

Best practice - Green Hydrogen plant with high performance

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GEFÖRDERT DURCH



Bundesministerium
für Wirtschaft
und Energie

Bundesministerium
für Bildung
und Forschung

AUFGUND EINES BESCHLUSSES DES DEUTSCHEN BUNDESTAGES



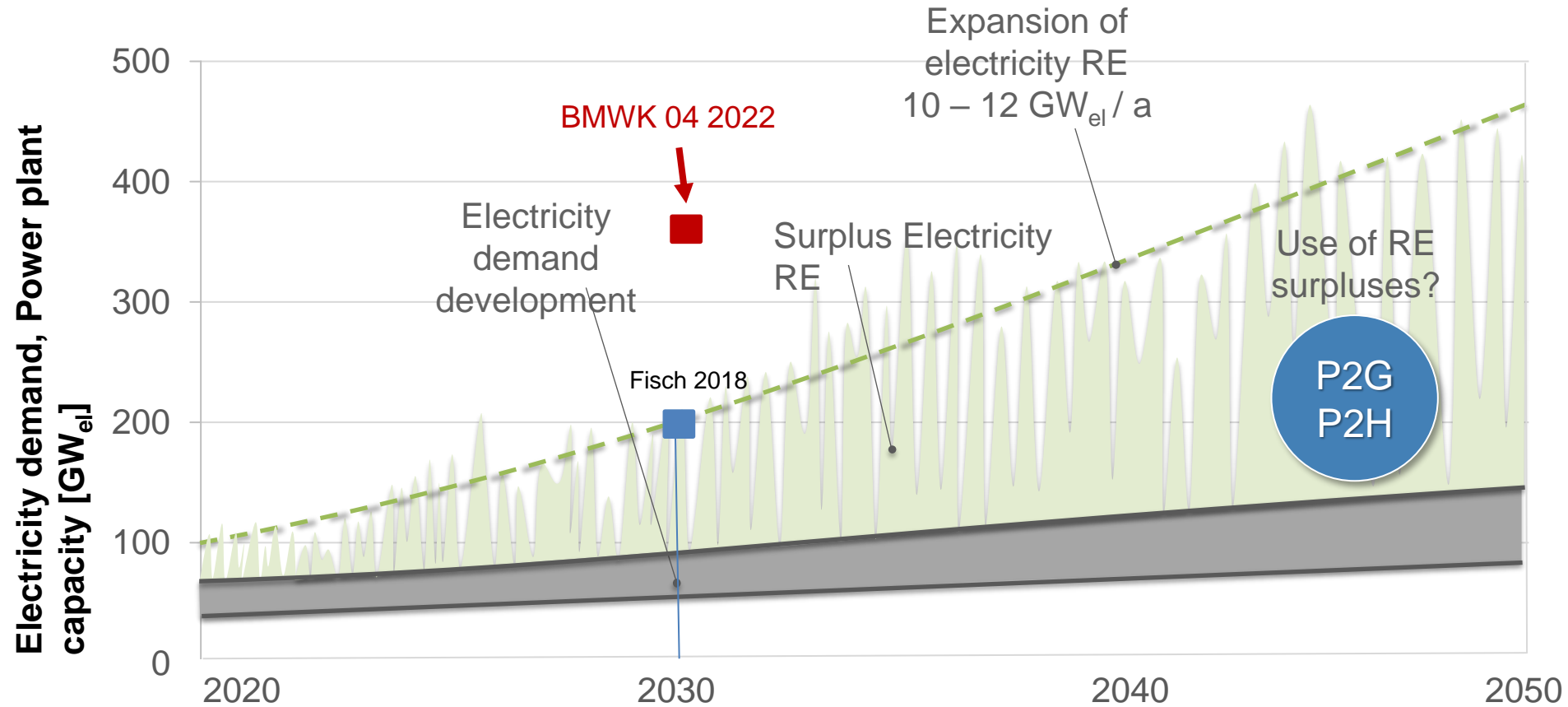
**„Renewable Energy storage is the challenge
for implementing energy transition “**

**„Green hydrogen is necessary to achieve
climate protection targets“**

**„Priority use for decarbonization
of industry & mobility,
not for the heating of buildings“**

(2018, MNF)

Development of electricity demand & power plant capacity



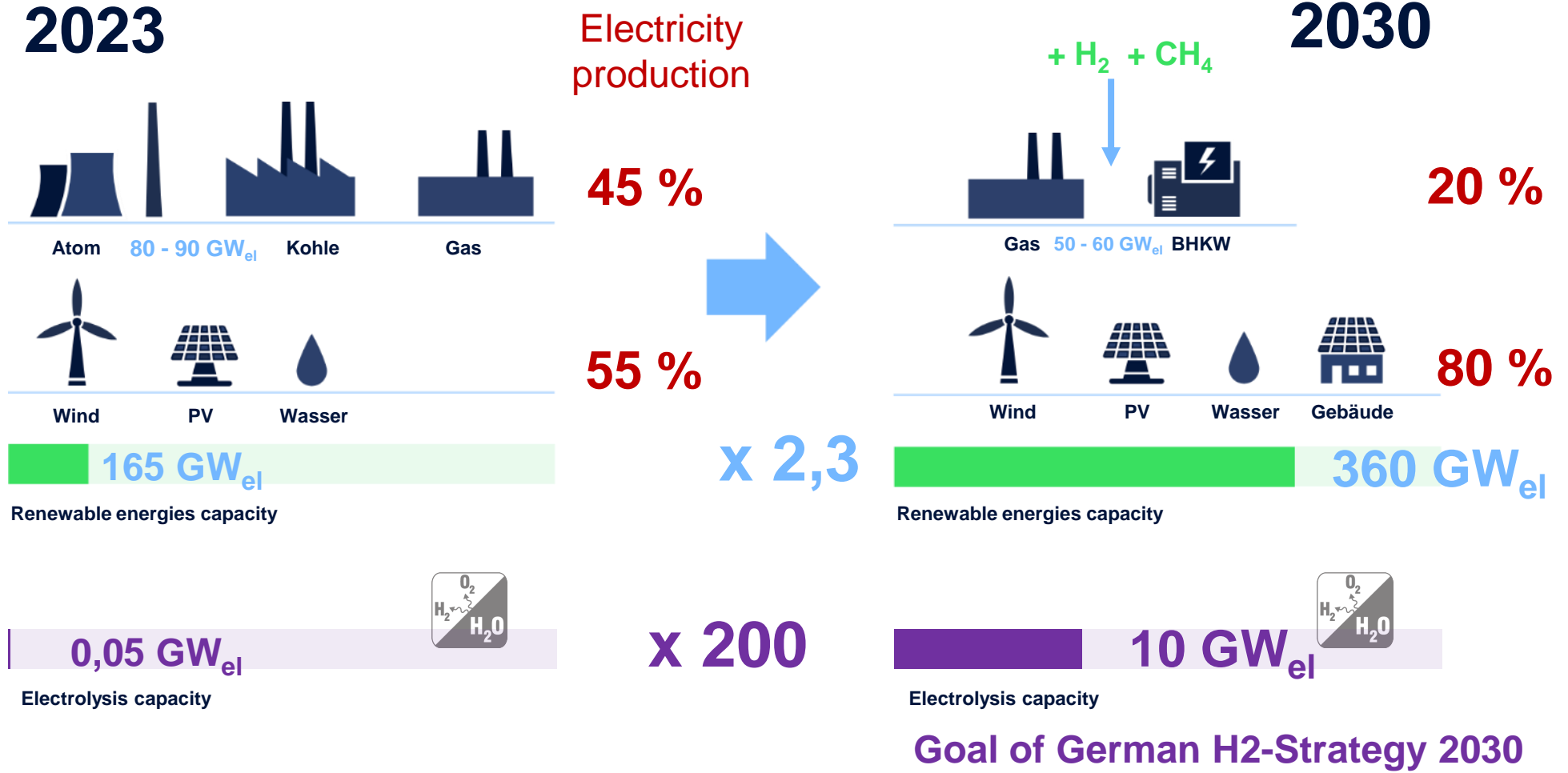
Electricity consumption will increase considerably from today's
 approx. 550 TWh/a
> 800 TWh/a (2050)

