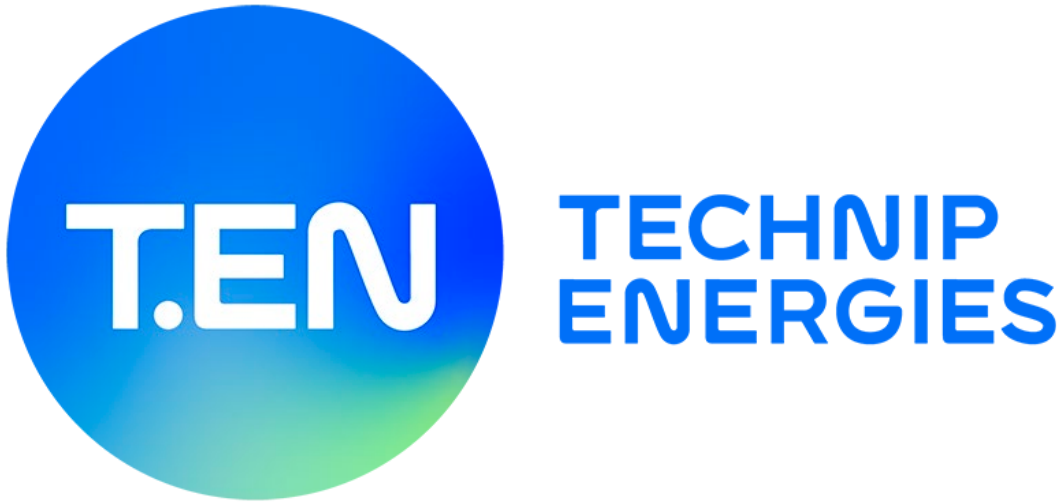

AVEVAWORLD
PARIS


T.EN
TECHNIP
ENERGIES

AVEVA World 2024

Capturing CO2 from air – an unusual dynamic simulation

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Agenda

1. Technip Energies
2. Direct Air Capture Technology
3. Dynamic Simulations
4. Conclusion
5. Questions

Technip Energies at a glance

Listed on
Euronext Paris
Stock Exchange

Headquartered in
Paris

65+
Years of operations

€6bn
Full year 2023 adjusted revenue

A leading engineering & technology company for the energy transition

€17bn
Backlog at end June 2024

~16,000
Employees in 34 countries

25+
Leading proprietary technologies

500+
Projects under execution

Our solutions to accelerate the energy transition

Our services and capabilities

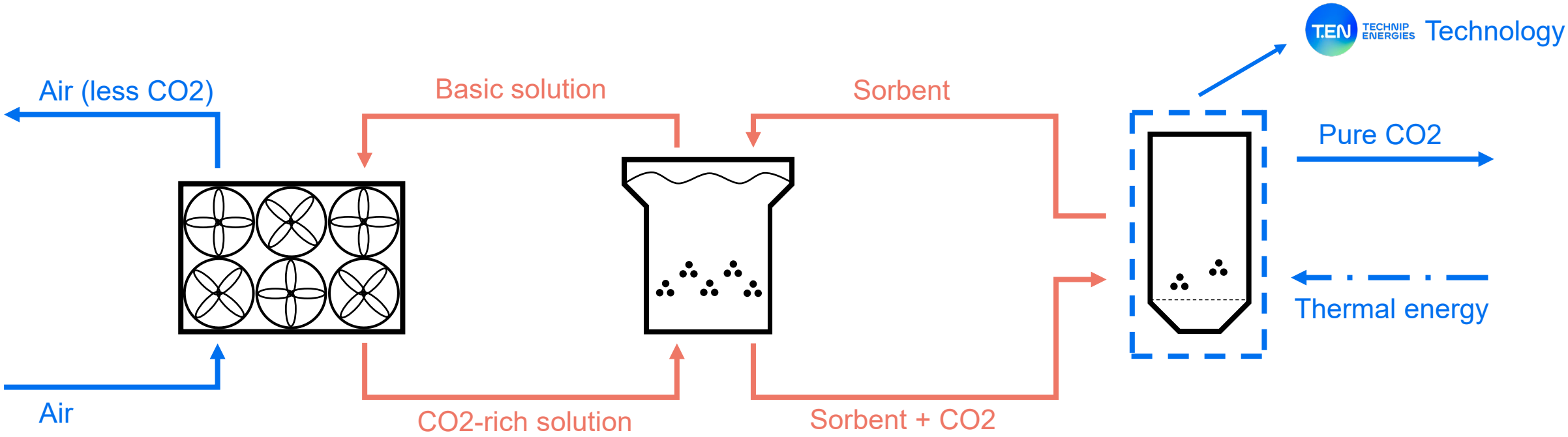
- **Consulting**
- **Engineering, Procurement & Construction** (EPC)
- **Project Management Consultancy** (PMC)
- **Modularization**
- **Technology scale-up**
- **Products**

