Dynamic simulation of the ENEFIT280 Process

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Outotec

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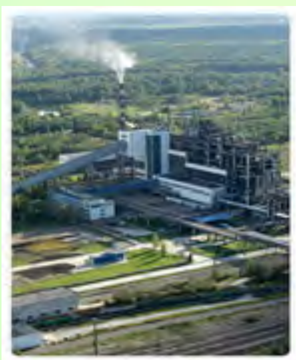
A new generation of Enefit Technology

Outotec More out of ore & Eesti Energia



Narva Oil Plant

Current Production:
Oil - 170,000 tonnes/year

Enefit280 new capacity:
Oil - 290,000 tonnes/year

Total Production (near future):
Oil - 460,000 tonnes/year

Outotec and Eesti Energia have formed a Joint Venture called Enefit Outotec Technology (EOT) to develop and market Enefit technology featuring:

- Enhanced heat recovery;
- Reduced mechanical equipment;
- Reduction of emissions;
- Delivering higher oil yields
- Design for highest availability.

The next generation of oil shale processing is called Enefit280. The construction of this first-of-its-kind plant in Estonia is complete and the plant is currently in the commissioning phase.

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Outotec
More out of ore

Non-ferrous Solutions	Ferrous Solutions	Energy, Light Metals and Environmental Solutions
Processing of copper, nickel, zinc, lead, gold, silver and platinum group metals in the entire value chain from ore to metal	Processing of iron ores and other ferriferous materials in the entire value chain from ore to metal	For sulfuric acid production, off-gas handling, alumina refining, roasting, calcining, biomass processing, oil shale & oil sands processing and industrial water treatment

Services for a plant's entire lifetime

- Sales EUR 1,386 million with EUR 344 million generated by services (2011)
- Presence in 25 countries, deliveries to 80 countries
- Over 4,500 professionals
- Extensive IPR portfolio
  - Over 5,500 national patents or applications, 600 patent families and 70 trademarks
- R&D expenditure EUR 34 million (2011)

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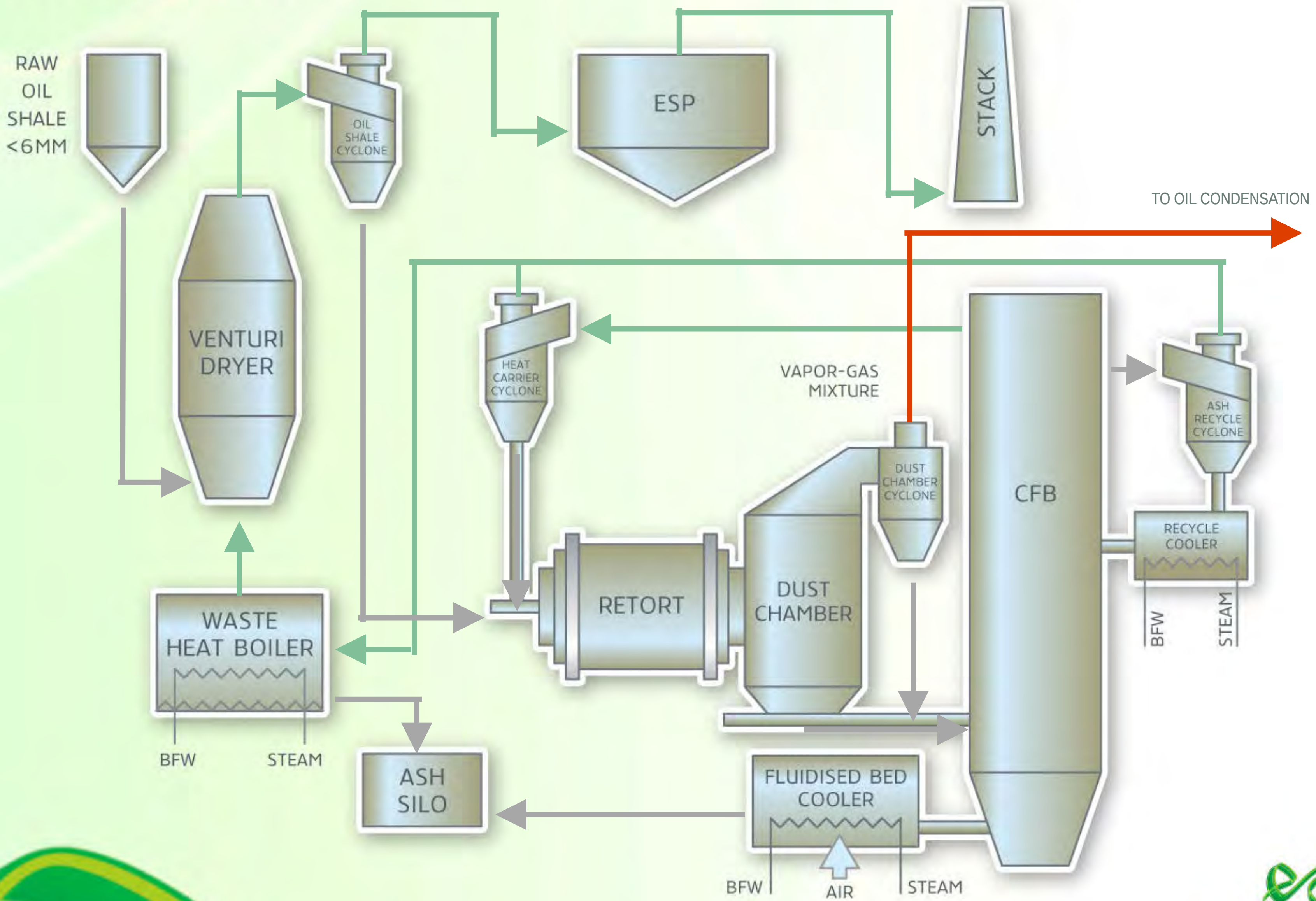
Process overview