(2018, MNF)

RE : Renewable Energy

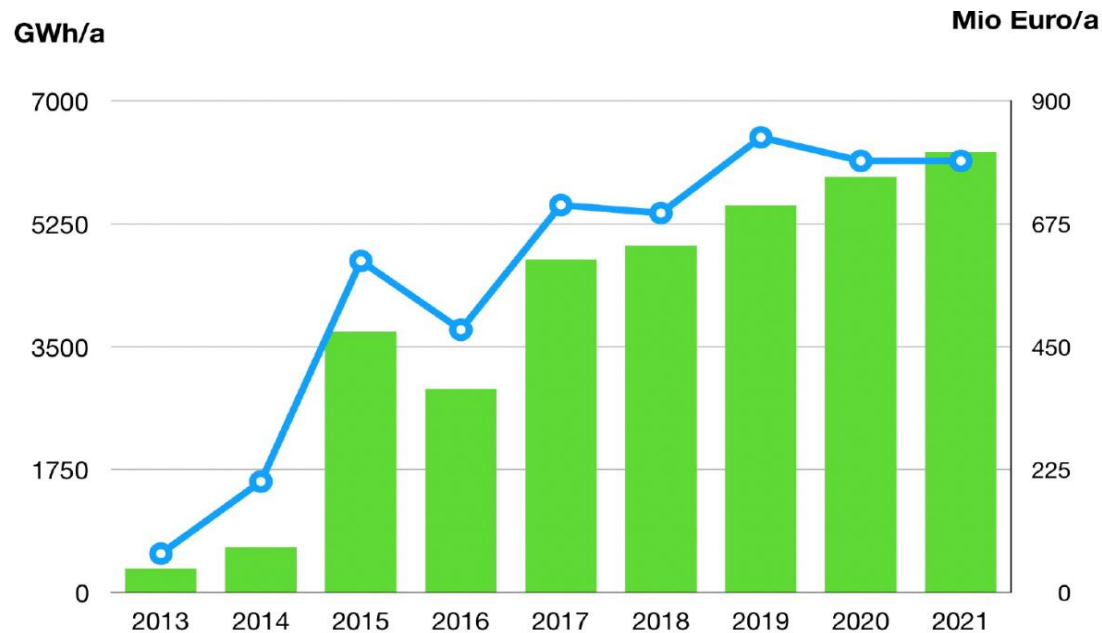
Political Hydrogen goals

Electricity system in transition



Sector Coupling is the key

Balancing volatile generation only within electricity sector is not cost-efficient!



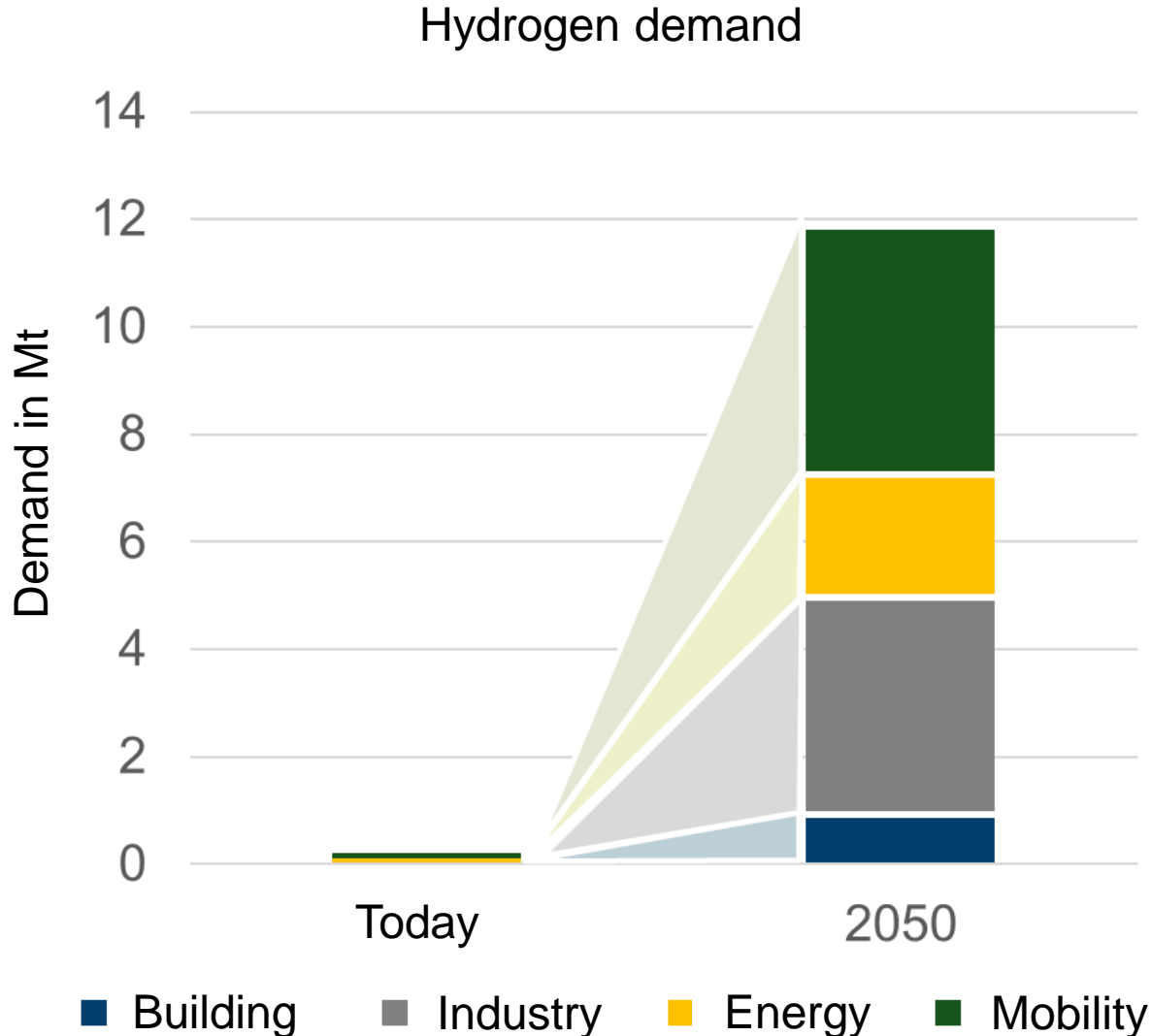
Payment to operators for shutdown
Wind and PV systems

2023: > 8 TWh/a > 1 Billion €

Sector coupling by PtH or PtG as key elements requested!

