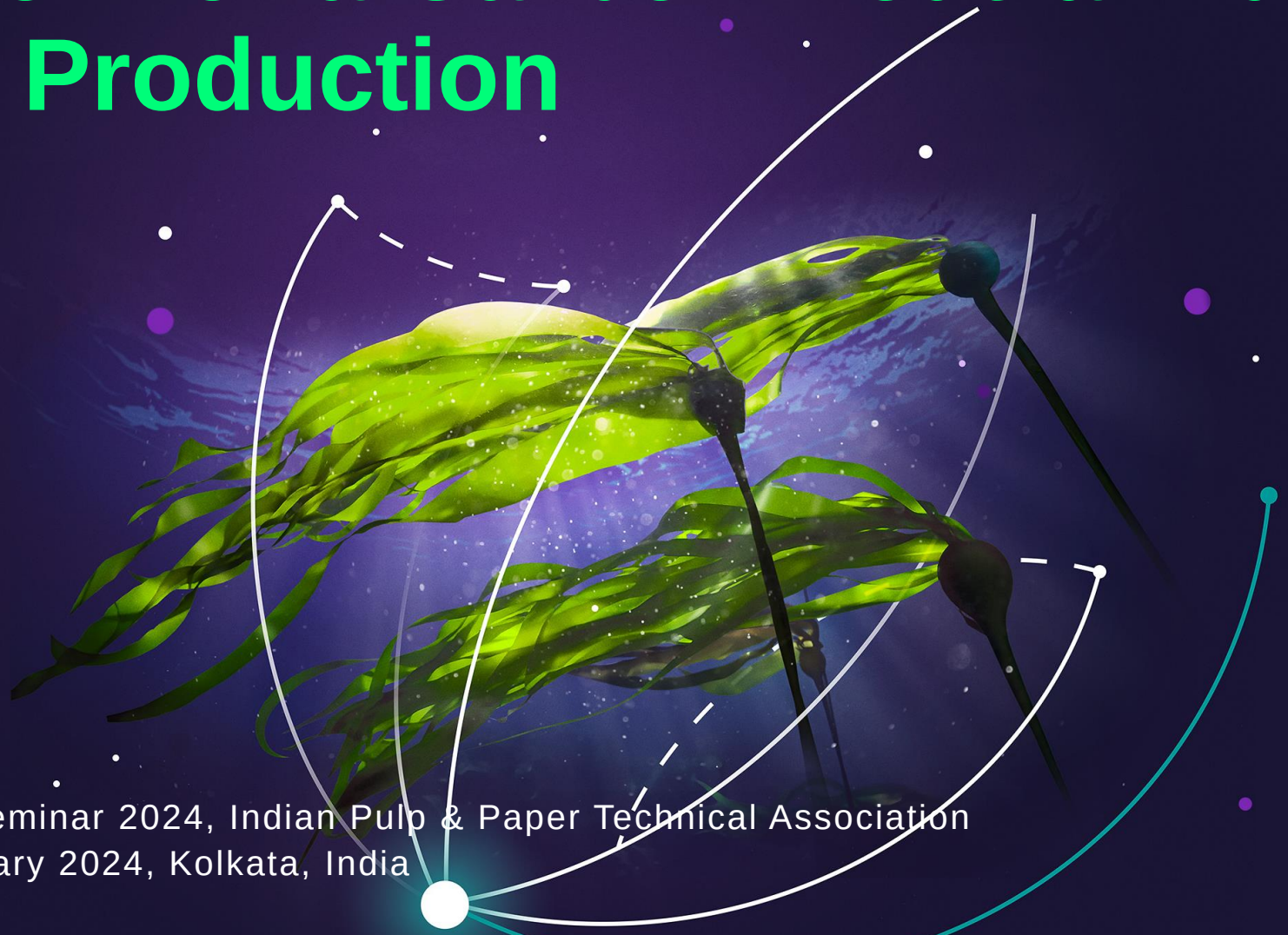
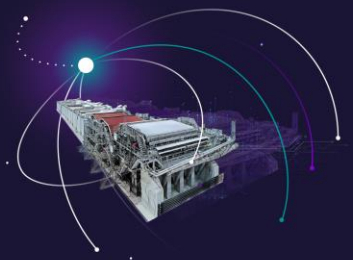
Solution for a Carbon Neutral Pulp & Paper Production





59th AGM and Seminar 2024, Indian Pulp & Paper Technical Association
23rd - 24th February 2024, Kolkata, India

H. Schwarz, M. Sundararaj, G. Tripathi Siemens Energy – Transformation of Industry

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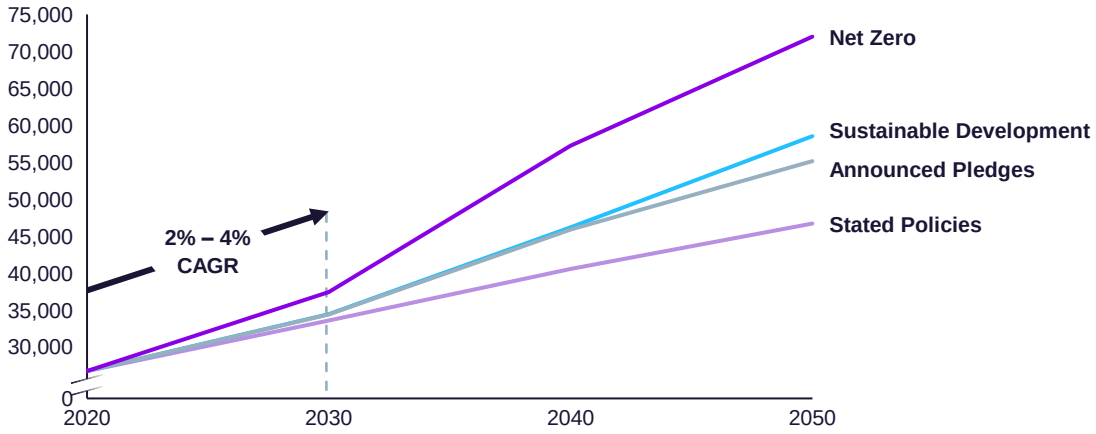
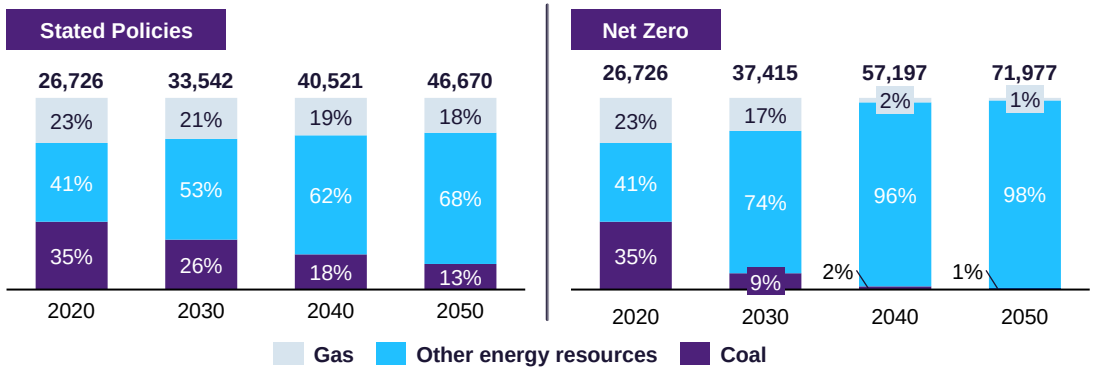
Scenarios how global electricity market will develop …

