Jun 17th 2026

ENHANCING CHEMICAL PROCESS DESIGN AND OPERATION THROUGH MODEFRONTIER: CASE STUDIES FROM NEXTCHEM

NEXTCHEM
MAIRE Sustainable Technology Solutions

AGENDA

01 WHO IS NEXTCHEM

02 NX CPO & E-SAF PRODUCTION

03 GREEN AMMONIA PRODUCTION

04 CONCLUSION & NEXT STEPS

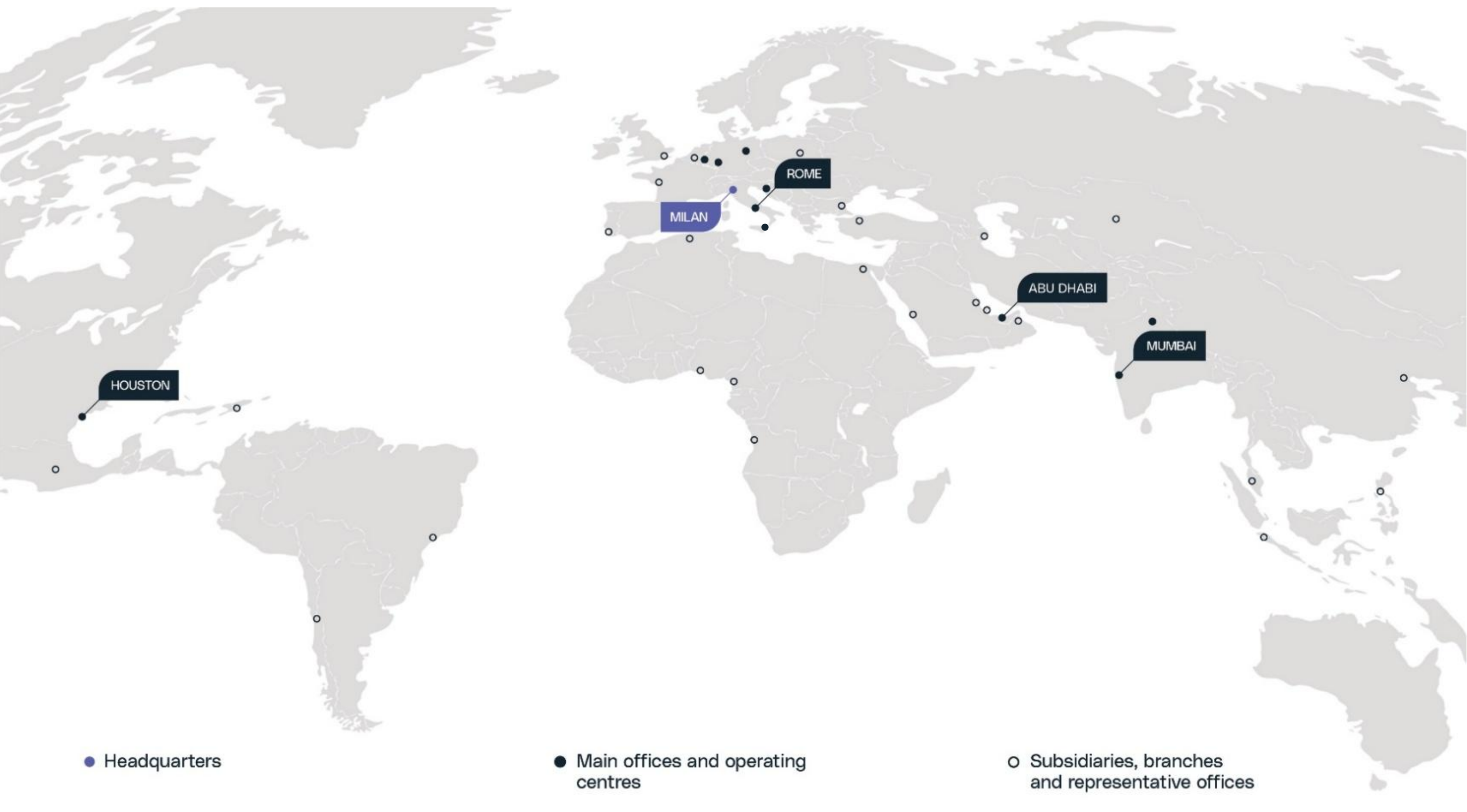
01

WHO IS NEXTCHEM

MAIRE AT A GLANCE

We are a technology and Engineering Group that develops and implements innovative solutions to enable the Energy Transition.

We offer Sustainable Technology Solutions, optimizing conventional processes and creating new ones from non-fossil feedstock and Integrated E&C Solutions, bringing into reality complex plants and frontier project to provide access to the latest technologies.



7.1 Revenues (€ billion)

12.7 Backlog (€ billion)

284.5 Net Income (€ million)

50 Countries

~11,500 Employees

~50,000 People engaged worldwide*

Data as of 31st December, 2025
*The data includes employees, collaborators and sub-contractors

BRAND ARCHITECTURE

MAIRE

Sustainable Technology Solutions

NEXTCHEM
MAIRE Sustainable Technology Solutions

Integrated E&C Solutions

TECNIMONT
MAIRE Integrated E&C Solutions

KT
MAIRE Integrated E&C Solutions

Project Development

MET DEVELOPMENT
MAIRE Project Development

A STREAMLINED STRUCTURE

Three business lines serving major driving forces

Sustainable Fertilizers & Nitrogen-Based Fuels

Driving sustainable nitrogen solutions in **fertilizers**, leveraging our leadership in **urea**, while innovating in **ammonia** for hydrogen transport

Low-Carbon Energy Vectors

Advancing low-carbon energy via **hydrogen** and **CO^2 valorization**, powering aviation, shipping, chemicals, as well as **sustainable plastics** innovation

Sustainable Materials & Circular Solutions

Enhancing **circularity** by transforming waste into valuable resources, while using **chemical** and **mechanical recycling** for sustainable material recovery

ONE MISSION, MANY EXCELLENCES

ITALY

CONSER
Designs and licenses technologies for Maleic Anhydride (MAN) and its derivatives, Butanediol (BDO), Gamma-Butyrolactone (GBL) and n-Methyl Pyrrolidone (NMP) production with a focus on minimizing waste and energy consumption.

HYDEP
Provides engineering solutions for low-carbon hydrogen production. HyDEP supports the deployment green hydrogen technologies, specializing in the mechanical and electrochemical sectors.

KT TECH
Engineers and licenses proprietary process technologies for hydrogen, syngas, sulfur recovery, and emissions reduction. KT-Tech specializes in advanced reforming concepts, including ATR and catalytic partial oxidation.

MYRECHEMICAL
Develops and licenses technologies for the conversion of waste and renewables into circular fuels and chemicals.

MYREMONO
Develops and licenses sustainable technologies for plastic value chain intermediate production from renewable and circular feedstocks. MyRemono enables continuous chemical recycling process to recover monomers through an innovative plastic catalytic depolymerization technology.

CIRCULAR TECH
Provides advanced technology solutions for plastic and waste recycling. Circular Tech supports the transition toward circular material flows, enabling the recovery and transformation of post-consumer and industrial waste streams.

NEXT-N
Integrates intellectual property and advanced engineering services for next generation nuclear power.
It works alongside leading technology providers to support the design and industrialization of innovative plants.

MYREPLAST INDUSTRIES
Develops an innovative mechanical upcycling process to produce high-purity recycled and compounded polymers based on proprietary NX Replast™ technology

GERMANY

TPI
Delivers engineering and technology solutions for LDPE high-pressure plants. TPI is a leader in the engineering and design services and focuses on project execution and support.

GASCONTEC
A company focused on hydrogen and methanol technology. The portfolio includes the Autothermal Reforming (ATR), a proven technology to produce low-carbon footprint syngas with high rates of carbon capture.

NETHERLANDS

STAMICARBON
Designs and licenses nitrogen fertilizer technologies, specializing in urea, ammonia, and nitric acid. Stamicarbon offers tailored solutions and services to maintain, improve, and optimize plants in every stage of their life cycle, with a focus on sustainable fertilizer production.

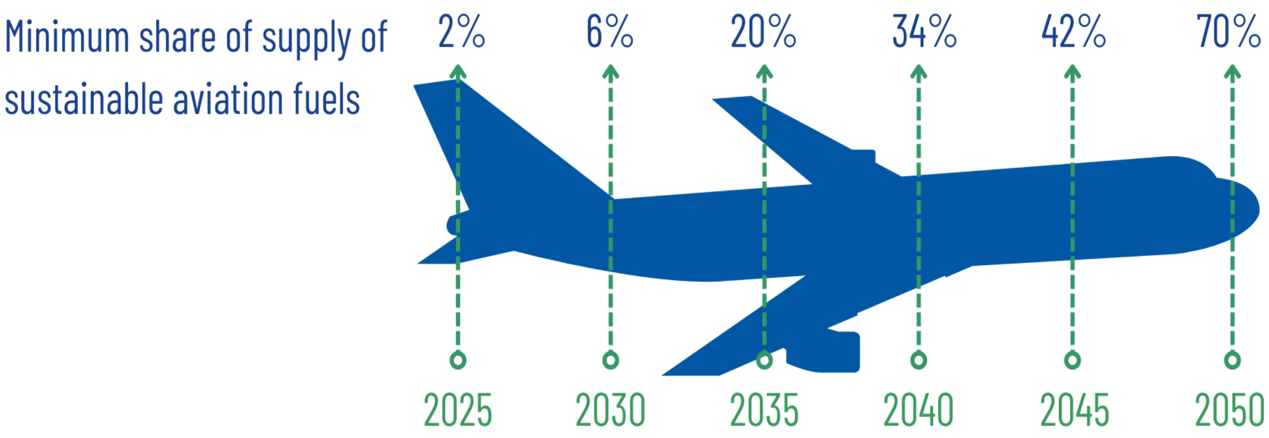
02

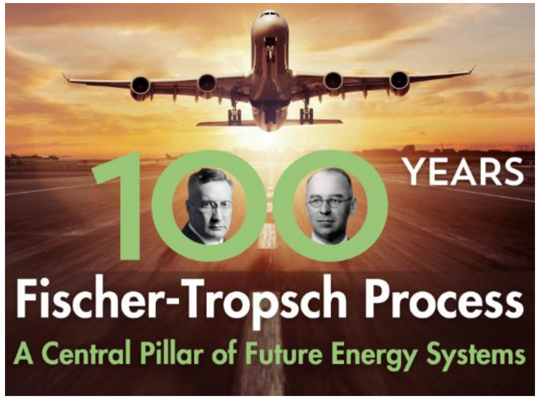
NX CPO & E-SAF PRODUCTION

THE CHALLENGE: MAKING SAF COST-COMPETITIVE

There is a Regulatory Push towards Sustainable Aviation Fuel (SAF):

- Mandatory SAF blending (ReFuelEU Aviation)
- Demand is locked-in by policy
- Risk shifts to producers’ cost structure





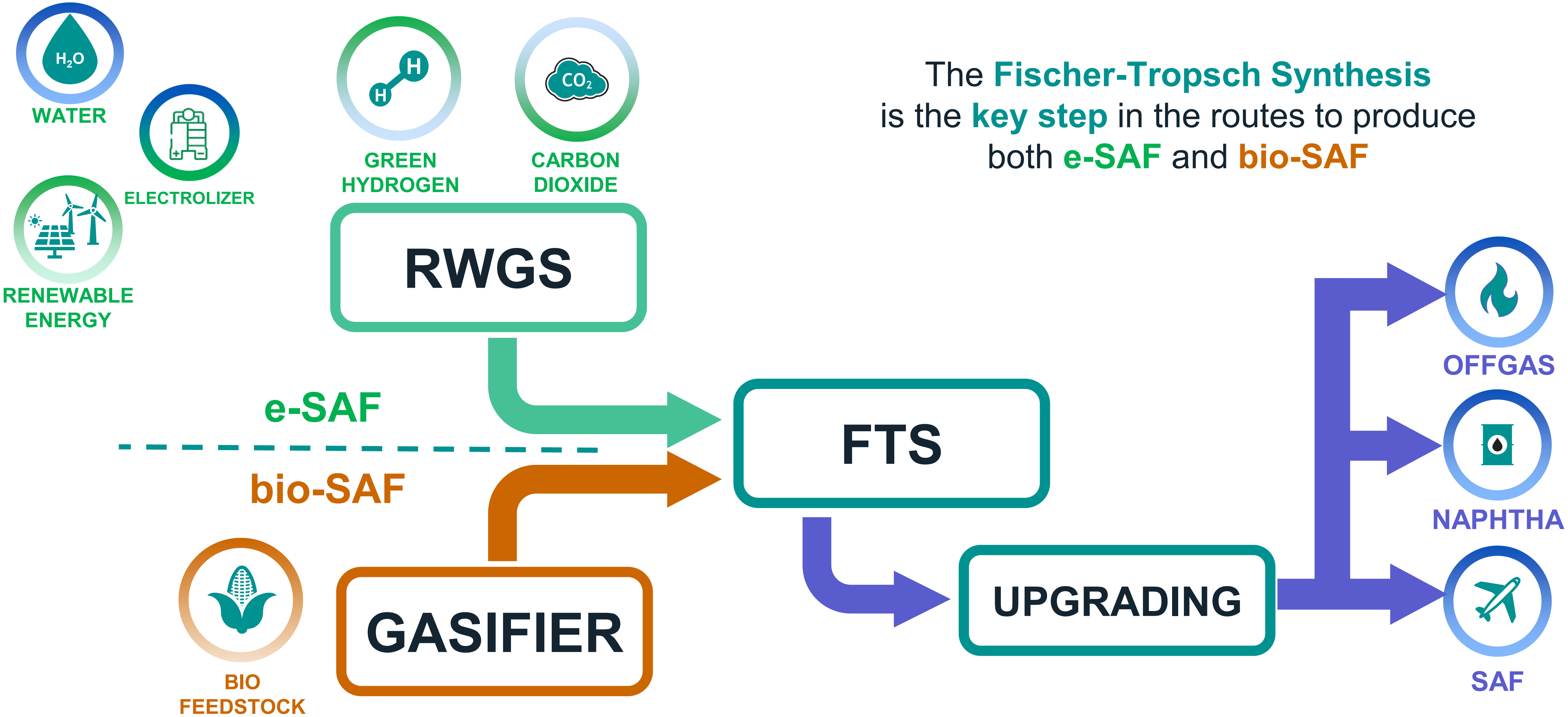
Multiple production pathways are possible

- HEFA (Hydroprocessed Esters and Fatty Acids) is the most mature and commercially deployed, but its scalability is limited by feedstock availability
- E-SAF (Synthetic SAF via Fischer-Tropsch Synthesis) enables long term scalability with near-carbon-neutral fuel production but is hindered by production costs.

Closing the cost Gap via Process intensification is critical to unlock large-scale SAF adoption

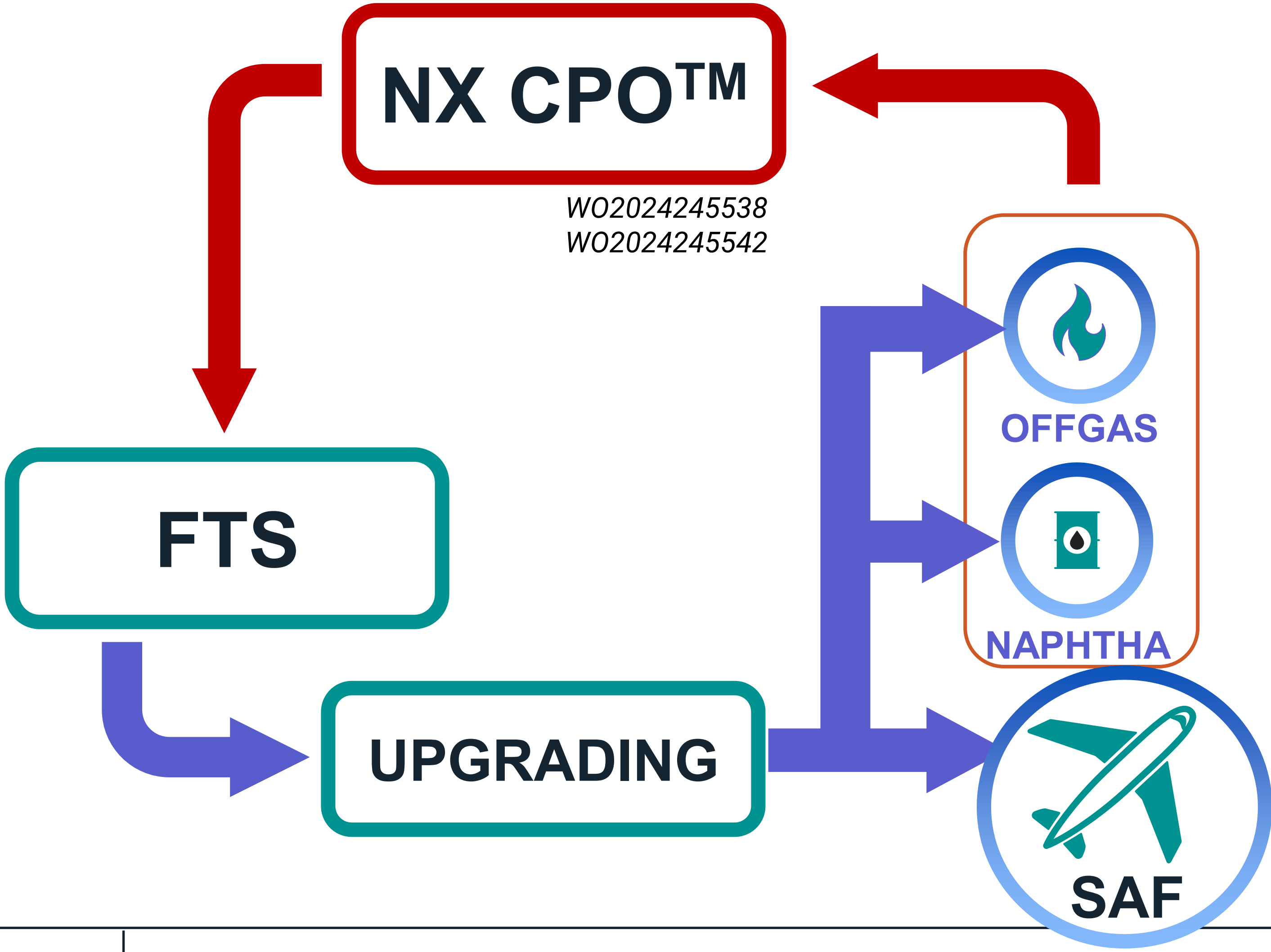
E-SAF PRODUCTION – FISCHER TROPSCH SYNTHESIS