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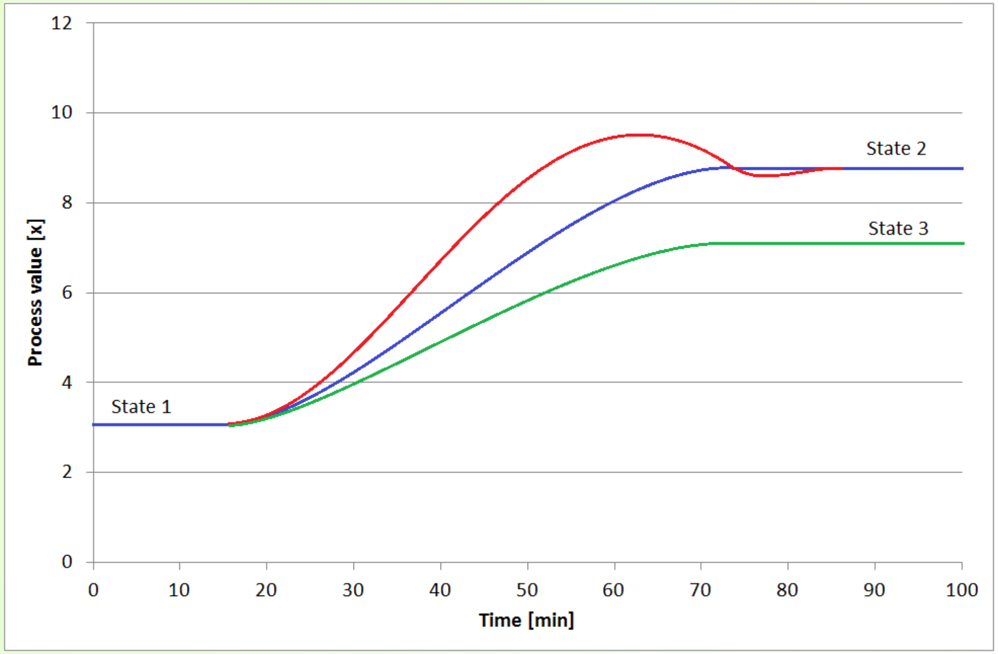
What is dynamic simulation?