Global electricity generation scenarios (TWh)



Global electricity generation by source (TWh)[1]

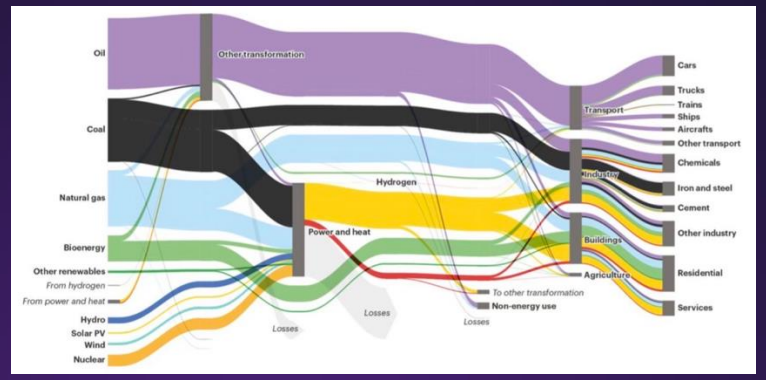


Source: IEA WEO 2021

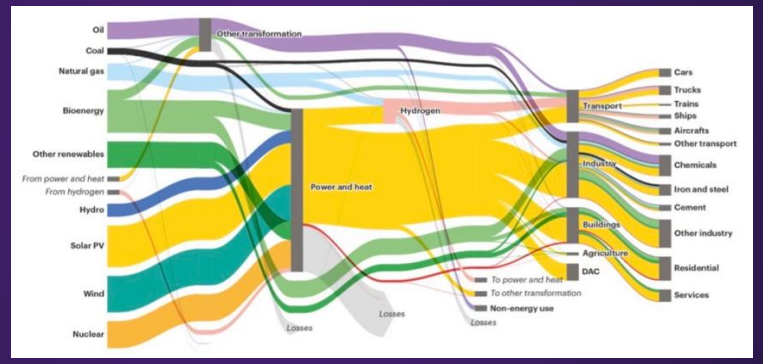
***1** Other energy includes: Hydro, Nuclear, Geothermal, Oil, Hydrogen based, Bioenergy*

Massive growth in renewables installations until 2030

Additions until 2030		
Stated Policies	+120%	+240%



global energy conversion 2020



global energy conversion 2050

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Fiber Industry

- 4th most energy-intensive industry
- ~2% of global GHG emissions

Market Segments

Tissue & Special Paper Mills		Pulp Mills	
Green Solutions beyond Pulp & Paper		Board Mills	

Major CO_2 emission routes

- *Direct emissions*[1,2,3,4]
- *Purchased electricity*
- *Transportation*

+ 7% pulp, paper, board production
- 21% energy usage (total energy mix)
- 75% CO2 emissions (- 37Mt CO2)

cepi 2015-2050 PATHWAYS FOR DECARBONISATION

Regulatory drivers for decarbonization

- Increasing CO_2 penalties and decarb funding
- Demand for CO_2 free products from off-takers / consumers (Amazon, Coca-Cola, Maersk …)
- Investor / shareholder push for responsible sourcing by mill owners

February `24, Kolkata

Fiber Industry has already commenced their decarbonization journey

Decarbonization potentials (direct emissions), use-cases

1 Efficiency increase — *30%*

- **energy-efficient components and system design** (gearless, **electric drive trains** …)
- EAD measures to lift **operational uptime**
- **process** and control (closed cycles, **waste-heat-recovery**, economy of scale …)

2 Fuel shift — *35%*

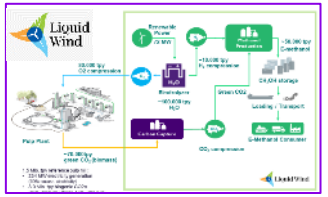
- steam generation with **low carbon boilers** (multifuel, biogas, electric …)
- integrated **CHP** power plants w/ flex-fuel turbines
- **waste incineration** power plants (residual wood, rejects, municipal waste …)

3 Demand side flexibility — *10%*

- **flexible operations**, providing **grid control**
- **peak-shaving** through storage (electric, thermal, mechanical, chemical …) and temporary generation (gas motors, gas turbines)
- **sector coupling**, district heating