Our markets

- **Natural gas**
- **Hydrogen**
- **Downstream**
- **Sustainable Fuels**
- **Carbon Capture, Utilization & Storage** (CCUS)
- **Circularity**
- **Zero-carbon energies**
- **Industries**
- **Loading Systems**

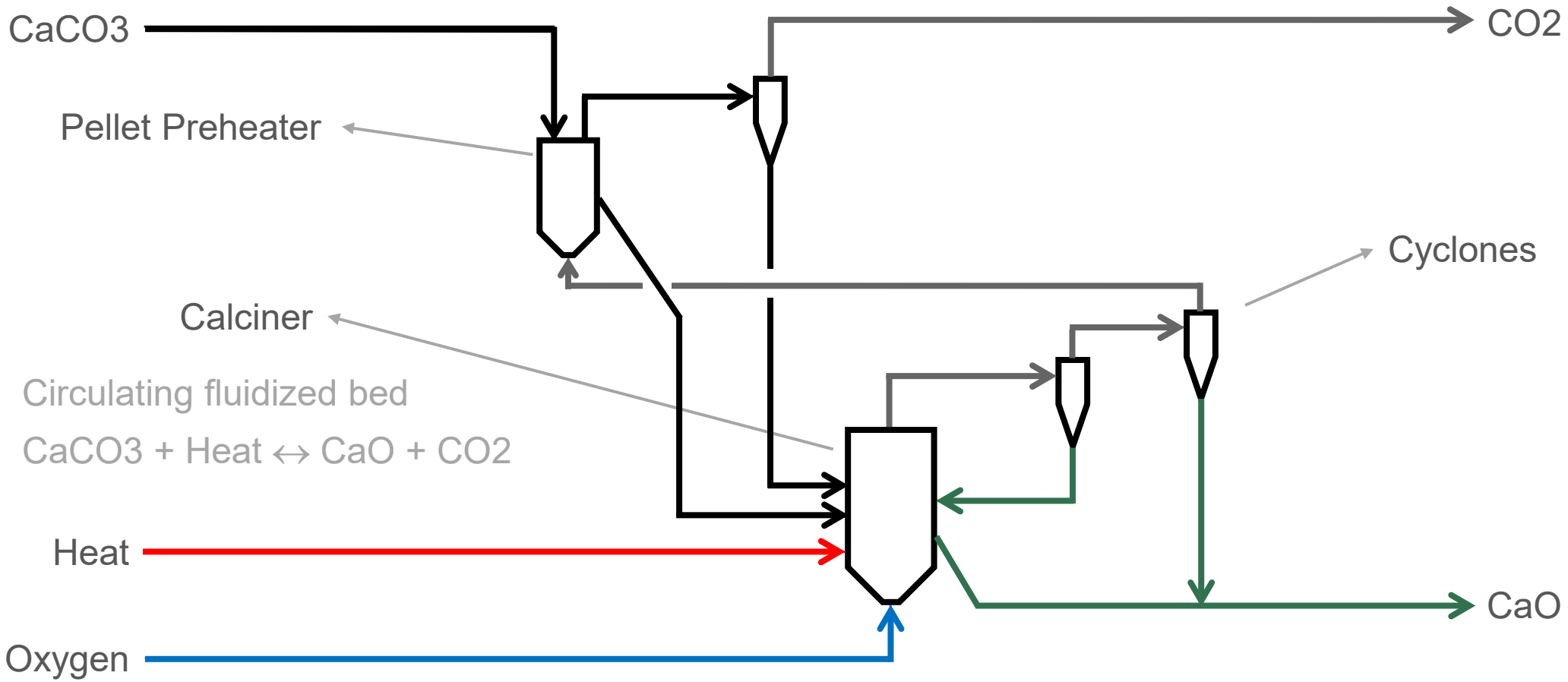
Direct Air Capture Technology

Overview



Direct Air Capture Technology

Calciner Unit



Dynamic Simulations

Objectives

Simulate start-up and other scenarios

Test different operation setups

Calculate non-measured variables (heat losses, recirculation flow)

Provide an “ideal” reference, to which operating data can be compared

Operator training

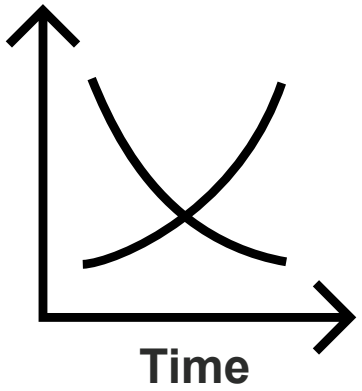