German „Energiewende“ until 2050

Hydrogen demand

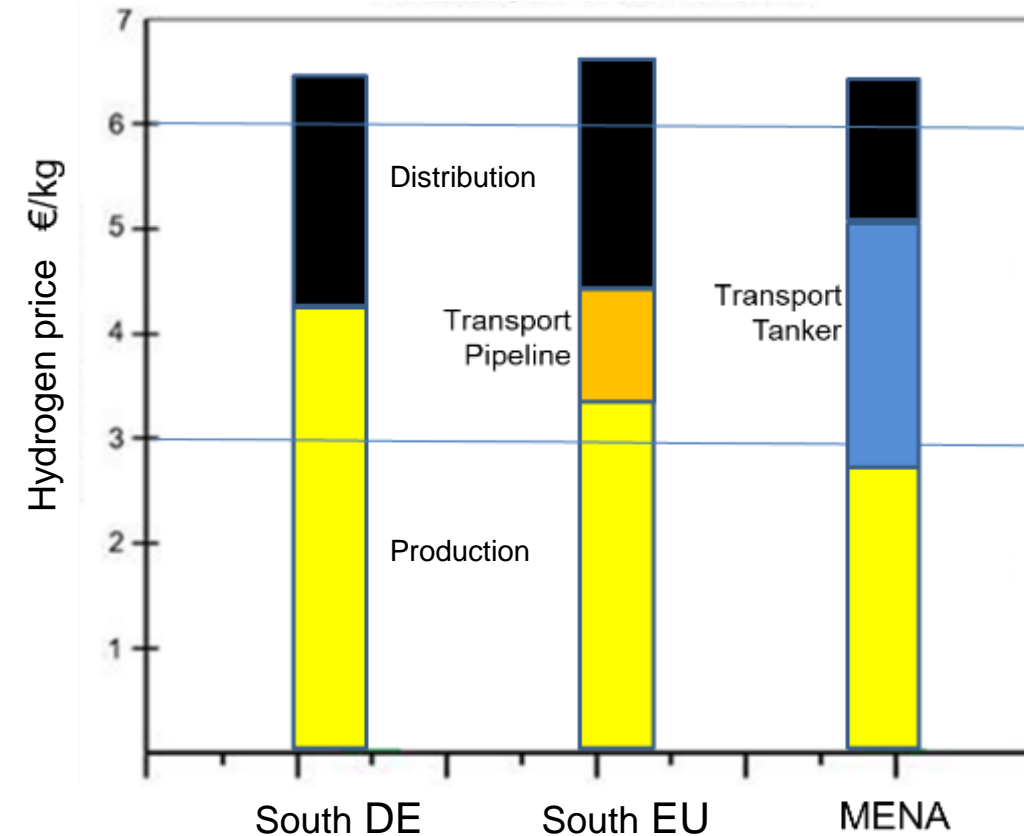


- H₂- Demand in 2050: 12 Mio.t
- 50% produced locally in Germany
- approx. 60 GW_{el} Ely- Capacity req.
- Priority use in **Mobility and Industry**

*Based on:
Kosteneffiziente und klimagerechte
Transformationsstrategien für das deutsche
Energiesystem bis zum Jahr 2050.
Forschungszentrum Jülich GmbH, 2019*

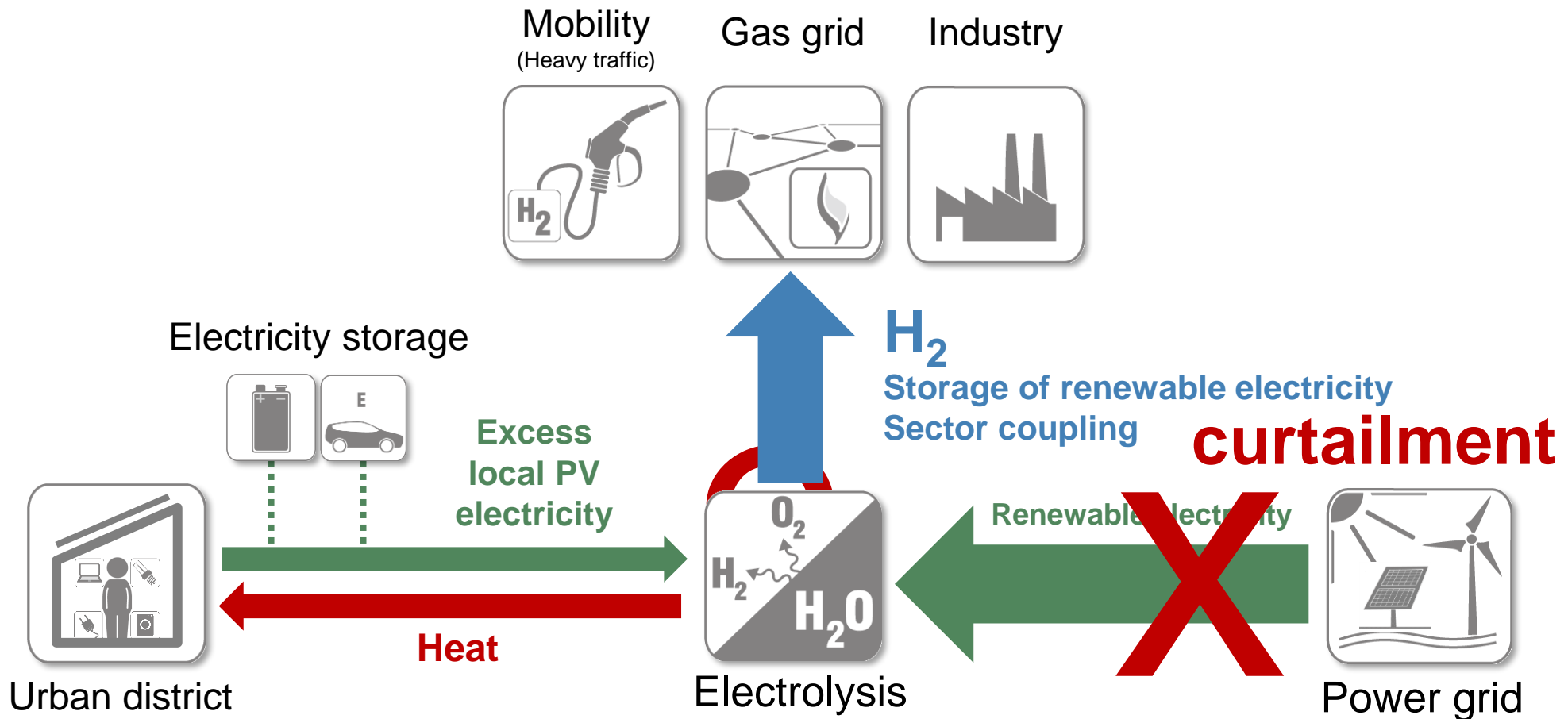
Production Costs- „Green Hydrogen“

Location	Global radiation <i>kWh/(m²a)</i>	Electricity yield		H ₂ - Production costs		
		Electricity price <i>kWh/(kWp a)</i>	<i>ct/kWh</i>	OPEX €/kg	CAPEX €/kg	Total €/kg
South Germany	1.100	1.250	5,0	2,8	1,2	4- 4,5
South Europe	1.800	1.700 *)	3,8	2,1	1,2	3,3- 3,5
MENA-Region	2.300	1.850 *)	3,0	1,9	1,1	2,8 - 3,0



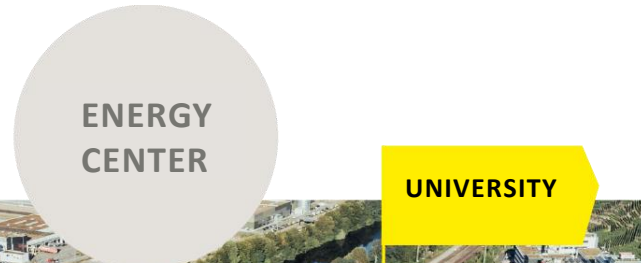
Quelle: SIZ energieplus, 2021

Hydrogen in the city – why?