4 Emerging & breakthrough technologies — *25%*

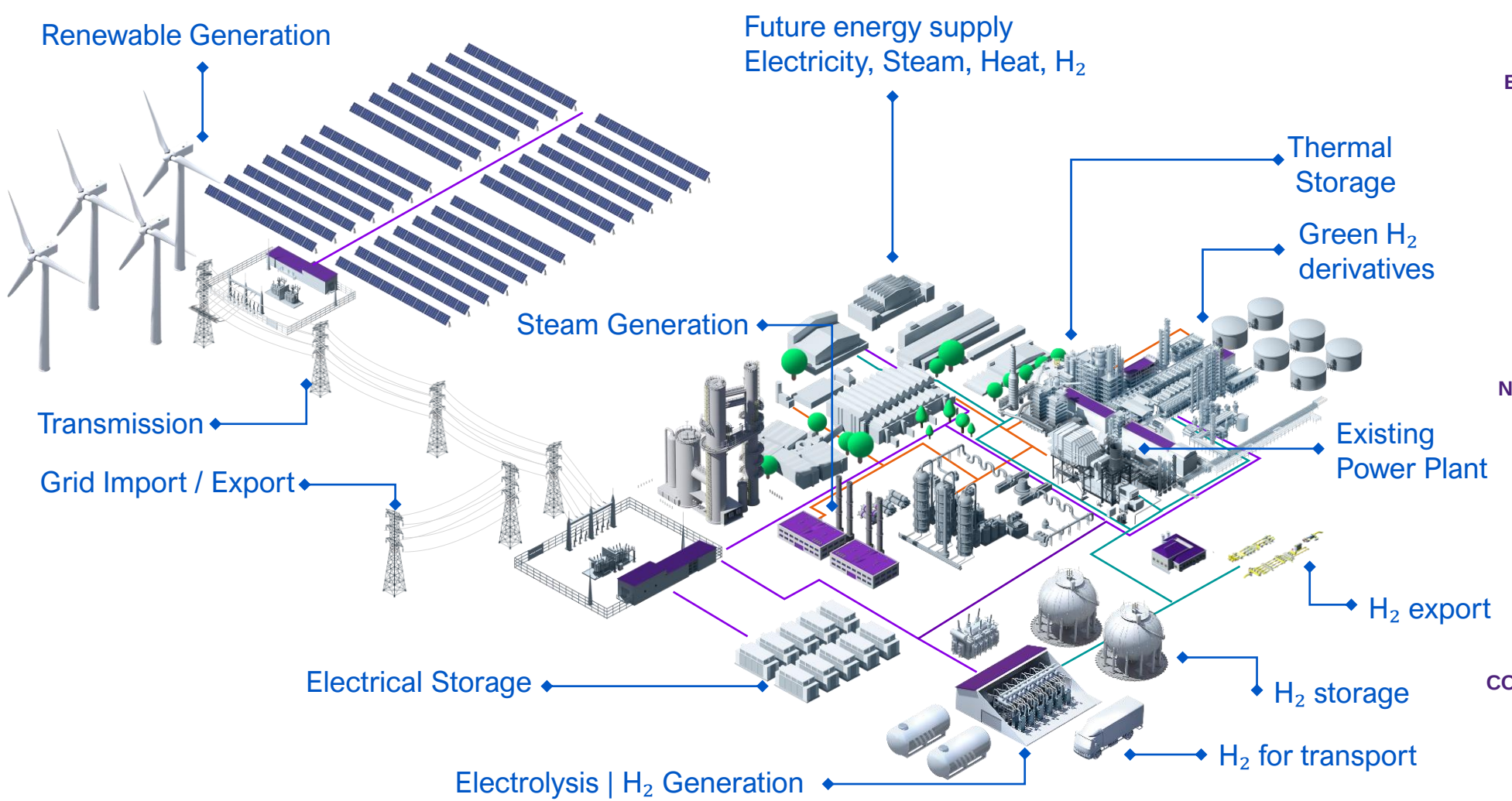
- EAD and **process knowhow** for commercial scale (220ktpy) non-fossil **biochemicals** production (BioMEG, BioMPG, RFF, industrial sugars)
- **industrial integration** of **eFuel** production, made from renewable energy, water and biogenic CO2



% *contribution to decarb targets*

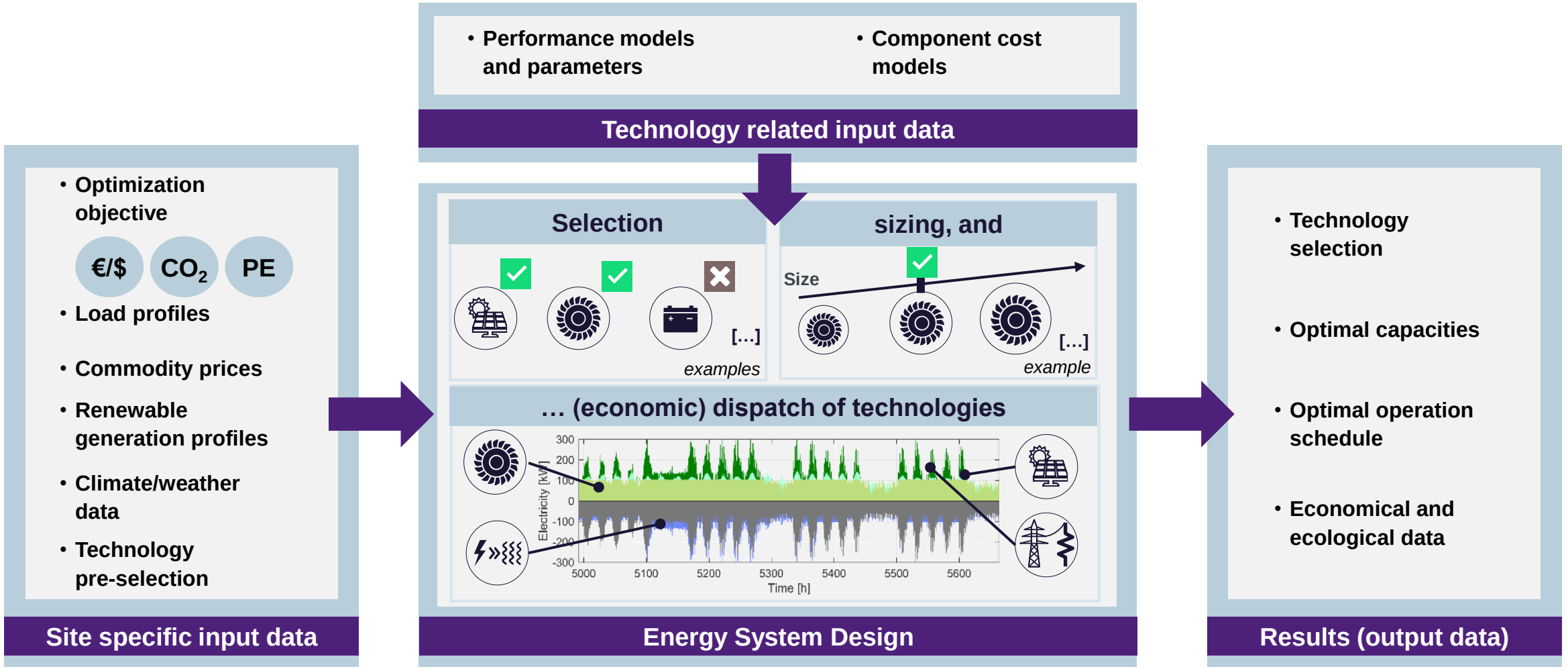
Design Challenge - Multi-Modal Energy Systems