Dynamic Simulations

What is dynamic (process) simulation?

Tool based on chemical/physical principles used to model the behavior of process variables over time

Main applications

- Engineering Studies
- Operator Training Simulators



Key elements

- Thermodynamics (method and components)
- Unit operations (topology + sizing/performance information)
- Control scheme (to ensure stable operation)

Dynamic Simulations

Methodology

AVEVA Dynamic Simulation

Phase 1 – Pilot

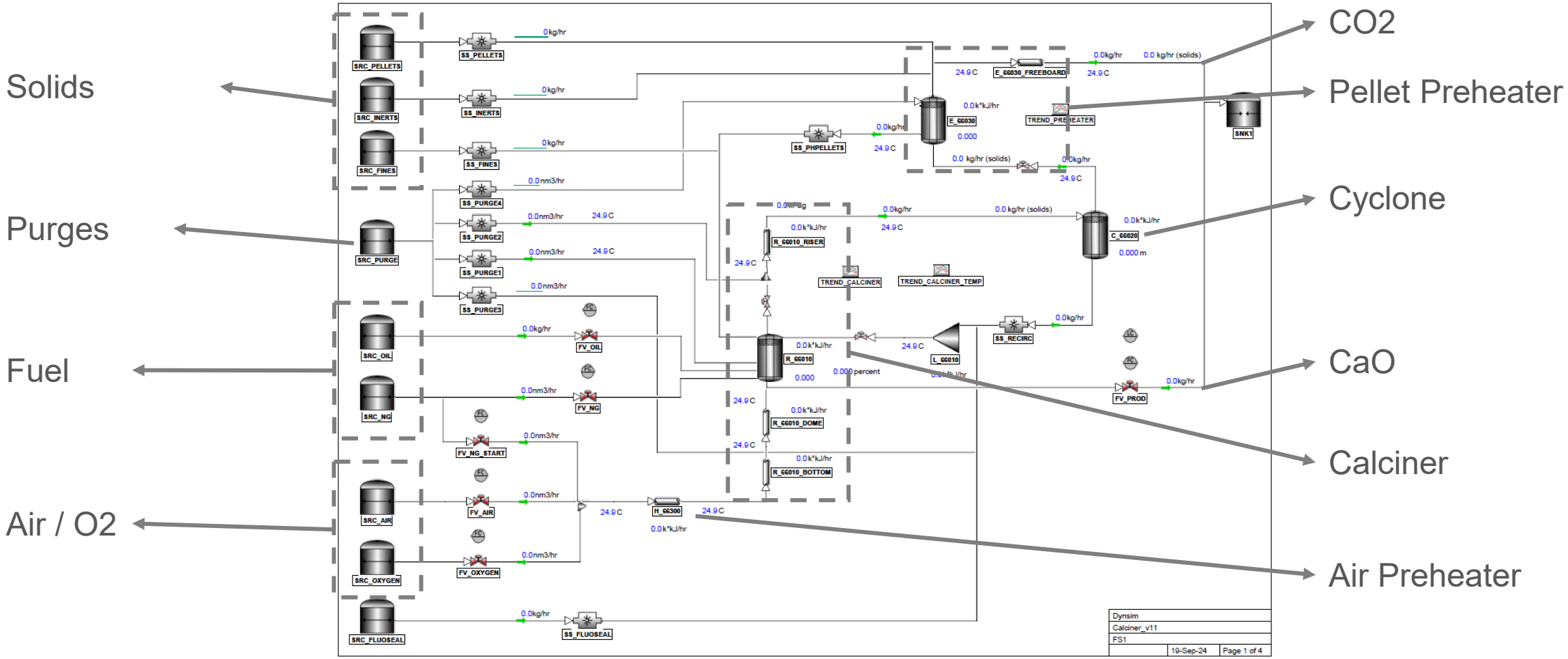
- Model initially built based on design data (Heat & Material Balance)
- Model adjusted to match available operating data (flow rates, temperatures)