- Steady state simulation in Aspen Plus (from AspenTech):
  - Several states with various process values
- Dynamic simulation in Indiss Plus (from RSI):
  - Prediction of how to get from one steady state to another
  - Introducing the factor of time



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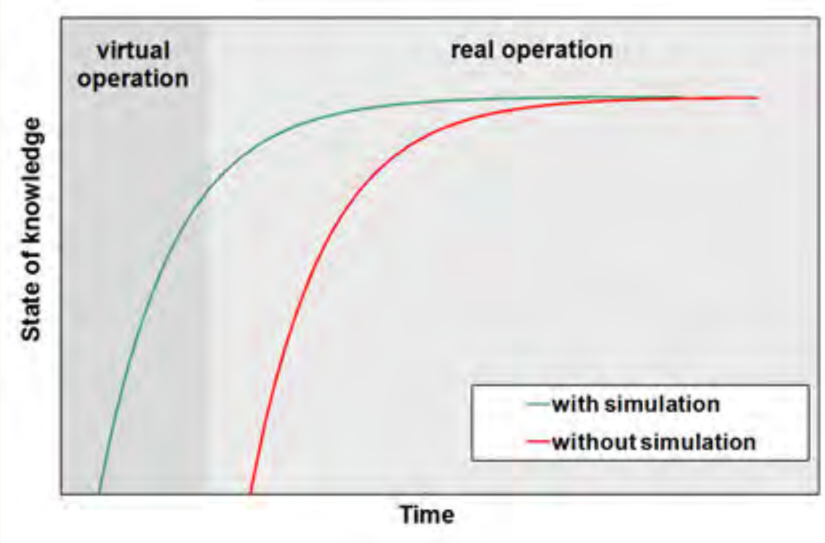
The need for dynamic simulation

- The plant is the first-of-its-kind (no practical experience of plant behavior)
- Test the behavior of the plant before commissioning (especially start up, ramp up and shutdown scenarios)
  - Ability to ‘hit the ground running’ during plant hot commissioning/ production ramp up
- Future plant scale-up can be verified by dynamic simulation
- Basis for an operator training simulator



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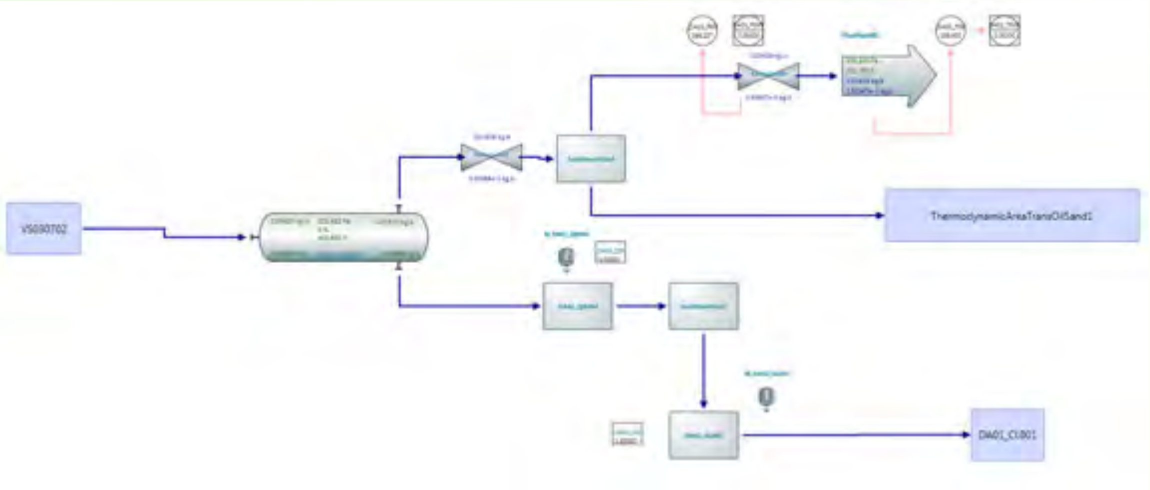
Functionality of Indiss Plus

- Object orientated programming
  - Objects connected by stream lines
  - Around 140 objects available



Objects:
- pump, blower
- vessels
- valves
- measurements
- controller
- etc.

- Element database comparable to Aspen (~1360 elements)
- Streams divided in gas and solid flow

