Hydrogen & e-Fuels as Enablers of a Renewable Energy and Mobility System

Wiener Motorensymposium 2022

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Content

Austrian Energy Scenario 2050

AVL executed a scenario analyses towards the Austrian Energy system 2050

Methodology:

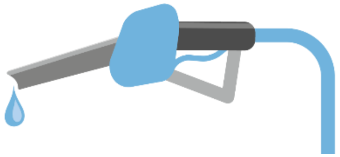
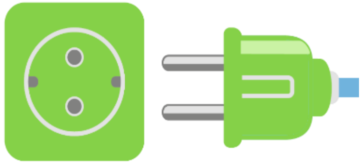
- Demand scenario for each sector in 2050
- Average weather data from 2017-19 and scaled to max. renewable potential (118 TWh, IndustRiES Study, 2019)
- Hourly simulation of energy use and production for an energy scenario 2050 based on assumptions

Key assumptions:

- Full decarbonization achieved (target 2040)
- Implementation of the Austrian Mobility Strategy (Mobilitätsmasterplan 2030)
  - Passenger car transport reduction by >20%
  - Road goods transport stays constant, increase covered by other transport modes
- Strong reduction of heating demand by thermal insulation and shift to electrical heating (heat pumps)
- Largely decoupled economic growth and energy consumption of industry
- 30% of required hydrogen produced in Austria with local electrolyses

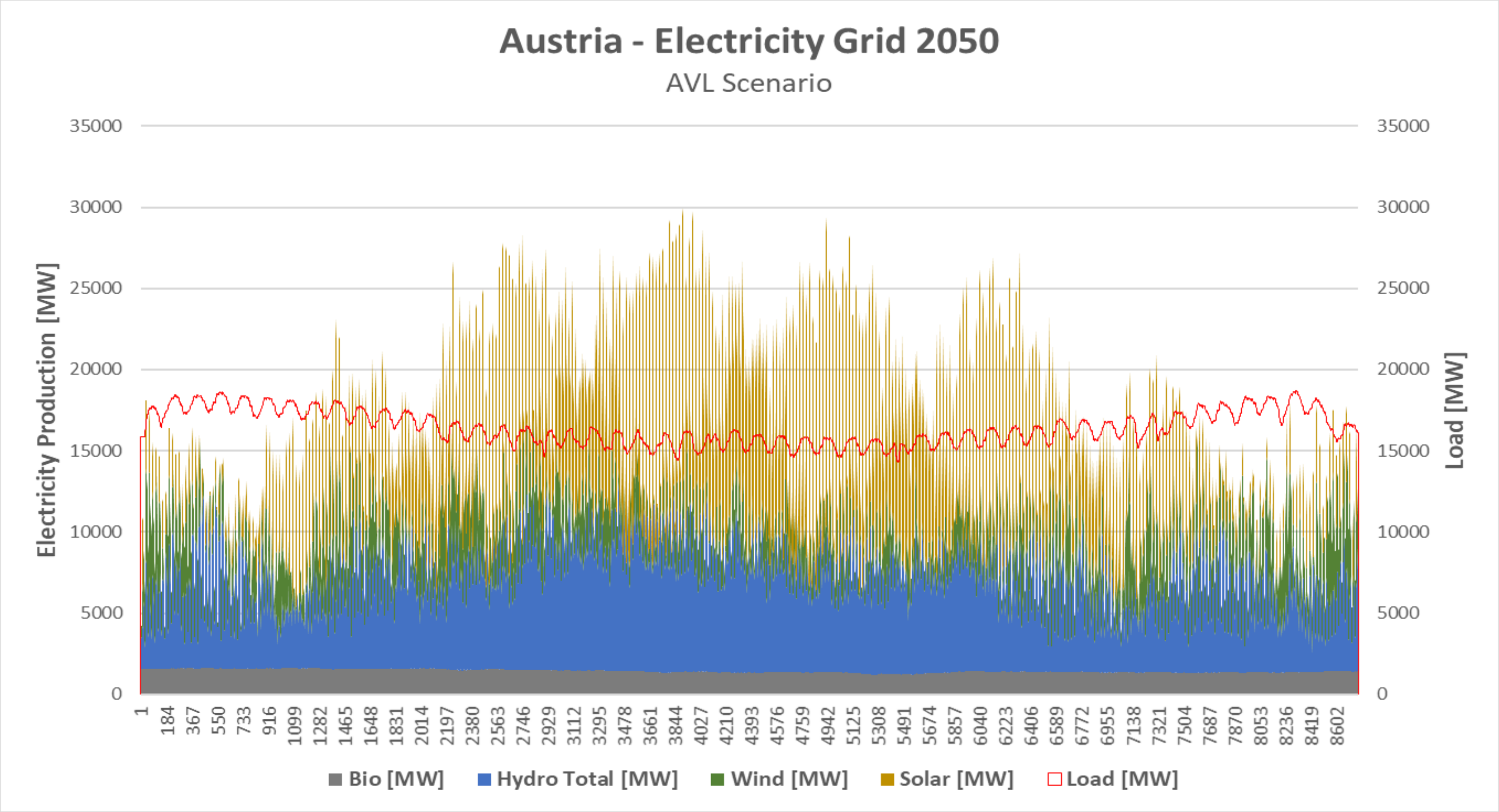
Compensation of fossil energy use of Austria

All values in TWh

							
Mobility	Passenger Cars	47,1		11,6		1,6	
	Truck Light	6,8	23,5	2,8	9,0	0,4	8,6
	Truck Heavy	16,7		6,1		8,2	
	Transit/Export	22,9		6,2		5,6	
	Other Mobility	15,2		2,2		12,4	
	Total Mobility	**108,8**		**29,0**	(Total: 32,8)	**28,2**	
Buildings	Gas	15,4	26,3	**7,2**	(Total: 20,5)		
	Oil	10,9					
Industry, Service, Agriculture	Gas	36,9	78,2	**18,0**	(Total: 60,0)	**25,0**	
	Oil	8,5					
	Coal	32,8					
Total		**213,3***		**54,2**	(Total: 113,3)	**53,2**	
		Status 2019		Replaced with electricity & hydrogen			

*...only end-use considered (excl. storage, export, gas for electricity production,...)