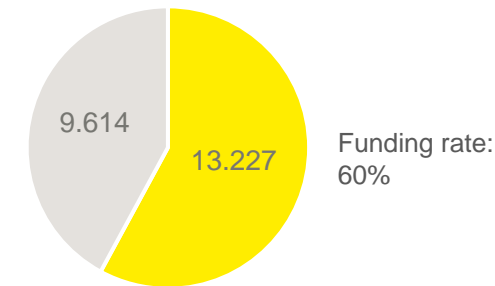
$\eta = 55\% - 68\%$
 $\eta = 80\% - 85\%$

How to balance volatility?
Renewable waste heat potential (approx. 600 GWh/a) approx 120 TWh/a
(corresponds to today's district heating demand)



Keyfacts

- 12 ha, 85.000 m²_{BGF}, 80% Living (> 550 RU)
- Project duration: 2017 – 2024
- 13 interdisciplinary partners (City of Esslingen, research and science, real estate project development, energy suppliers, investors)
- Funding-relevant costs (T€)

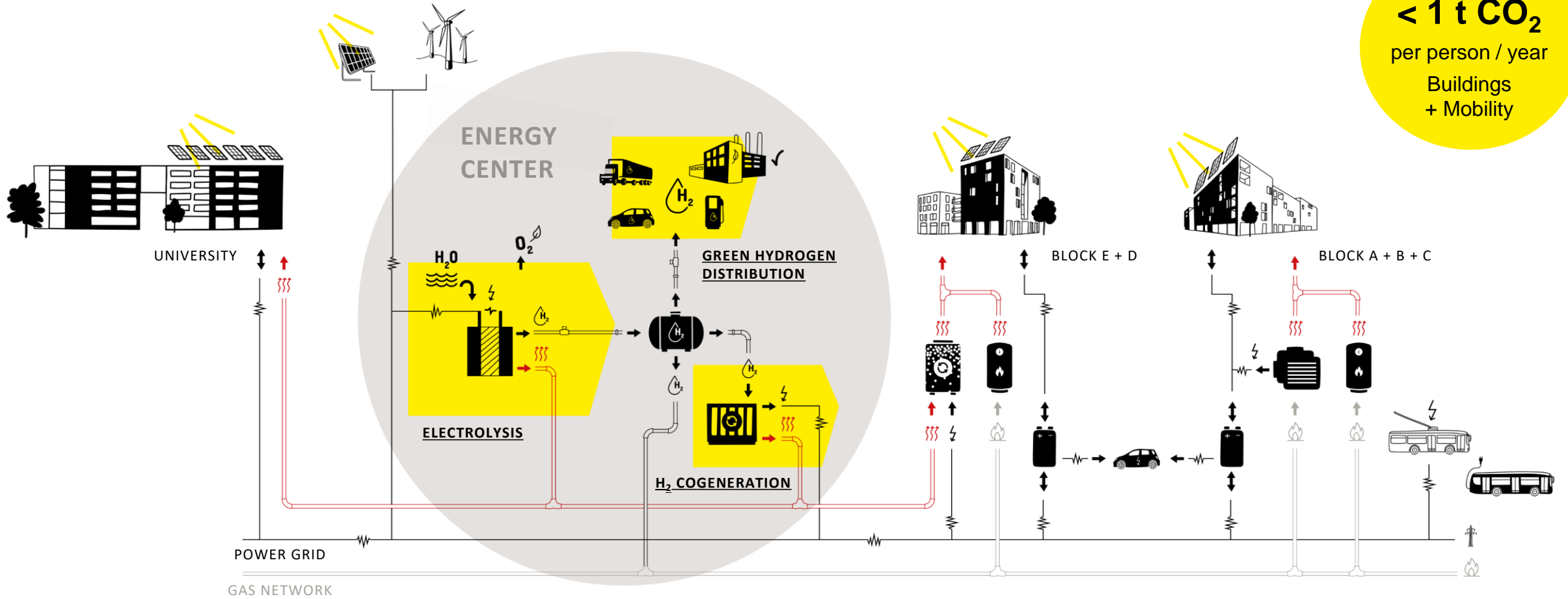


■ Governmental funding ■ Own funds



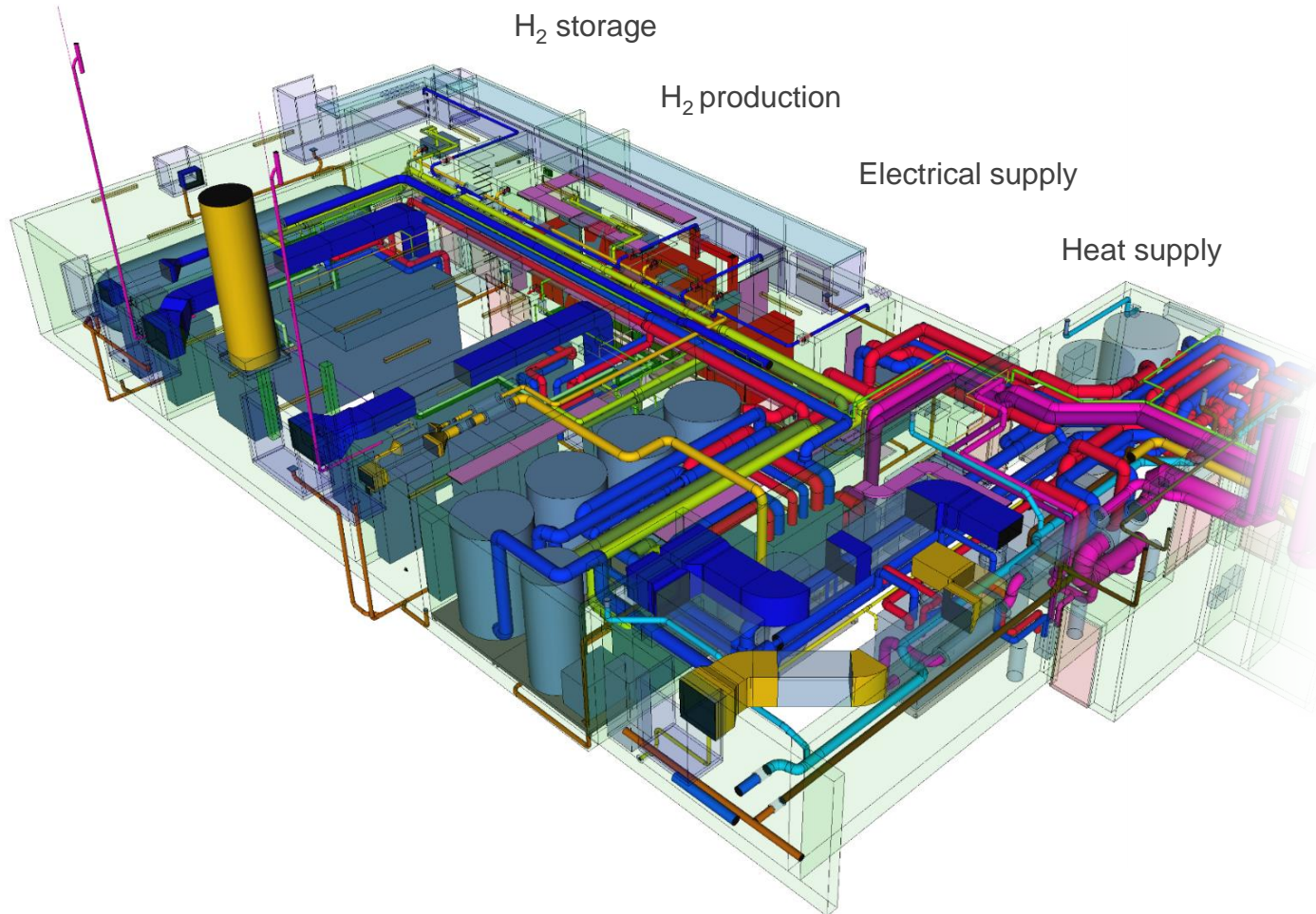
on the basis of a decision by the German Bundestag

Energy concept



Construction phase





Components

- Electrolysis: Cooling the stacks
→ 250 kW_{th} (~ 55-60°C)
- Heat pump: Rectifiers, inverters, transformer
→ 220 kW_{th} (~ 65°C)
- H₂/Biomethan CHP:
→ 190 kW_{th (H₂)}
- Peak load boiler