The **Fischer-Tropsch Synthesis** is the **key step** in the routes to produce both **e-SAF** and **bio-SAF**



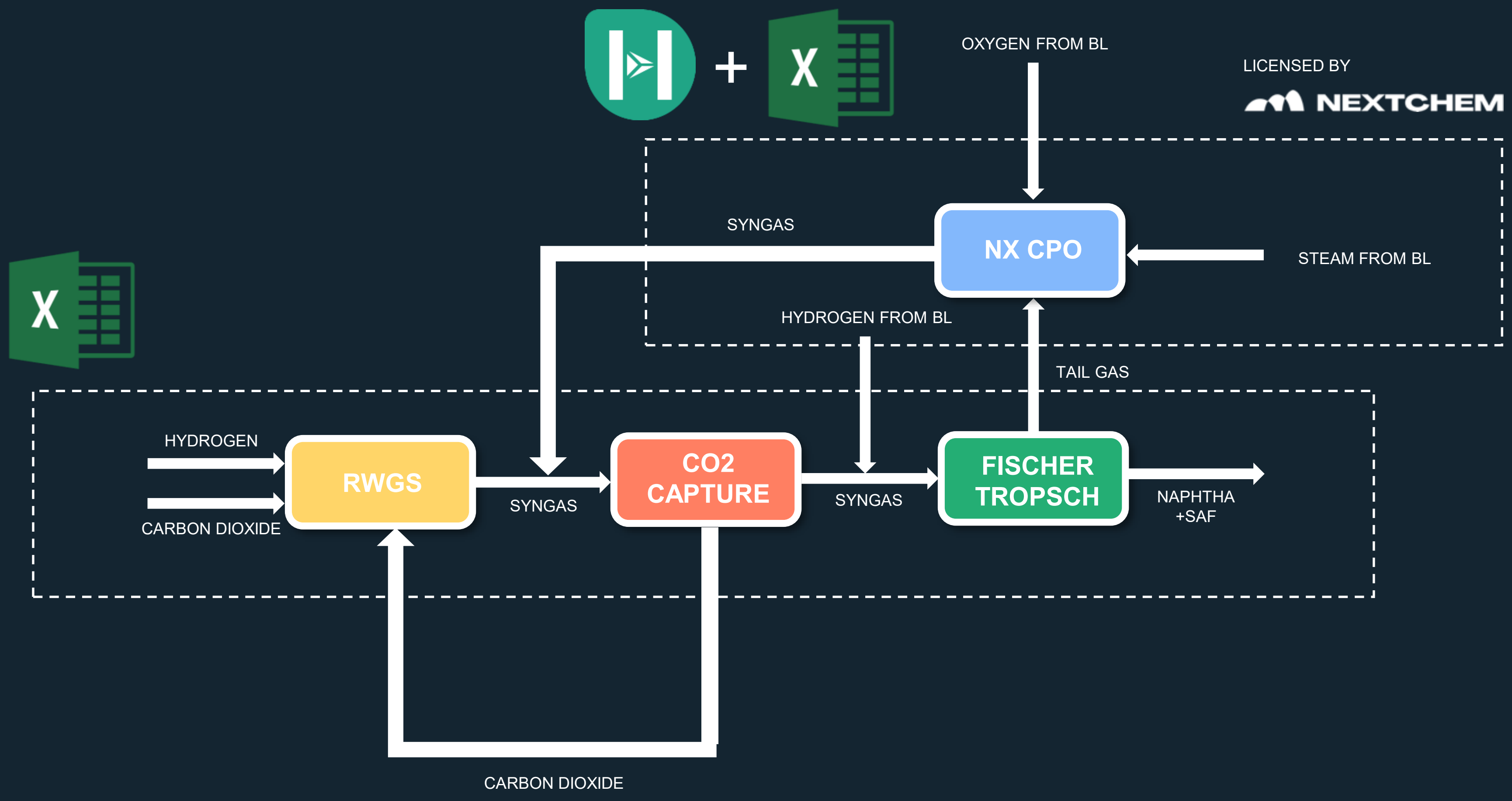
E-SAF PRODUCTION – BOOSTING THE CAPACITY

Syngas	
Capacity	50 – 50000 Nm^3/h
Pressure	5 – 20 bar
Carbon Conversion	> 99 %
Heat Balance	Exothermic process
H_2/CO molar ratio	2.2



NX CPO™ for E-**SAF** production
From **FRONT-END** to **SIDE-UNIT,**
leading to E-SAF production increase
Up to **30-50%**

SYSTEM MODELING



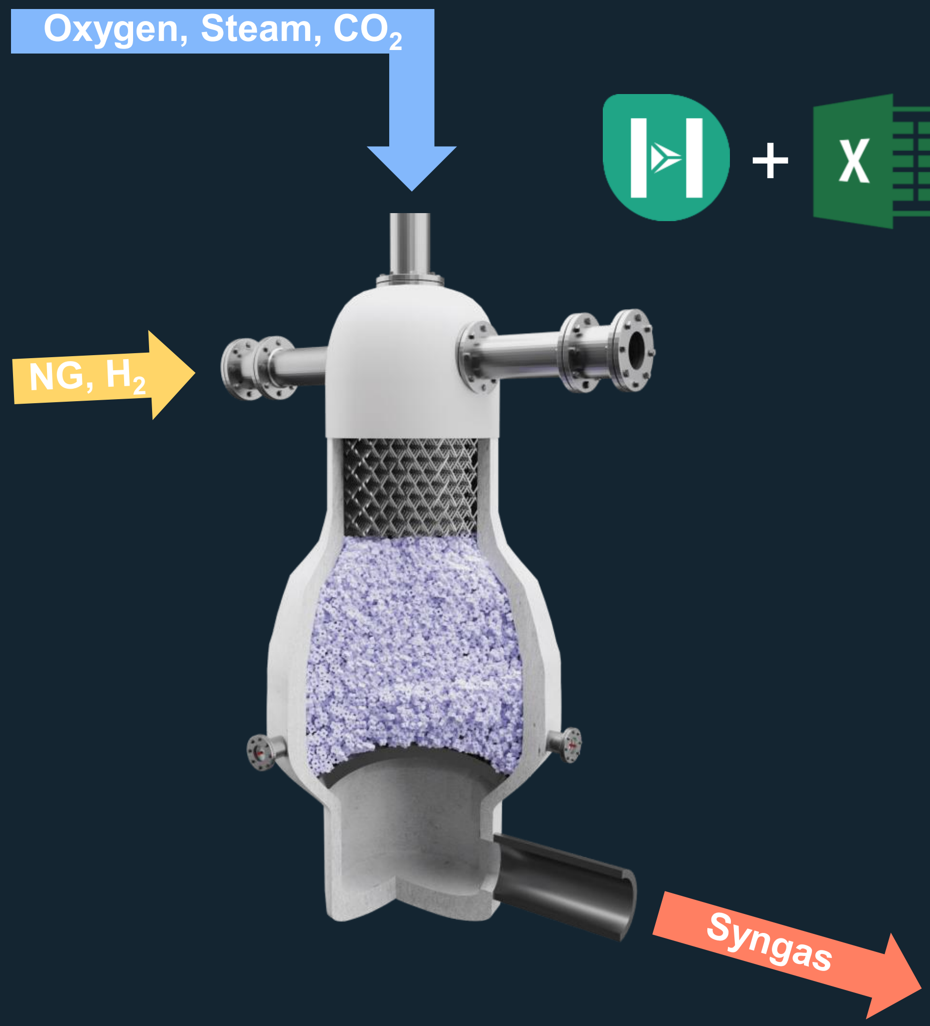
NX CPO™ MODELING IN ASPEN HYSYS

Modeling in ASPEN HYSYS is carried out with a physics informed Neural Network based on

~150 experimental data points used for model development, collected under a wide range of operating conditions, including variations in:

- Inlet temperature
- Inlet pressure
- Oxygen/Carbon (O/C) ratio
- Steam/Carbon (S/C) ratio
- CO_2/Carbon (CO_2/C) ratio
- Hydrogen Inlet concentration (H_2)

Ensures robust calibration and validation of the NX CPO model across diverse scenarios



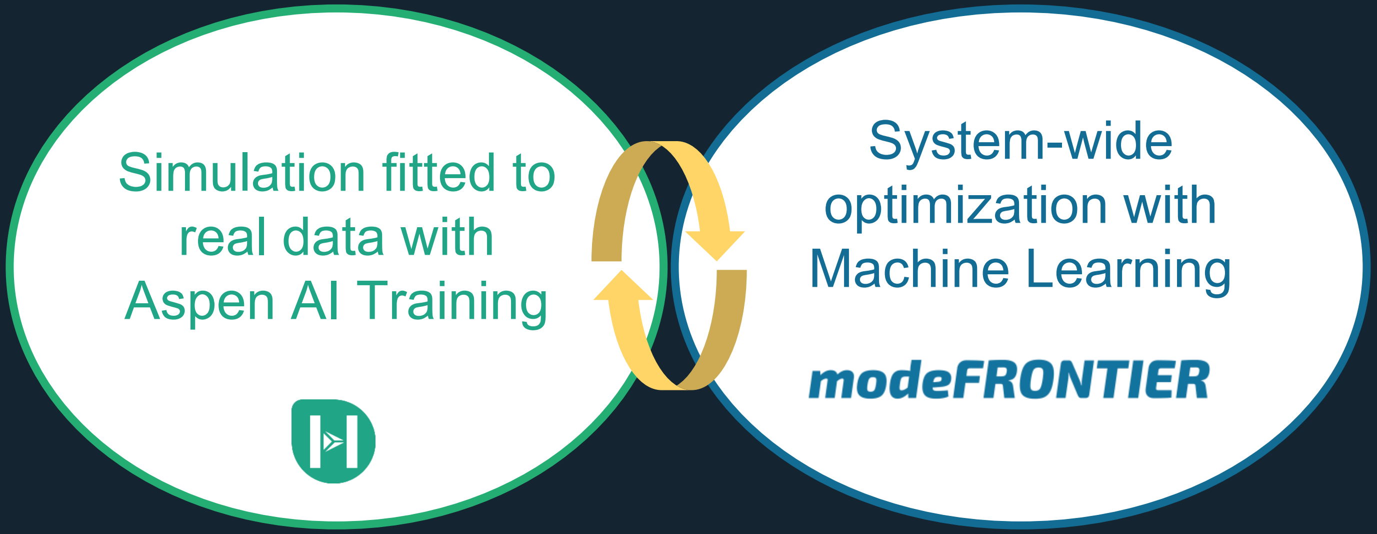
MULTI-OBJECTIVE SYSTEM OPTIMIZATION

A multi-objective optimization of the e-SAF production unit is carried out using modeFRONTIER, focusing on adjusting **three key parameters of the NX CPO process.**

- Steam to Carbon Ratio
- Oxygen to Carbon Ratio
- Reactor Inlet Temperature

The primary objectives of this optimization is to:

- Minimize Hydrogen Consumption
- Minimize the amount of CO_2 recycled
- Maximize the production of SAF

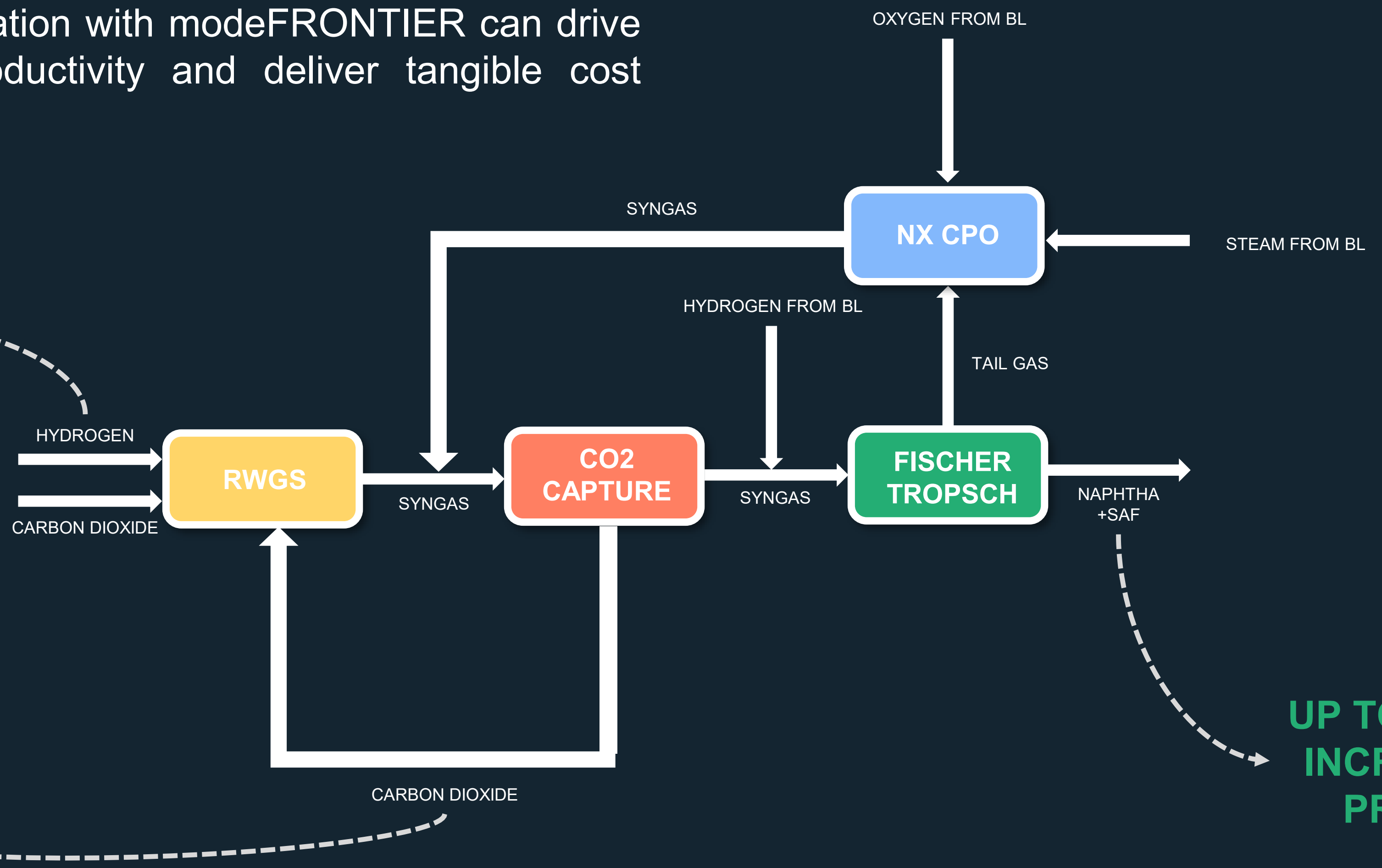


MULTI-OBJECTIVE SYSTEM OPTIMIZATION - RESULTS

Application of the multi-objective optimization to this case study highlighted how CPO optimization with modeFRONTIER can drive further improvements in productivity and deliver tangible cost savings.

UP TO 3.6% FURTHER DECREASE IN HYDROGEN CONSUMPTION

UP TO 14% FURTHER DECREASE IN CO_2 CAPTURED AND RECYCLED



UP TO 3%FURTHER INCREASE IN SAF PRODUCTION

03

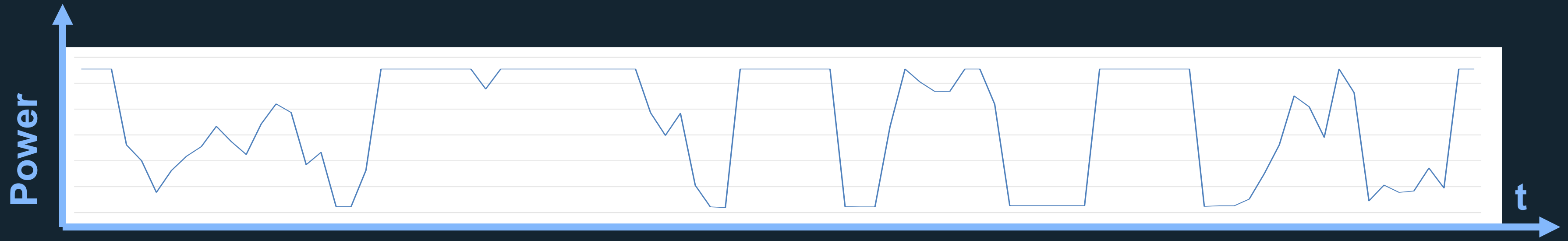
GREEN AMMONIA PRODUCTION

NEW CHALLENGES OF THE ENERGY TRANSITION

Green Chemicals plants are powered by **renewable energy sources**, which are often employed for Hydrogen production by Water Electrolysis. Hydrogen product can be either used as an energy carrier, or as feedstock for the downstream plants.