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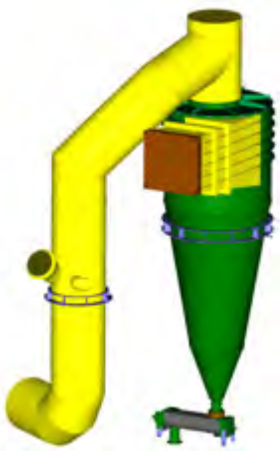
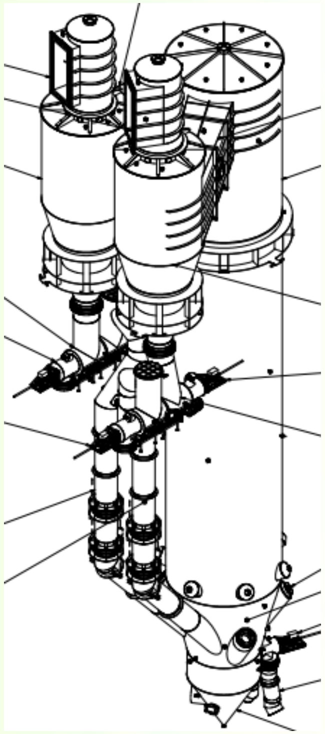
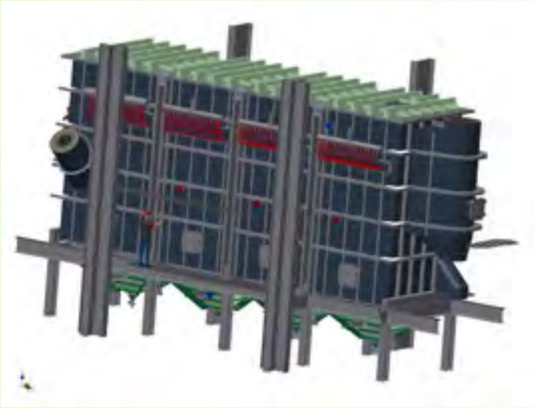
New solid equipment

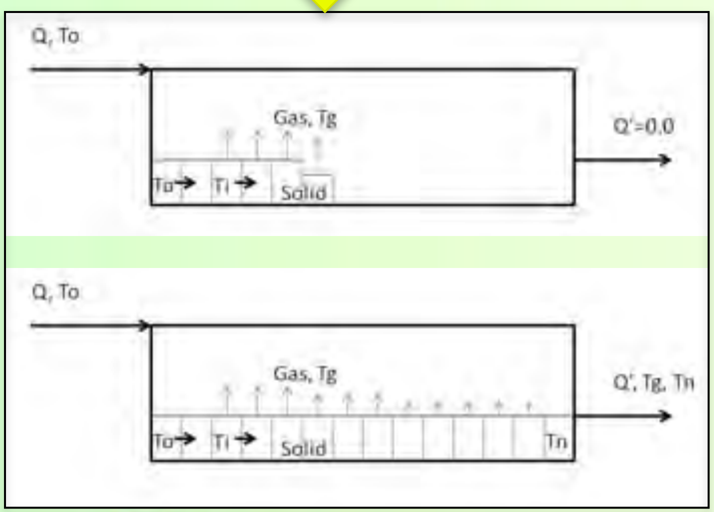
- Screw conveyor
- Venturi dryer
- Solid split (cyclone, ESP, bag house)
- Seal pot
- Cooling fluid bed
- Circulating fluid bed
- Retort







Solid example: the retort



- Cracking of organics and heavy organics into lighter fraction
- Represents the chemical reactions with a configurable kinetic order relative to solid reactants
- Assume a selected set of inorganic transformations
- The retort is divided in an adjustable number of cells
- The goal was to reach real time simulation for the complete process

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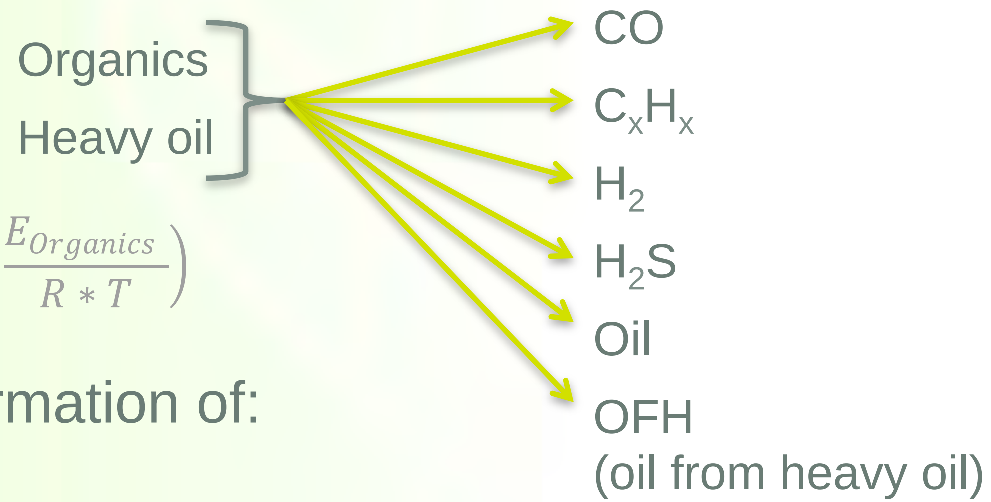
Reactions in the retort