- Capital Expenditures
- Operational Expenditures
- Efficiency
- Limitations
- Availability
- Decarbonization targets
- Capacities
- Alternatives



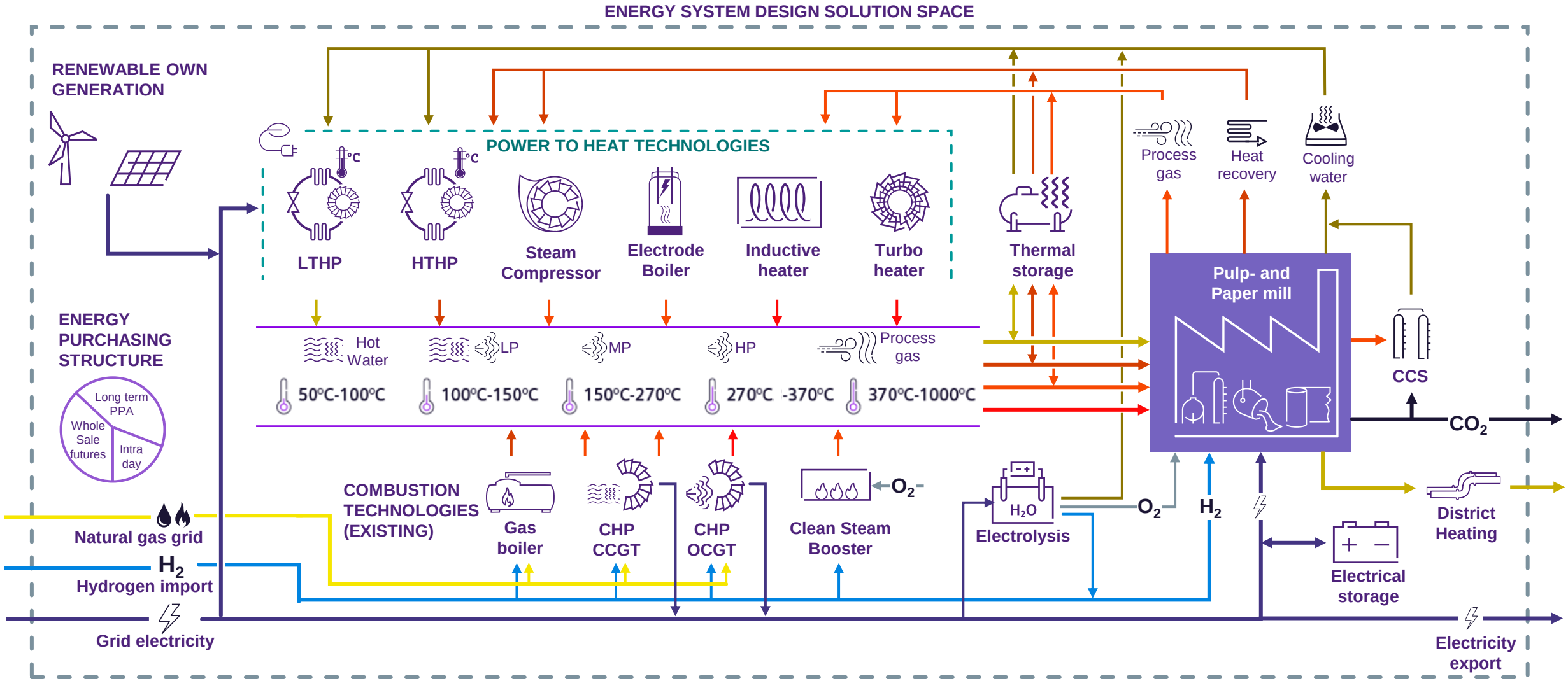
- Electricity
- Steam
- H_2 Hydrogen
- Natural Gas
- Cooling
- Fuel
- CO_2 CO2-Emissions
- Water

Energy System Design – projecting energy costs, simulating heat & power systems, optimizing existing assets as well as **future-proof mill concepts**