Heat distribution & consumers

- Local heat network
- Low temperature systems
(surface heating, decentralized fresh water stations)
- 50% of heat demand covered by emission-free waste heat from electrolysis

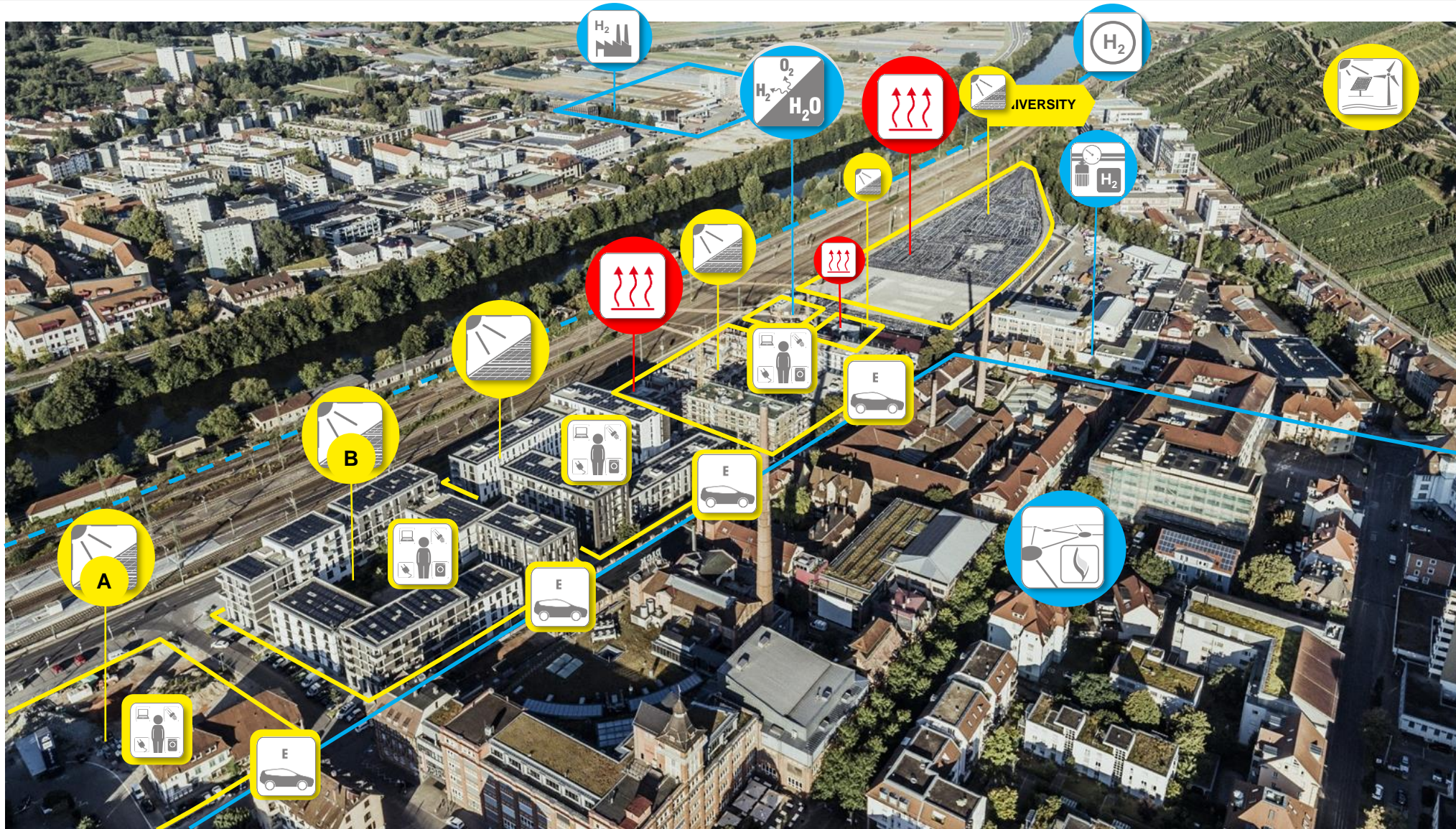
Electrolysis



- Power: 2x 500 kW_{el}
(Skid with 6 IMET Cell Stacks)
- Nominal: 2x 100 Nm³ H₂/h
- Operating pressure: 11,5 bar
- Elektrolyte: 30% Potassium hydroxide, 500 l
- Utilization rate: 5,2 kWh_{el} / m³ H₂
(ca. 60%)
- Waste Heat: approx. 60 °C



Concept map and H₂ usage



i. Short-term

Decarbonisation of the gas network of the city of Esslingen as a backup for an economic operator model

ii. Medium-term

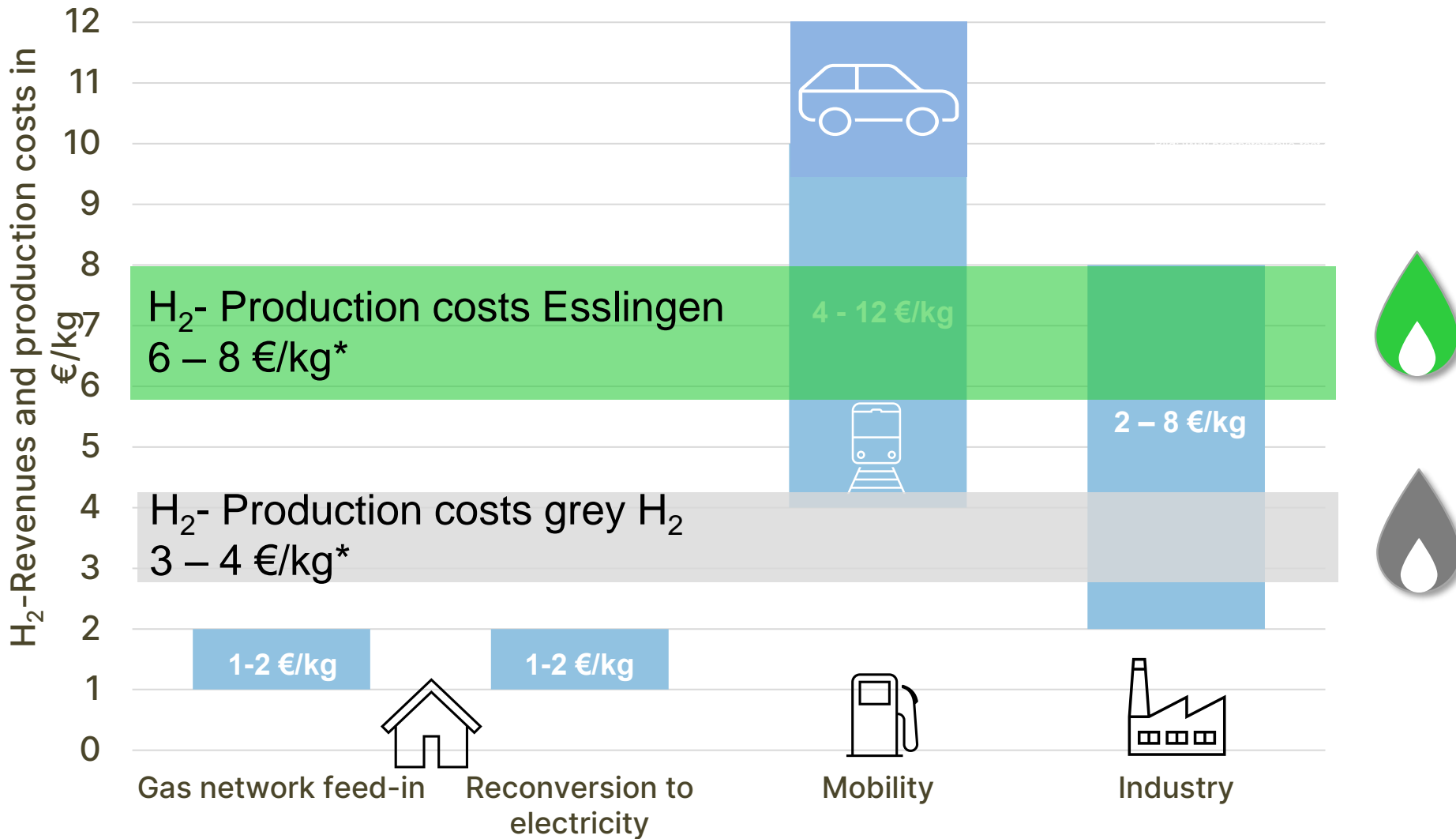
Industry/Mobility: Fuel cell test stands