Austrian Electricity Grid – Scenario 2050



	2019	2050	%
Renewable Electricity Production	54TWh	**118TWh[1]**	+118%
Electricity Consumption	64TWh	**136TWh[2]**	+112%
Fossil Energy in End-Use	180TWh	0TWh	-100%
Excess Electricity		**11TWh**	
Electricity Shortage		**36TWh**	
Total Balance		**-25TWh**	

1…IndustRiES Study, 2019 - actual build-up plan 81TWh (Erneuerbaren-Ausbau-Gesetz 2022)
2…113TWh end-use & additionally considered 30% local production of hydrogen (excl. losses)

Austrian Electricity Scenario 2050 – Conclusions

- The **overall electricity demand** for Austria will roughly **double to 136 TWh** till 2050 if full decarbonization in all sectors is achieved
- In total, Austria will face an **energy deficit on balance of about 25 TWh**, excluding excess electricity this deficit increases to 36 TWh
- This energy deficit is mainly concentrated in the **winter months**
- The potential of **excess electricity** is in the range of **11 TWh**, but concentrated only over 2000 hrs
- The total **hydrogen demand** for Austria for **end use** is estimated to be **53.2 TWh**
- A significant amount of **hydrogen needs to be imported**, as local production of the full demand is unrealistic
- If the renewable electricity gap is partly closed by hydrogen power plants, the **total hydrogen demand** will increase up to **80 TWh**

Hydrogen and Hydrogen derivates will play a key role in decarbonization to supplement and close the gaps of renewable electricity in Mobility, Industry & Energy

SOEC Technology

Public

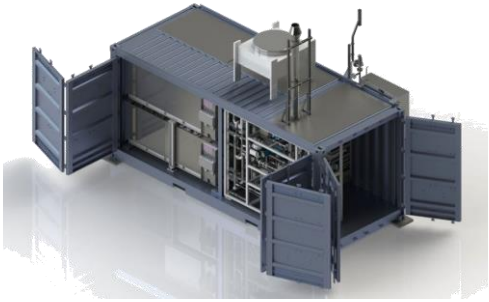
Overview of Electrolysis Technologies

	Alkaline	PEM	SOEC
Status	Mature		R&D
Market Share	>90%	<10%	0%
Temperature	Amb-120 °C	Amb-90°C	600-800 °C
Pressure	Up to ~35 bar	Up to ~30 bar	atmospheric
Dynamics	weak	good	medium
Cost and efficiency outlook 2030			
CAPEX	400-800 EUR/kW [1)]	300-1270 EUR/kW [2)]	500 - 800 EUR/kW [3)]
OPEX	2-5 % [2)]	2-5 % [2)]	2 % [2)]
Efficiency	48-63 kWh/kgH_2 [1)]	44-53 kWh/kgH_2 [1)]	36-43 kWh/kgH_2 [1)]
Efficiency	53-69 % [1)]	63-76 % [1)]	77-92 % [1)]

[1)] Source: FCH-JU
[2)] Of CAPEX p.a.
[3)] AVL

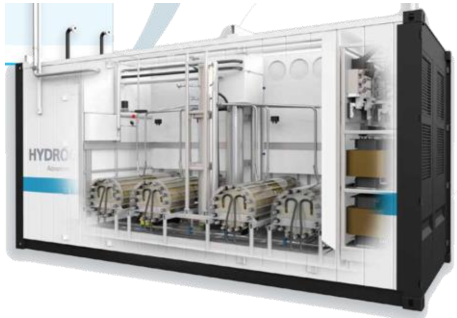
PEM…Polymer Electrolyte Membrane
SOEC…Solid Oxide Electrolysis Cell