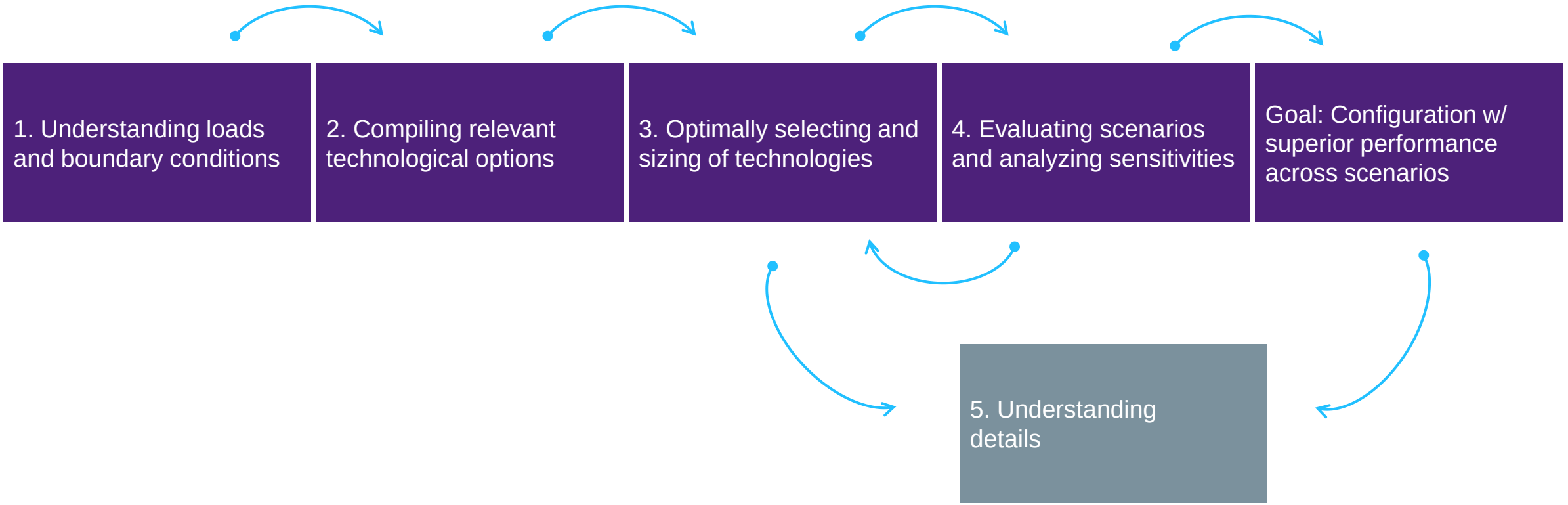
PE: primary energy

Holistic Approach: Multi modal energy system design



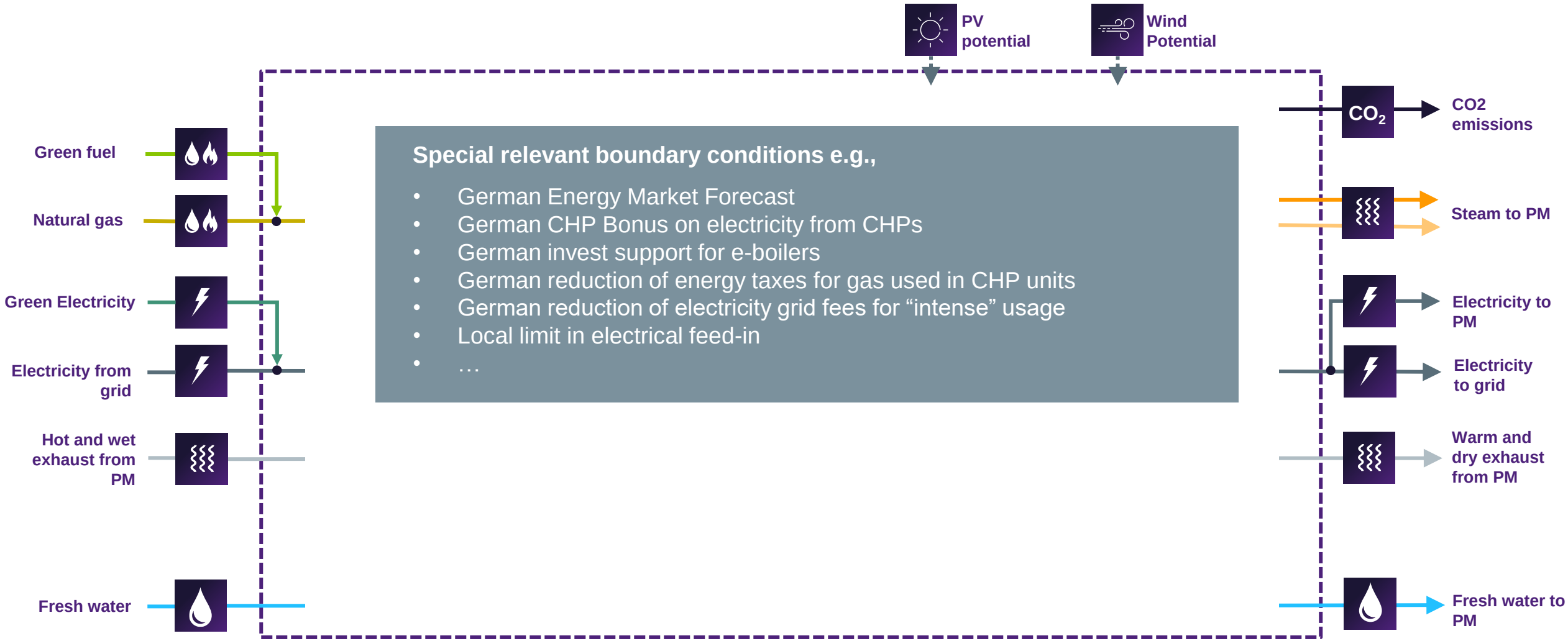
CCPP – Combined Cycle Power Plant | CoGen – Co-generation Unit | HP – High Pressure | OCGT – Open Cycle Gas Turbine (Power Plant) | PM – Paper Mill | PV – Photovoltaic

Energy System Design for Paper Mill
Approach



Energy System Design for Paper Mill

1. Understanding loads and boundary conditions



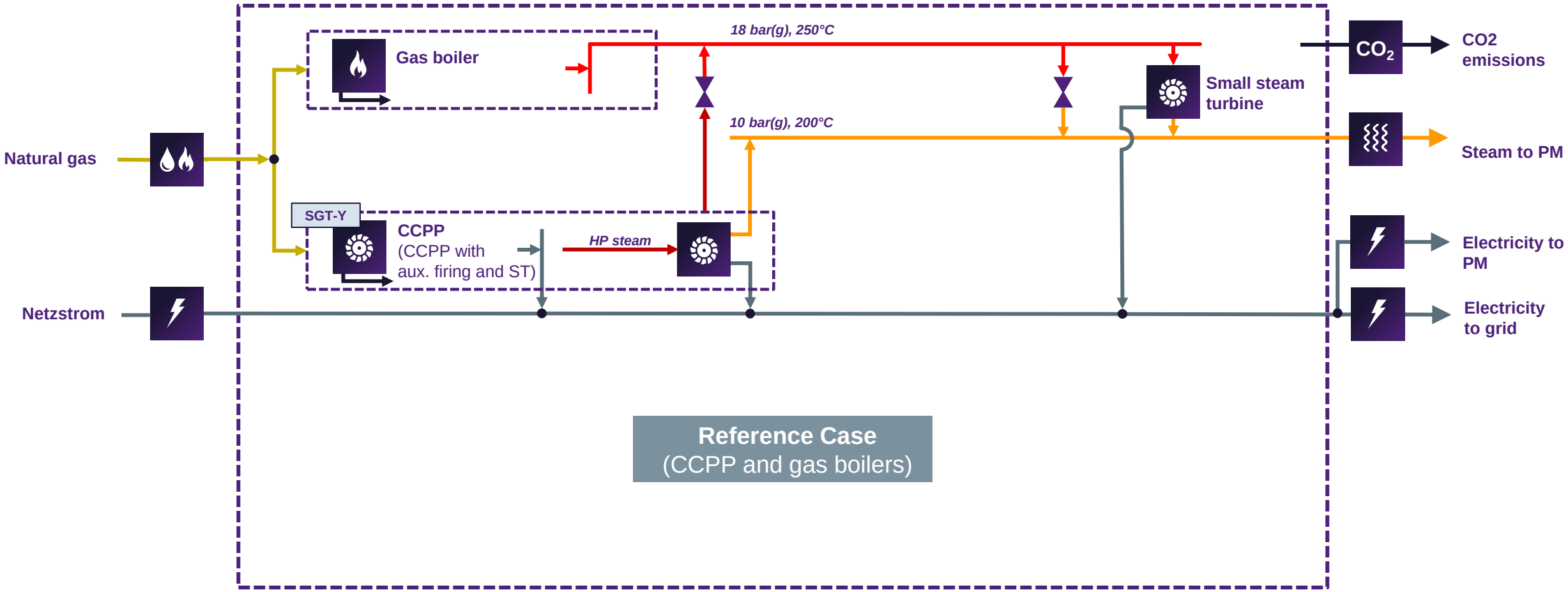
Special relevant boundary conditions e.g.,