Renewable energy sources are often discontinuous

- **Complex plant design**
- **Inherently face frequent load variations**

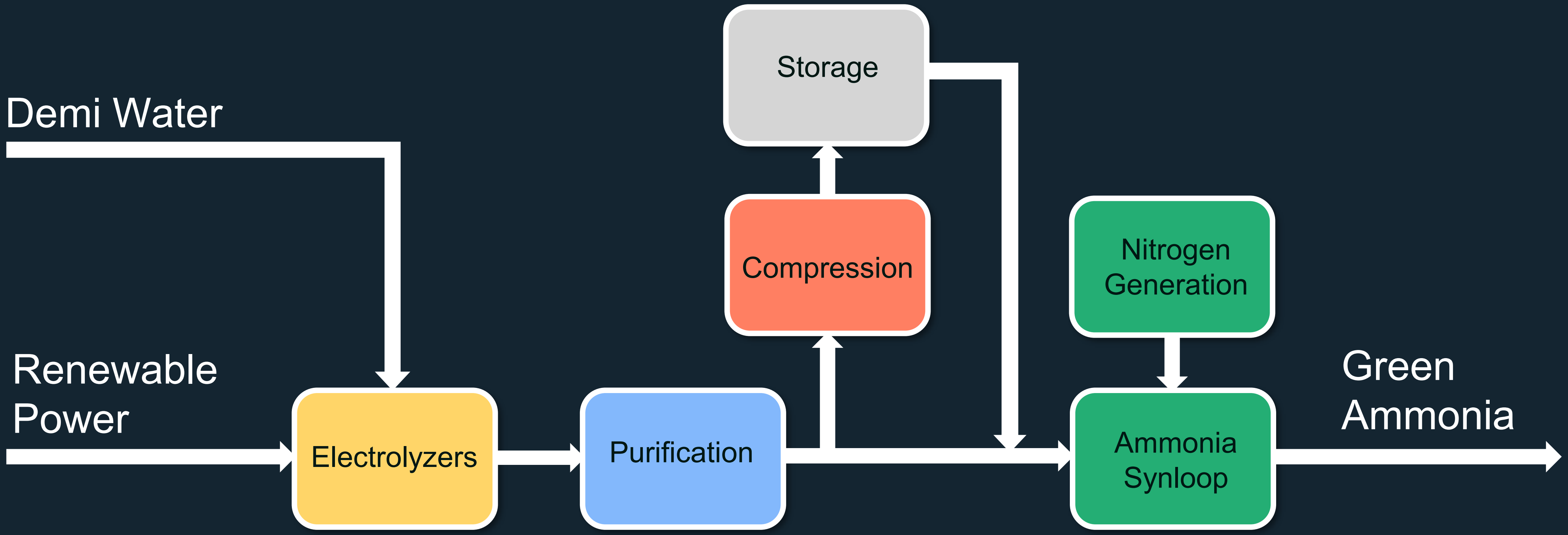


New challenges arise on the technical front

- The design must account for a **wide range** of different **operating conditions**
- The **operation of the plant must be optimized** to minimize costs and material wastes
- **Optimization involves managing a time series of events**, based on the system's dynamic behavior and its response to the fluctuations in power availability

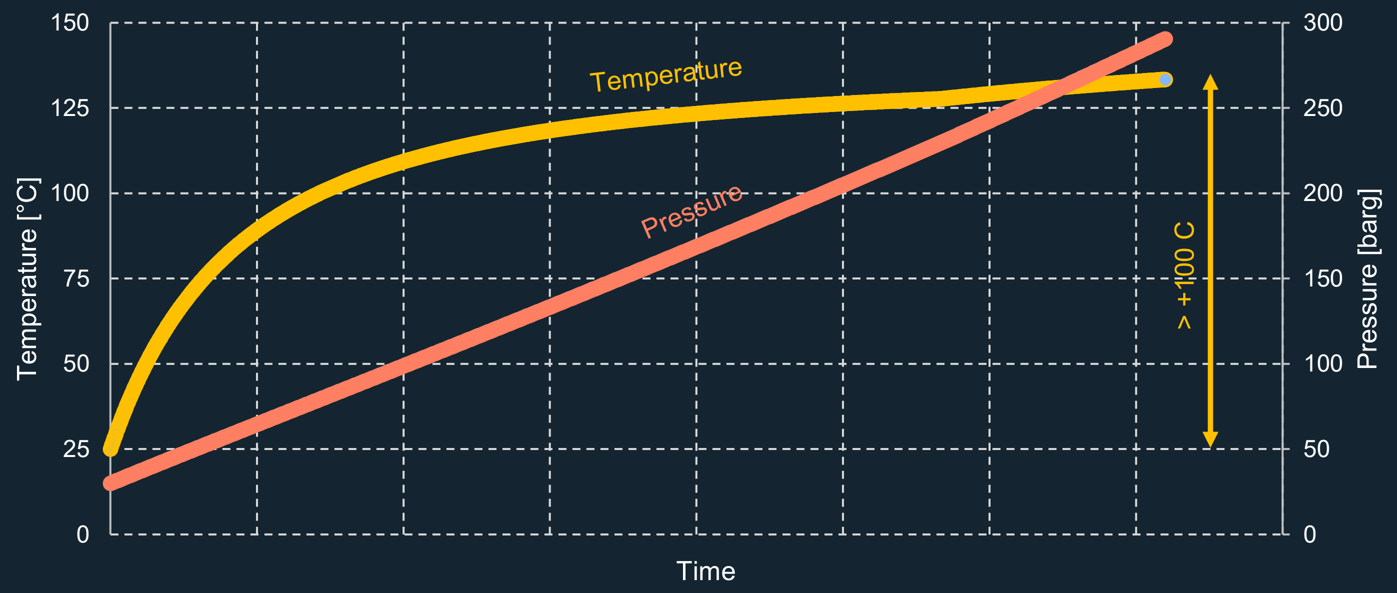
CASE STUDY: GREEN AMMONIA PRODUCTION

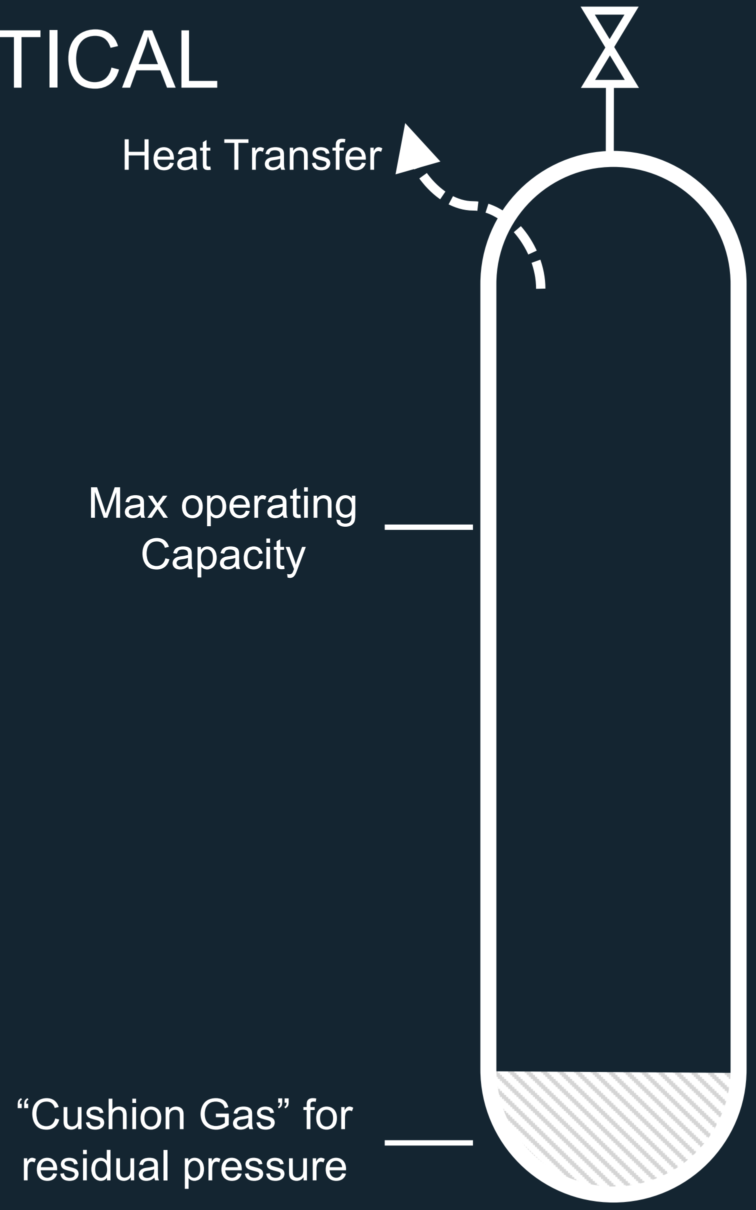
While electrolyzers are highly flexible and respond quickly to changes in power availability, **Hydrogen Storage** is employed to buffer these fluctuations, enhancing the **stability** of the downstream ammonia plant and ensuring **continuous operation** during periods of low power supply and, consequently, reduced hydrogen production.



H2 STORAGE DYNAMIC BEHAVIOR IS CRITICAL

- During cyclic filling and emptying of the Hydrogen Storage vessels there are strong **temperature variations** due to Thermodynamic effects and Heat Transfer phenomena

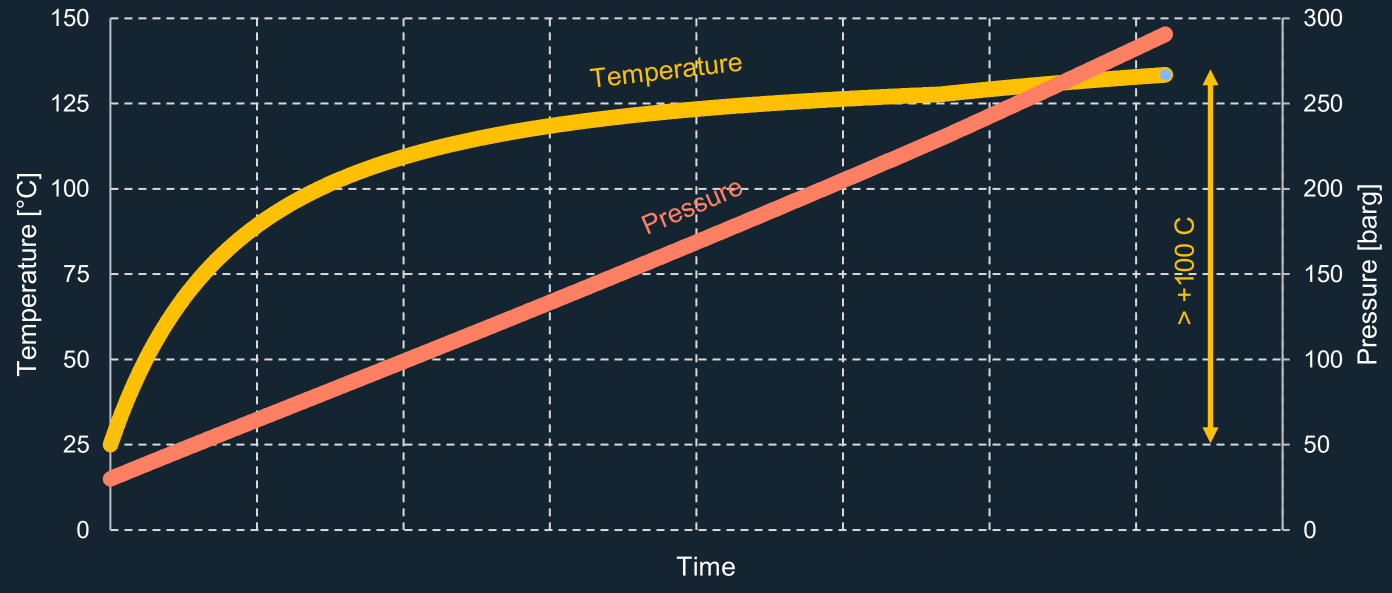


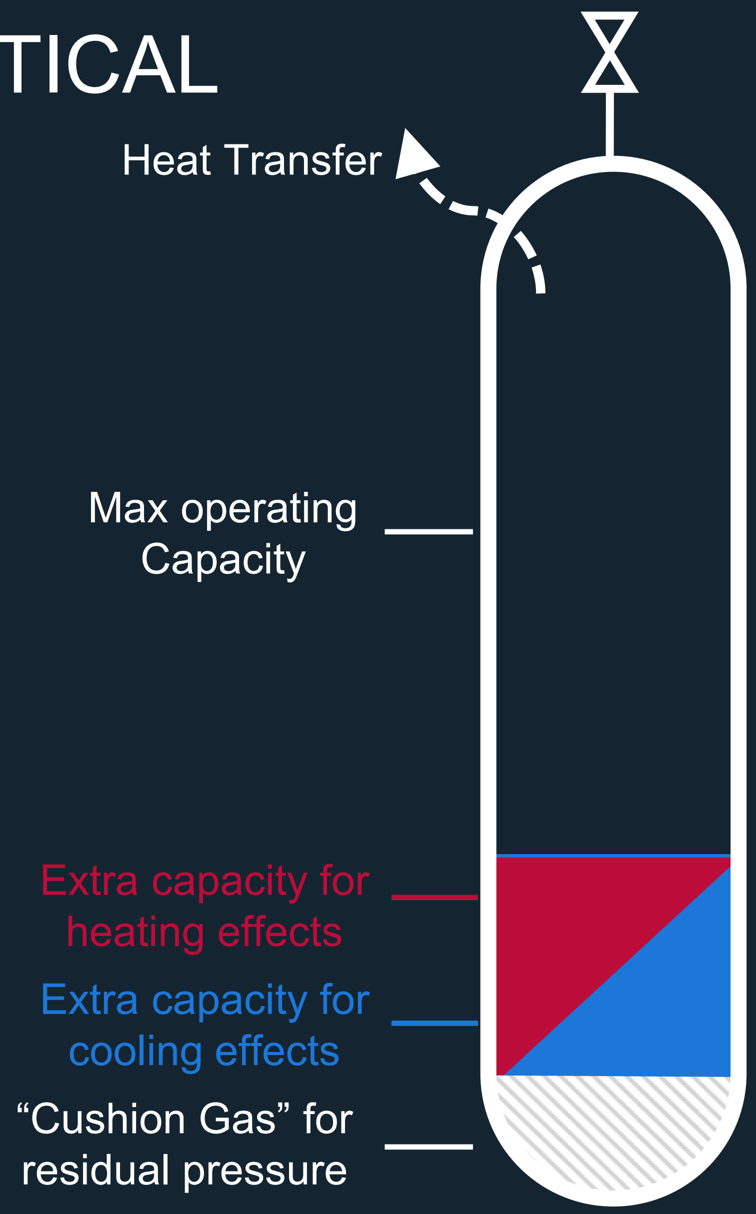


H2 STORAGE DYNAMIC BEHAVIOR IS CRITICAL

- During cyclic filling and emptying of the Hydrogen Storage vessels there are strong **temperature variations** due to Thermodynamic effects and Heat Transfer phenomena

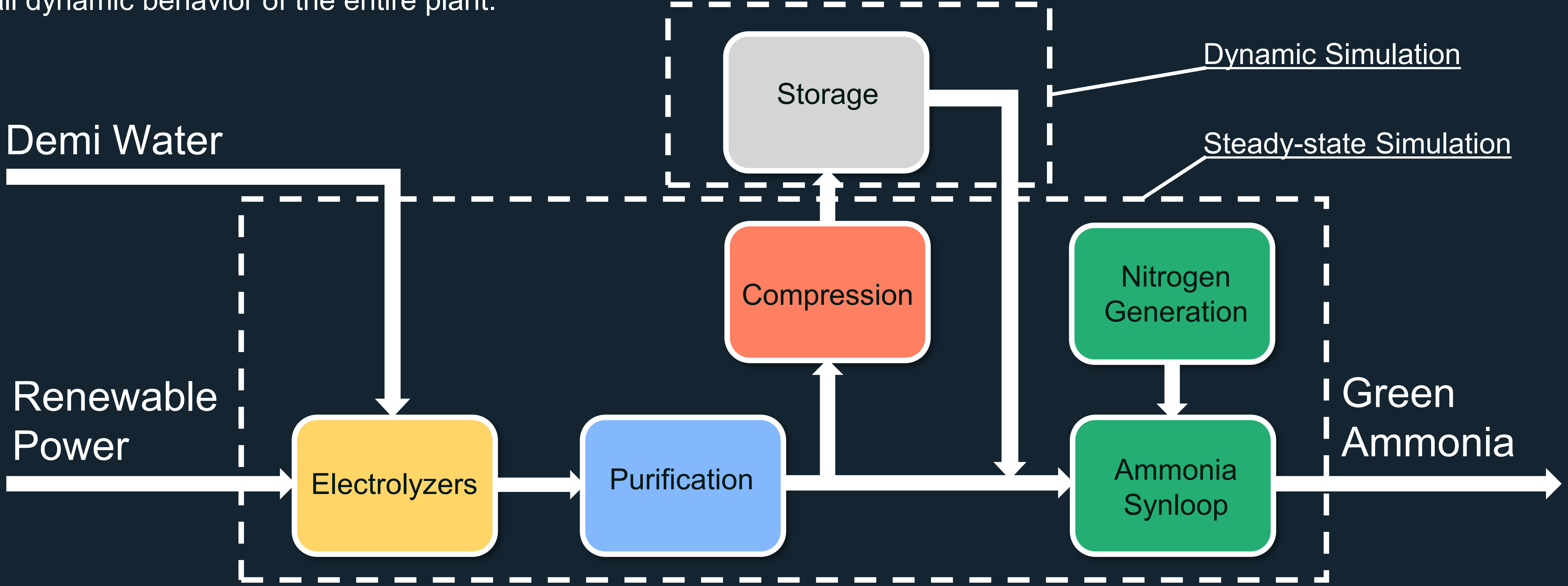
- As a result, during filling, the full capacity of the storage cannot be utilized, because the heating effects cause the stored gas to expand and decrease its density, therefore taking up more volume. Similarly, during emptying, cooling effects prevent the complete release of the stored gas.