Phase 2 – Large-scale

- Ongoing work

Dynamic Simulations

Model topology (Pilot)



Dynamic Simulations

Assumptions

Conversion reaction

- Calcination is a chemical equilibrium
- Reaction modeled with an overall conversion, assumed as an exponential function of temperature

Fluidization

- Particle size not considered
- Assumed fixed void fraction for holdup/level calculations

Dynamic Simulations

Challenges and Solutions

Solids properties

- Component database is much more used (and validated) for oil & gas & chemicals

➢ Validation by comparison with literature values

Solids flow

- Solver is based on pressure-flow relationship, not necessarily appropriate to model solids flow

➢ Flow is “forced” through “Stream Sets” (directly set by user or a custom equation)

Dynamic Simulations

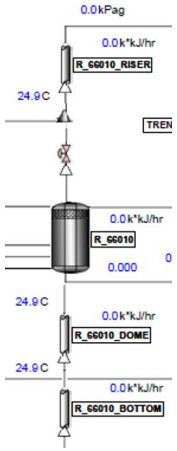
Challenges and Solutions

Solids entrainment

- Normally the solids remain in the heavy phase of the “Drum” and do not go to the gas phase
- Configuration of an entrainment fraction to force part of the solids to go to the gas product
  - This fraction is proportional to the gas flow in the fluidized beds
- This entrainment defines the solids recirculation and the cyclones separation efficiency

Discretization of fluidized beds

- Most unit operations assume a perfect mixing and calculate single holdup properties
- To better represent the temperature gradients in the Calciner and Pellet Preheater, they were modeled using more than one unit operation



AVEVA Dynamic Simulation

File Edit View Input Run Tools Options Draw Window Help

User: simsci Environment: Engineer SimExecutive: SimExecutive

IC RESET
Simulation Time: 0:00:00.00
Set Speed: 100 % of Real Time
Simulation Speed: 100.23 %