SOEC



Source: Sunfire

PEM-EL



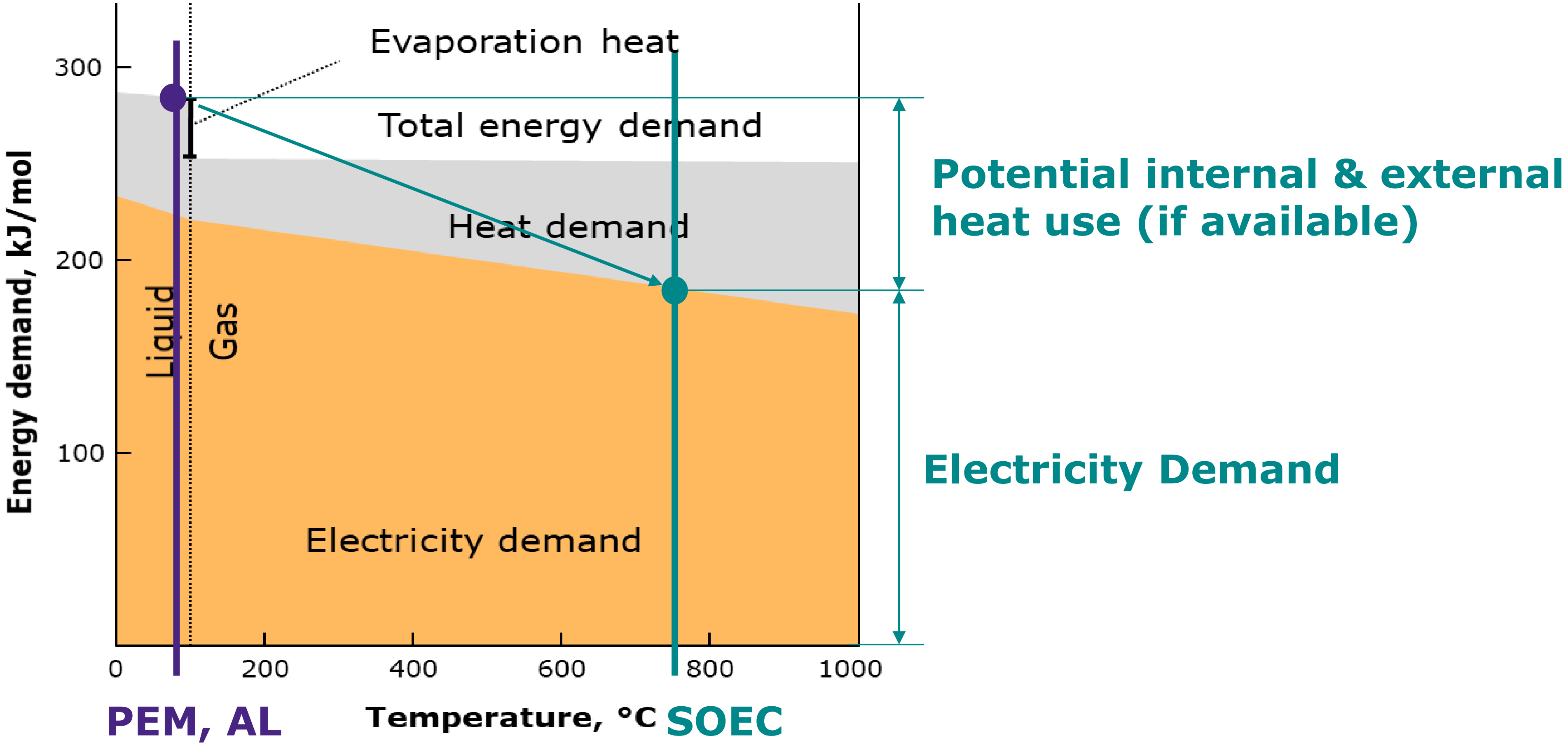
Source: Hydrogenics

Alkaline

Source: McPhy

SOEC combines low cost potential with highest efficiencies as a basis for economic e-fuel production

Efficiency Advantage of SOEC



SOEC requires less electricity input and enables a decoupling of the electrolysis reaction from the evaporation

SOEC for Hydrogen Production

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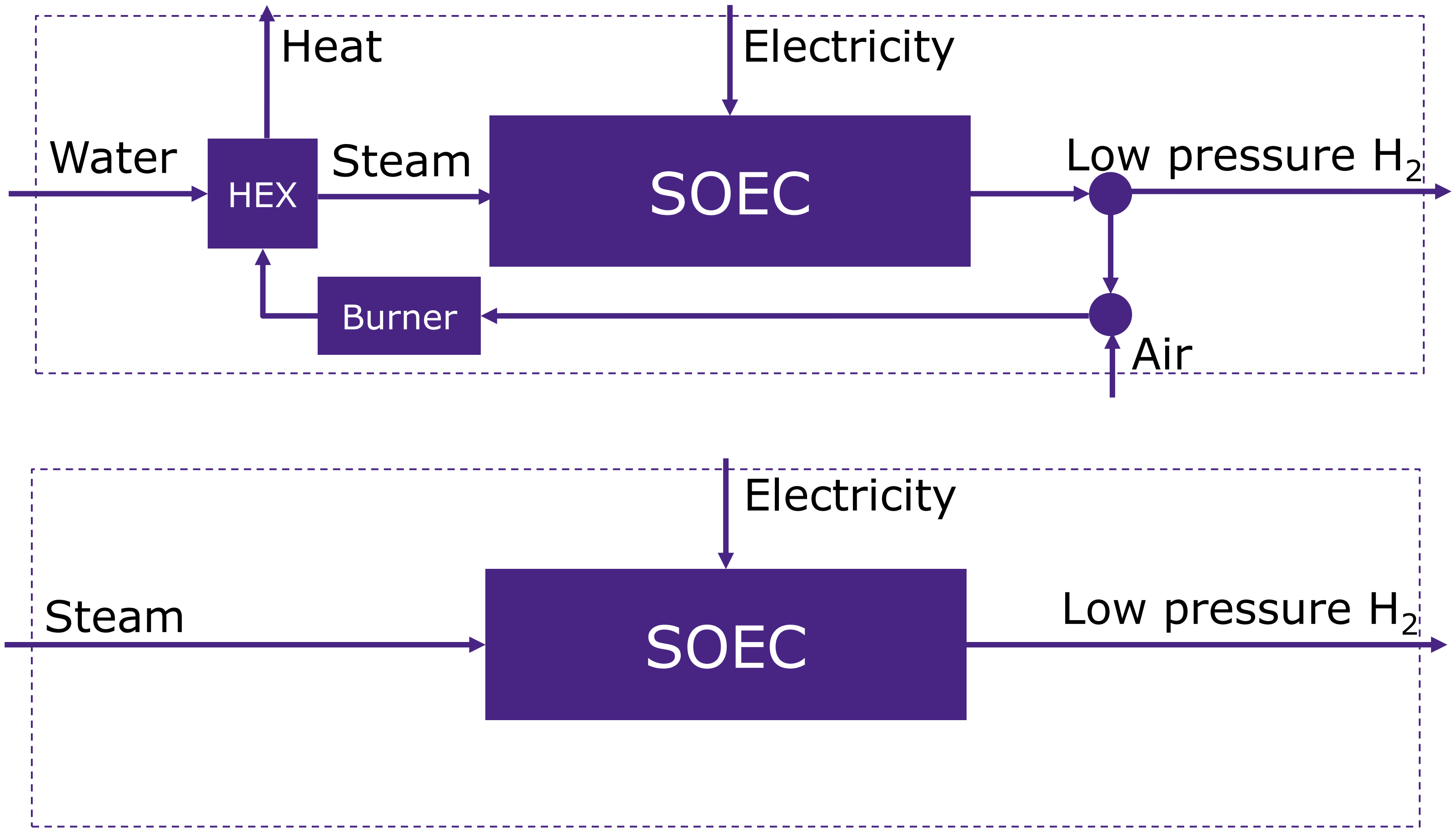
Efficiency Potential of SOEC