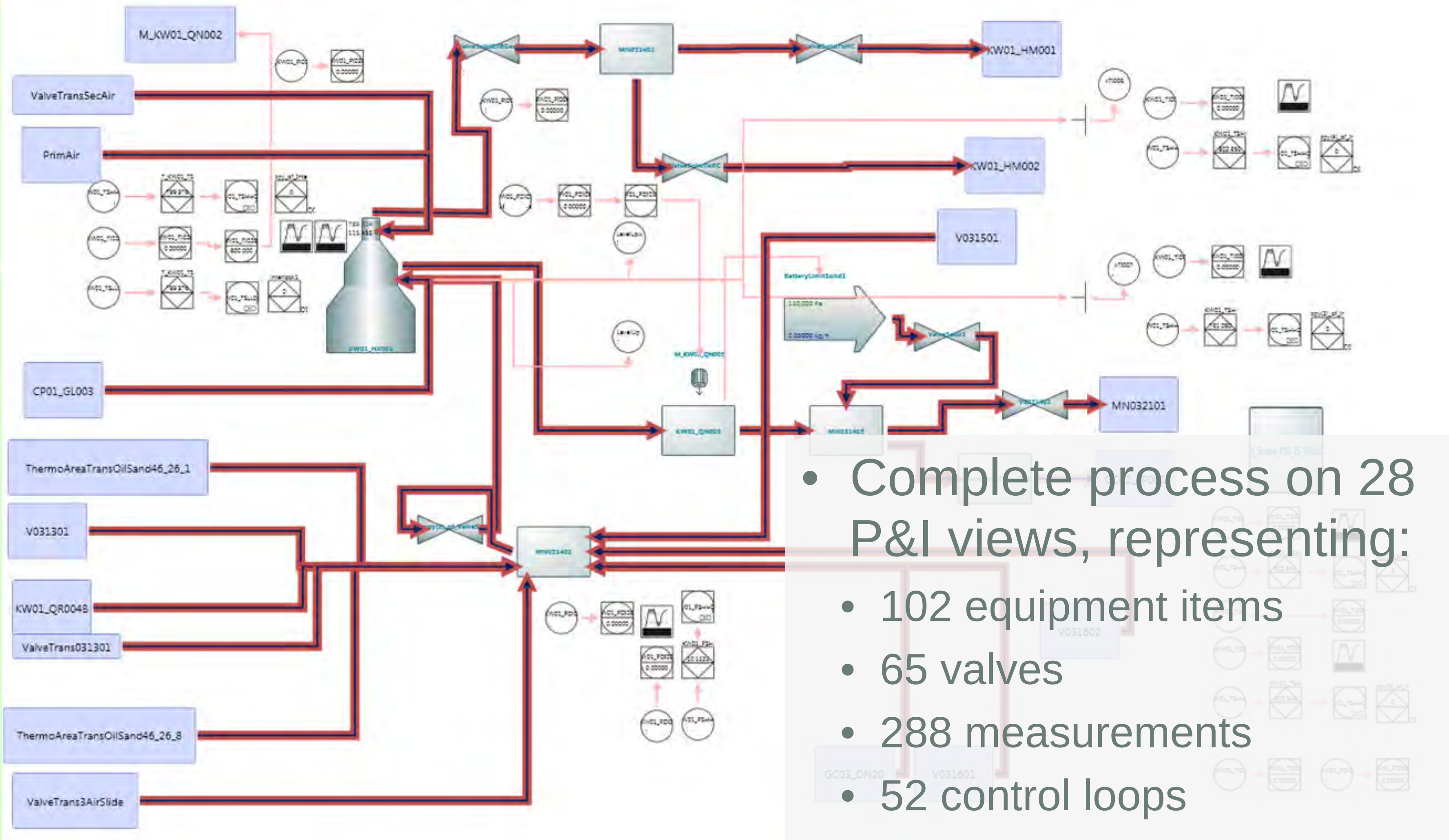
$$Production[i] = X * CompTable[i]$$

$$X = M_{Organics}^{OrganicsExponent} * A_{Organics} * \exp\left(-\frac{E_{Organics}}{R * T}\right)$$