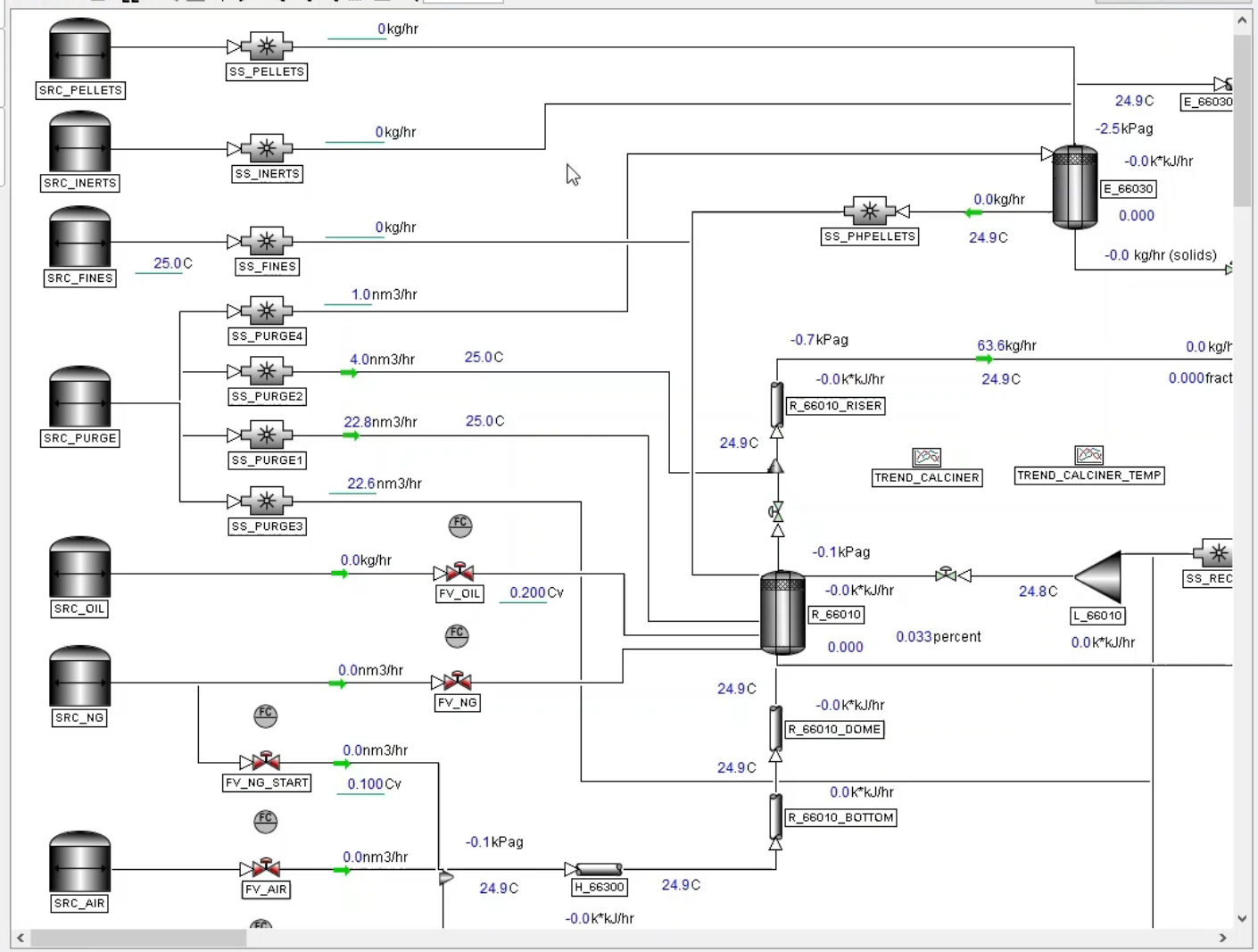
Current IC: 2
Cold Start
Current Backtrack: 2
Oldest Backtrack: 3
Backtrack Actions: Disabled

Active Malfunctions

Actions Supported for : Undo Redo
Trend data change : TREND_OVERALL_1 @ FS1
Trend data change : TREND_OVERALL_1 @ FS1
Trend data change : TREND_OVERALL_2 @ FS1
Trend data change : TREND_OVERALL_2 @ FS1