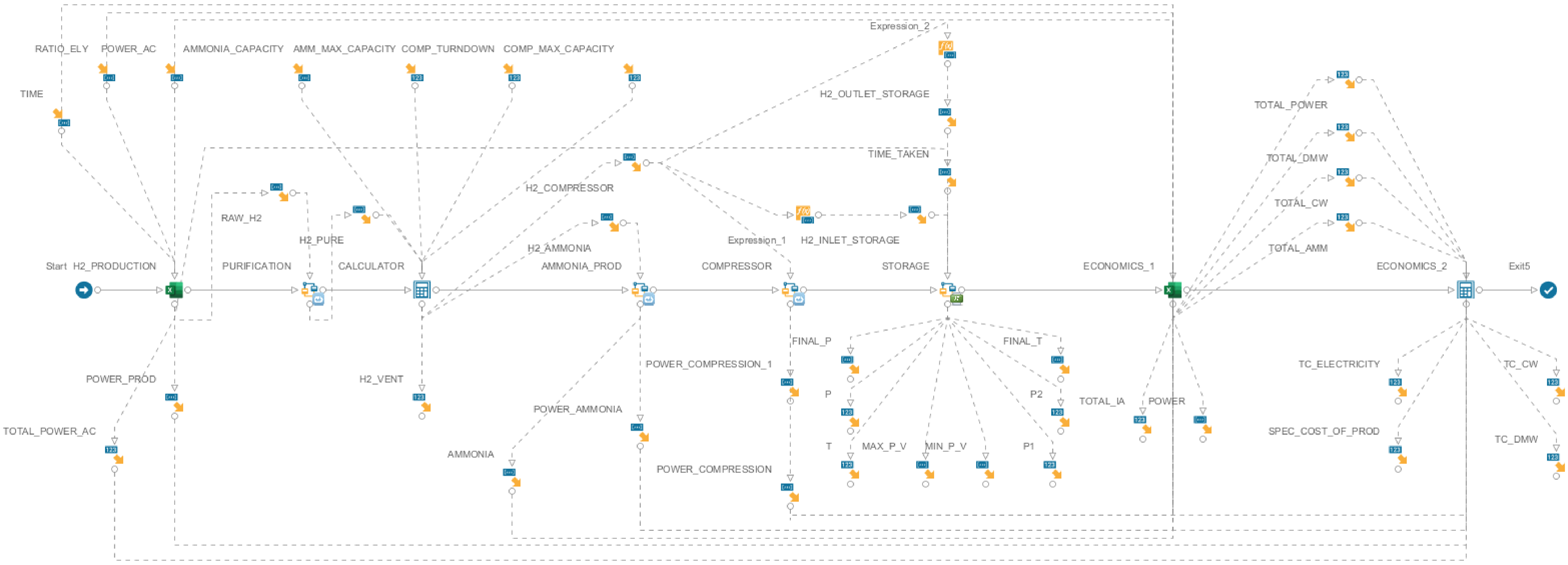


HYBRID DYNAMIC+STEADY-STATE SIMULATION APPROACH

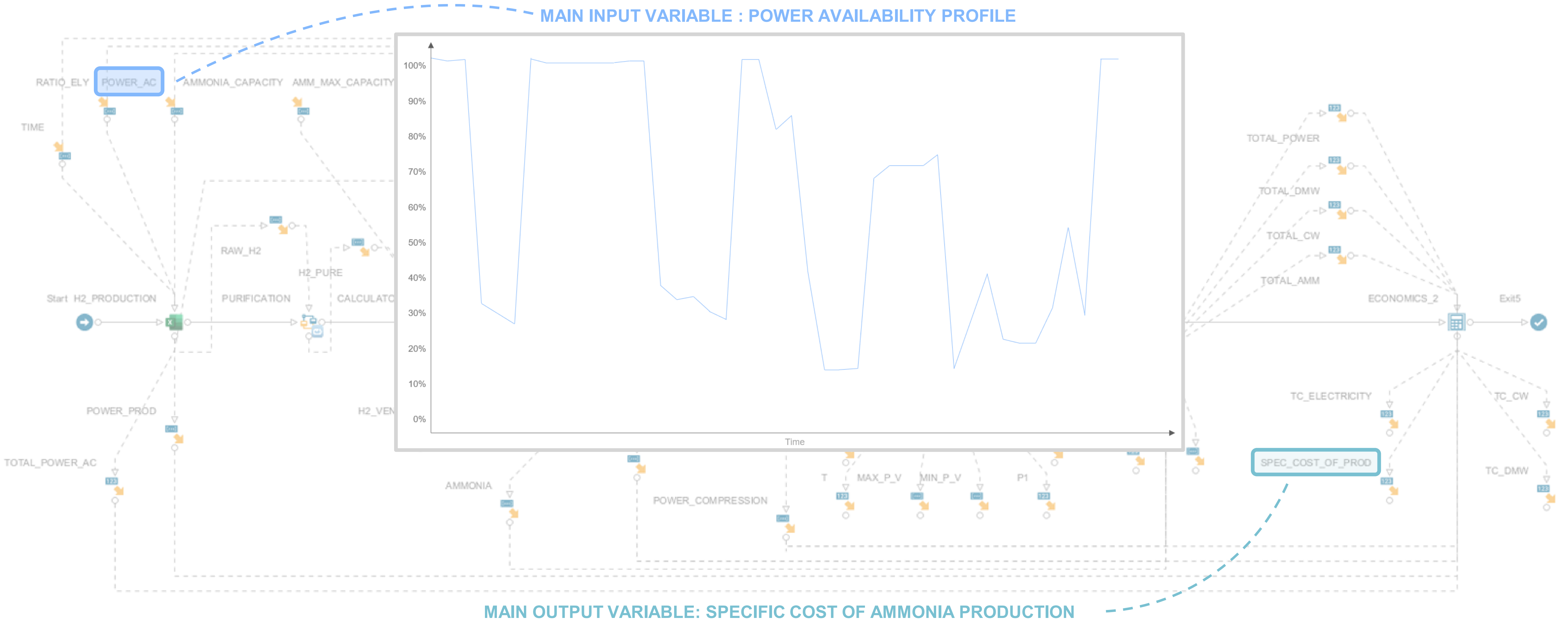
The storage system requires dynamic simulation to capture its time-dependent behavior, but optimizing the entire system with a fully dynamic simulation would be computationally prohibitive due to the system's complexity and the long optimization period. To address this issue, **modeFRONTIER** is used to **combine dynamic simulation** for the storage with **steady-state simulation** in **ASPEN HYSYS** for the rest of the system, assuming that the characteristic times of the latter are negligible in the overall dynamic behavior of the entire plant.



ModeFRONTIER WORKFLOW



ModeFRONTIER WORKFLOW



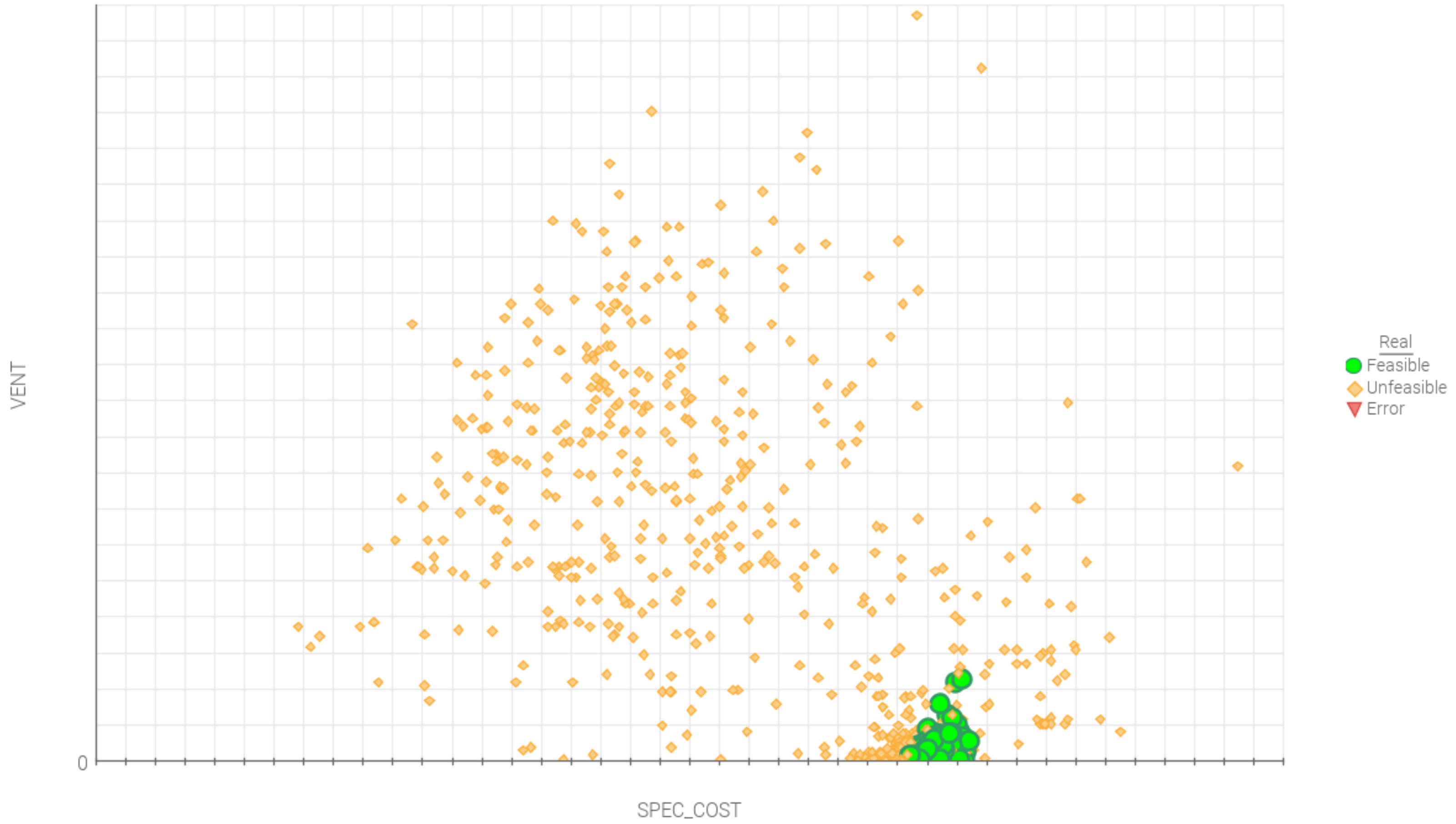
RESULTS

The profiles are optimized to minimize hydrogen losses to vent within the system, while targeting the lowest specific cost of ammonia production.

Feasible outcomes remain within the established operational and technical limits, ensuring compliance with all requirements, both in terms of storage pressure and power availability.

Furthermore, the specific cost of ammonia production has been **reduced by 10%**, all while ensuring **continuous operation** throughout the entire analyzed timeframe.

