Integrating high renewable share into today’s gas turbine power plant energy systems

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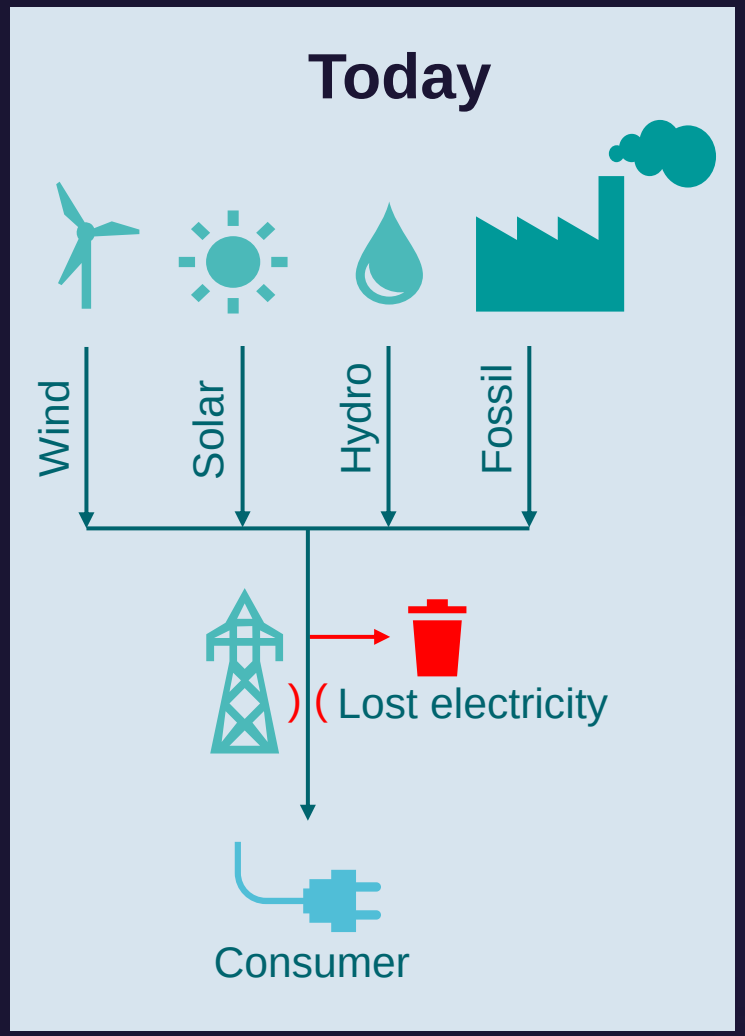
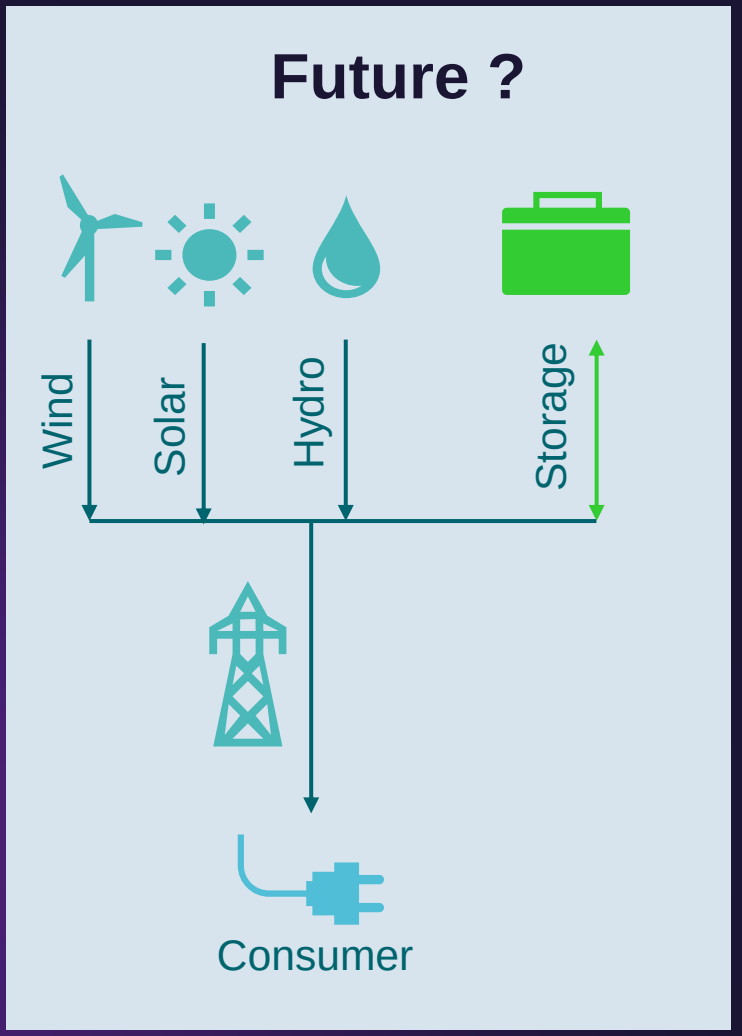
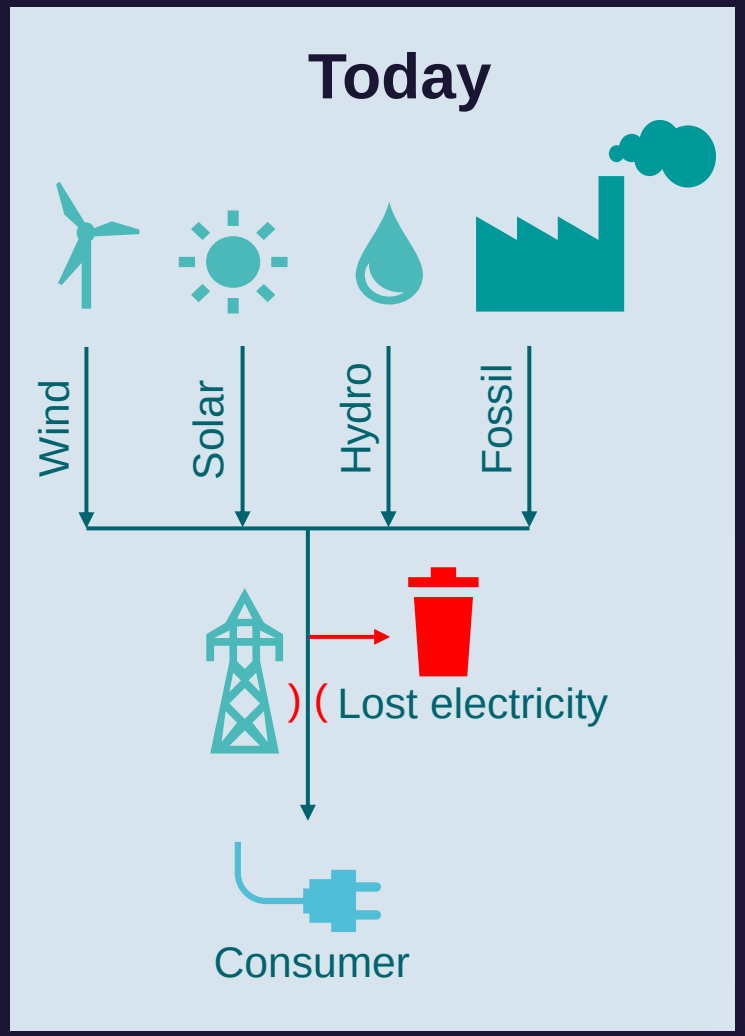
Transition of today’s energy systems