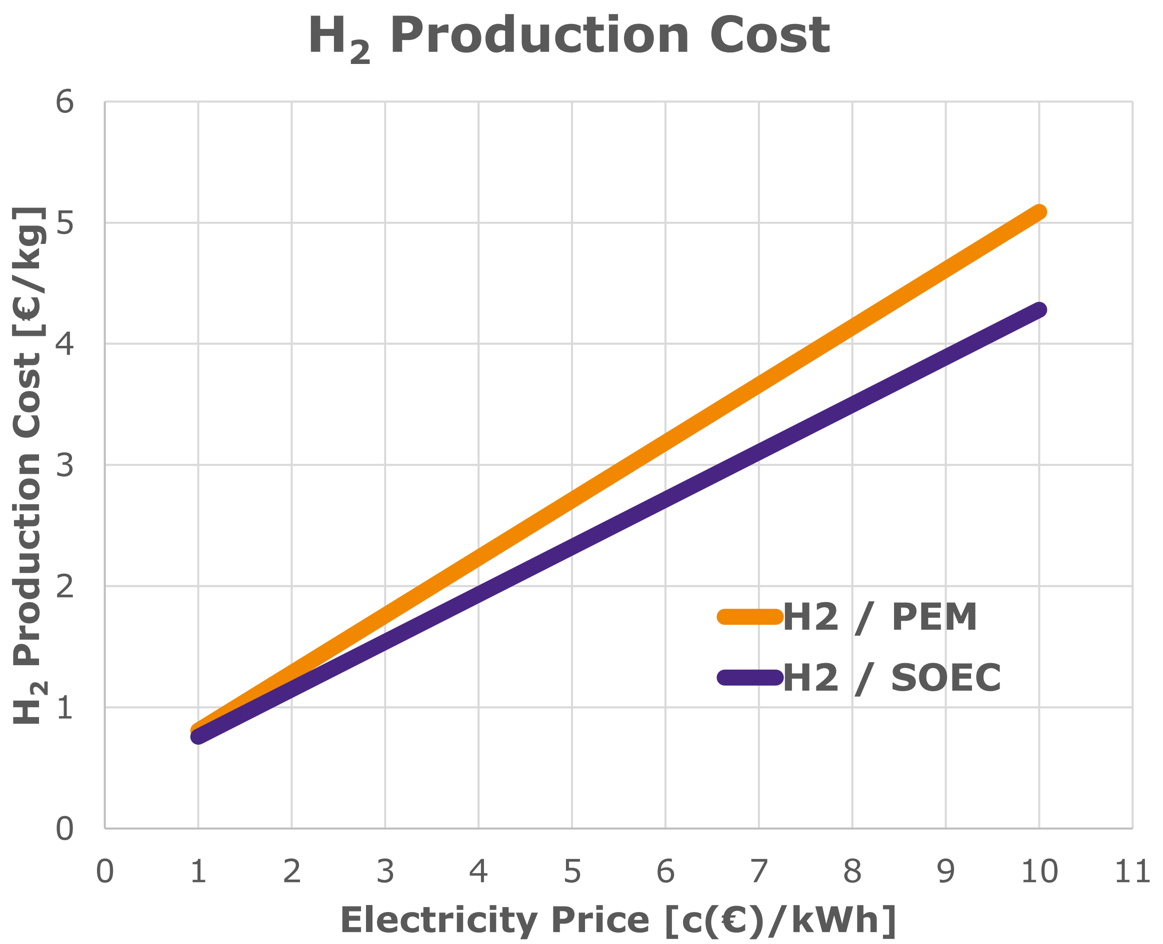
Net Efficiency*:

80%

90%

*Efficiency: LHV H_2 (out)/electricity consumption (in)

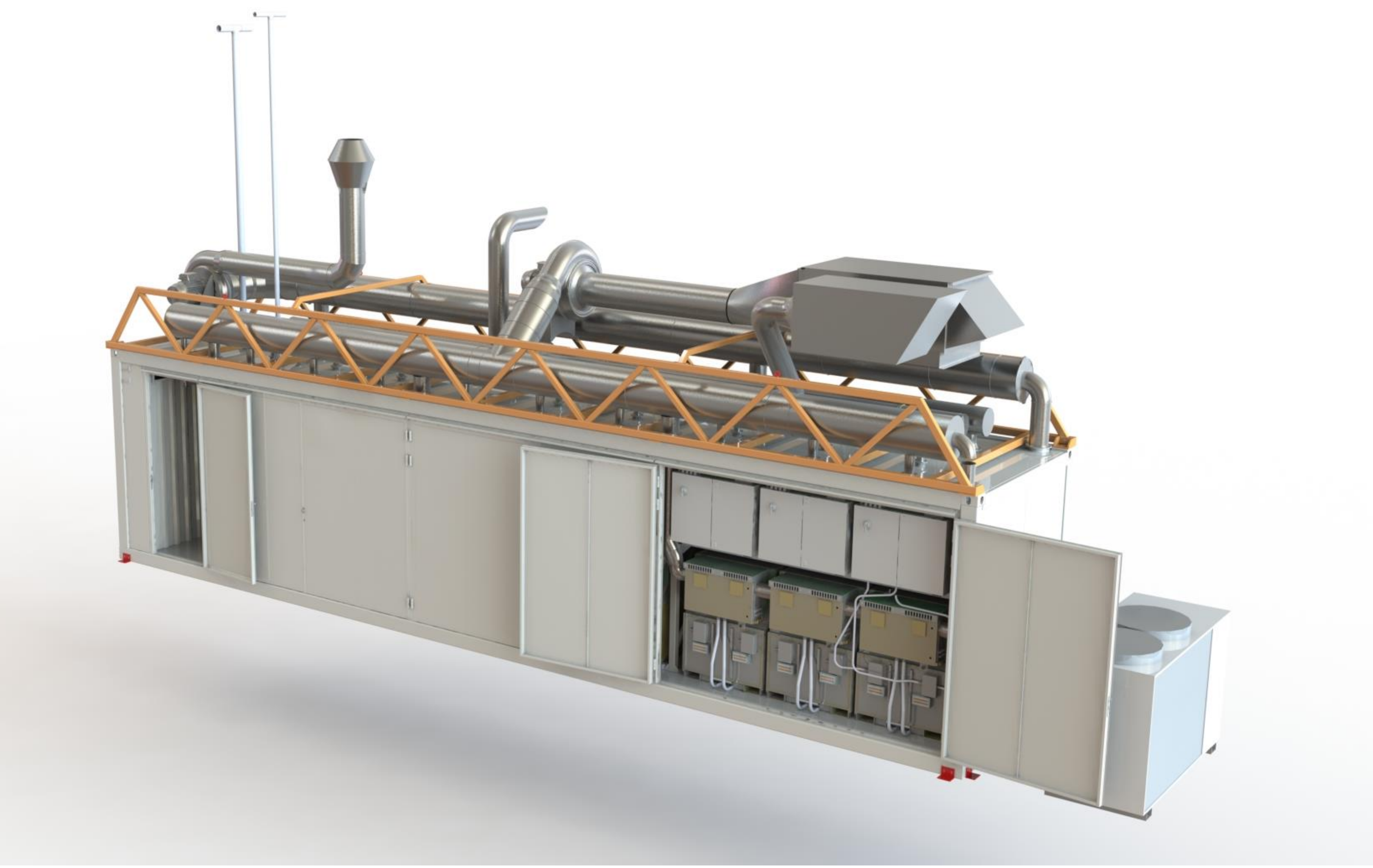
The effect of Efficiency



- SOEC H_2 production cost estimated to be 10-15% lower compared to PEM EL*
- Electrolysis is a strongly OPEX driven business case, therefore efficiency is key