- German Energy Market Forecast
- German CHP Bonus on electricity from CHPs
- German invest support for e-boilers
- German reduction of energy taxes for gas used in CHP units
- German reduction of electricity grid fees for “intense” usage
- Local limit in electrical feed-in
- …

CCPP – Combined Cycle Power Plant | CoGen – Co-generation Unit | HP – High Pressure | OCGT – Open Cycle Gas Turbine (Power Plant) | PM – Paper Mill | PV – Photovoltaic

Energy System Design for Paper Mill

2. Compiling relevant technological options – reference case



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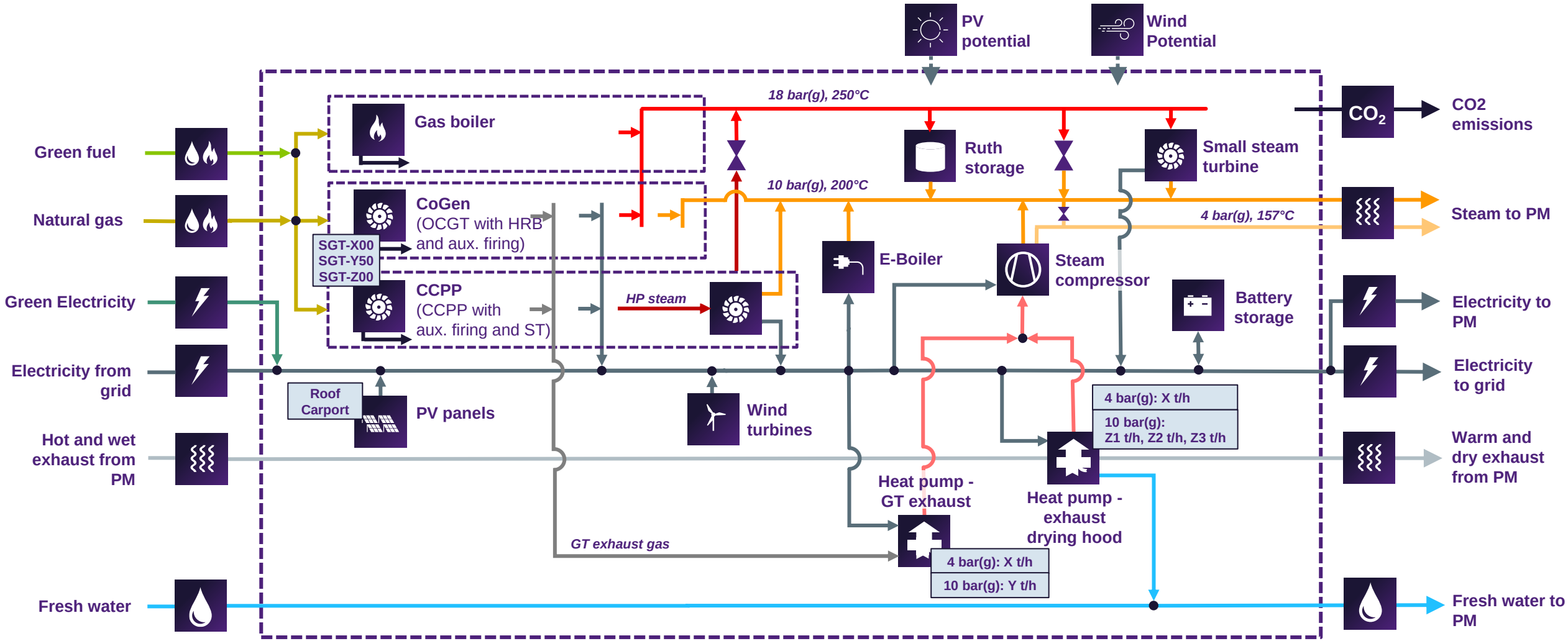
Energy System Design for Paper Mill