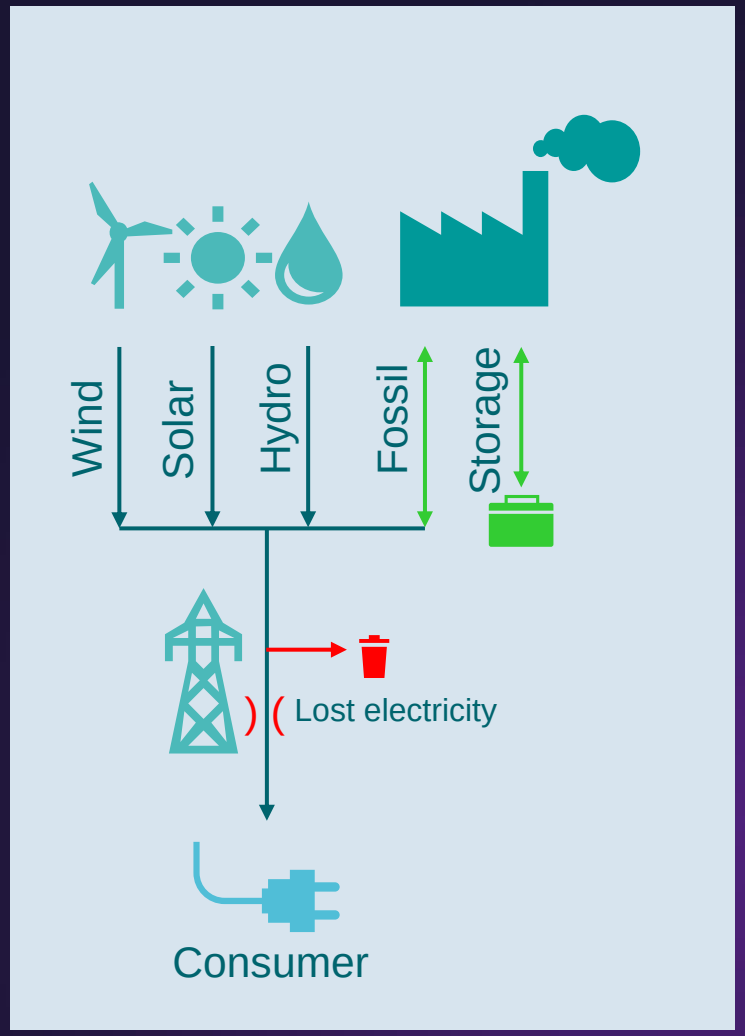
Energy system today and tomorrow

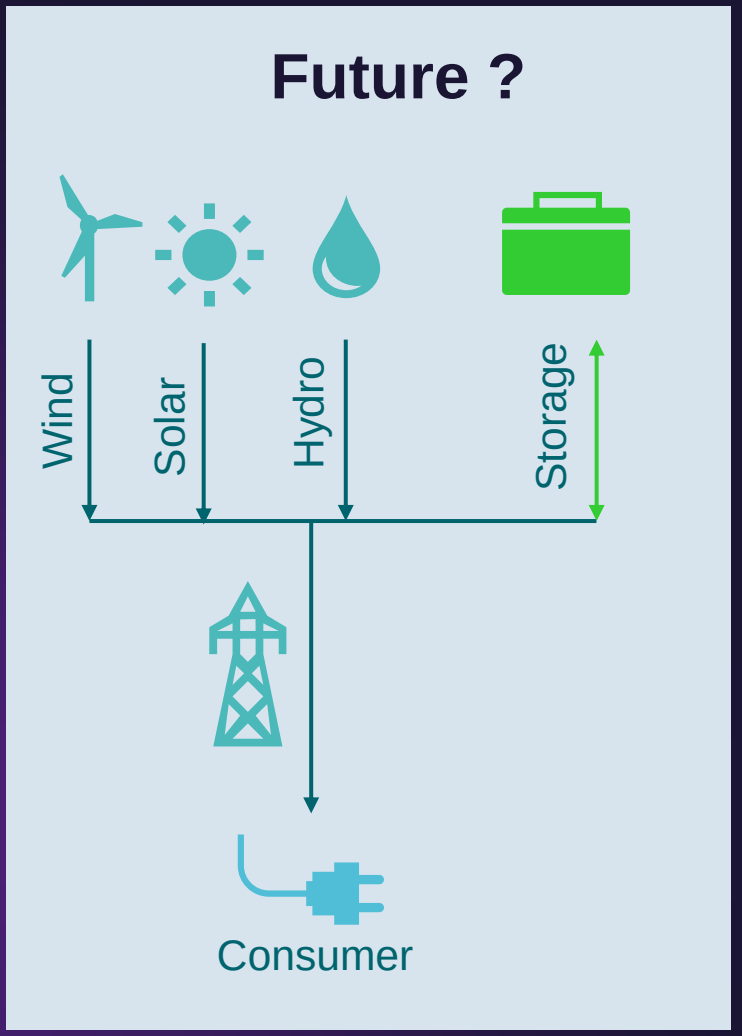




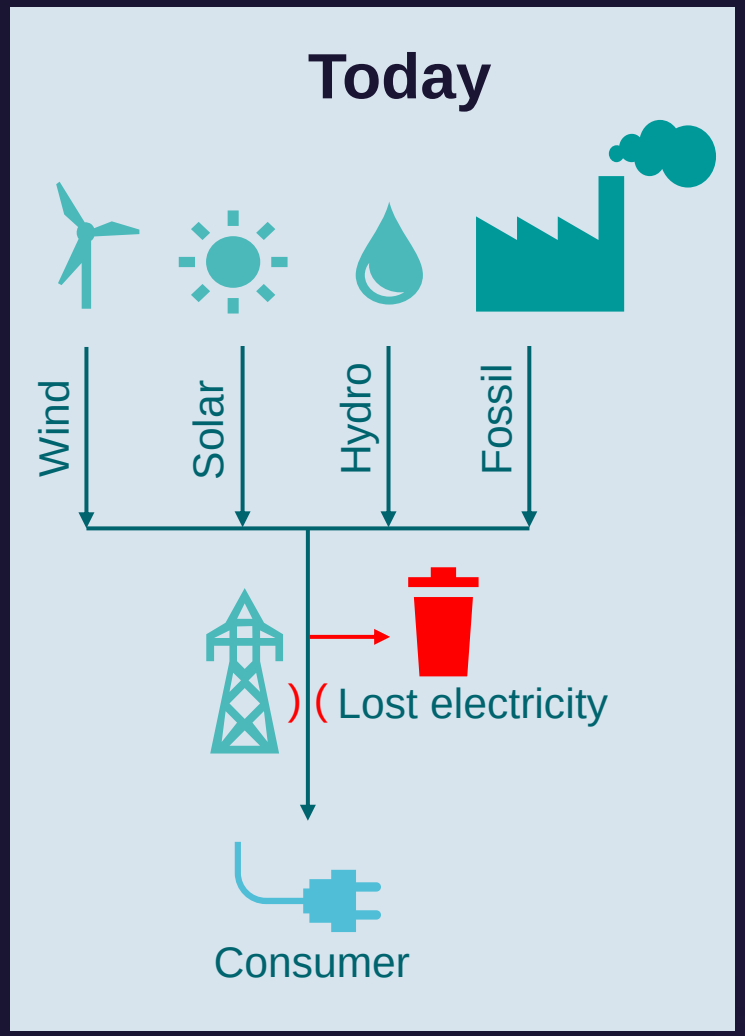
Energy system today and tomorrow
… and in between?