*…fully industrialized SOEC production assumed, considering typical European renewables cost

SOEC Electrolyzer Development



- 1MW Solid Oxide Electrolysis System
- Size: 40ft Container
- Steam electrolysis
- Target Efficiency:
  - ~80% with water input
  - ~90% with steam input
- Tests start in mid 2022
- First field deployments in late 2022

Industrialization of SOEC in Austria

European Commission

European Commission Hydrogen IPCEI initiative

AVL

christof industries

Establishment of a SOEC Electrolyzer production in Austria

SOEC for e-Fuel Production

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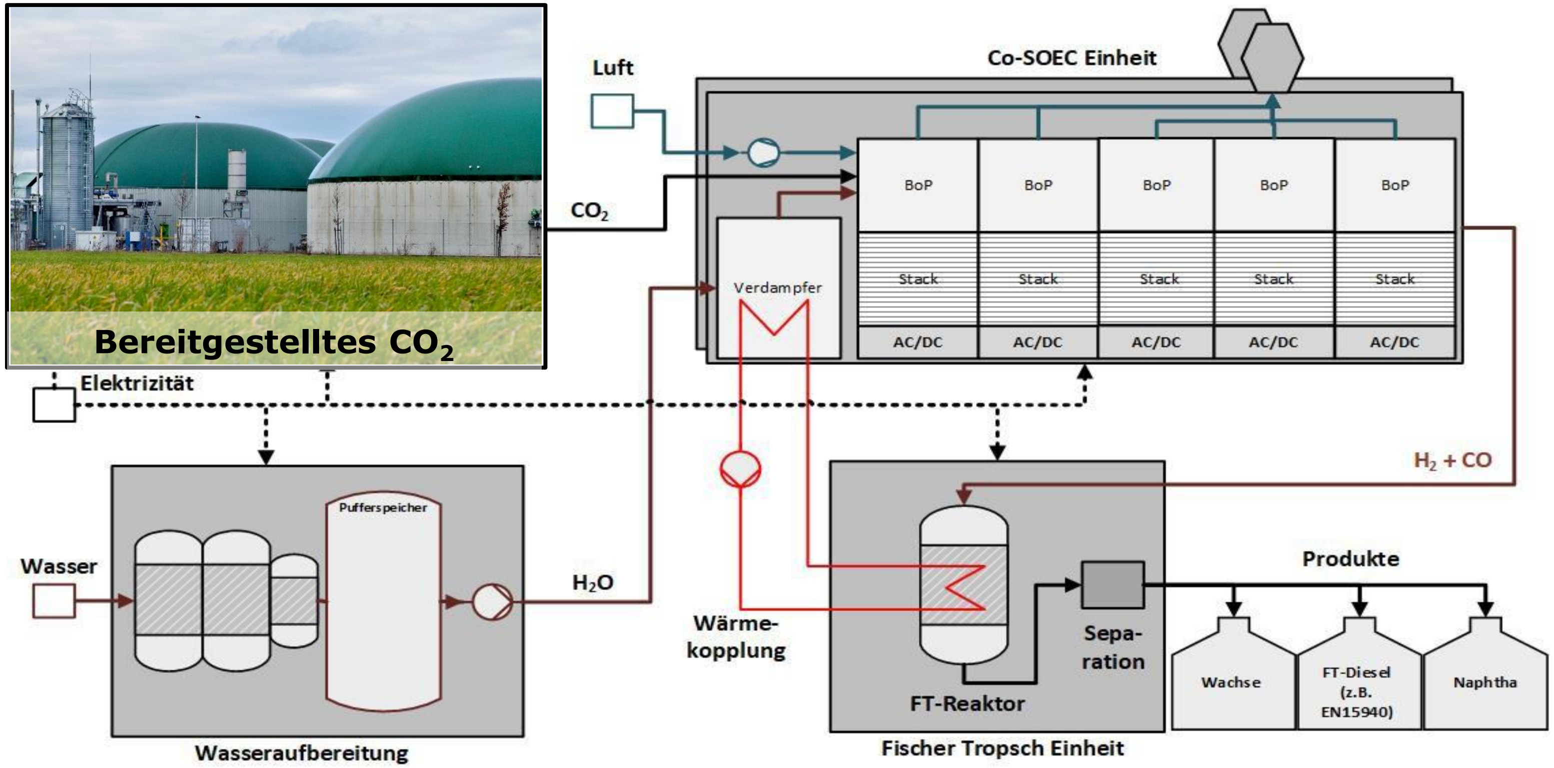
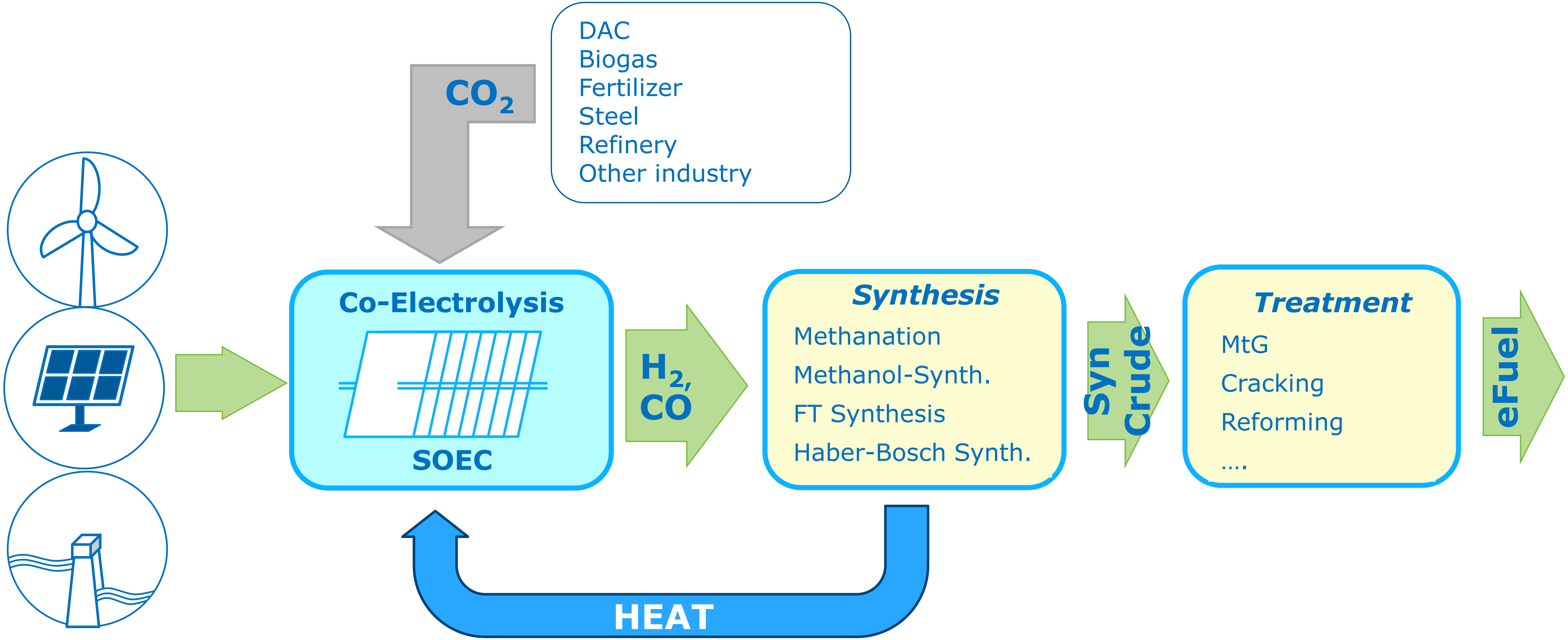
Power-to-Liquid Demo Plant