iii. Long-term

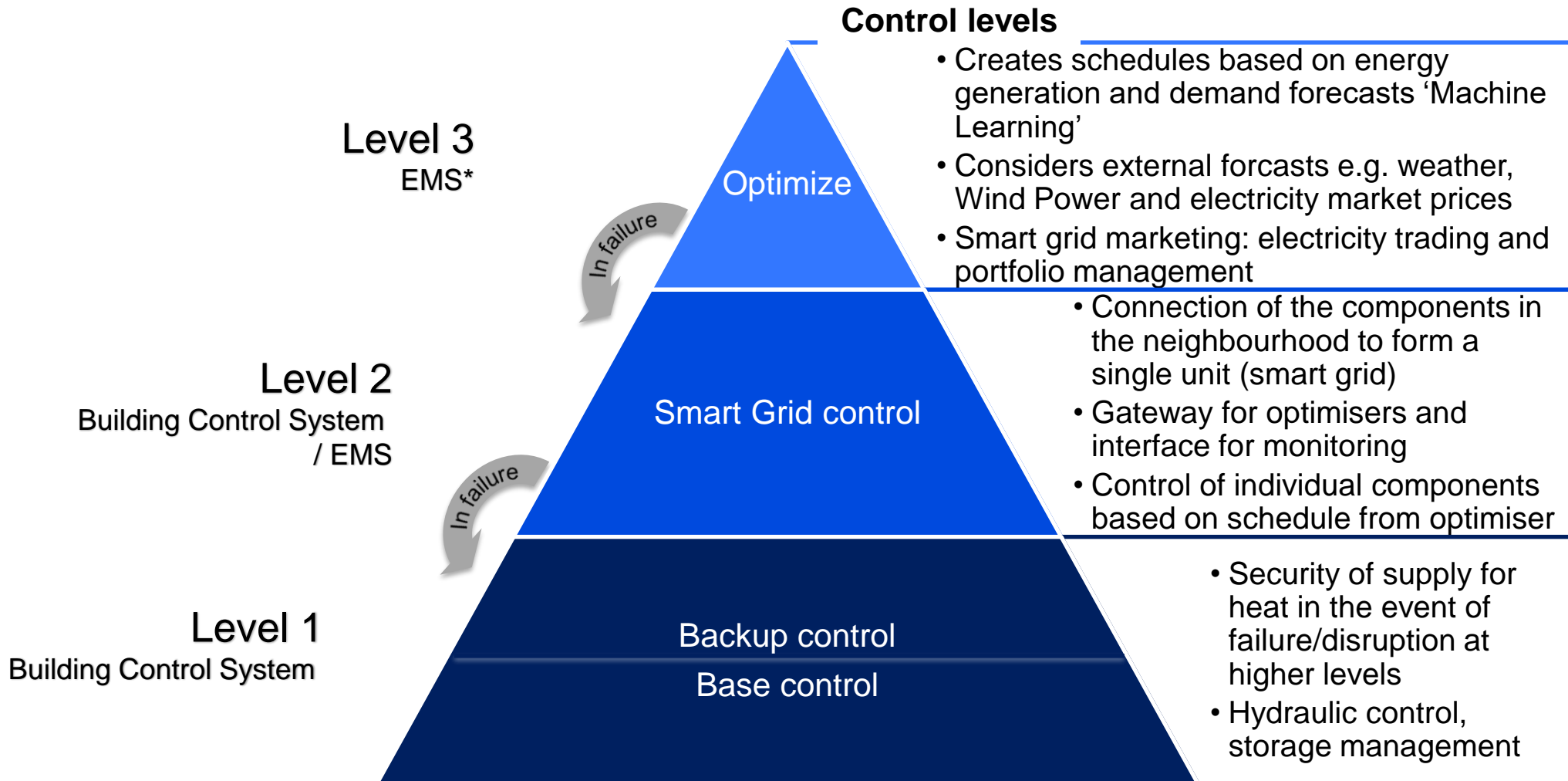
H₂ Pipeline: Scaling the hydrogen economy in the region