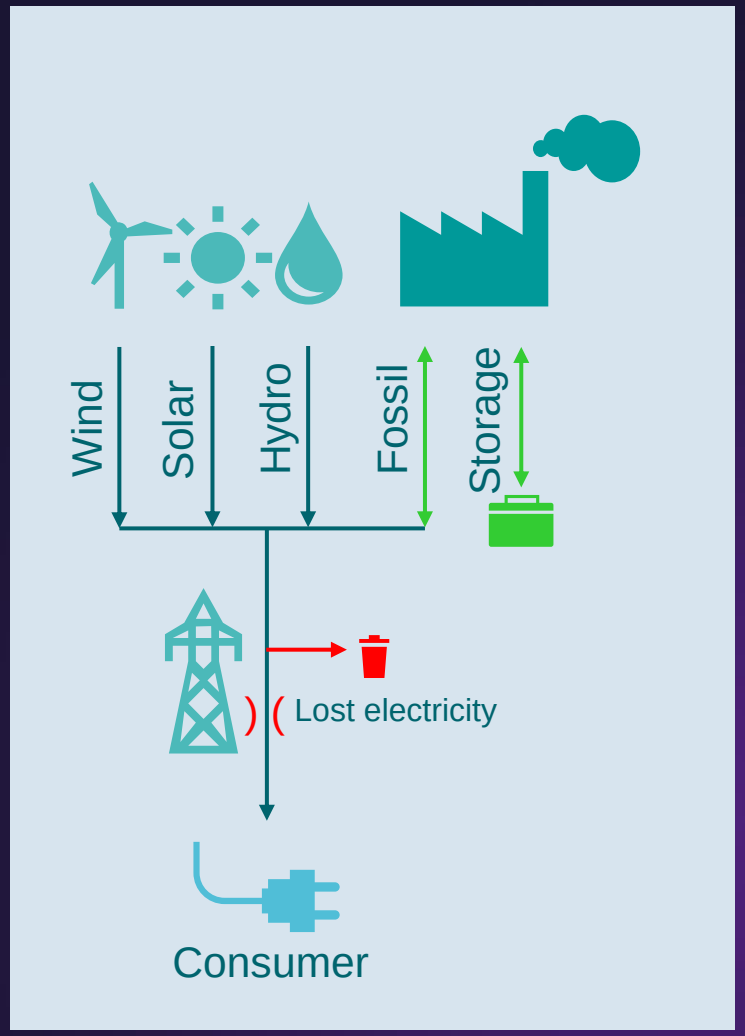


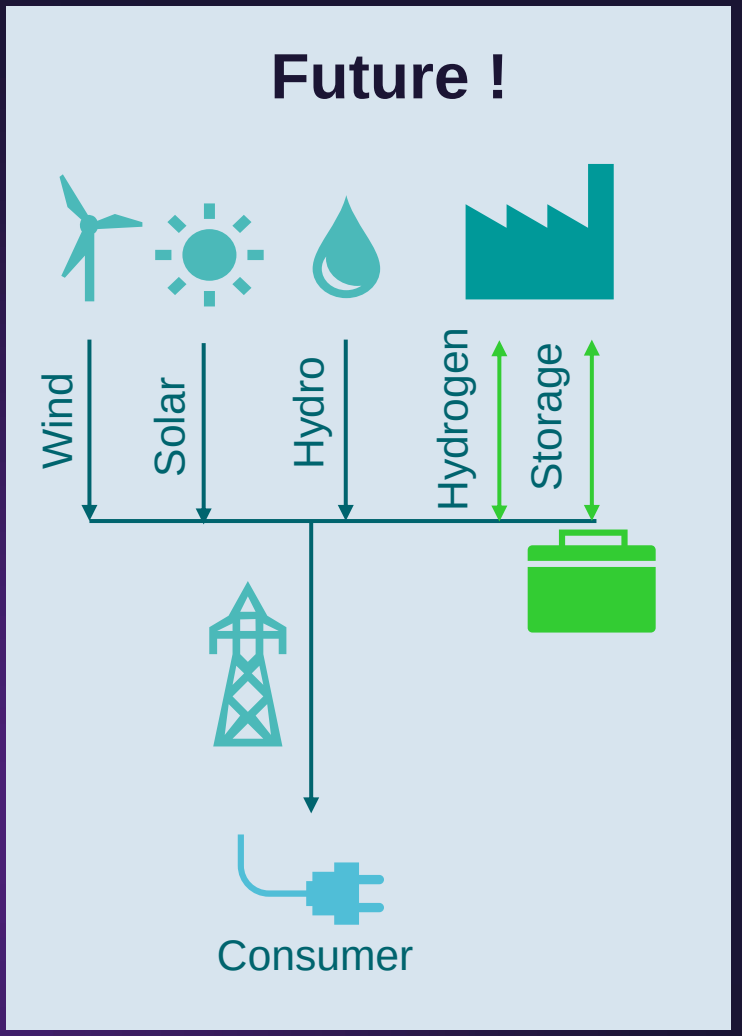




Energy system today and tomorrow
… and in “reliable supply” scenario







Transition towards a CO_2 free energy supply
Questions to be answered

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Technical feasibility

- Grid stability
- Handling of residual load
- Handling grid limitations

Commercial viability

- For new and available assets
- Invest in future energy system

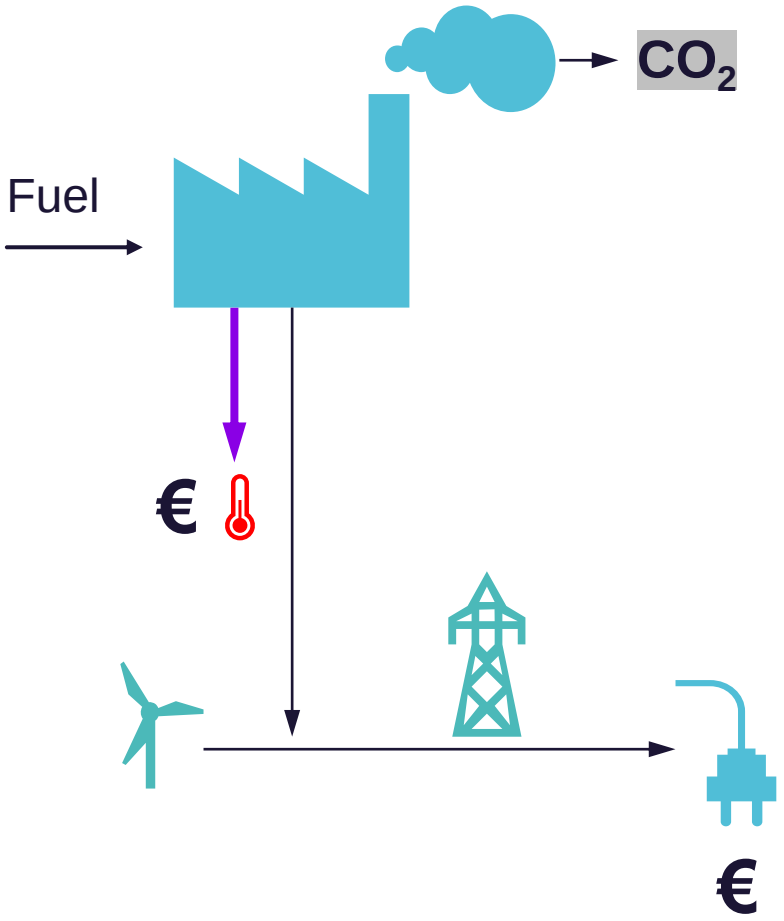
Environmental benefit

- Less dissipation of renewable electricity
- Reuse of CO_2 / sector integration

Case 1
Power to X for Fossil plants

Methanol production for increased revenues

System Overview Today



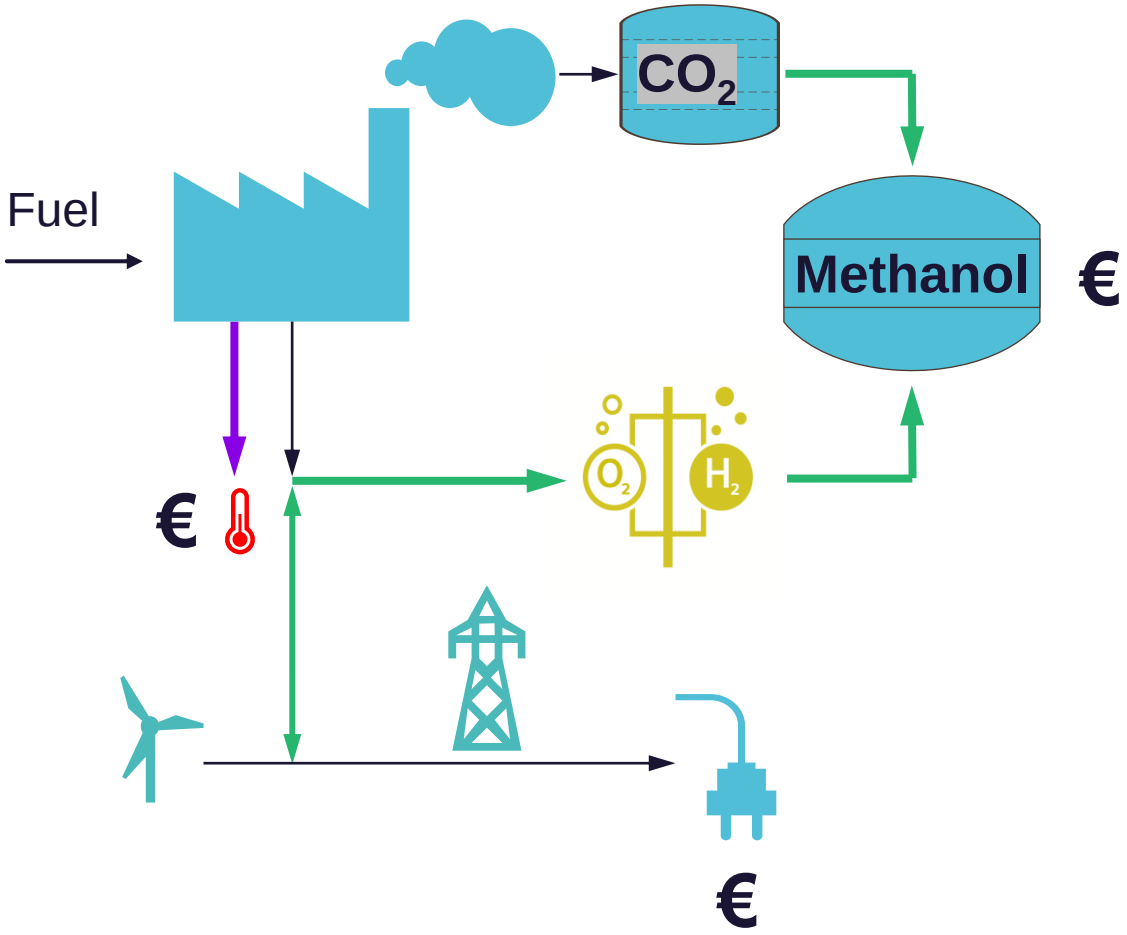
Conventional Power Block
- CO_2 emitting
  - Biofuel
  - Fossil fuel