Feasibility of Profiles and Objective Performance



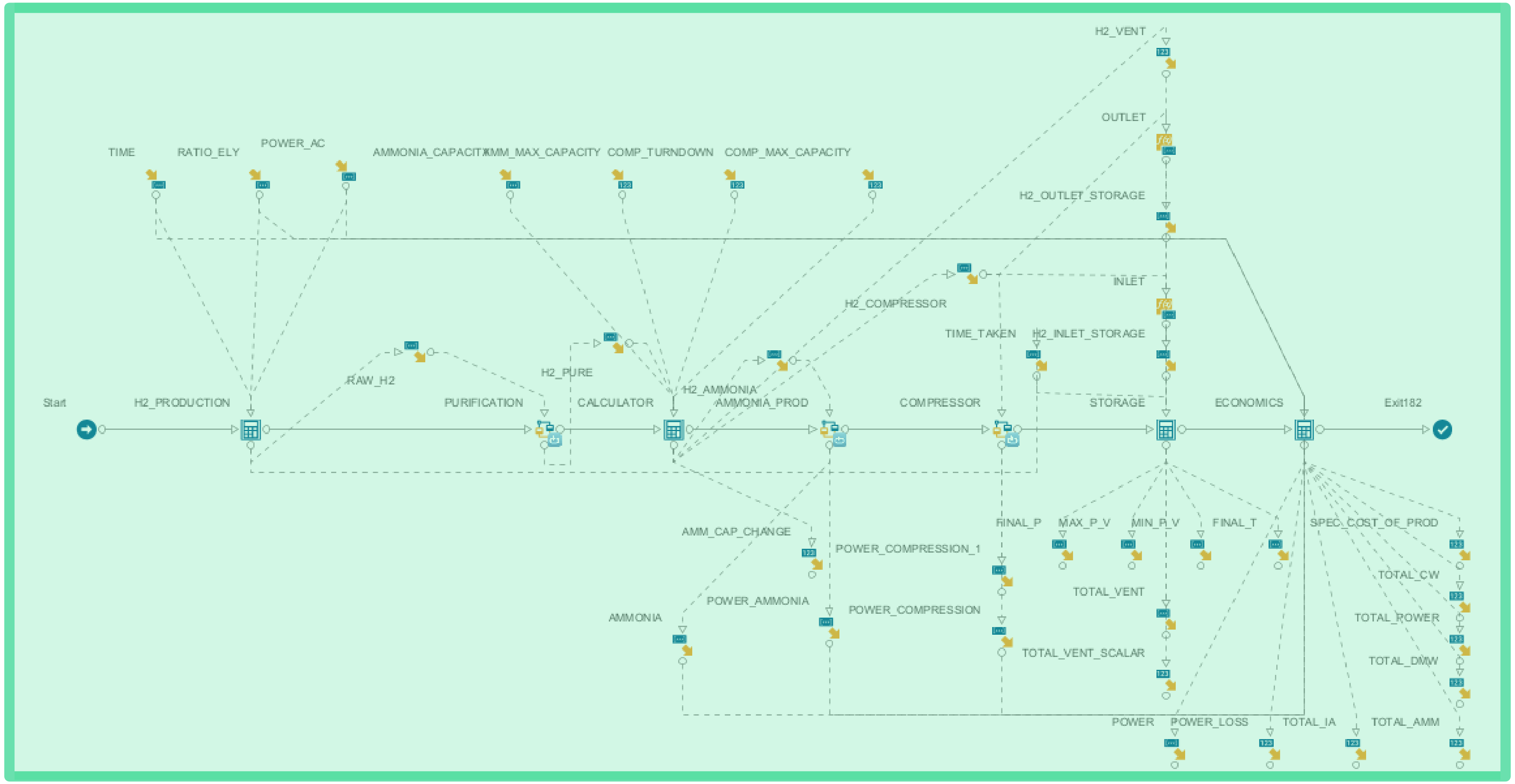
86
Optimized Variables

127
Constraints

1566
Cases Investigated

202 014
Simulations

RUNNING ON VOLTA



336
Optimized Variables

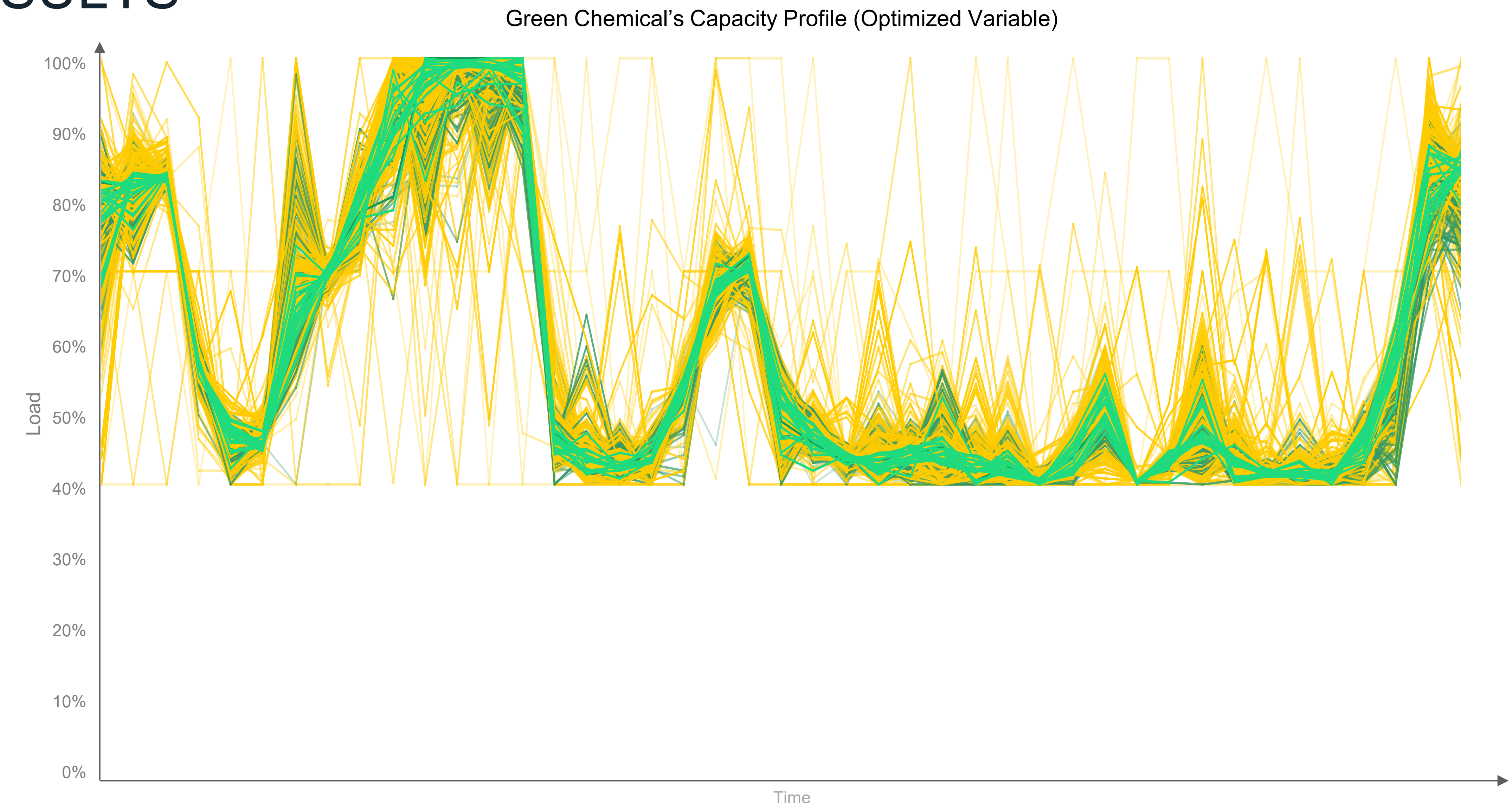
502
Constraints

1500
Cases Investigated

756 000
Simulations

6
Hours

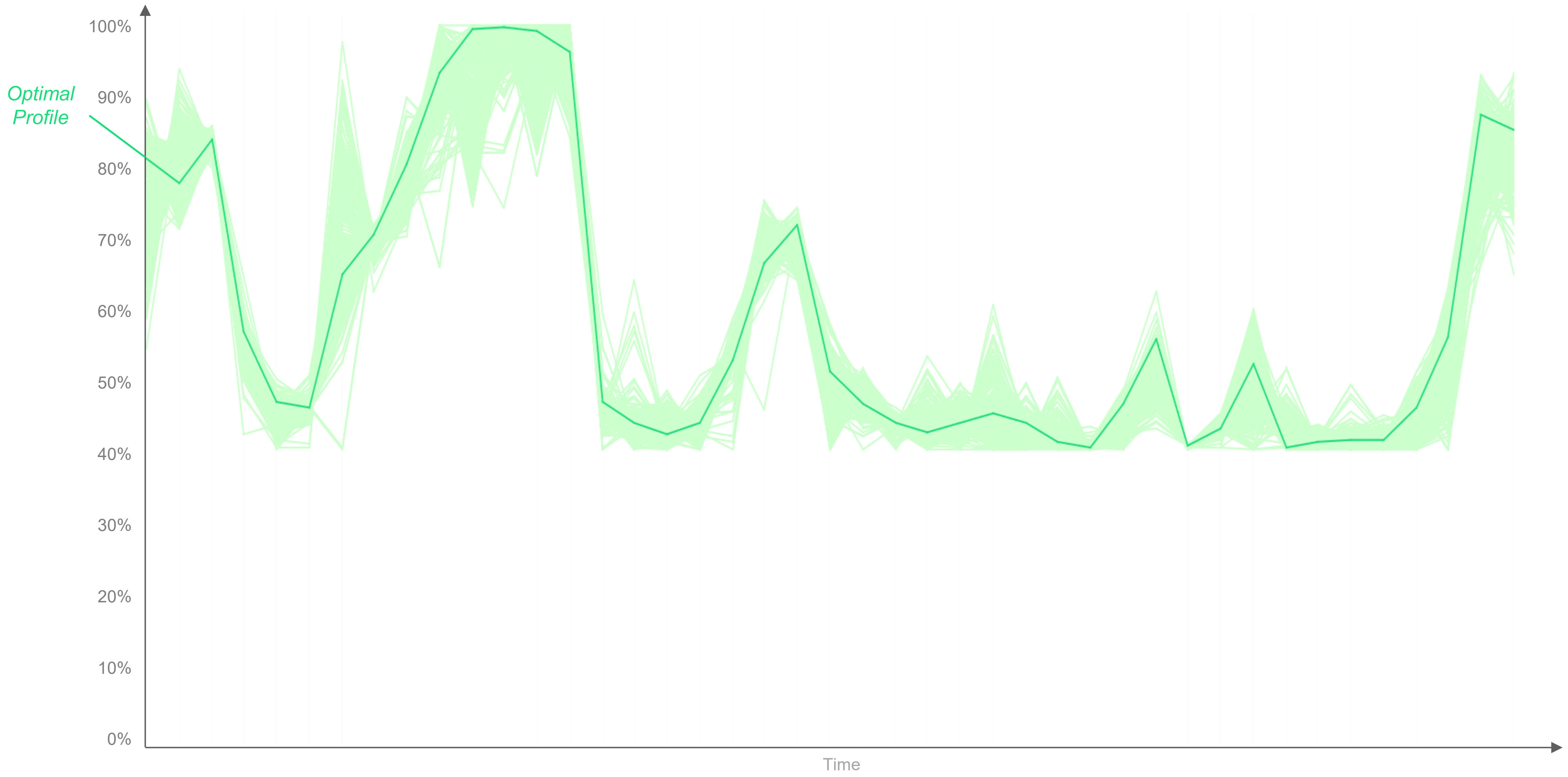
RESULTS



Green Chemical's Capacity Profile (Optimized Variable)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Load
Time

RESULTS

Ammonia Capacity Profile (Feasible Solutions)



RESULTS

The Power Availability Profile and the Ammonia Capacity Profile (Optimized Variable) for the Optimal Case

RESULTS

The Power Availability Profile and the Ammonia Capacity Profile (Optimized Variable) for the Optimal Case
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Time

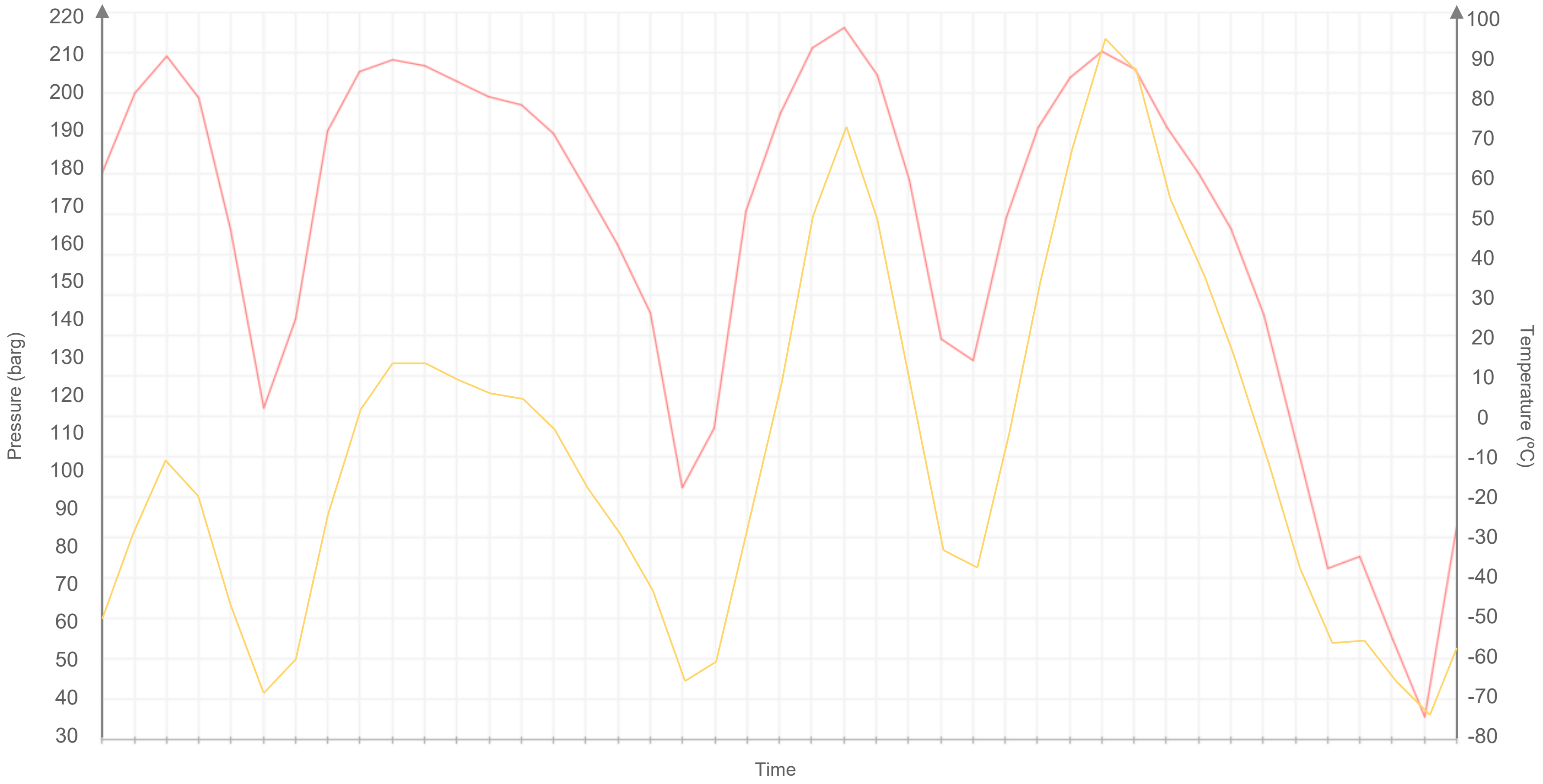
RESULTS

The graph displays the temperature and pressure profiles of the hydrogen storage unit over time. Heating and cooling effects play a significant role in influencing these profiles.

The pressure increases as the storage unit is filled, when hydrogen is being stored. The temperature within the storage unit also rises affecting the actual capacity of the storage. And, vice versa, for emptying.

The heating and cooling effects are accounted in the dynamic simulation and a minimum temperature of -74 ºC is achieved. Neglecting these effects would have led to a shortage of hydrogen of about 15-20% on the last day of operation.

Temperature and Pressure Profile for the Storage Unit



05

CONCLUSION & NEXT STEPS

BENEFITS

Optimization of NX CPO for SAF Production

Accurate tuning of the three main reactants stabilizes operation at maximum performance

Operational expenditures can be further reduced by up to 5%:

Conventional e-SAF plant

e-SAF + CPO

e-SAF + CPO + optimization

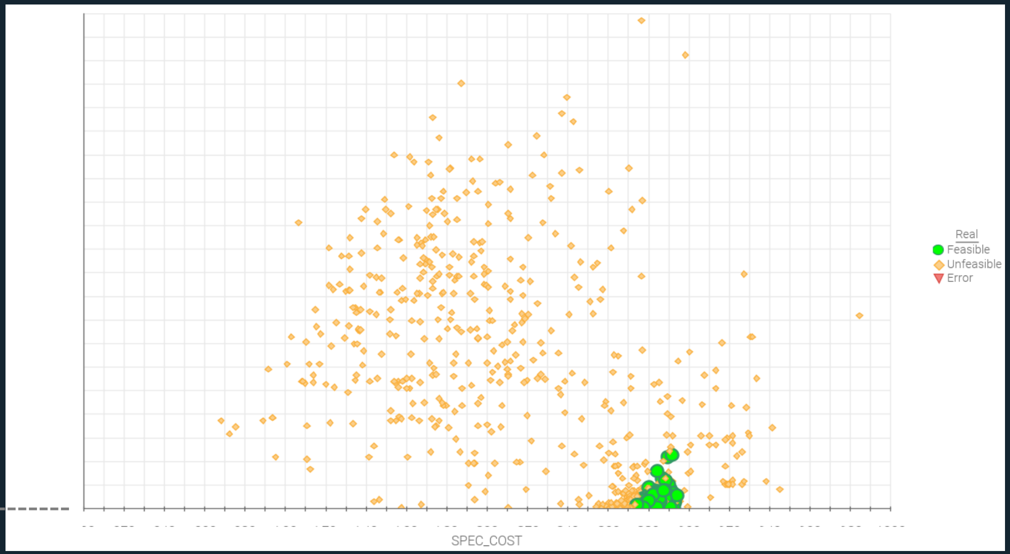
For a reference case of a 40 ktpa e-SAF plant, this results in up to **2–5 M$/year** savings from reduced electrical consumption, based on typical electricity prices of 40-100 $/MWh

Optimization of Green Ammonia

it is possible to optimize complex, multivariable, and highly constrained systems in a precise physical-chemical environment without requiring excessively long computational times, resulting in reduced cost of production (-10%), reduced wastes and improved system stability.

Feasibility of Profiles and Objective Performance

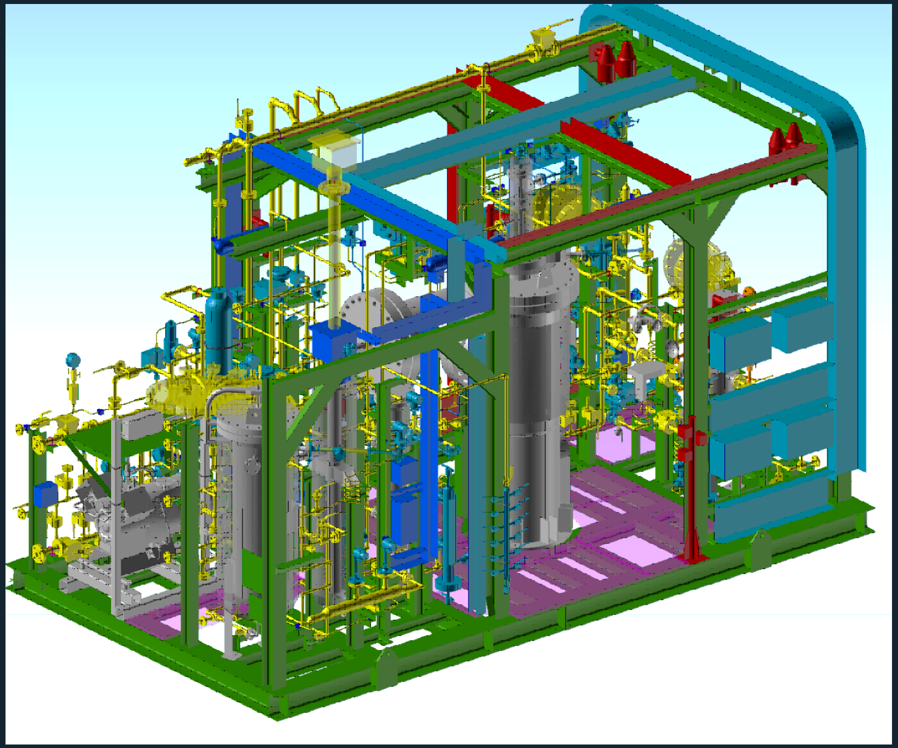
No Hydrogen Losses to Vent



NEXT STEPS

NEXTCHEM was awarded by Sarlux S.r.l. (part of SARAS group) licensing, engineering services, proprietary equipment and catalyst supply to integrate its NX CPO™ technology in a 300 tpy SAF demo plant in Italy

This case study will be further consolidated with demo plant results, confirming whether this approach can effectively deliver a production boost.



NEXTCHEM

Thank you for your kind attention

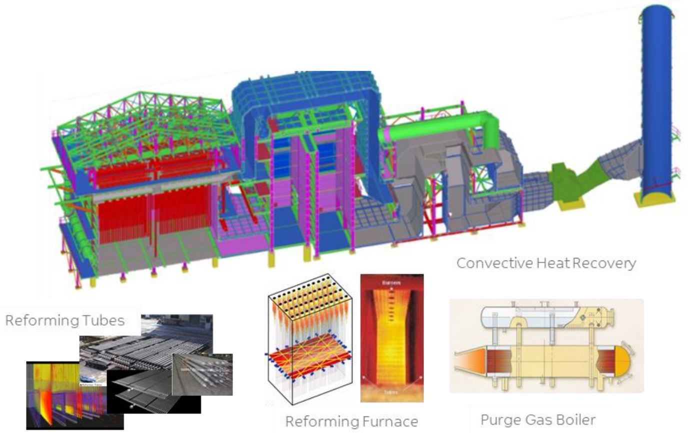
Edoardo Disaro’
e.disaro@nextchem.com

BACK-UP SLIDES

SYNGAS PRODUCTION TECHNOLOGIES

STEAM METHANE REFORMING SMR

$$CH_4 + H_2O \rightarrow CO + 3\ H_2$$
$$CO + H_2O \rightarrow CO_2 + H_2$$



NX Reform™ Blue Hydrogen

AUTOTHERMAL REFORMING ATR

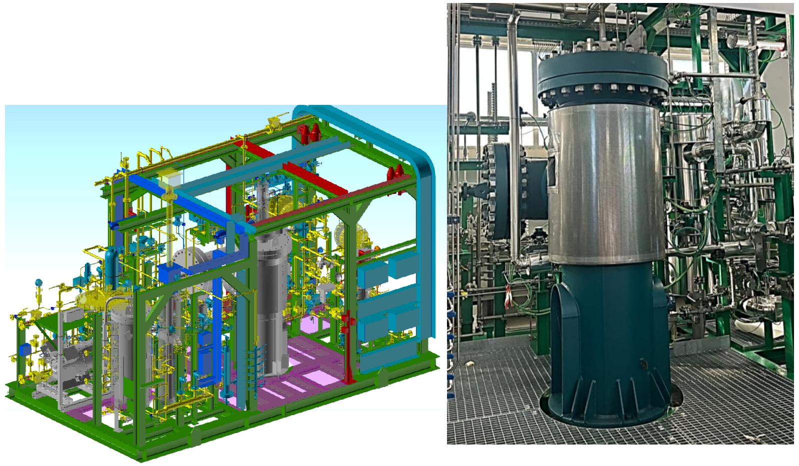
$$CH_4 + 3/2\ O_2 \rightarrow CO + 2\ H_2O$$
$$CH_4 + H_2O \rightarrow CO + 3\ H_2$$
$$CO + H_2O \rightarrow CO_2 + H_2$$

NEXTCHEM
MAIRE Sustainable Technology Solutions

NX AdWinHydrogen® Suite

CATALYTIC PARTIAL OXIDATION SCT-CPO

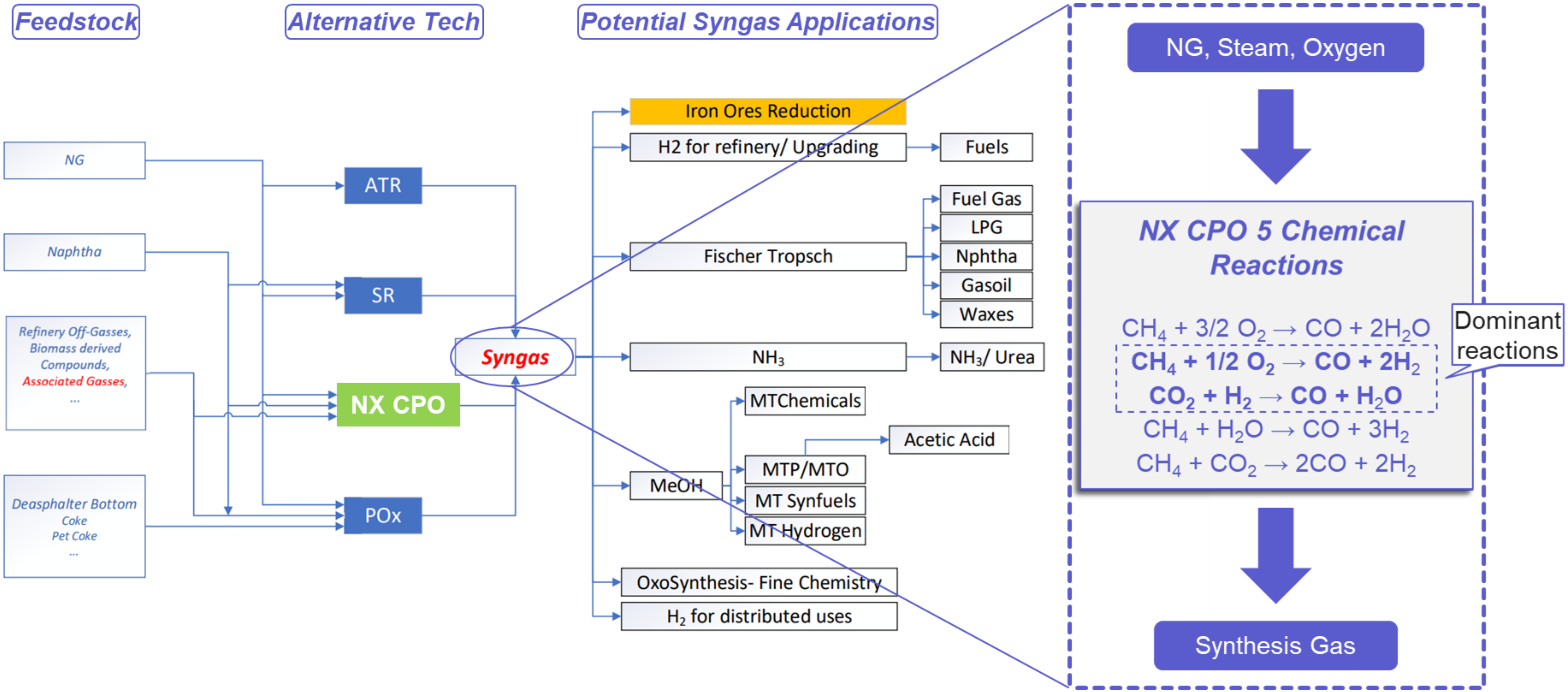
$$CH_4 + ½\ O_2 \rightarrow CO + 2\ H_2$$
$$CO + H_2O \rightarrow CO_2 + H_2$$