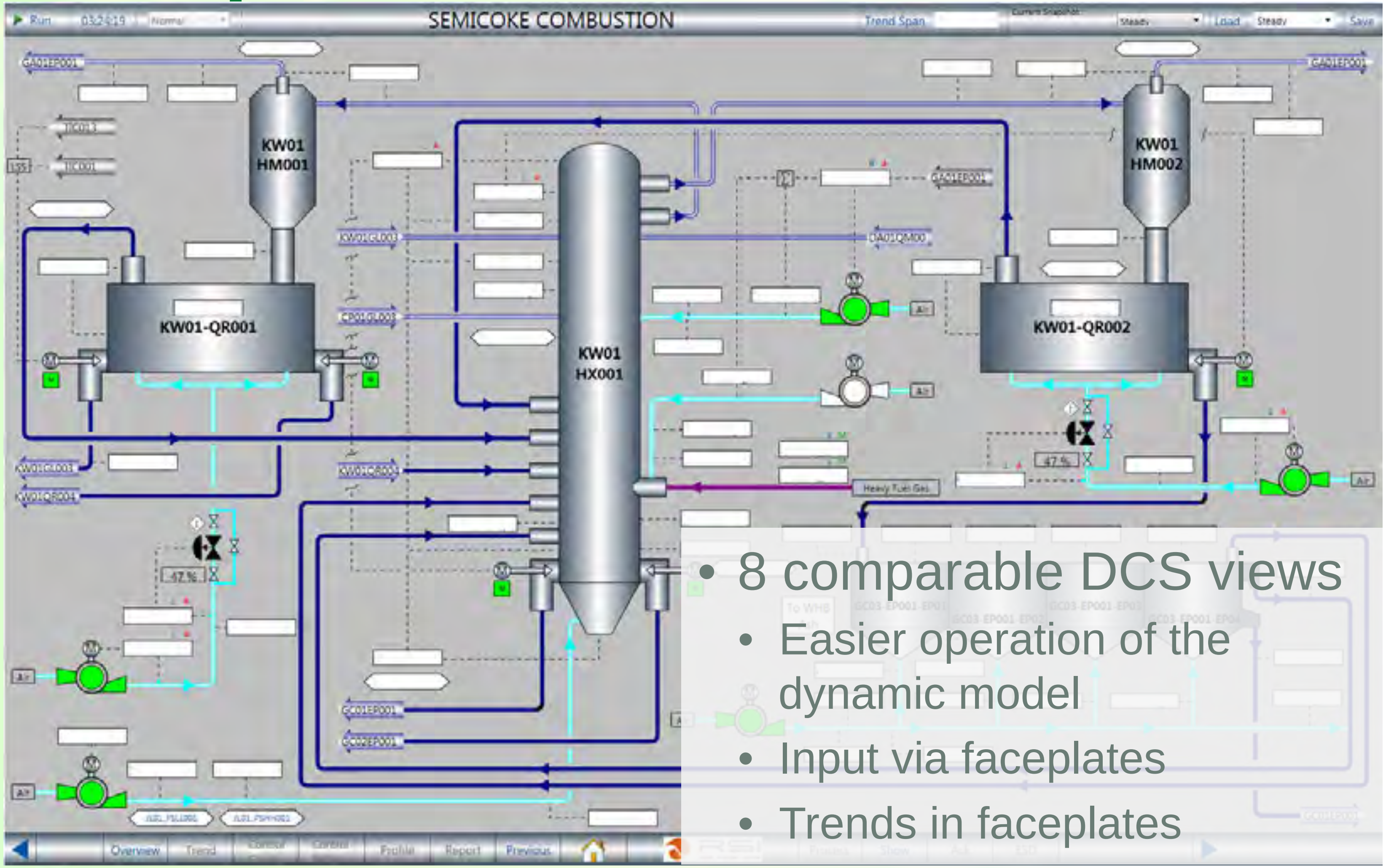
- Mass balance closed over formation of:
  - H_2O, N_2, CO_2
  - CaS, $CaCl_2$, semi coke, heavy coke
- Inorganic reaction: $MgCO_3 \rightarrow MgO + CO_2$
- The temperature gradient along the solids path is computed
- Exchange heat with the external environment taking into account the thermal inertia of the envelope boundary