Power Plant containing
- conventional power block

Revenues
- Electricity
  - spot market
  - grid services
- Heat
  - process steam
  - district heat

Renewables
- Grid limitations
- Residual load (lifetime consumption, start costs)

System Overview new w/ power to x



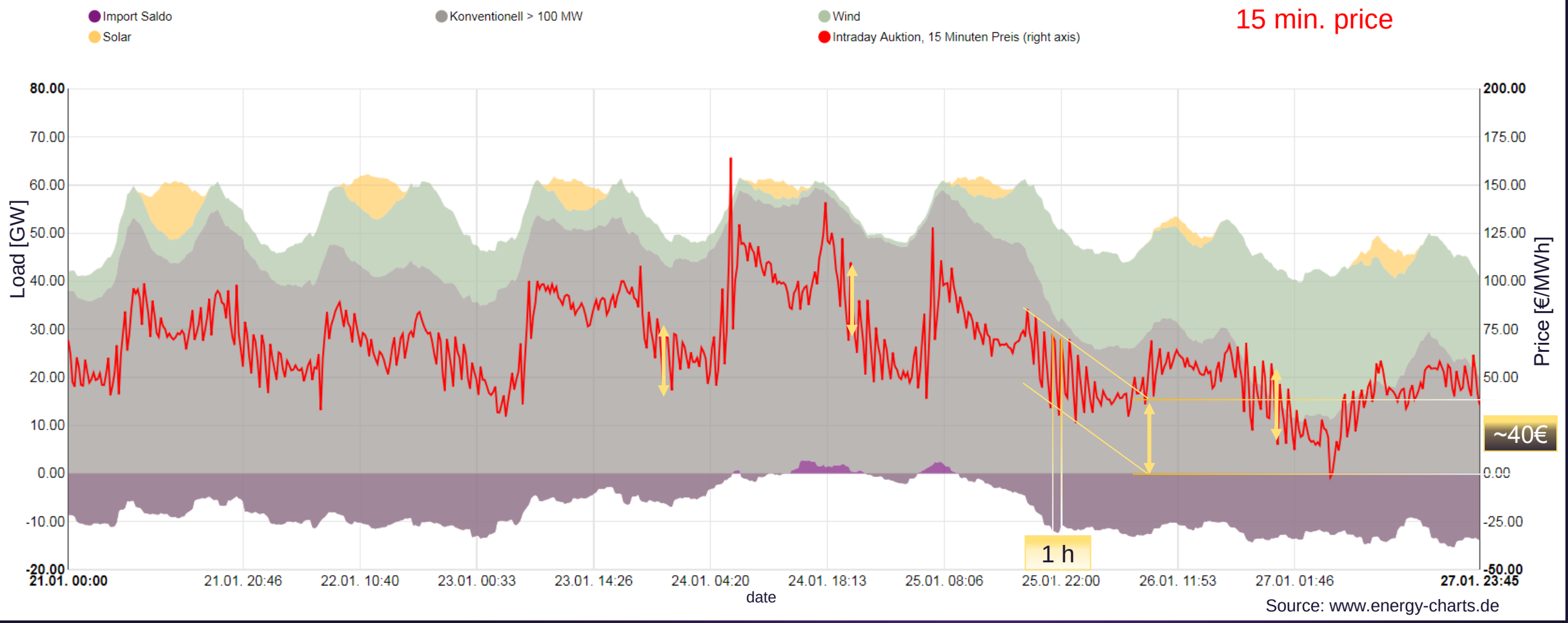
Conventional Power Block
- CO_2 emitting
  - Biofuel
  - Fossil fuel

Power Plant containing
- conventional power block
- Electrolysis
- carbon capture plant
- e-fuel generation
- Battery for very fast load shedding and black start

Revenues
- Electricity
  - spot market
  - grid services
- Heat
  - process steam
  - district heat
- H_2, CO_2 or e-fuel
- Improved grid services

Renewables
- Grid limitations
- Residual load (lifetime consumption, start costs)

German load profile and stock exchange electricity price EEX
Calendar week 4 in 2019



Source: www.energy-charts.de

German stock exchange electricity price EEX 26th and 27th of january 2019

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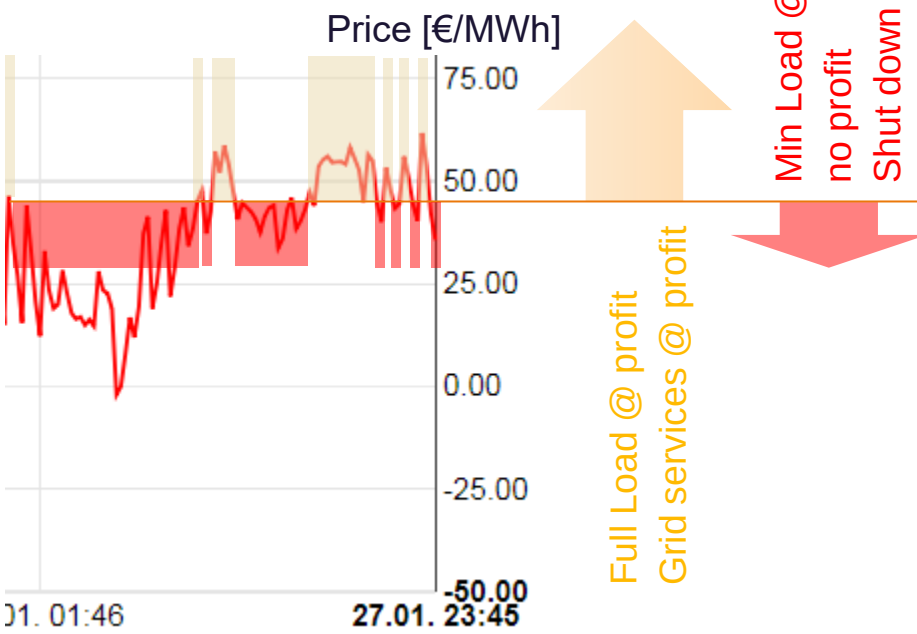
15 min. price



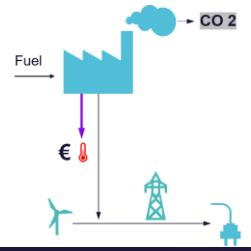
Full Load @ profit
Grid services @ profit