FS FS1, Calciner_v11

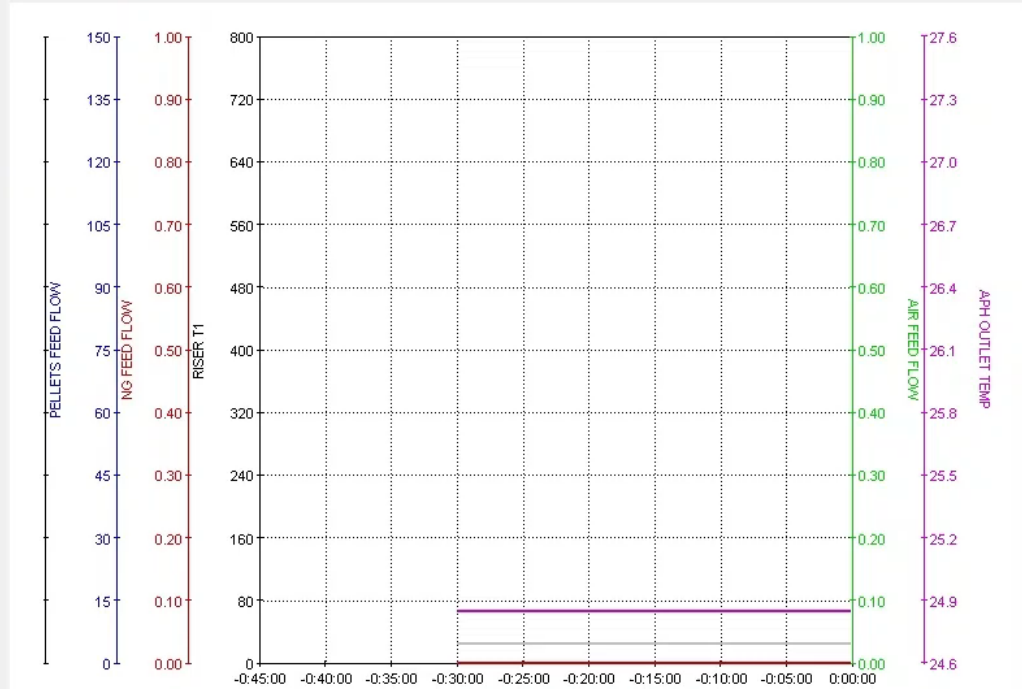
Row 1, Col 1 100% Model Editing



TREND_OVERALL_1

OK Apply Cancel CSV Print Show Configuration Hide Table Show Legend

Color	Name	Value	Units	Custom Description	Min	Max	Auto	Axis	Collection Set	Da
	S101.W	0.0	Default (kg/hr)	PELLETS FEED FLOW	0.0	150.0	☐	☑	Medium	En
	AIRSTART_2.F	0.0	Default (nm3/hr	AIR FEED FLOW	0.0	1.0	☑	☑	Medium	En
	NGSTART_2.F	0.0	Default (nm3/hr	NG FEED FLOW	0.0	1.0	☑	☑	Medium	En
	MIXFEED_2.T	24.8500	Default (C)	APH OUTLET TEMP	24.6	27.6	☑	☑	Medium	En
	R_66010.T	24.8835	Default (C)	RISER T1	0.0	800.0	☐	☑	Medium	En
	S107.T	24.8832	Default (C)	RISER T8	0.0	800.0	☐	☐	Medium	En
	S112.T	24.8707	Default (C)	CYCLONE OUT TEMP	0.0	800.0	☐	☐	Medium	En
	E_66030.T	24.8588	Default (C)	PPH BED TEMP	0.0	800.0	☐	☐	Medium	En



Freeze

TREND#TREND_OVERALL_1 TREND#TREND_OVERALL_2

Messages

Command:

Selection cleared

Dynamic Simulations

Large-scale model (Ongoing)