Example view of P&I Diagram



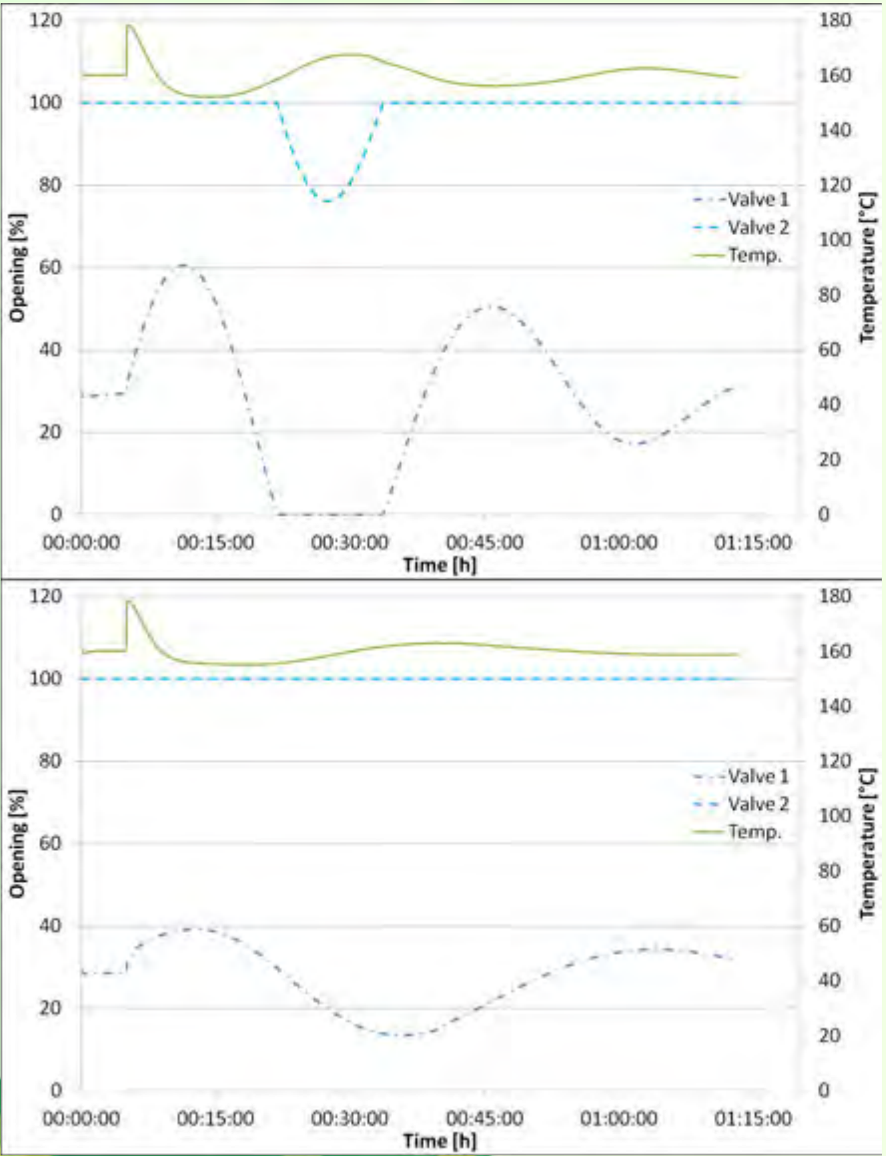
- Complete process on 28 P&I views, representing:
  - 102 equipment items
  - 65 valves
  - 288 measurements
  - 52 control loops

Example of user interface view



- 8 comparable DCS views
  - Easier operation of the dynamic model
  - Input via faceplates
  - Trends in faceplates

Results: controllability



- Trigger
  - Sudden jump in feed
  - Leads to sudden temperature change
- Modified parameters of this controller
- Result
  - Smoother plant behavior
  - Mitigate operational process tuning on site
  - Ability to ‘hit the ground running’ during plant hot commissioning/ production ramp up