Min Load @ no profit
Shut down

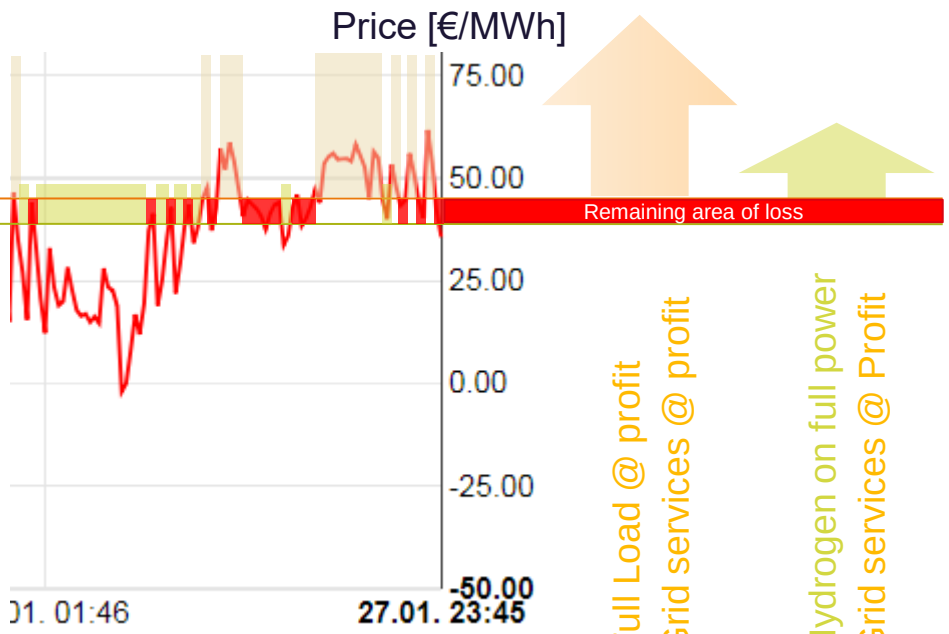
el. production price*
e.g., 46 €/MWh

methanol revenue
36 €/MWh

*) incl. CO2 certificates

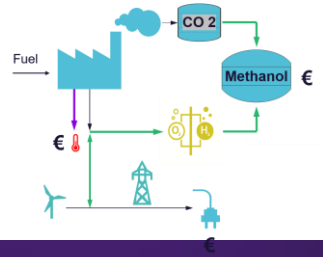


15 min. price



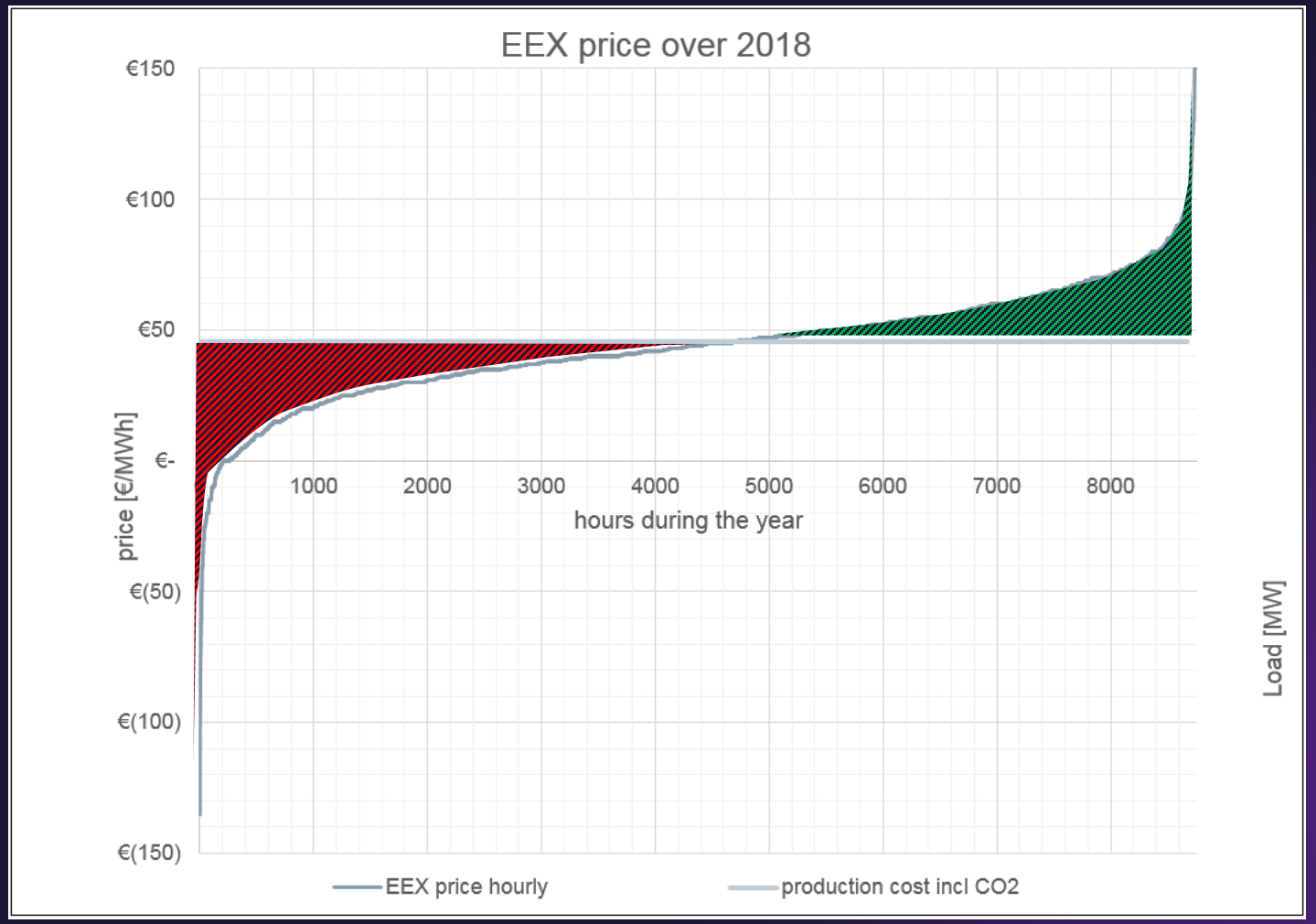
Full Load @ profit
Grid services @ profit

Hydrogen on full power
Grid services @ Profit



Source: www.energy-charts.de

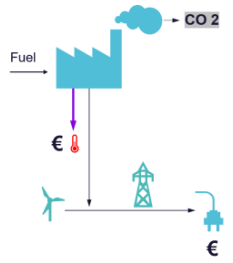
2018 hourly EEX spot prices in sorted order Standard Power Plant



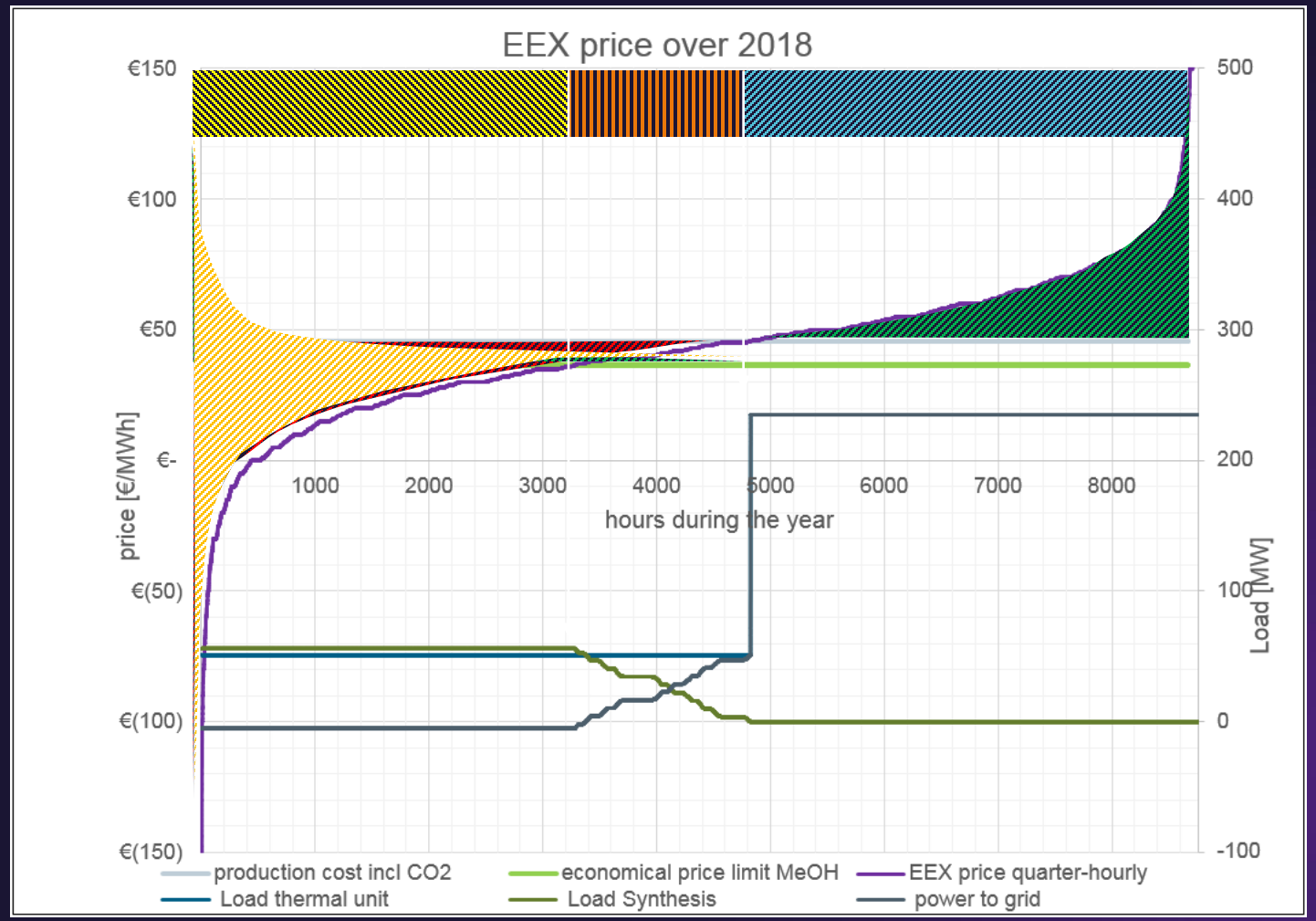
Profit

Loss

- Electricity production only



Operation regime of Power-to-X Power Plant → change of business model



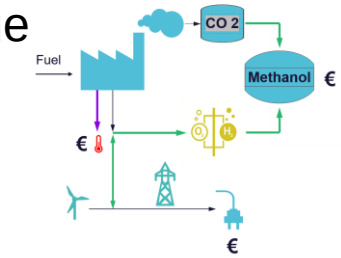
Mainly electricity production electrolyzer off or primary frequency control