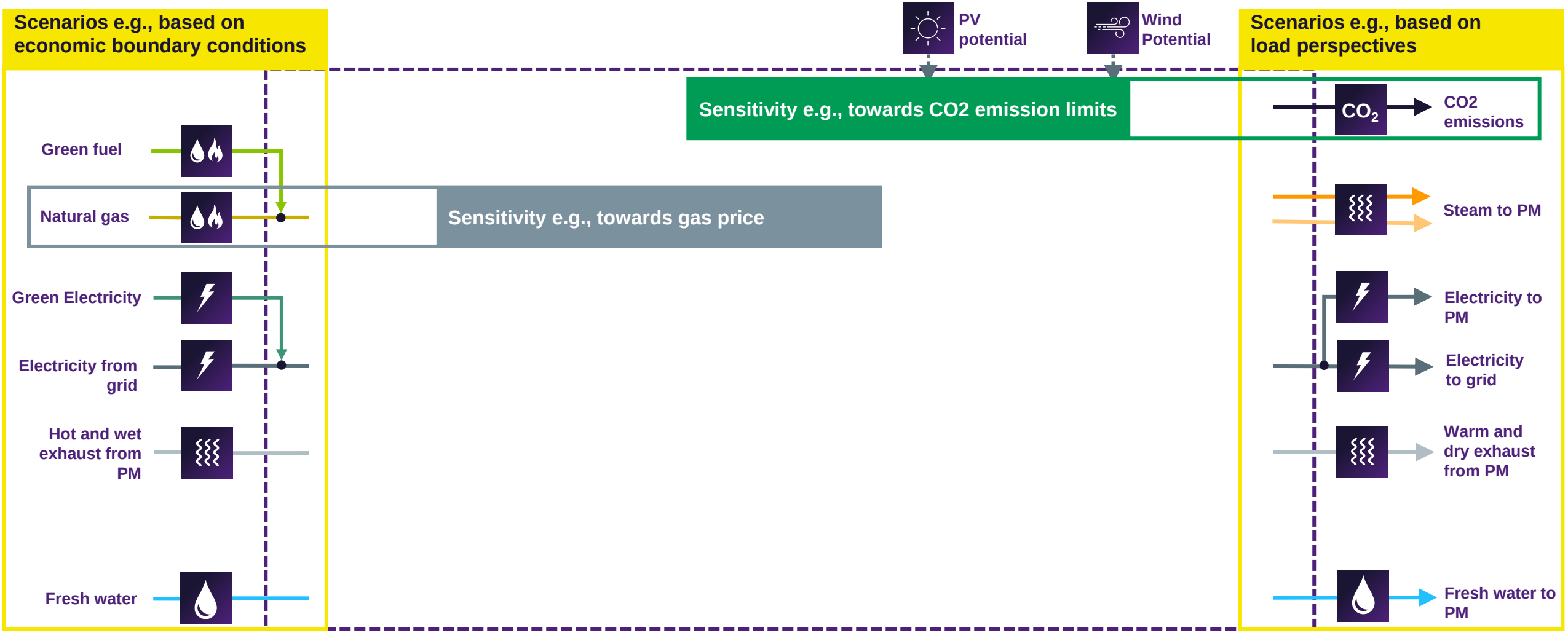
2. Compiling relevant technological options



CCPP – Combined Cycle Power Plant | CoGen – Co-generation Unit | HP – High Pressure | OCGT – Open Cycle Gas Turbine (Power Plant) | PM – Paper Mill | PV – Photovoltaic

Energy System Design for Paper Mill

4. Evaluating scenarios and analyzing sensitivities I



CCPP – Combined Cycle Power Plant | CoGen – Co-generation Unit | HP – High Pressure | OCGT – Open Cycle Gas Turbine (Power Plant) | PM – Paper Mill | PV – Photovoltaic

Energy System Design for Paper Mill
4. Evaluating scenarios and analyzing sensitivities II

E.g. Energy Market Forecast
Prices for electricity, gas, CO_2

Component, e.g. E-Boiler

Component → / Scenario ↓	C_1	C_2	C_3	C_4	C_5	C_6	C_7
Scenario A 2025	X			X	X	X	
Scenario B 2025		X		X	X	X	
Scenario A 2030	X			X		X	
Scenario B 2030		X		X			
Scenario A 2040	X		X	X			
Scenario B 2040		X	X	X		X	

Schematic representation

Either / or | in the 40ies | always | In the 20ies | often

Component → / ESD configuration ↓	C_1	C_2	C_3	C_4	C_5	C_6	C_7
ESD1	X			X		X	
ESD2		X		X		X	

Energy System Design for Paper Mill
4. Evaluating scenarios and analyzing sensitivities III