H₂-Disabler

Sales market for green hydrogen



*Costs before the crisis - status 2019

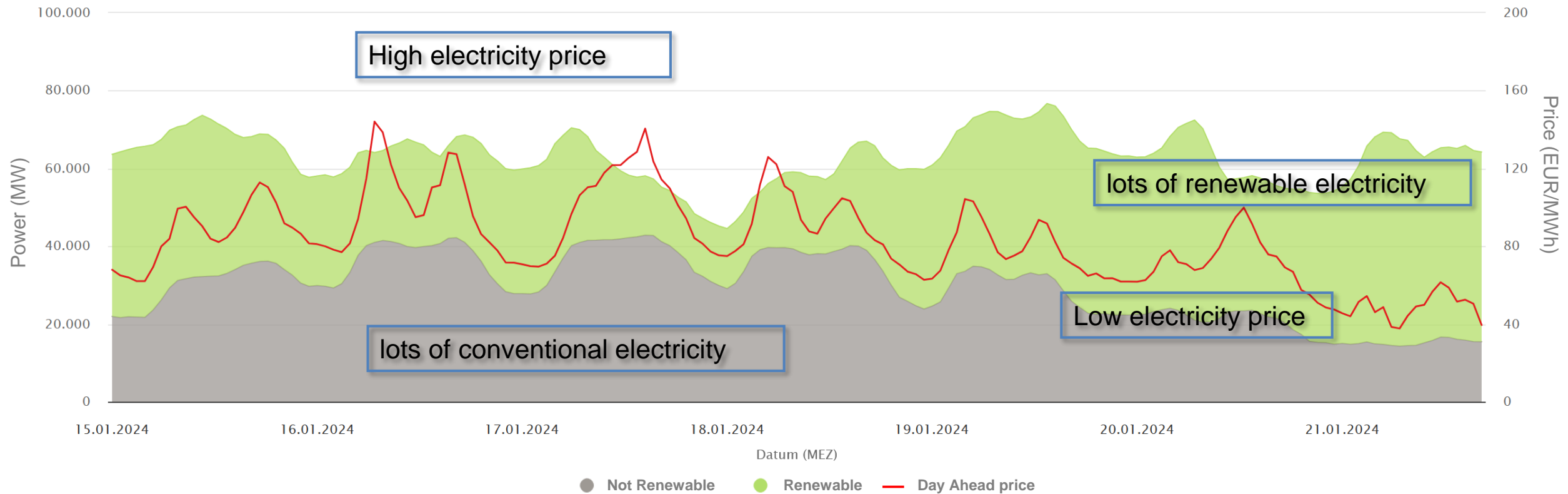


* EMS: Energy Management System

Using renewable electricity at low prices

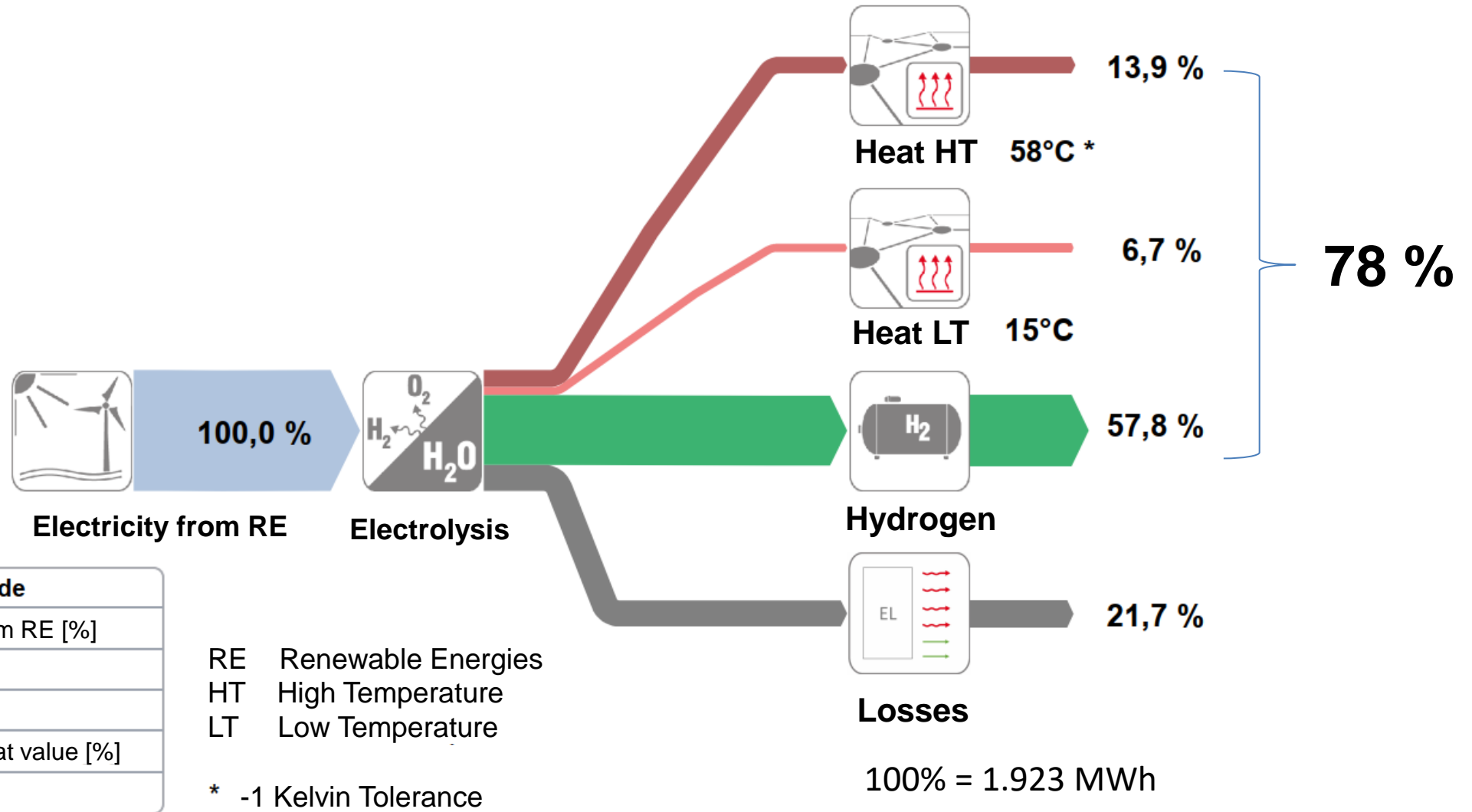
Energy management system






Electrical production and stock electricity prices in Germany - weak 3 / 2024



Electrolysis: Energy flow diagram

2023 Jan – Dec

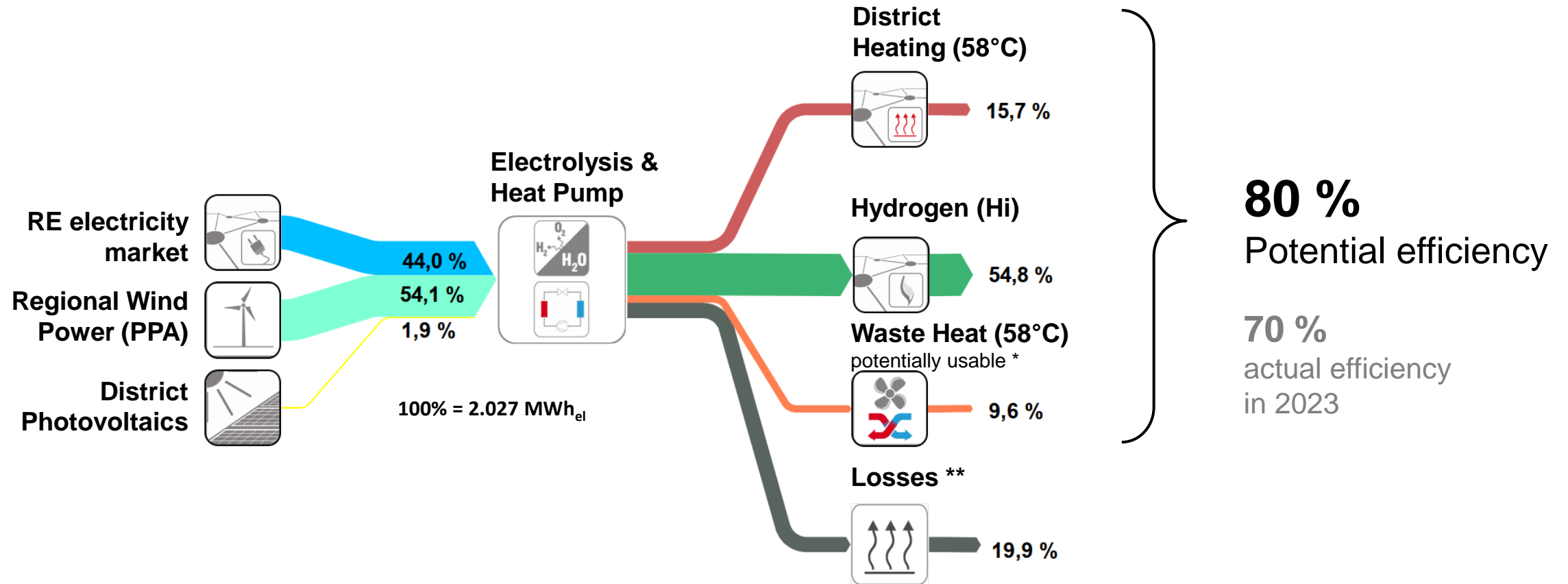


Legende	
	Electricity from RE [%]
	Losses [%]
	Heat LT [%]
	Hydrogen heat value [%]
	Heat HT [%]