Mixed operation Synthesis / therm. PP on min load

Thermal unit min load electrolyzer full load – no power to grid

Improvement:

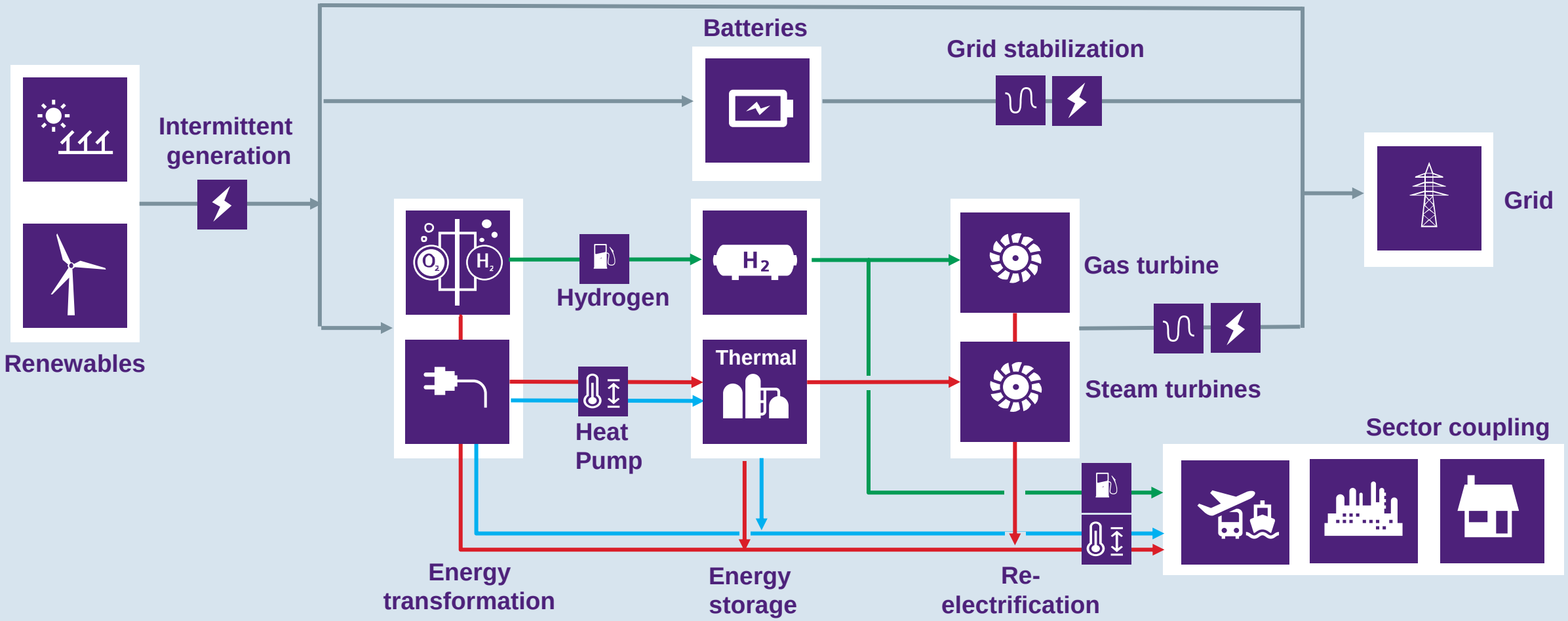
- reduce area of Losses
- add new value



Case Study 2
University Campus

CO_2-free autarkic energy system

Net-zero Energy System



Energy System Design Tool (ESD)

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ESD Modeling

Technology options

Technology pre-selection

Component models and parameters

Technology cost models

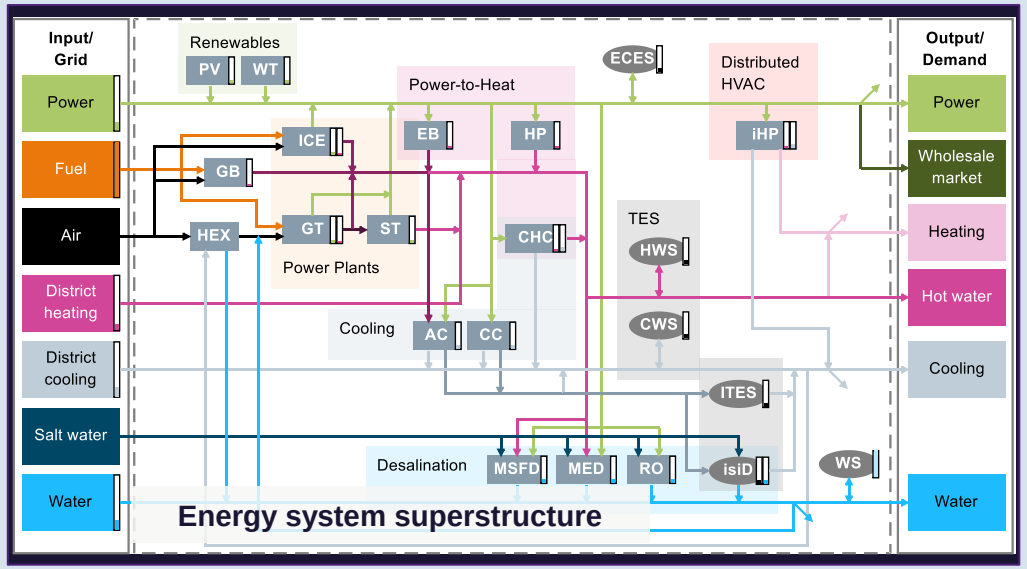
Local customer boundary conditions

Climate data

Commodity prices

Load profiles

Renewable generation profiles



Energy System Design (ESD)

Technology & component selection

Optimal capacities

Optimal operation schedule

Economical analysis

Best energy supply solution

Mandatory input

Optional input

Output

Cost optimized energy system
Use case: University campus (<20 MW)

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Demand

Heat: Max. 9 MW / ~30 GWh/a

Electricity: 9 MW / ~50 GWh/a

Supply

Time resolution

Hourly

20.000 t_{CO2} p.a.

Scenario "Reference" - CO_2 emission allowed

6 MW	6 MW	8 MW	-	-	-	2 MW	5 MWh	-	50 MWh

Scenario: "Future" - CO_2 emissions prohibited

31 MW	30 MW	x	8 MW	10 MW	5 MW	10 MW	60 MWh	1850 MWh	350 MWh

Effectiveness of energy supply system in “island” operation

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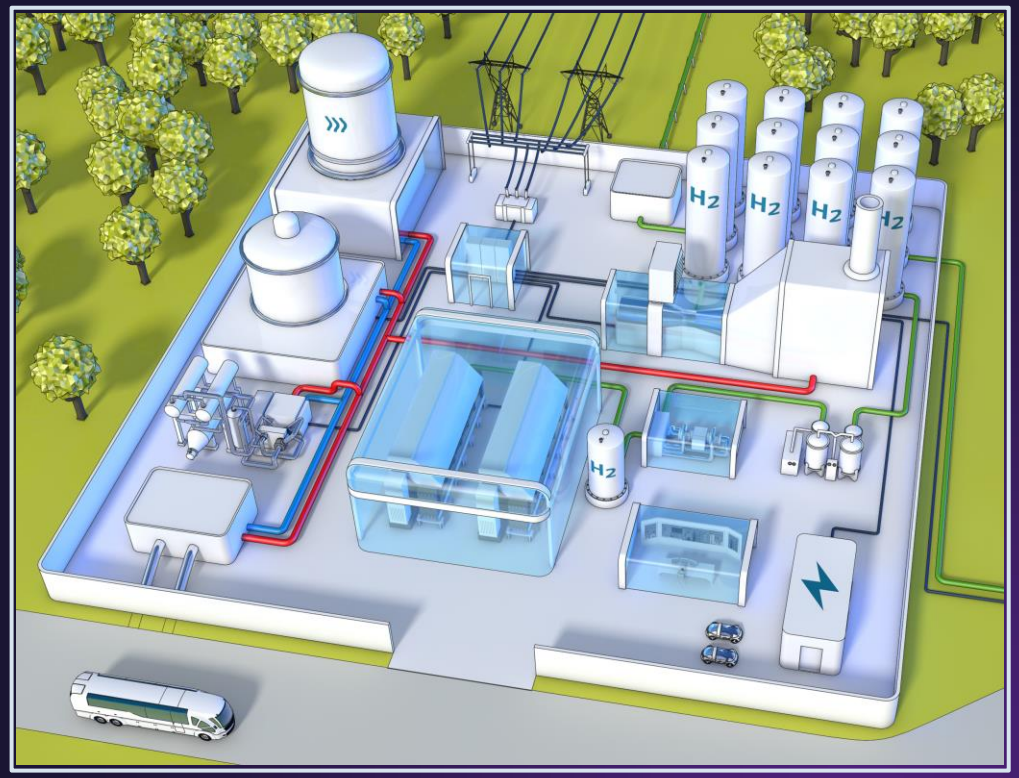
Total of 99 GWh