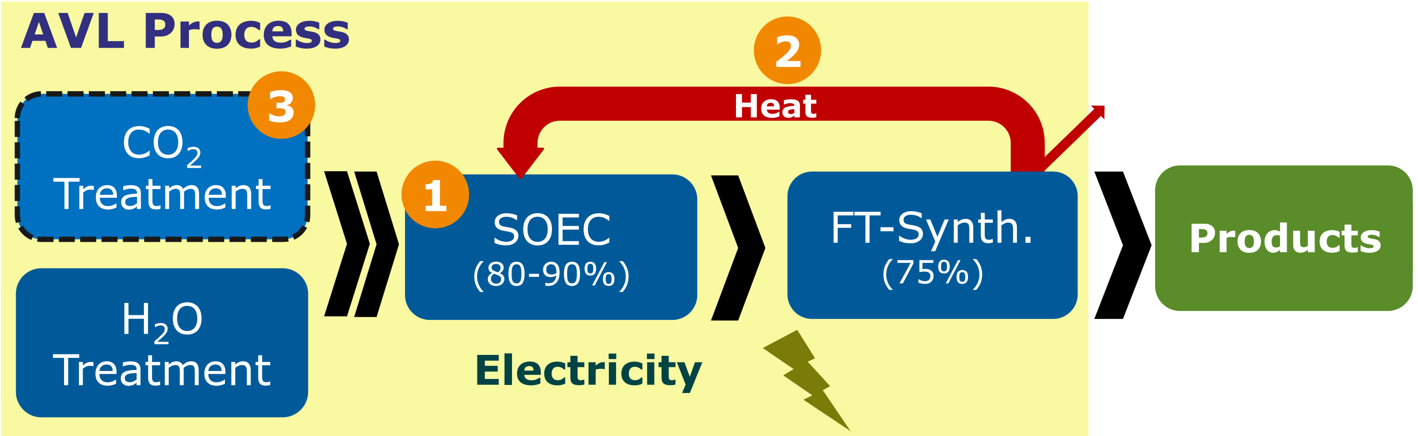


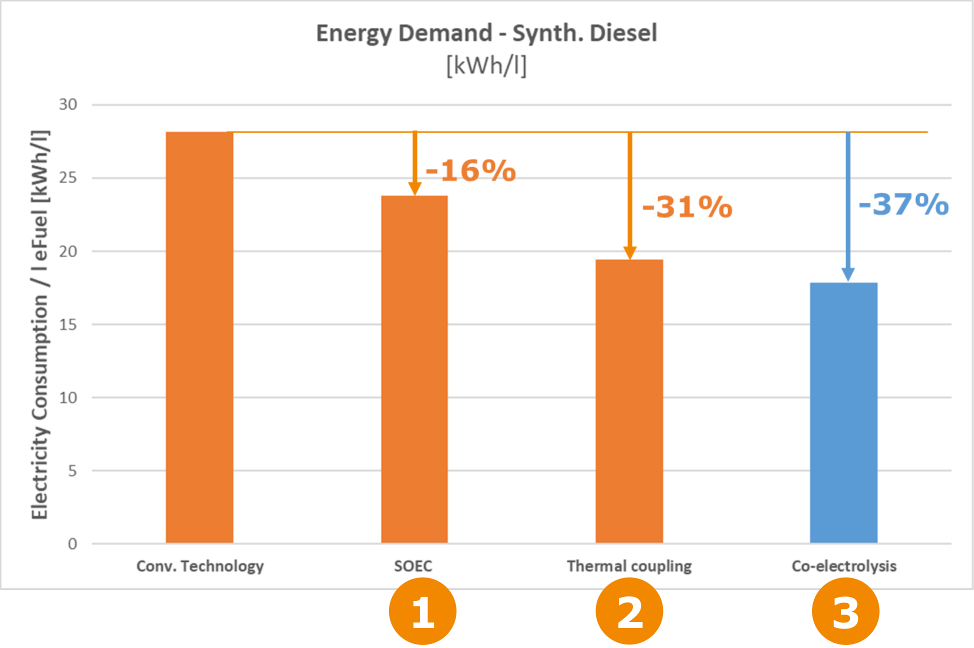
- 200kWel renewable Power
- CO_2 from renewable sources
- Production per year
  - Diesel: 30.000 L
  - Wax: 30.000 L
  - Naphta: 30.000 L
- Start of commissioning in Q2/2023
- Efficiency Improvement in efuel production of >30%

SOEC e-Fuel Process



Efficiency Improvement Potential of e-Fuel Production with SOEC





1. High-temperature electrolysis
2. Thermal Coupling
3. Co-electrolysis

Combined SOEC-FT process allows 30-40% higher efficiency compared to PEM and AL EL