New topology

- Different feeds
- Additional cyclones
- New equipment sizes

New chemical components and reactions

- New reaction: $CaO + CO_2 \rightarrow CaCO_3$
- New component: $Ca(OH)_2$

Same modeling approach for solids

Dynamic Simulations

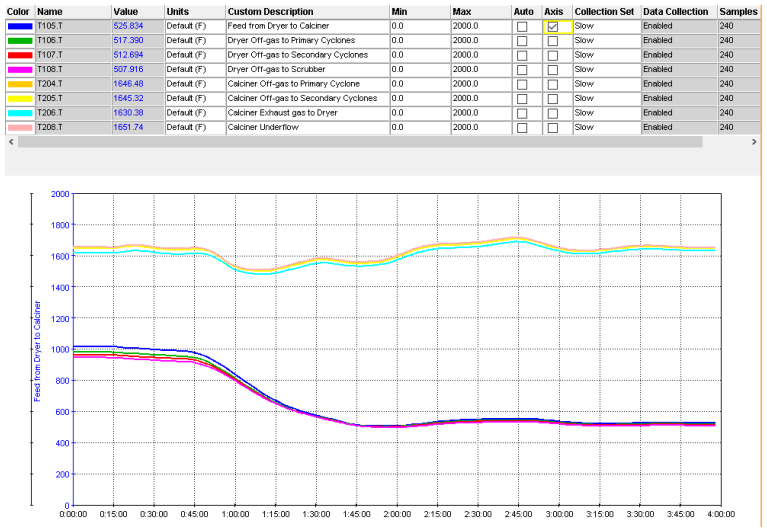
Large-scale model (Ongoing)

Simulation of part of start-up procedure

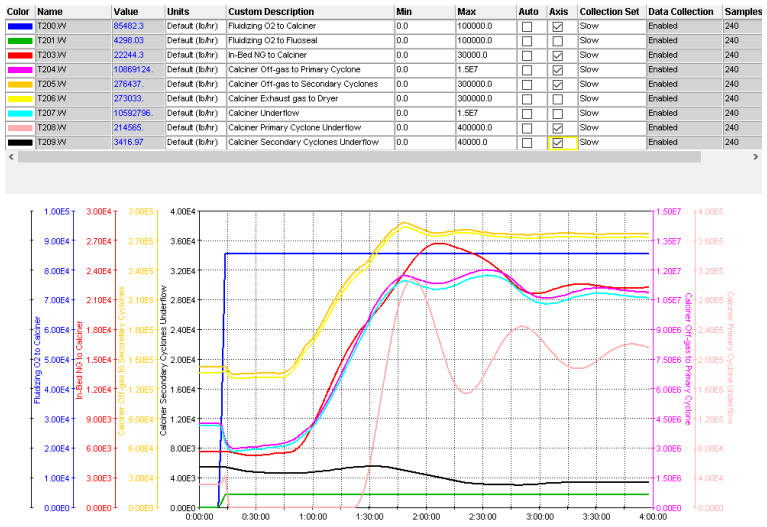
- Adjustment of the model to match different operating cases
  - Fine tuning of equations for heat transfer coefficients and solids entrainment

Next steps (planned)

- Other scenarios
- Operator training



Color	Name	Value	Units	Custom Description	Min	Max	Auto	Axis	Collection Set	Data Collection	Samples
	T105.T	525.834	Default (F)	Feed from Dryer to Calciner	0.0	2000.0		☑	Slow	Enabled	240
	T106.T	517.390	Default (F)	Dryer Off-gas to Primary Cyclones	0.0	2000.0			Slow	Enabled	240
	T107.T	512.694	Default (F)	Dryer Off-gas to Secondary Cyclones	0.0	2000.0			Slow	Enabled	240
	T108.T	507.916	Default (F)	Dryer Off-gas to Scrubber	0.0	2000.0			Slow	Enabled	240
	T204.T	1646.48	Default (F)	Calciner Off-gas to Primary Cyclone	0.0	2000.0			Slow	Enabled	240
	T205.T	1645.32	Default (F)	Calciner Off-gas to Secondary Cyclones	0.0	2000.0			Slow	Enabled	240
	T206.T	1630.38	Default (F)	Calciner Exhaust gas to Dryer	0.0	2000.0			Slow	Enabled	240
	T208.T	1651.74	Default (F)	Calciner Underflow	0.0	2000.0			Slow	Enabled	240