Renewable power generation

72 GWh

27 GWh

Intermittent electricity



Dispatchable electricity & heat

Total of 80 GWh

End energy demand

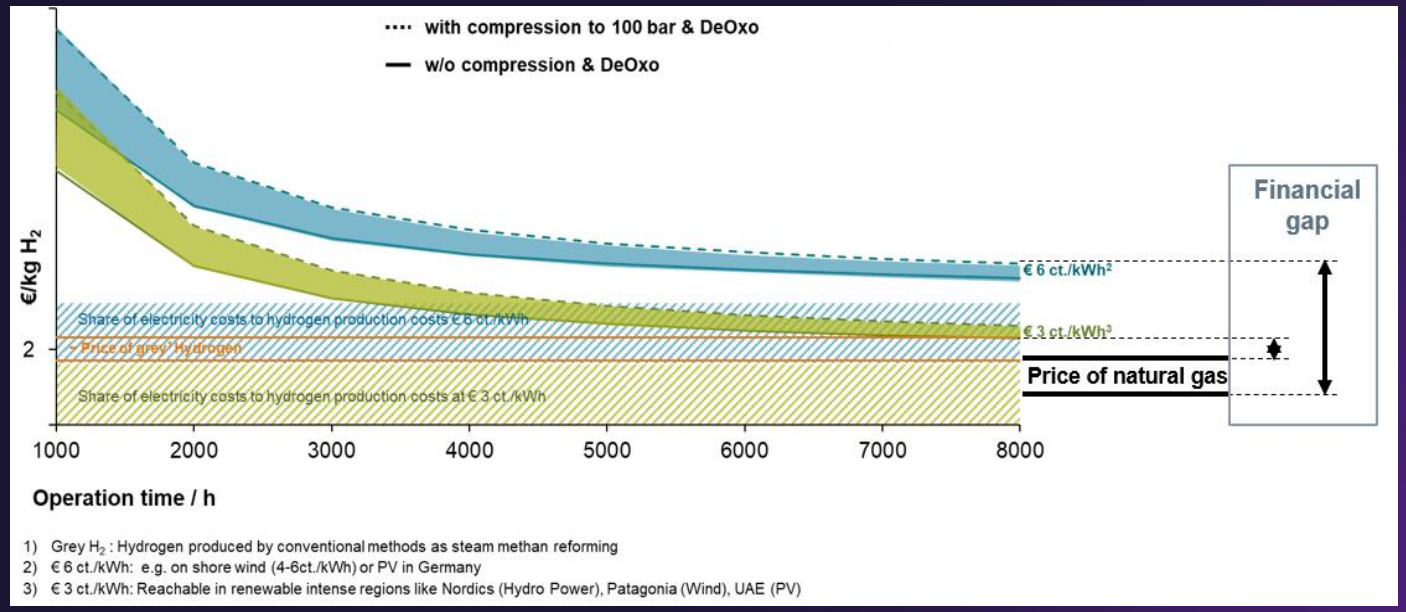
50 GWh

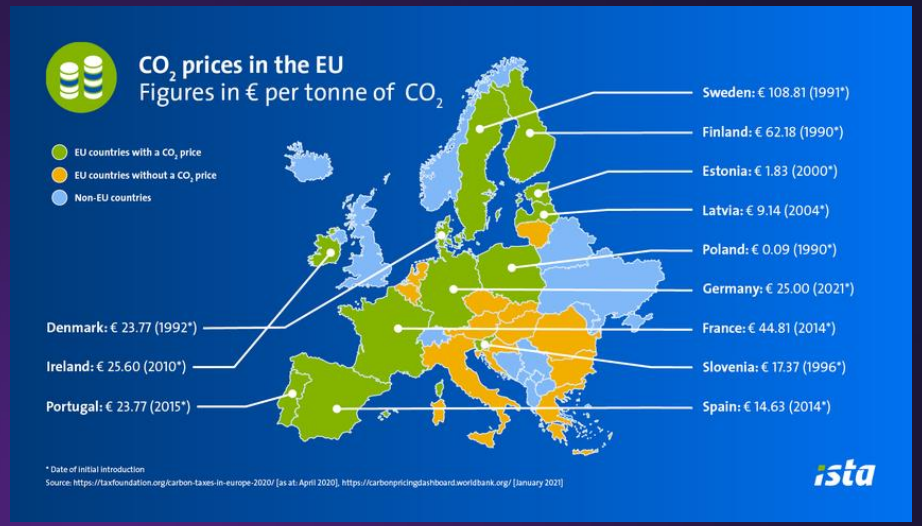
30 GWh

Effectiveness: >80% of renewable energy is used!

Energy System Optimization Results

The “Future” scenario resulted in a higher life cycle cost considering today’s fossil market conditions (e.g., higher H_2 and CO_2 prices),
CAPEX significantly higher than with “Reference” scenario but always cheaper than buffering with Battery only





Expected development of prices (electrolyser, CO_2) in the future will support to drive cost-competitiveness of net-zero scenario

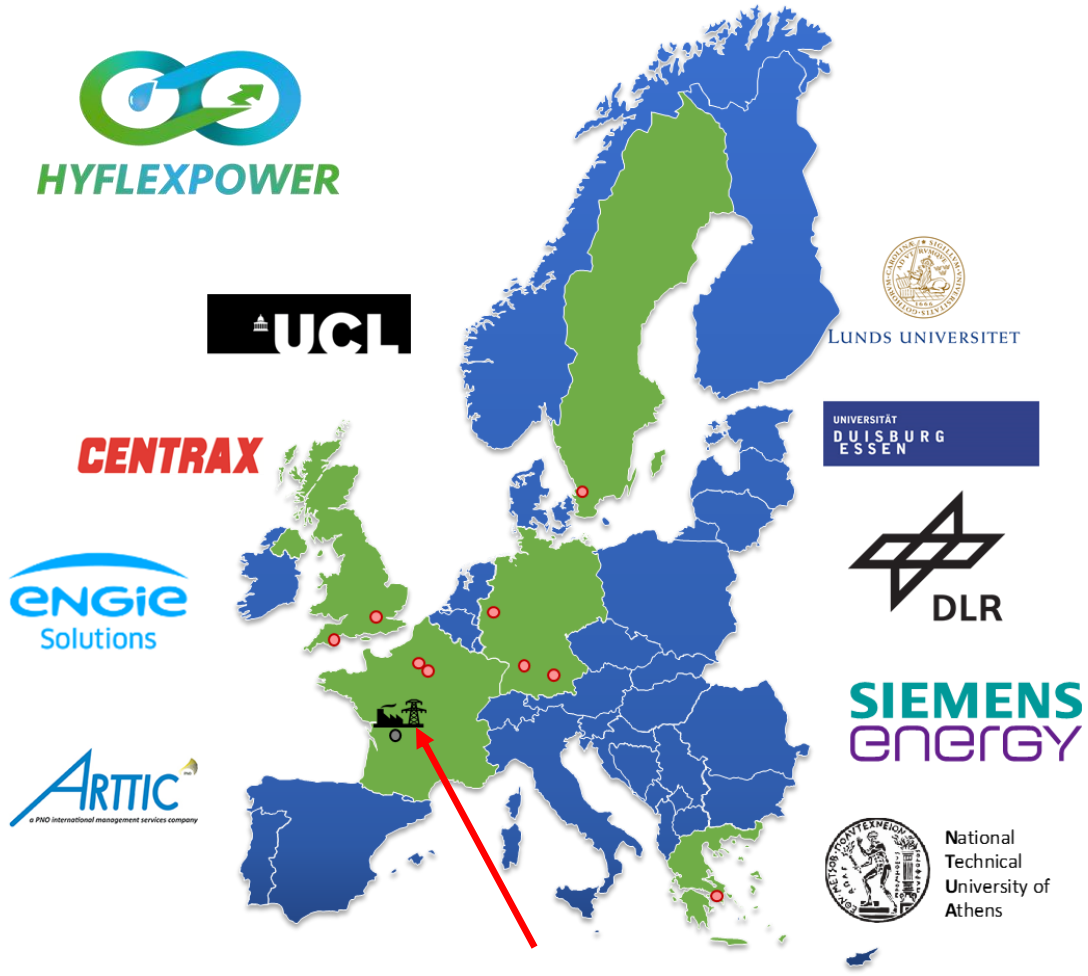
Case Study 3
HYFLEXPOWER

Power-to-H2-to-Power Demonstration project

HYFLEXPOWER Power-H_2-Power Project

World-first demonstration of a **power-H_2-power path for CO_2-free** power generation pilot including an advanced **H_2 gas turbine**