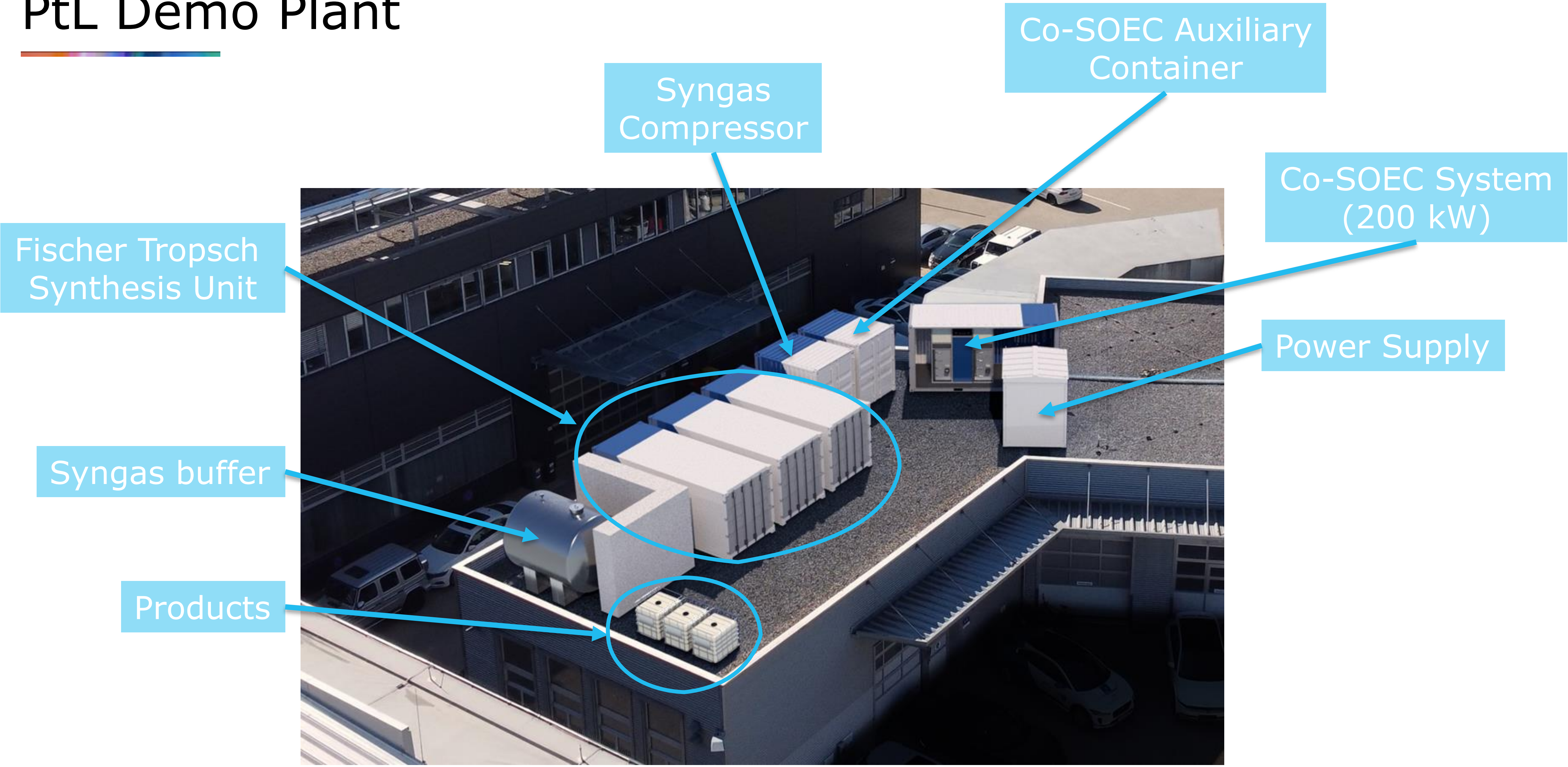
FT…Fischer Tropsch, PEM EL…Polymer Electrolyte Membrane Electrolysis, AL EL…Alkaline Electrolysis

Demonstration plant @AVL, Graz

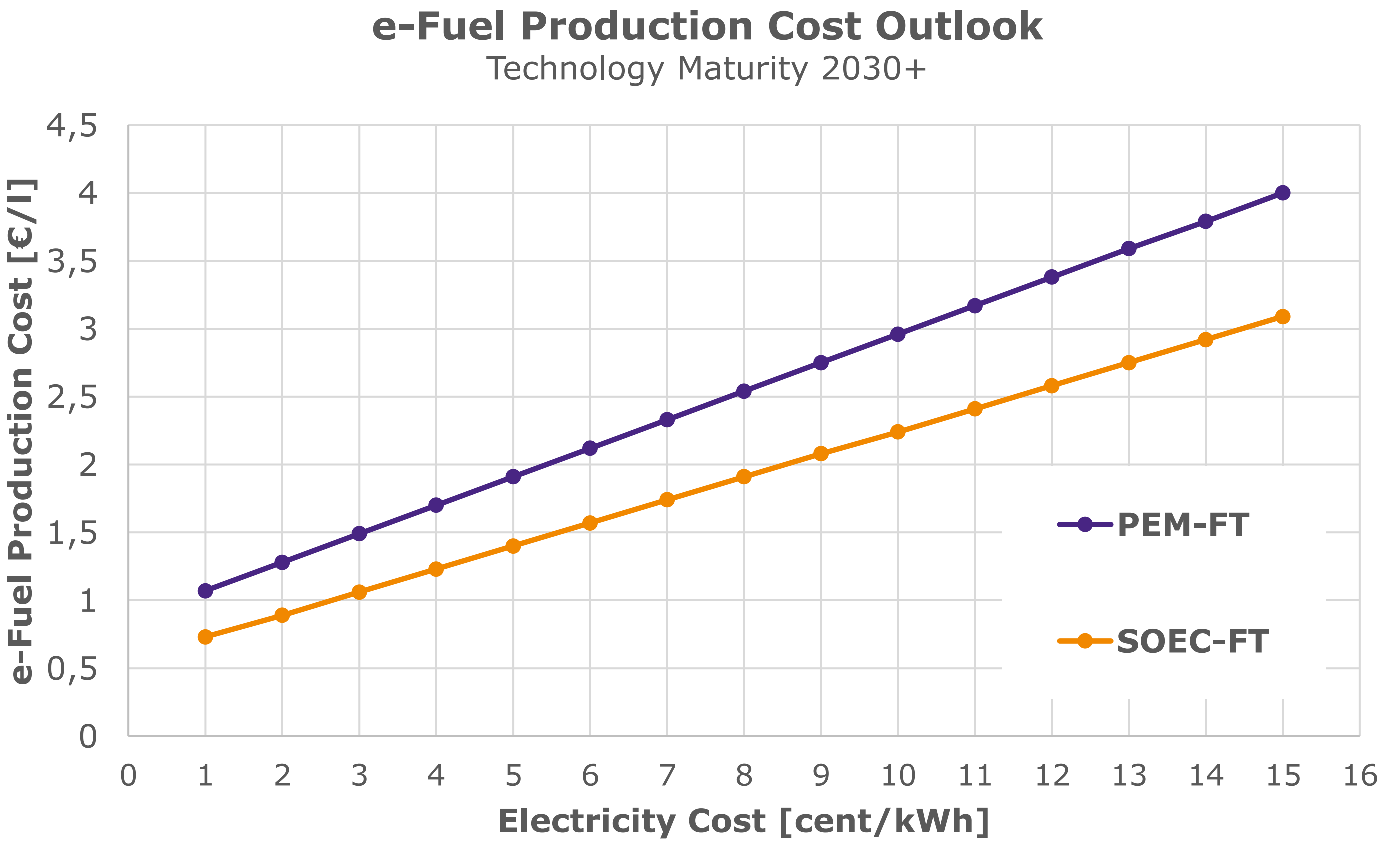
Main Entrance
Hans List Platz 1,
8020 Graz