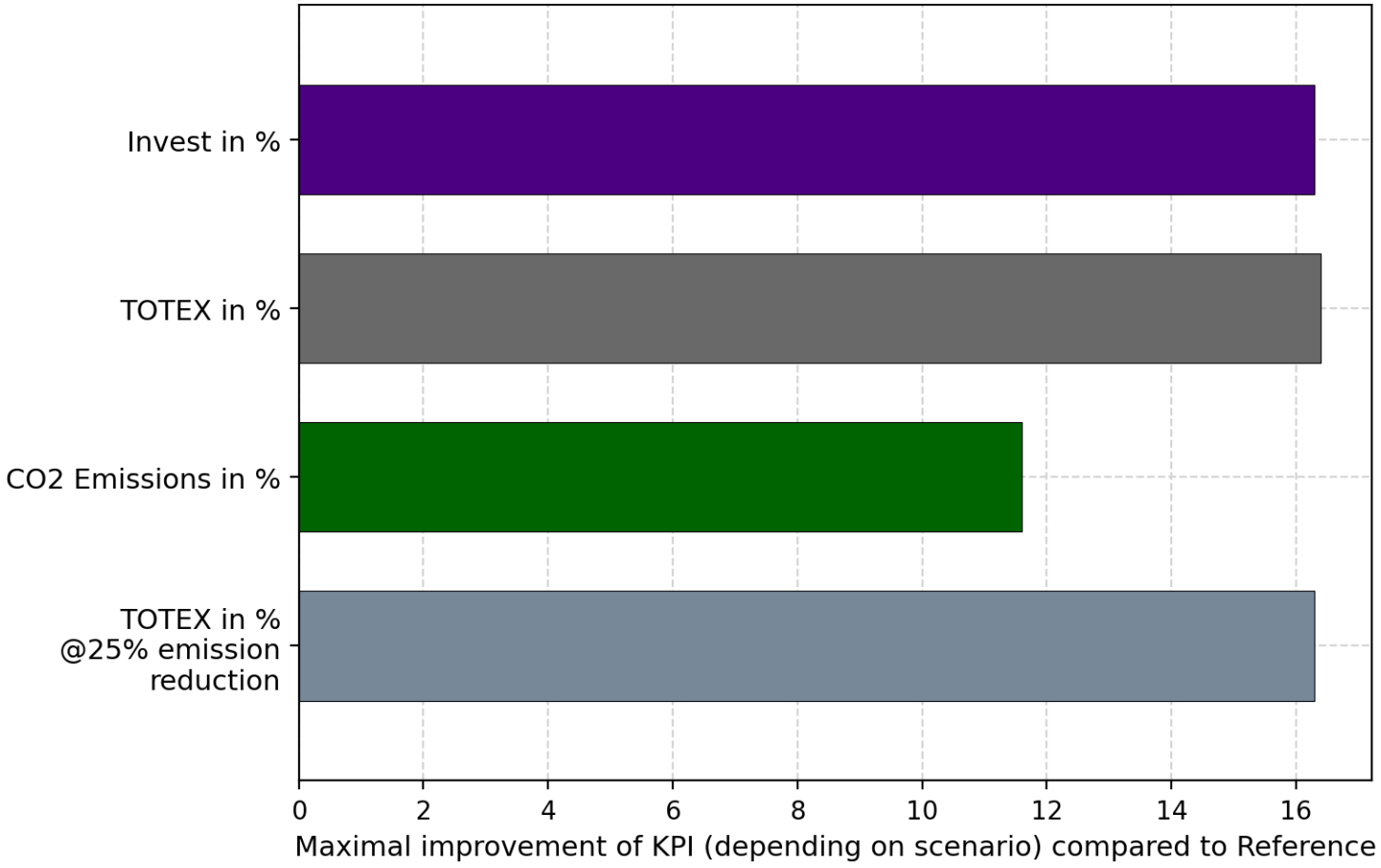
Configuration with superior performance

	Annual TOTEX	Annual CO_2 emissions	Annual TOTEX	Annual CO_2 emissions	Annual TOTEX	Annual CO_2 emissions
ESD configuration → / **Scenario ↓**	**REF**		**ESD1**		**ESD2**	
Customer Shock 2025			TOP1			TOP1
Scenario A 2025			TOP1			TOP1
Scenario B 2025				TOP1		
Customer Shock 2030			TOP1			TOP1
Scenario A 2030			TOP1	TOP1		
Scenario B 2030			TOP1	TOP1		
Customer Shock 2040			TOP1	TOP1		
Scenario A 2040				TOP1	TOP1	
Scenario B 2040			TOP1	TOP1		

Schematic representation

Goal: Configuration with superior performance in multiple scenarios and years

Energy System Design for Paper Mill
4. Improvement of key performance indicators



- **Decrease in invest as compared to reference solution of 16.3 %**
- **Decrease in Annual TOTEX (= Annual OPEX + Annual CAPEX) of 16.4 % (depending on year and scenario)**
- **Decrease of CO_2 emissions of up to 11.6 % cost optimal operation (depending on year and scenario)**
- **TOTEX increase if CO_2 emissions are reduced below cost optimal emissions. Again, the new configuration allows for reduced Annual TOTEX of up to 16.3 % (depending on year and scenario).**

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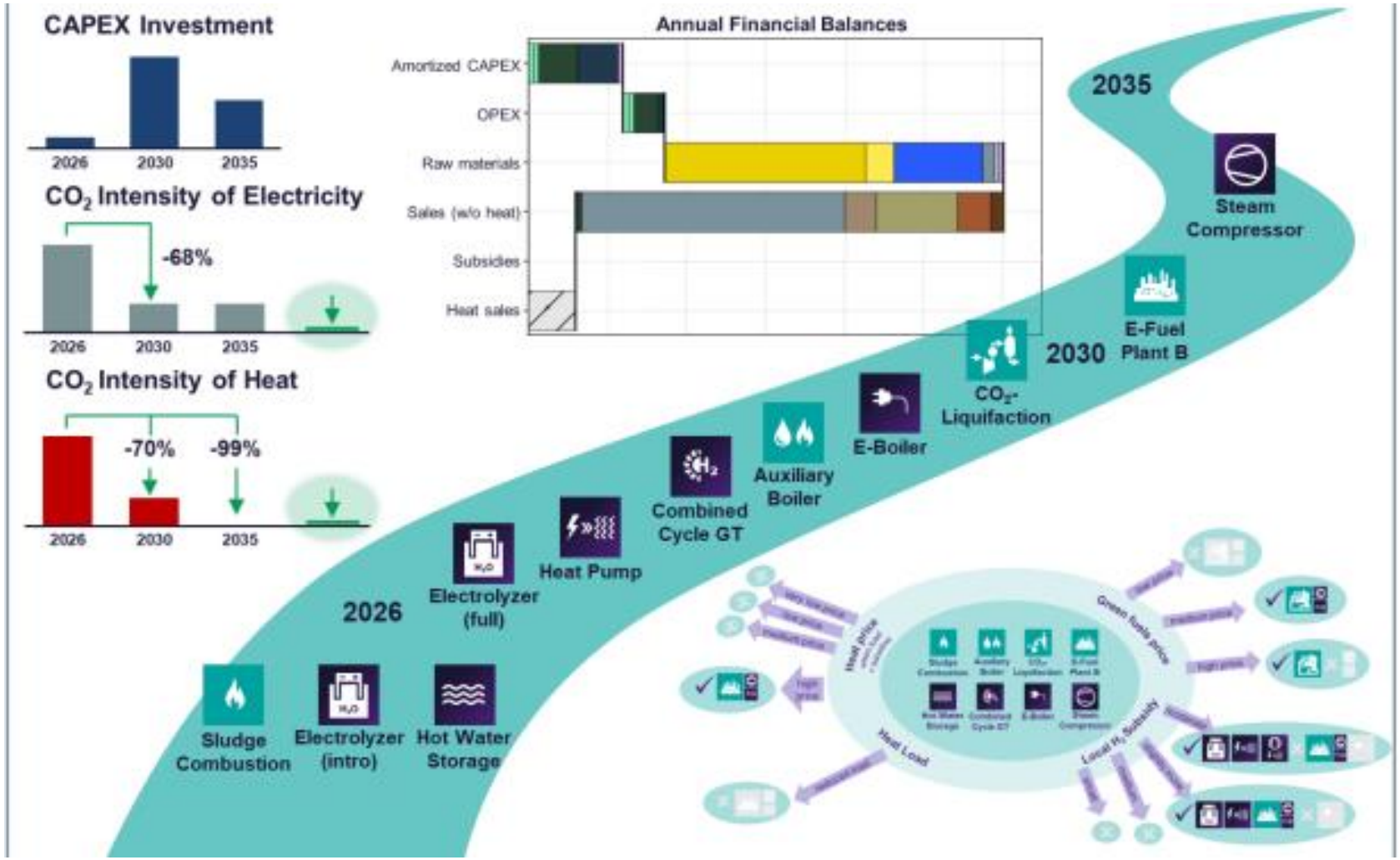
Starting the Transition with a Energy System Design in Pulp & Paper



Thank you for your attention!
Questions?

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