IAQUANIELLO et al., InTech, 2012, Chapter 12
BASINI et al., Ind. Eng. Chem. Res. 2013, 52, 17023

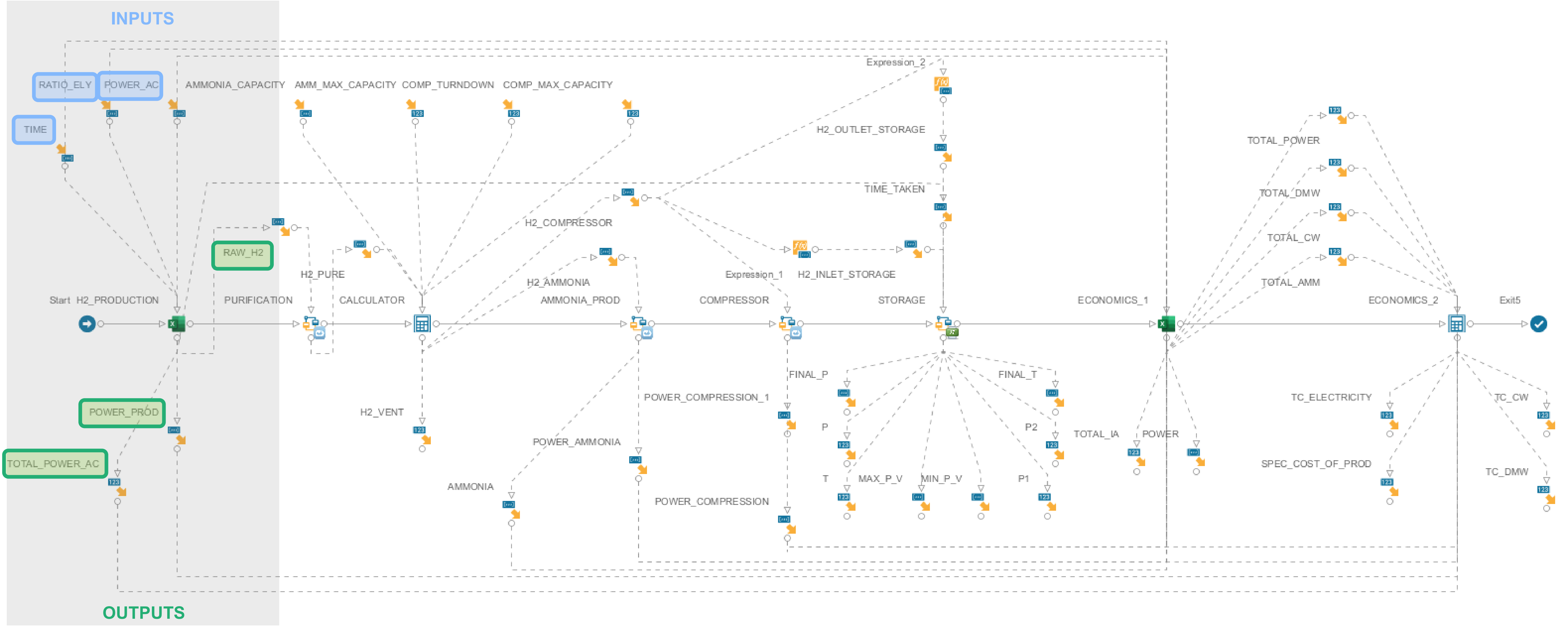
NX CPO™

NX CPO™ CHEMISTRY



ModeFRONTIER WORKFLOW

HYDROGEN PRODUCTION



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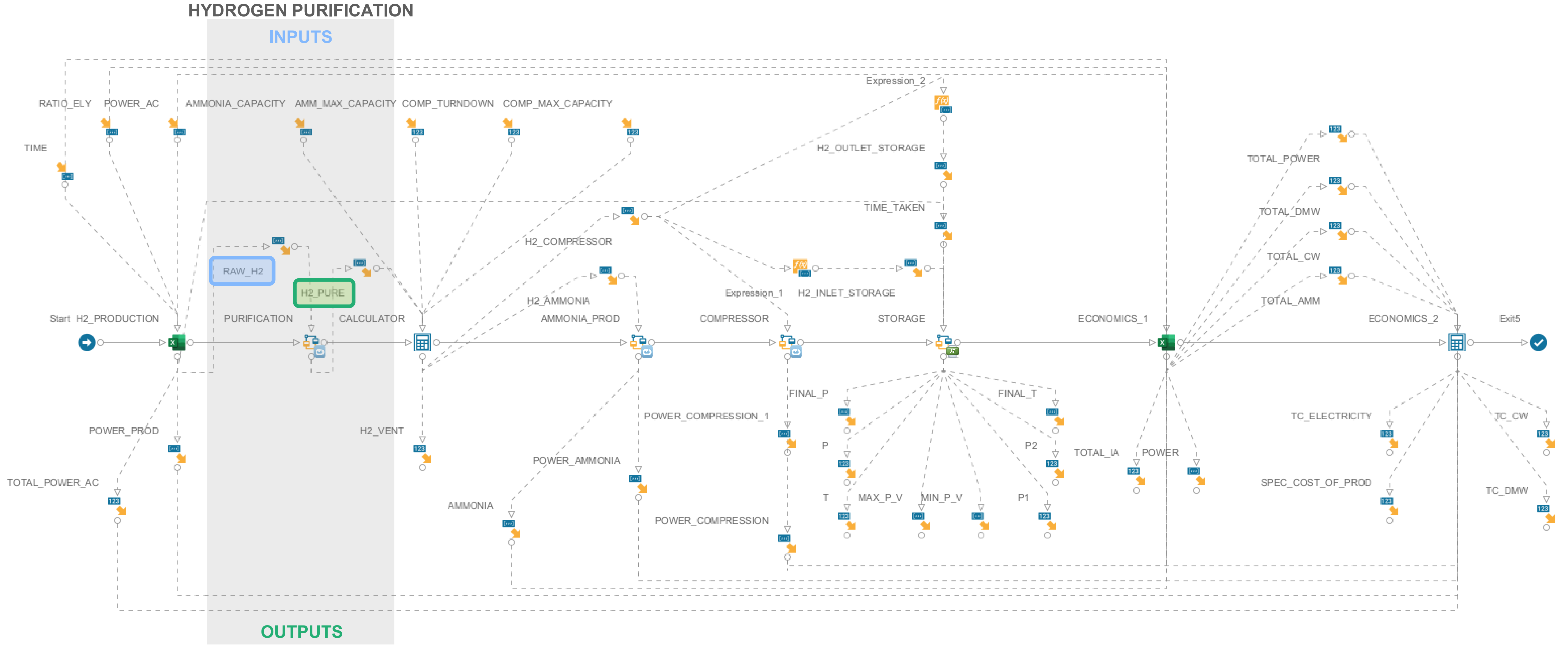
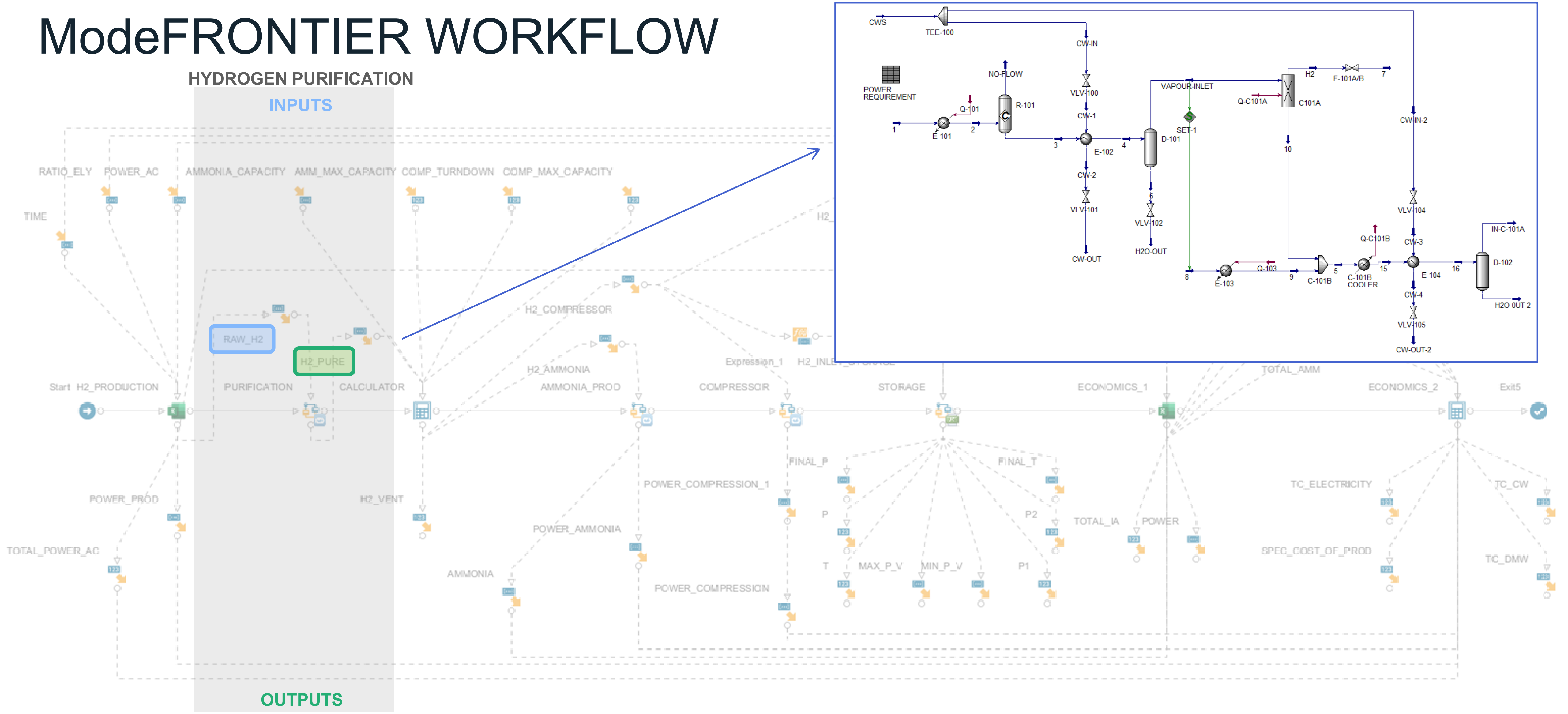
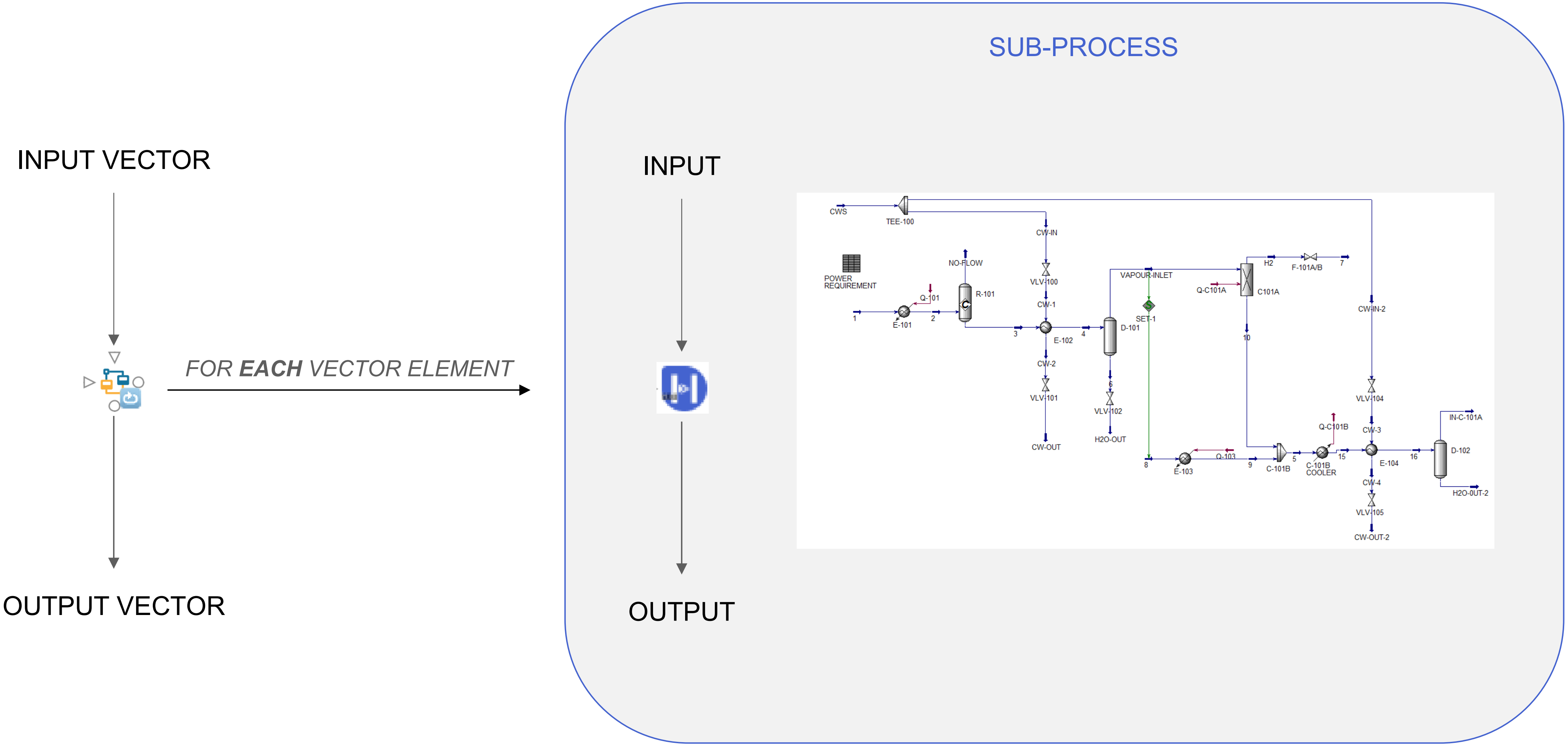