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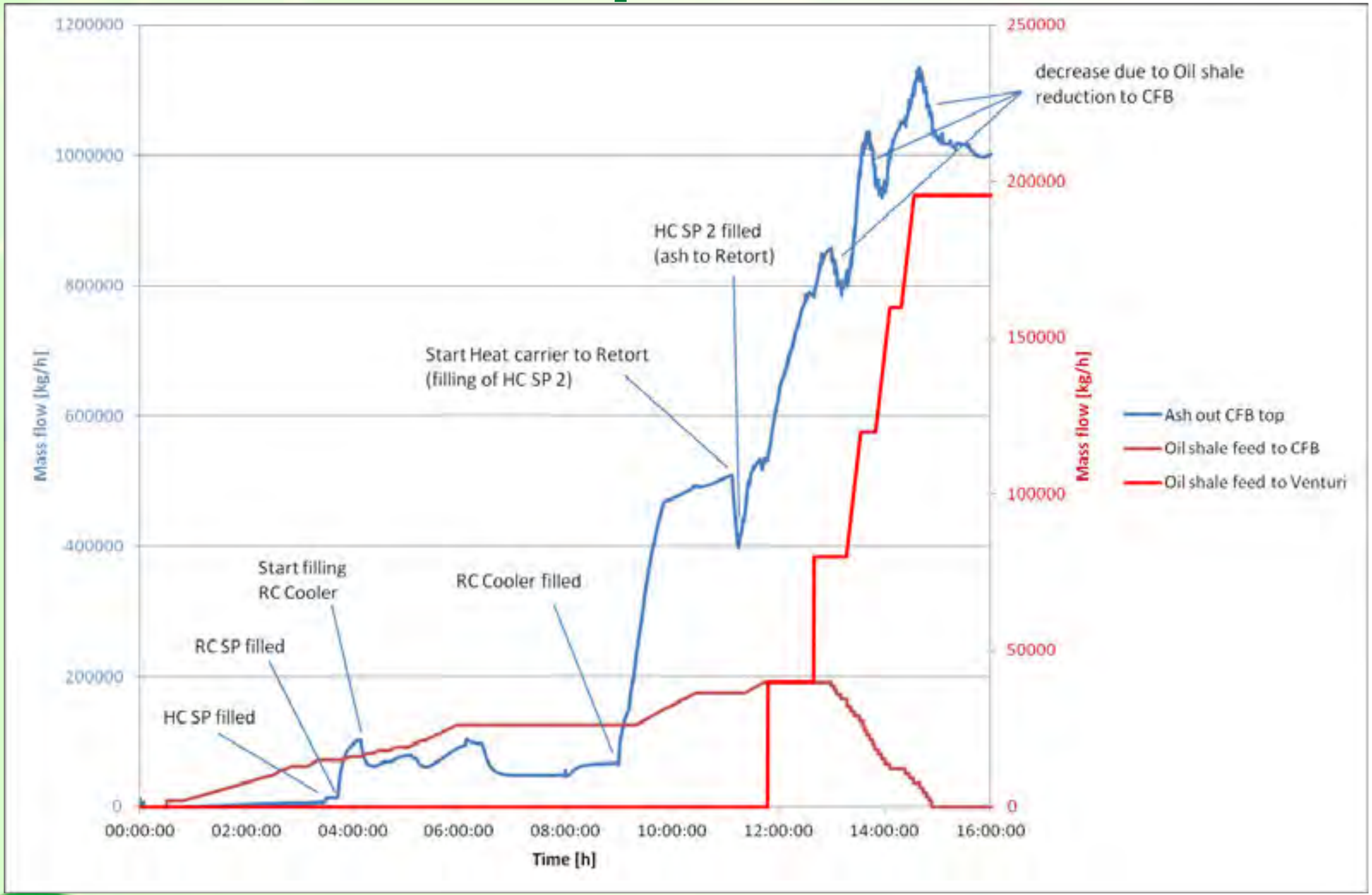
Results: start-up



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Results of dynamic simulation

- Determination of the best practices and procedures to start-up and shut down the Enefit280 plant
- Optimization of the control strategy of the plant
- Development/optimization of plant control parameters
- Better understanding of the behavior and controllability of the Enefit280 plant before plant commissioning

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Future initiatives

- The results of dynamic simulation have to be verified with real plant data after commissioning of the Enefit280 plant
- The dynamic simulation will be further developed based on experience achieved after commissioning the Enefit280 plant
- The dynamic model will form the basis of an operator training simulator for the Enefit280 plant

Summary

- Investment in and development of a dynamic simulator for the Enefit280 process has achieved the following key goals
  - Ability to simulate a first-of-its-kind technology before the plant is commissioned
  - Determine best procedures/practices for start up, production ramp up and shutdown scenarios
  - Optimization of plant control philosophy
  - Foundation stone of an operator training simulator

Thank you for your attention!

Any questions?

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