- Decarbonizing papermill by modernizing combined heat and power plant in Saillat-sur-Vienne, France.
- Siemens Energy led consortium with project value of 15.2 M€
- Project Start: May 1st, 2020 - Duration: 4 years



Power Plant Operator, academia and OEM formed strong consortium demonstrating CO_2-free power generation

HYFLEXPOWER has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 884229

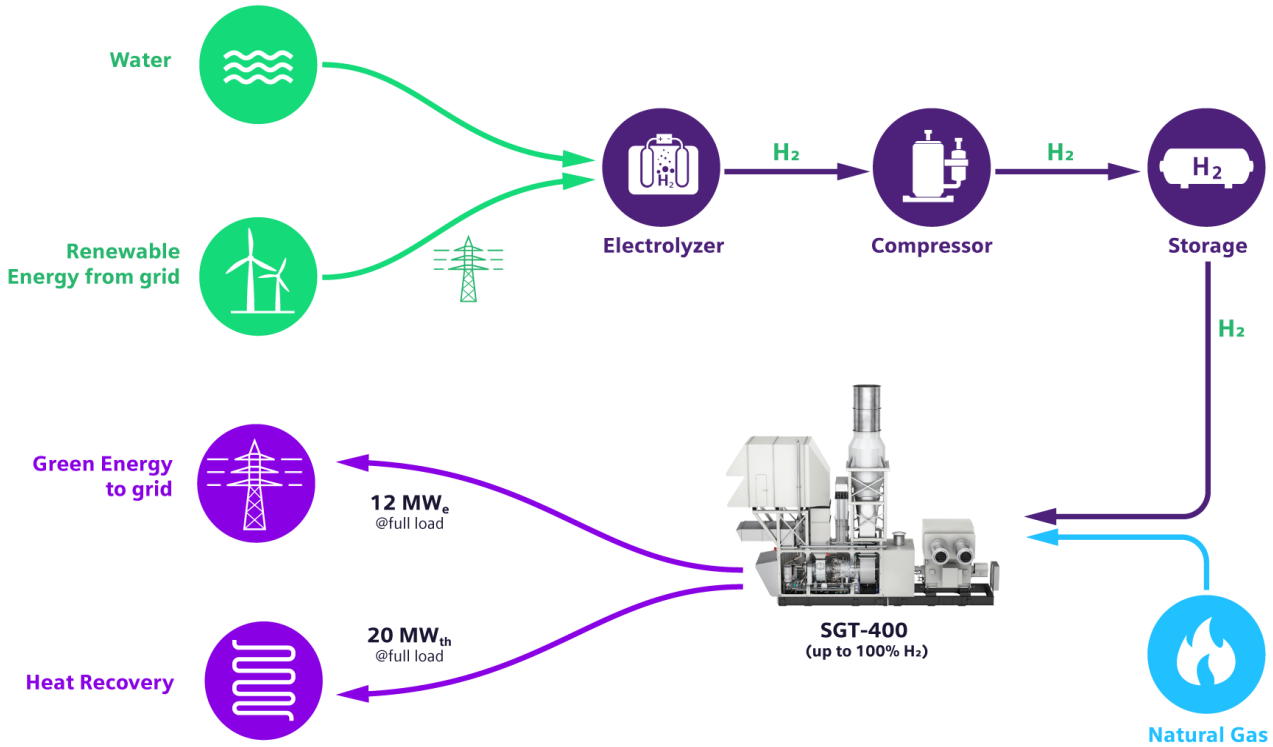
EU Framework Horizon 2020: HYFLEXPOWER

Project Concept & Key Milestones

2021 Installation of the **H_2 production, storage** & supply facility at site

2022 Initial demonstration of **advanced plant concept** with NG/ H_2 mixtures

2023 Pilot up to **100% H_2 for carbon-free energy production** from stored excess renewable energy (CO_2 saving 65,000t/yr.)



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HYFLEXPOWER

Expected Results & Impacts

- Industrial scale power-H_2-power solution pilot
  - Importance of H_2 as long-term energy storage technology
  - Decoupling renewable energy power generation from demand and enabling additional revenue streams
  - Utilization of existing assets to produce green power & heat
- Validation of SGT-400 dry low emissions (DLE) high-H_2 technology with up to 100% H_2
- Economic, environmental & social assessments for business case evaluation, carbon footprint, & policy recommendations

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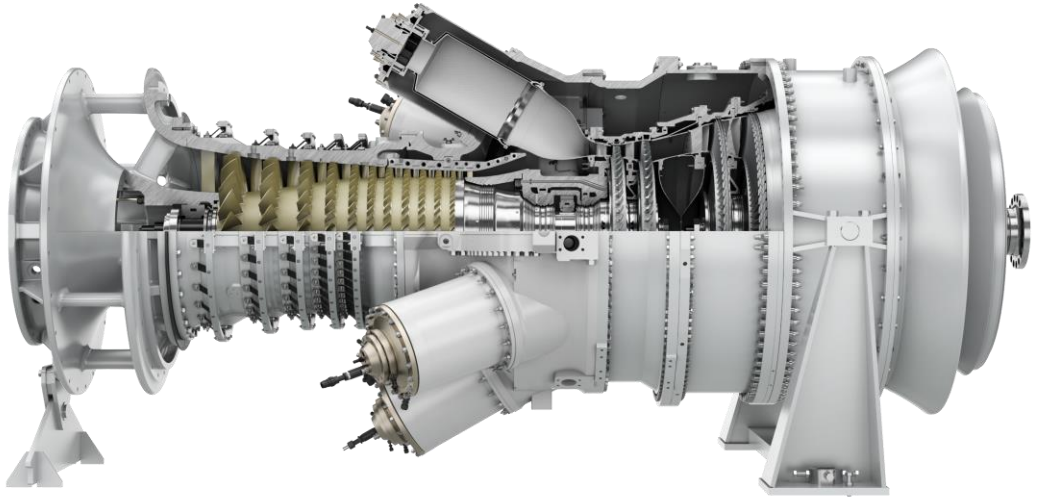
Conclusion

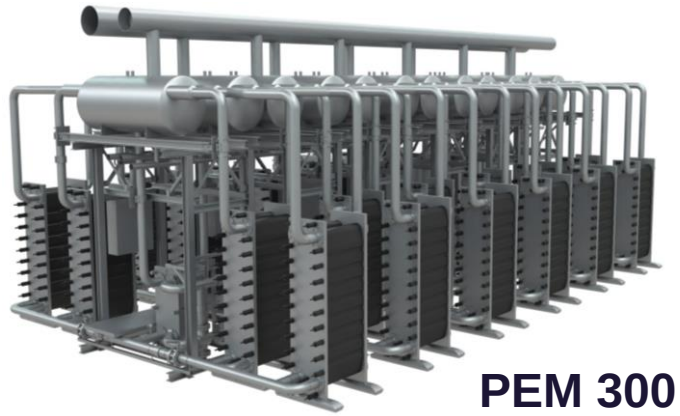
The way forward for transitioning energy systems

Energy System Transition

- Existing System not easy to switch in one day but gradual change to final system
- Opportunities for new revenue streams within existing system and integration of Power-to-X
- Heat needs to be considered in the equation
- Technology under development with decreasing prices expected to support transition implementation



SGT-400 Gas Turbine



PEM 300 Electrolyzer

Thank you.

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