ModeFRONTIER WORKFLOW

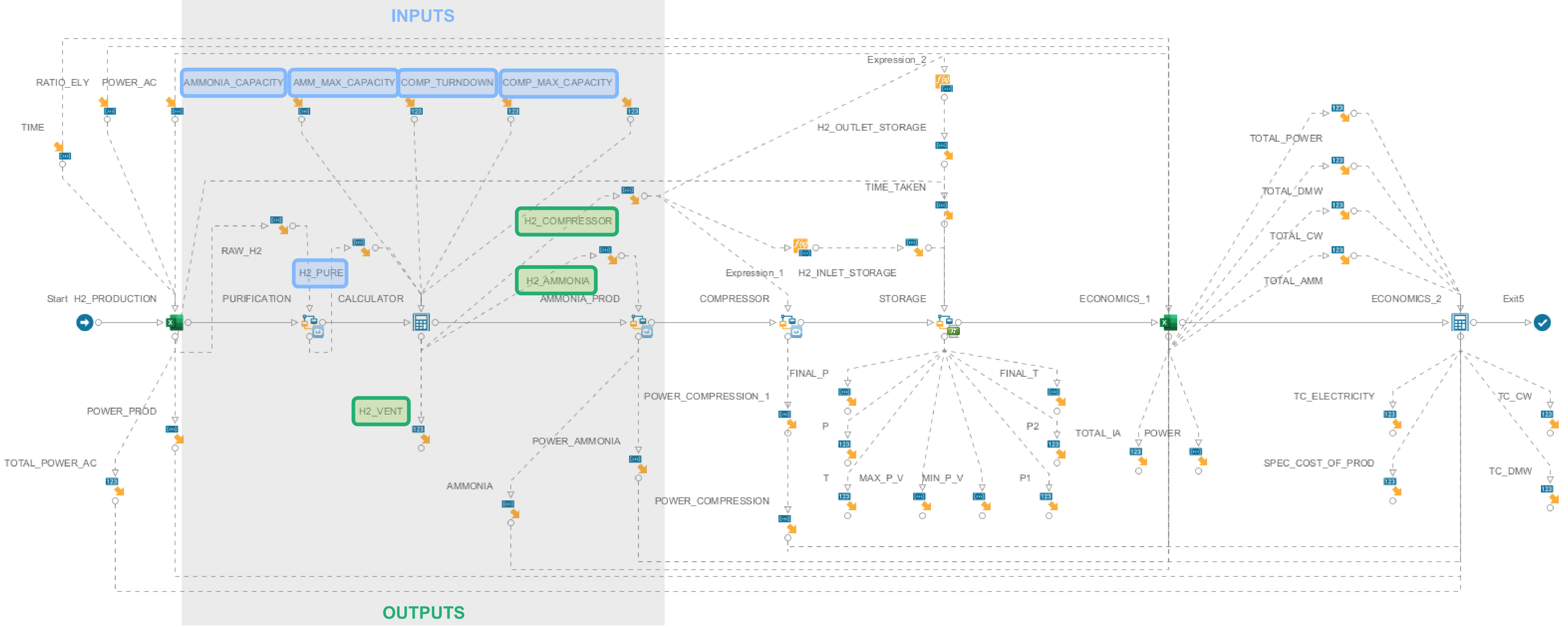


ModeFRONTIER SUBPROCESS



ModeFRONTIER WORKFLOW

RATIO OF HYDROGEN SENT TO AMMONIA AND COMPRESSION



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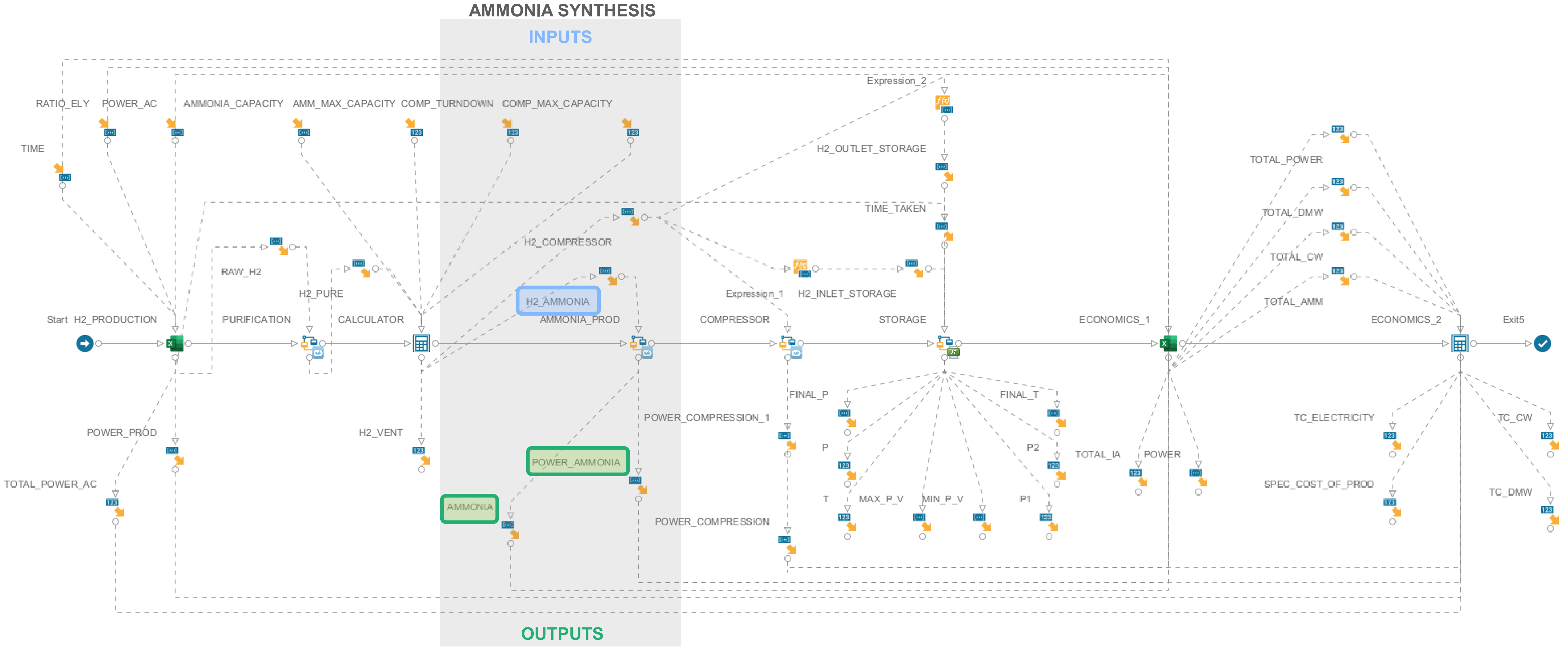

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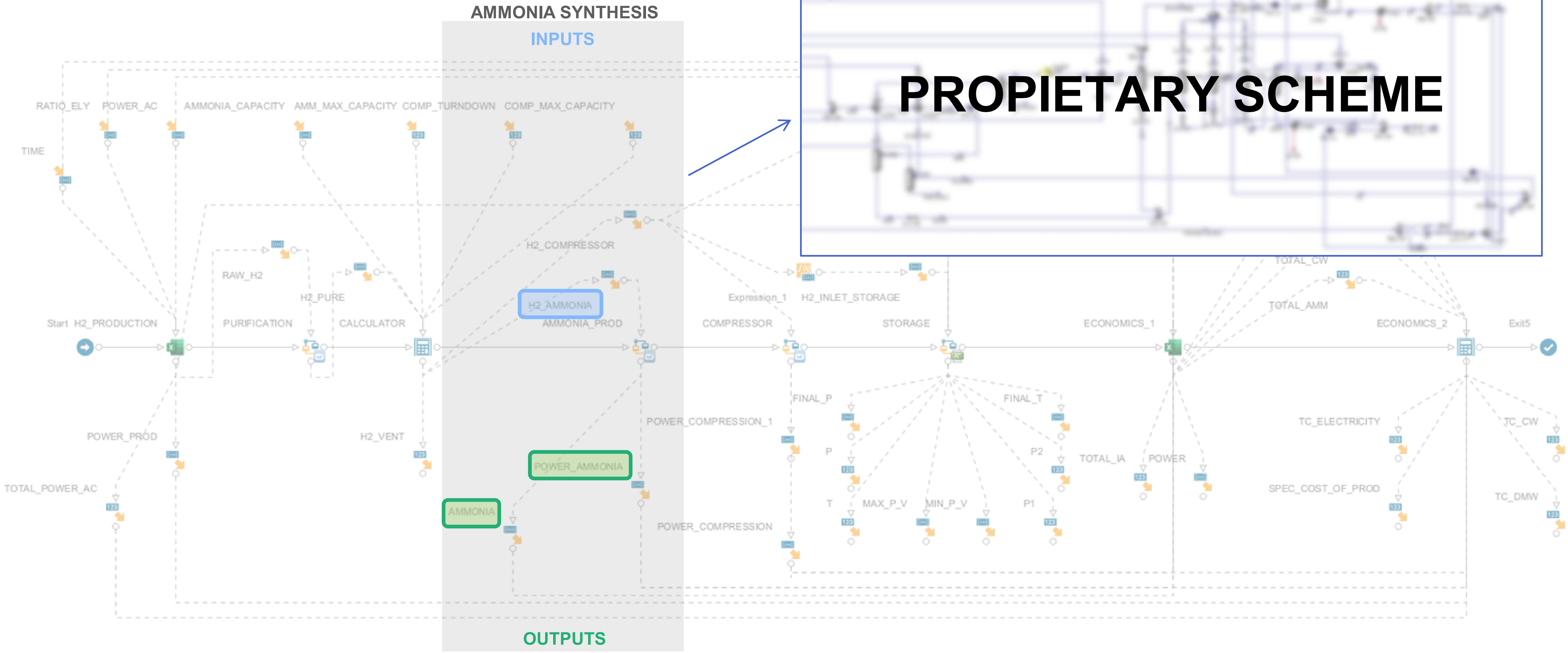

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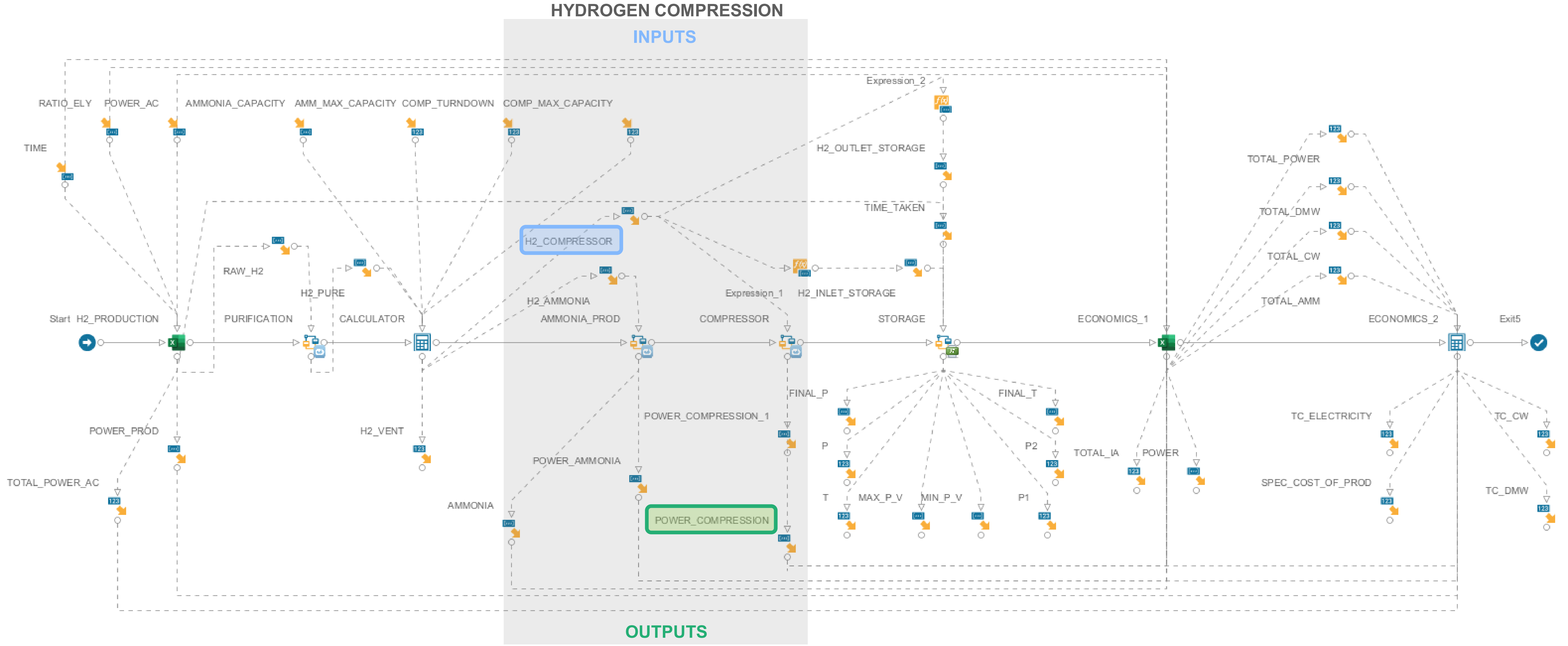

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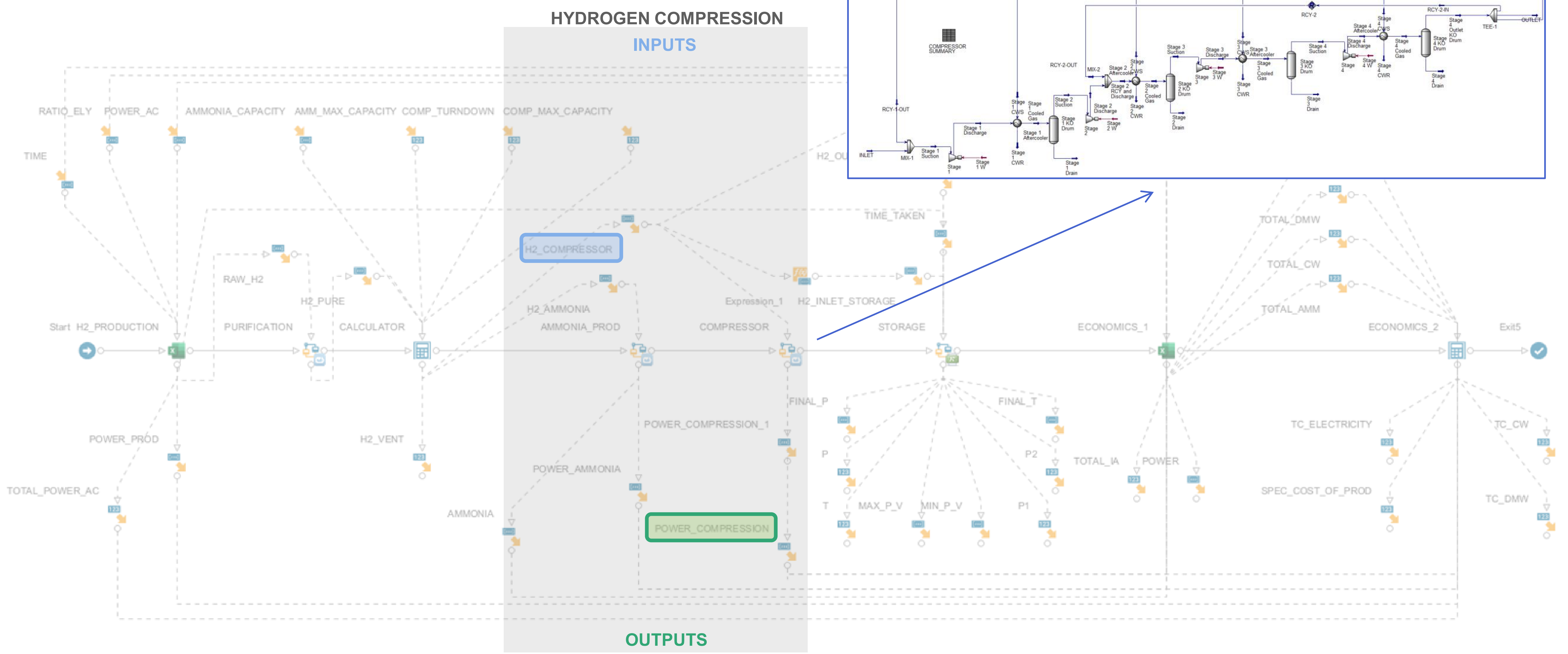

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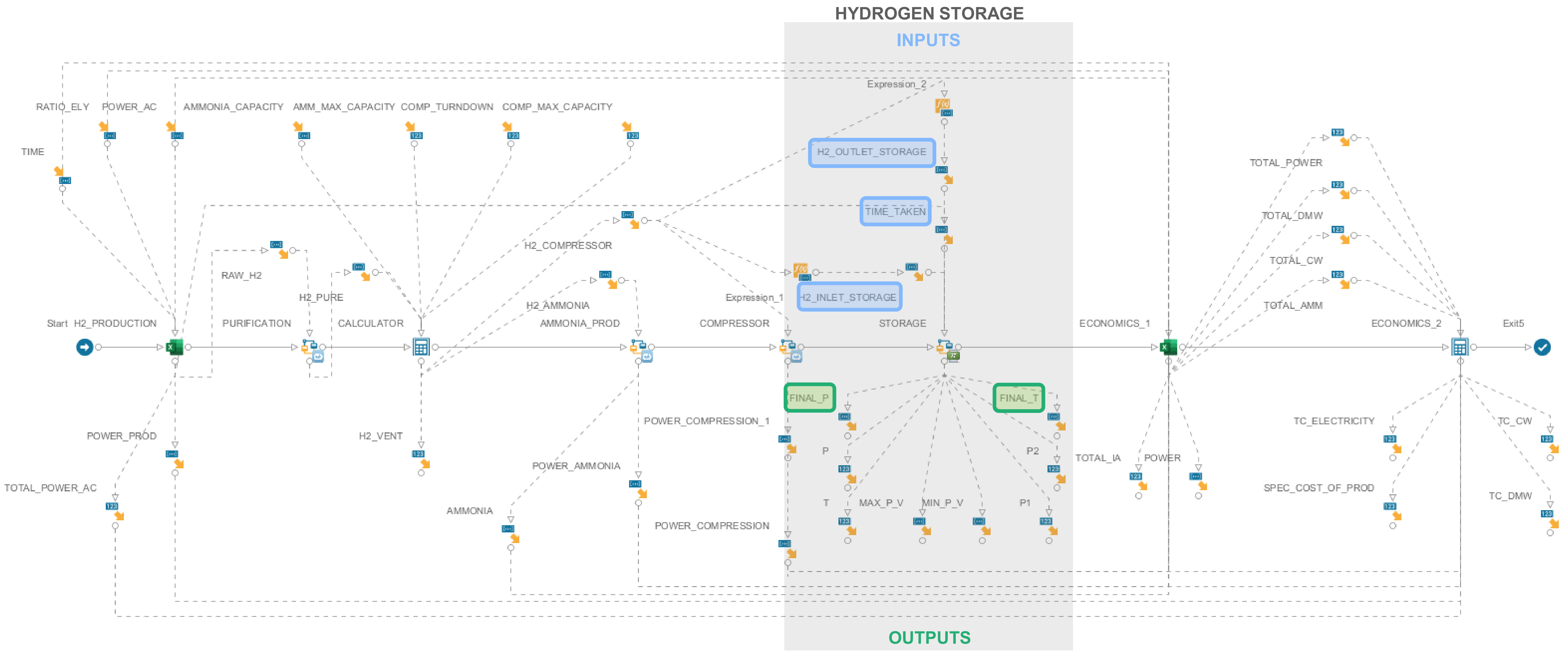