Color	Name	Value	Units	Custom Description	Min	Max	Auto	Axis	Collection Set	Data Collection	Samples
	T200.W	85482.3	Default (lb/hr)	Fluidizing O2 to Calciner	0.0	100000.0		☑	Slow	Enabled	240
	T201.W	4298.03	Default (lb/hr)	Fluidizing O2 to Fluoseal	0.0	100000.0			Slow	Enabled	240
	T203.W	22244.3	Default (lb/hr)	In-Bed NG to Calciner	0.0	30000.0		☑	Slow	Enabled	240
	T204.W	10869124.	Default (lb/hr)	Calciner Off-gas to Primary Cyclone	0.0	1.5E7		☑	Slow	Enabled	240
	T205.W	276437.	Default (lb/hr)	Calciner Off-gas to Secondary Cyclones	0.0	300000.0		☑	Slow	Enabled	240
	T206.W	273033.	Default (lb/hr)	Calciner Exhaust gas to Dryer	0.0	300000.0			Slow	Enabled	240
	T207.W	10592796.	Default (lb/hr)	Calciner Underflow	0.0	1.5E7			Slow	Enabled	240
	T208.W	214565.	Default (lb/hr)	Calciner Primary Cyclone Underflow	0.0	400000.0		☑	Slow	Enabled	240
	T209.W	3416.97	Default (lb/hr)	Calciner Secondary Cyclones Underflow	0.0	40000.0		☑	Slow	Enabled	240

OIL GAS AND ENERGY

Technip Energies builds a process model to run dynamic simulations of a Calciner unit

Challenge

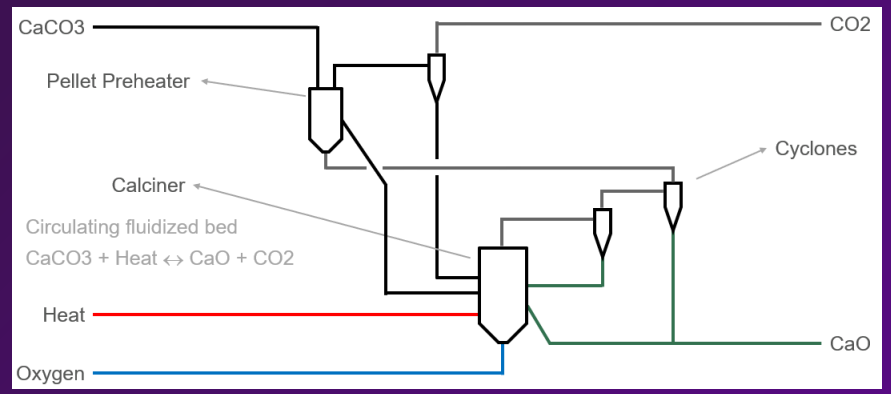
- Development of a simulator of a Calciner to support operators and engineers, in particular during start-up of the unit
- Increasing demand to simulate “unusual” processes with the Energy Transition, which present higher difficulty for modelling

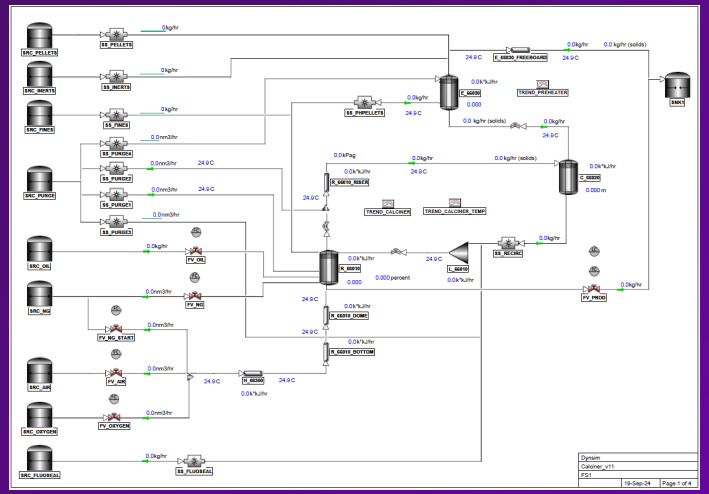
Solution

- Process model built in AVEVA Dynamic Simulation for the Calciner unit
- High level of customization needed to address the “unusual” aspect of the system

Results

- **Supported operation team during pilot phase**
- **Simulated start-up scenarios**
- **Evaluated different operating conditions and setups**
- **Calculated non-measured variables (e.g. solids recirculation flow rate)**





Questions?

Dynamic Simulation

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Calciner

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TECHNIP ENERGIES

Thank you