PtL Plant

PtL Demo Plant

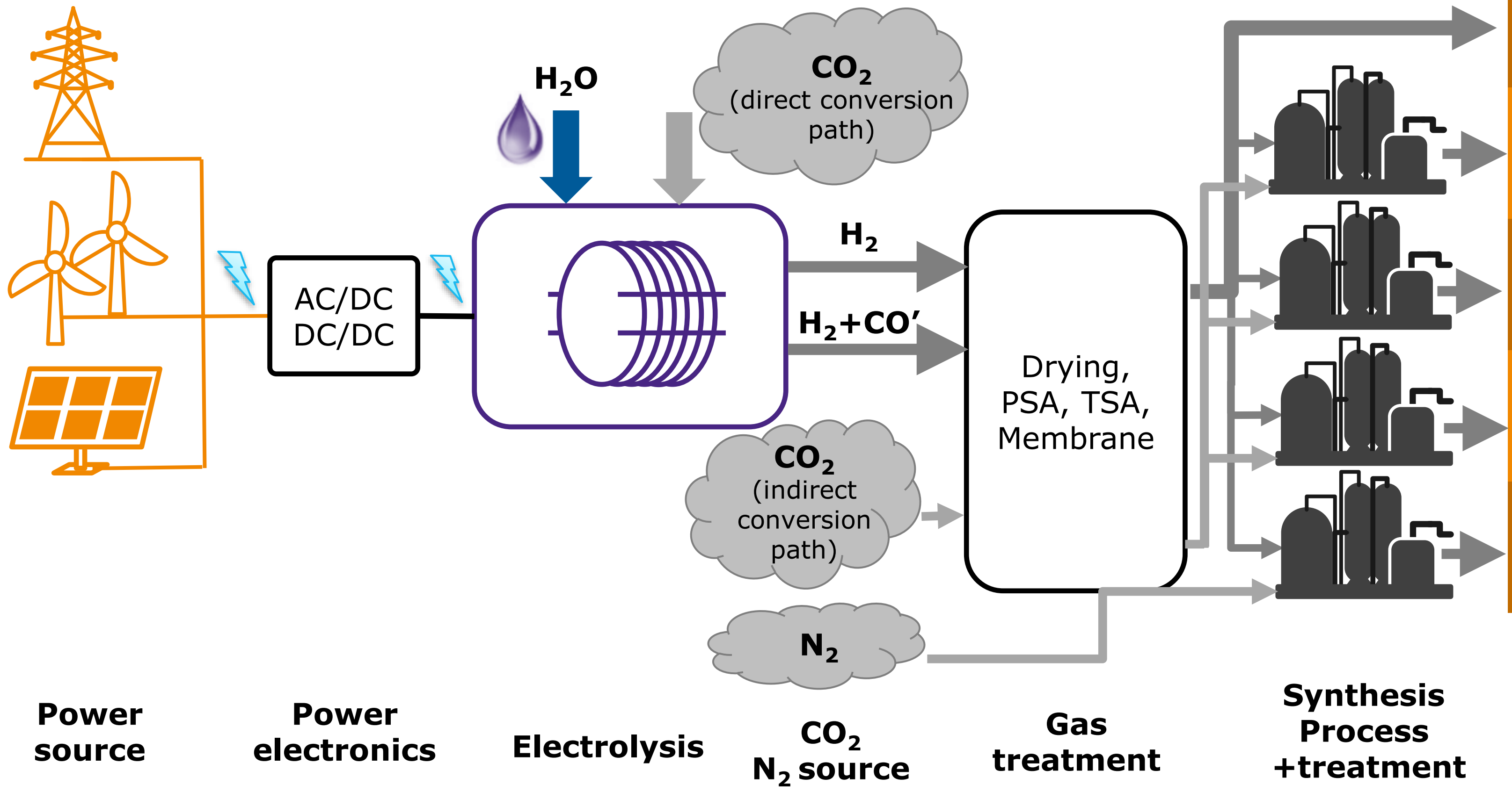


e-Fuel Production Cost



SOEC FT Process enables 20-30% lower production cost of e-Fuels

SOEC Power-to-X Routes



	Process Efficiency	
Product	**SOEC**	**SoA**
Hydrogen	**~85%**	~70%
Methane	**~80%**	~50%
FT Fuels	**~55%**	~40%
Methanol	**~70%**	~45%
Ammonia	**~70%**	~50%

SOEC improves the efficiency of all major eFuel production routes significantly

Conclusions

- Decarbonization of Austria will result in a significant renewable energy gap
- Austria will require up to 80TWh of hydrogen or hydrogen derivates, most of it being imported
- SOEC Technology has the advantages of a higher energy efficiency but still requires significant developments and cost reductions
- Based on the SOEC process hydrogen can be produced with up to 90% efficiency from available steam or up to 80% from liquid water
- Coupling of SOEC with synthesis processes can significantly improve the energy efficiency of e-Fuel production
- **Renewable electricity is the main path towards decarbonization, but it needs to be complemented with hydrogen and derivates**

Thank you

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