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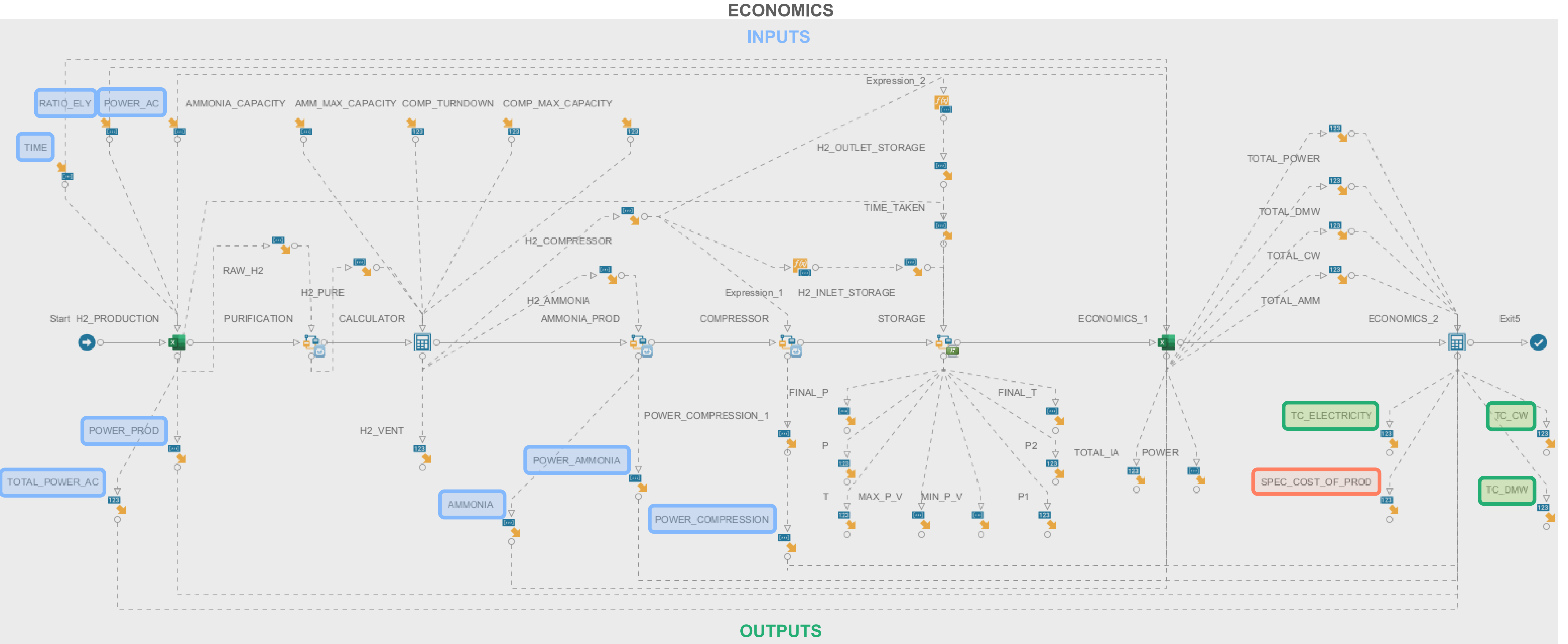
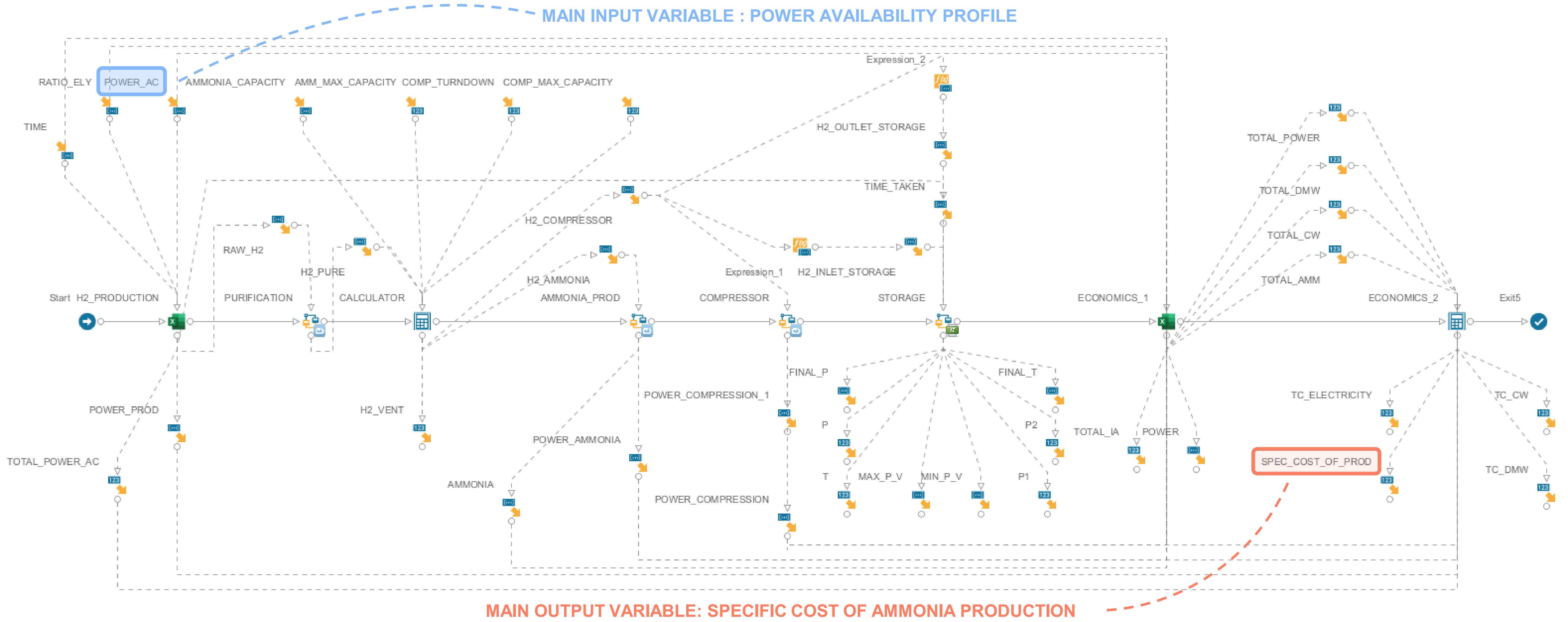


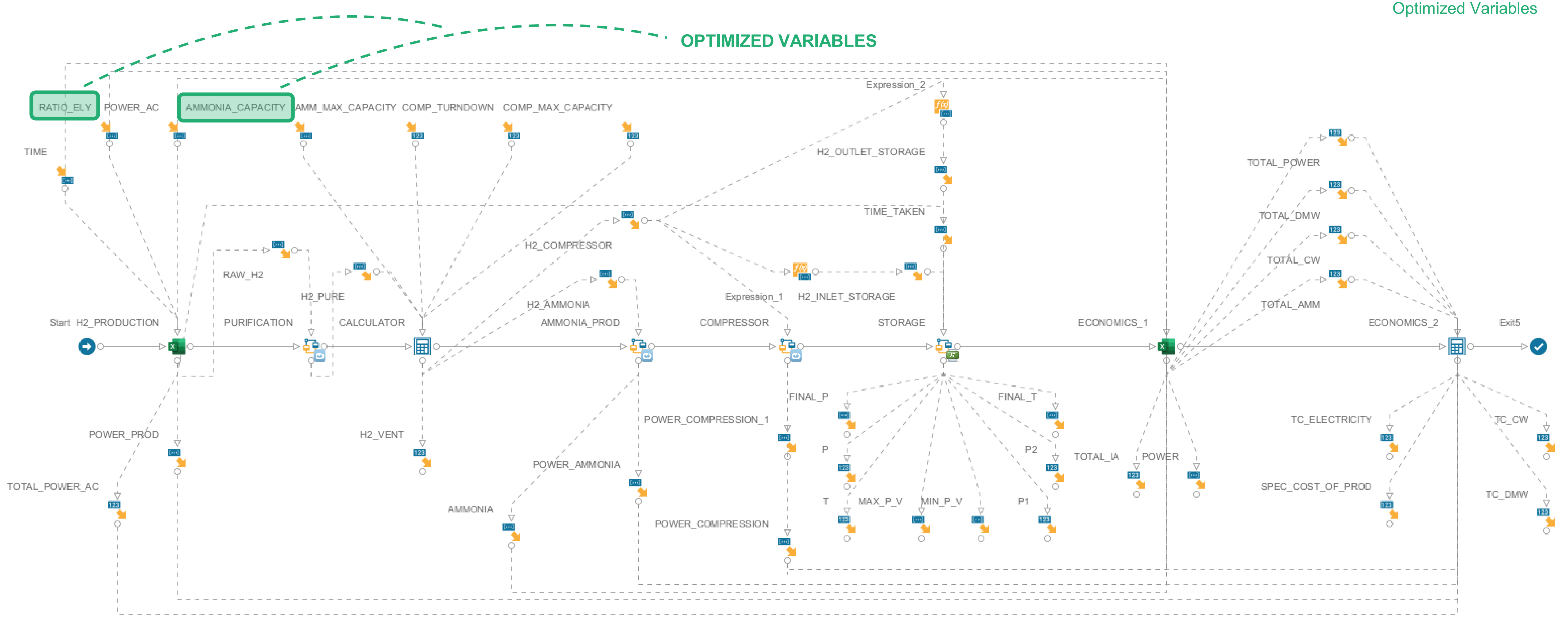
ModeFRONTIER WORKFLOW



ModeFRONTIER WORKFLOW

86

Optimized Variables



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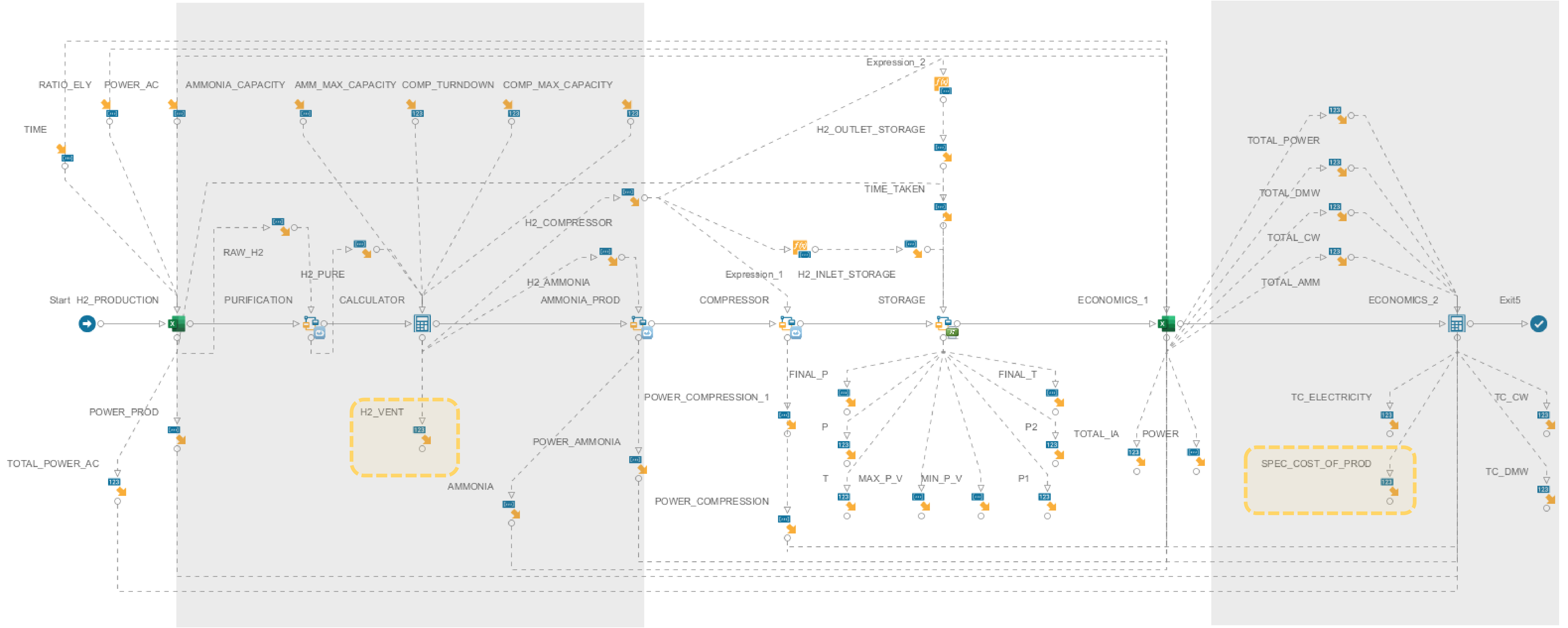
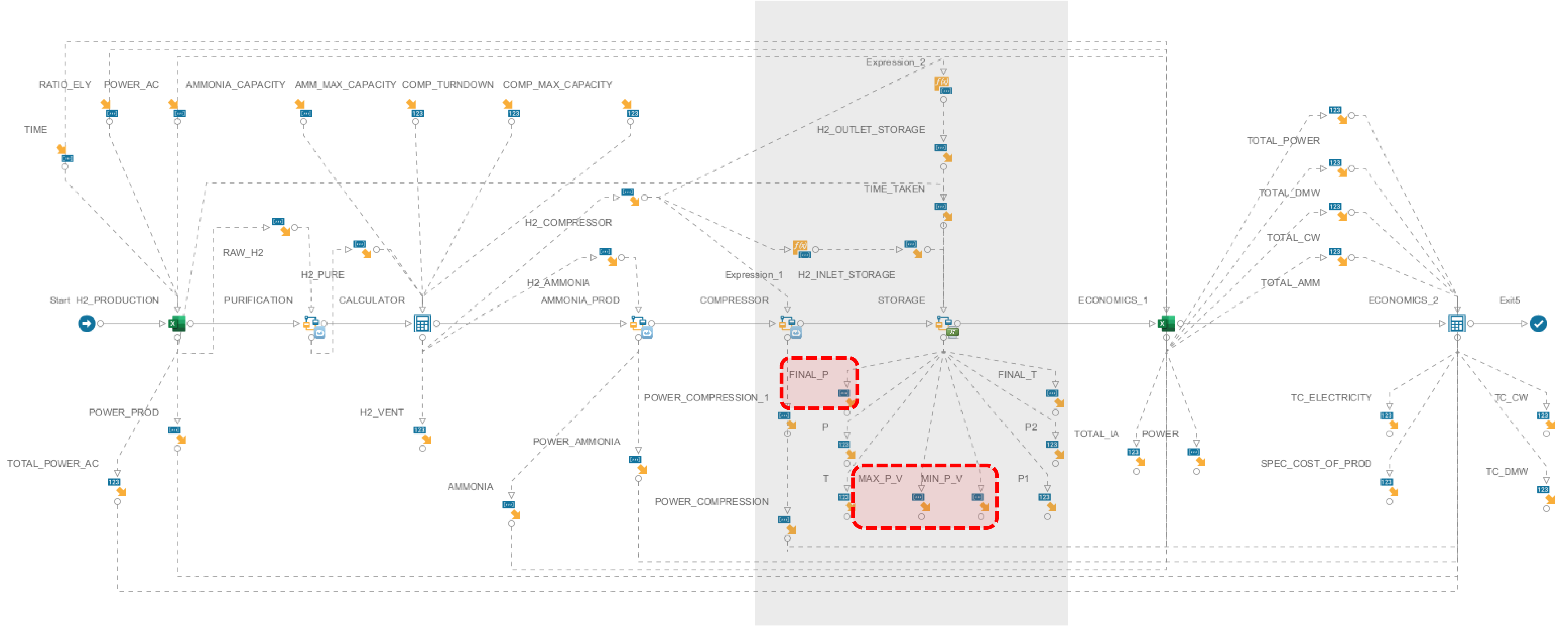


OBJECTIVES: MINIMIZE the specific cost of ammonia production and MINIMZE the losses of hydrogen to vent

ModeFRONTIER WORKFLOW

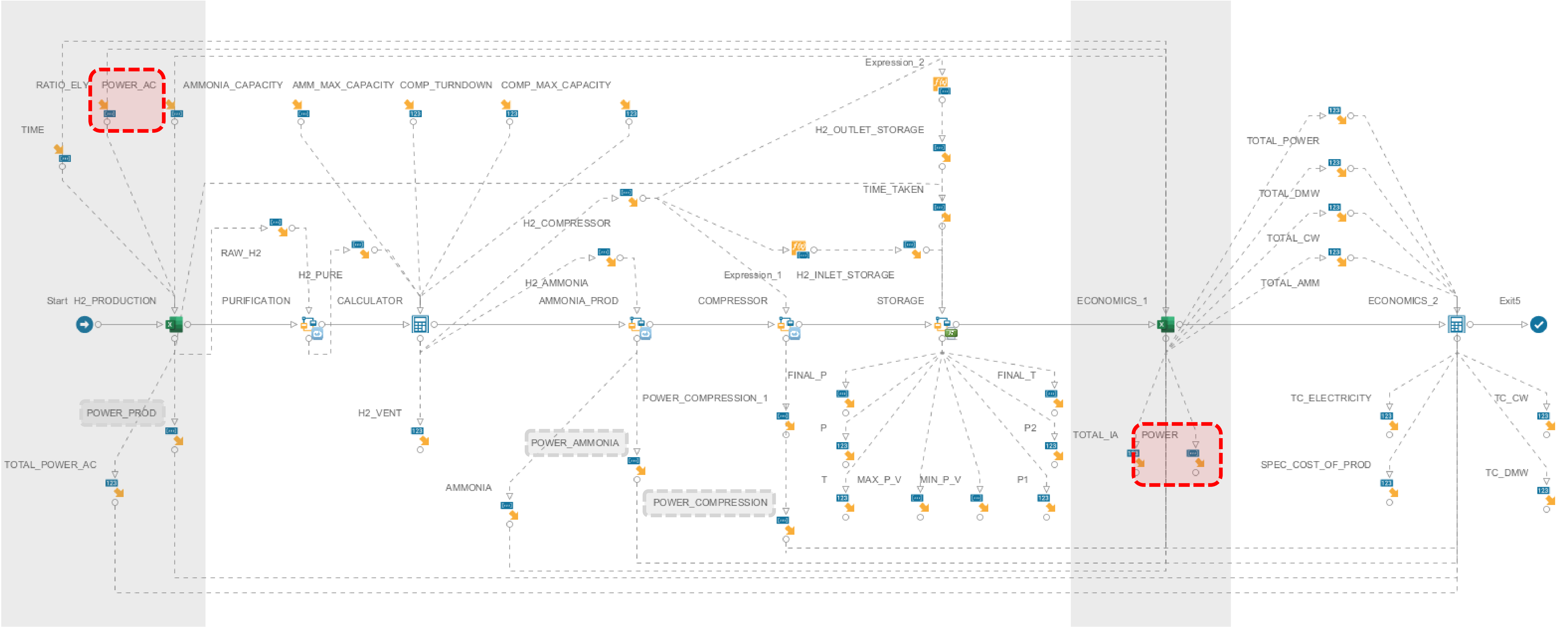
127
Constraints



CONSTRAINTS: The MAXIMUM pressure in the storage is LESS than the UPPER LIMIT and the MINIMUM pressure in the storage is GREATER than the LOWER LIMIT

ModeFRONTIER WORKFLOW

127
Constraints



CONSTRAINT: Total Power consumed is LESS THAN OR EQUAL TO the Power available to the system