL-01	100	33.99	47.48	*
N-PRO-01	100	97.14	84.93	*

gPROMS ProcessBuilder - key results

		Deviation from design data
NGL Storage	Temperature (°C)	0.01%
	Pressure (bar)	0.00%
	Mass Flow (kg/h)	-0.81%
Residue Gas	Temperature (°C)	0.01%
	Pressure (bar)	0.00%
	Molar Flow (kmol/h)	-0.01%
	HC Dew point (°C)	-0.35%
Ethane recovery mol (%)		0.51%
Propane recovery mol (%)		-0.65%

Challenges

- **For actual validation models to be compared to plant data**
  - **Proving difficult to get from plant**
  - **Validation shown here performed against design data to allow model development and testing to progress**

Why gPROMS ProcessBuilder?

- **Leverage advantages of Equation Oriented environment (vs Sequential Modular)**
  - **Mathematical optimization**
  - **Handling of multiple interacting recycles**
  - **Capability to extend model libraries via custom modeling**

Without the traditional challenges
- **Robustness**
- **Flowsheet build time**

Model initialisation procedures have allowed gPB flowsheets to be built in similar timeframe as traditional flowsheeting packages

- **Ability to run in both steady state and dynamic mode**

- **Collaboration with PSE to transfer knowledge and experience in solving large complex optimization problems**

Optimization problem

Natural gas dryers system

Objective function:	Operating and bed replacement cost
Constraints:	Breakthrough time, cycle balance, regeneration time, pressure drop
Decision variables:	Adsorption/regeneration step times, regeneration gas flow and temperature

NGL recovery

Objective function:	Annualized (revenue – operating cost)
Constraints:	Maximum capacities & turndown rates, maximum operating conditions, product specifications
Decision variables:	Stream splits, temperatures

Future work

- Define and test optimization problem with current model in gPROMS ProcessBuilder
- Validate steady state model against plant data
- Dynamic model of molecular sieve dehydrators in gPROMS ProcessBuilder
- Convert steady state gPROMS ProcessBuilder NGL model to dynamic mode

THANK YOU