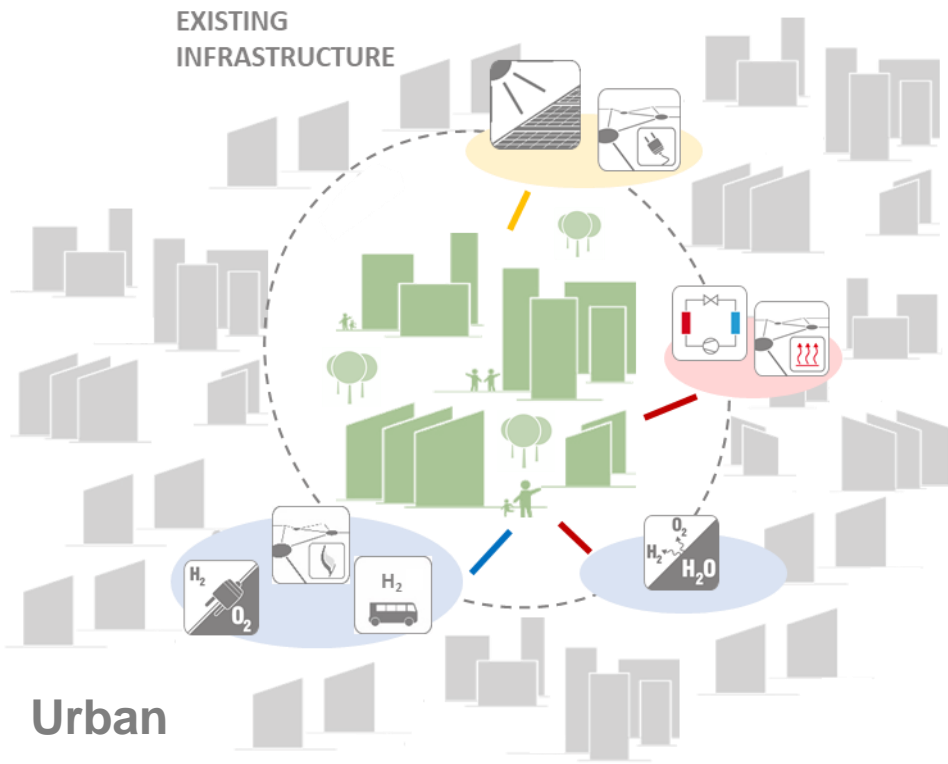
RE Renewable Energies
 HT High Temperature
 LT Low Temperature
 * -1 Kelvin Tolerance

Green Hydrogen Energy-Center

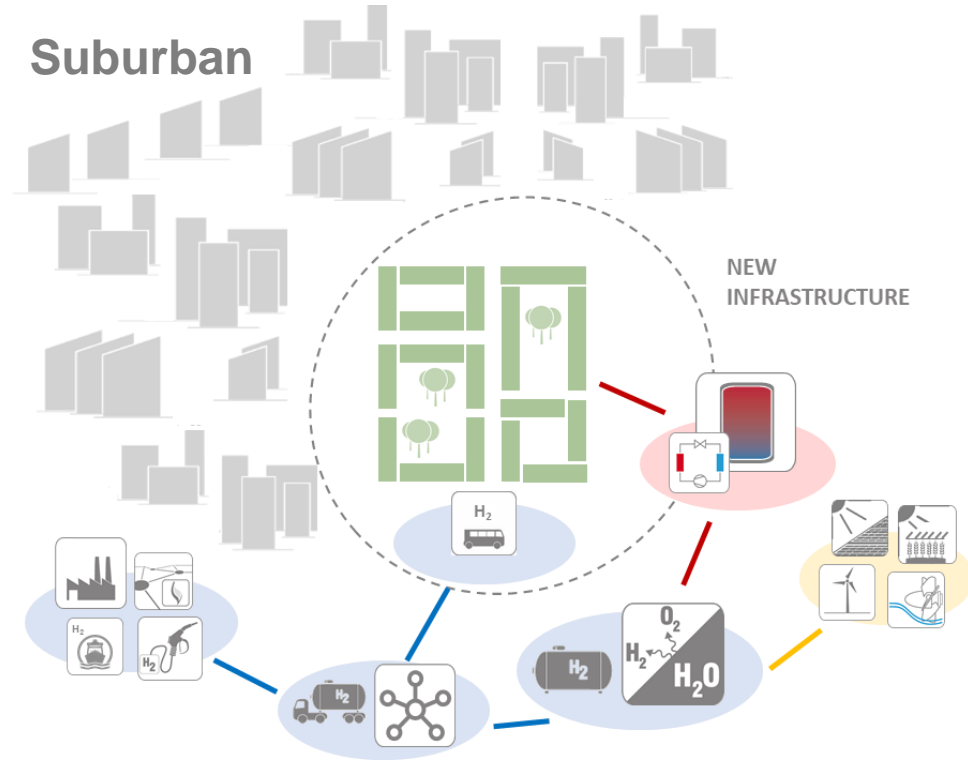
Energy flow diagram: 2023 Jan – Dec



Up-scaling on the outskirts of the city



- **Electrolysis < 10 MW_{el}**
- High connection density, low distribution losses
- No space for long-term heat storage
- Direct use of hydrogen
 - Urban mobility (Public transport)
 - H₂ Network (?)

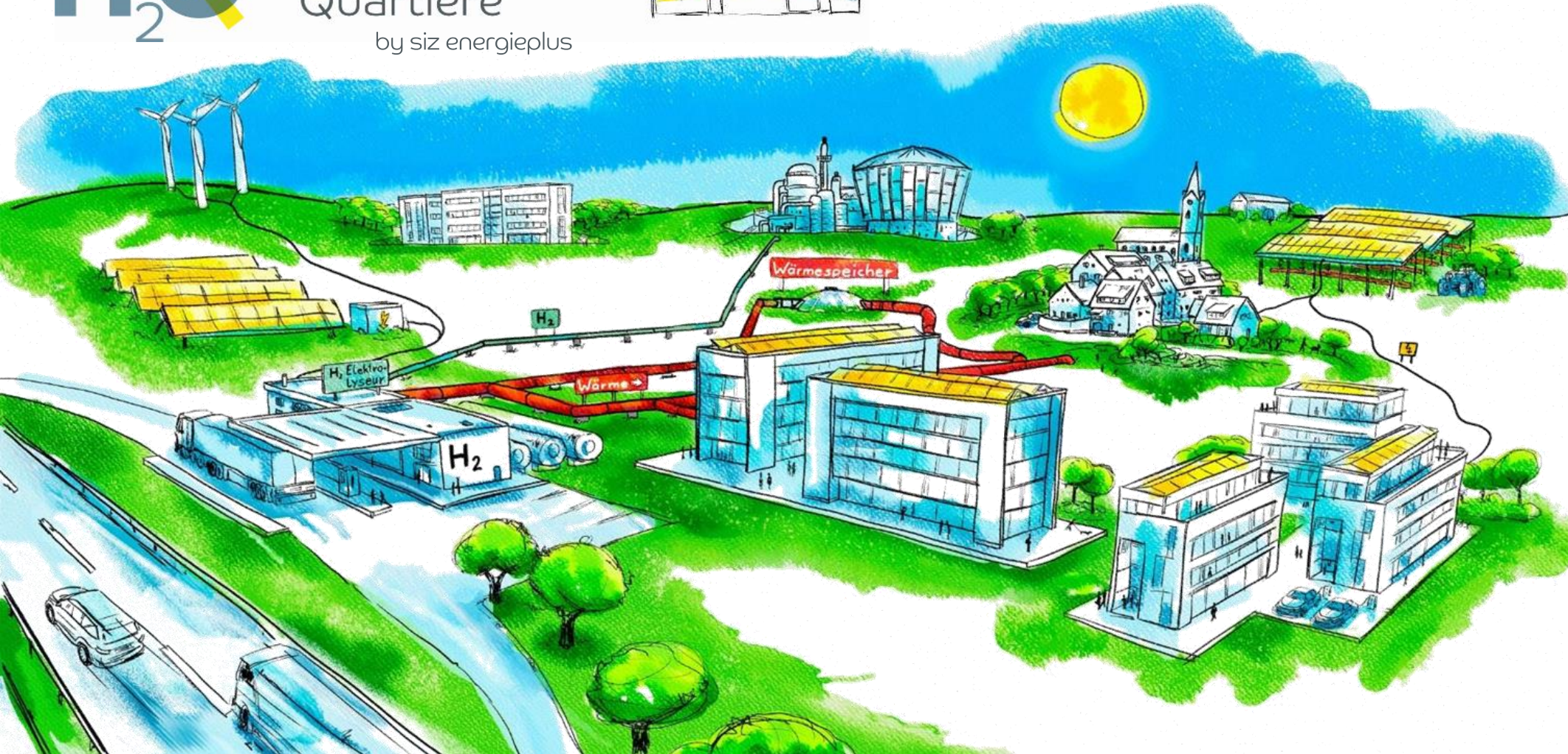
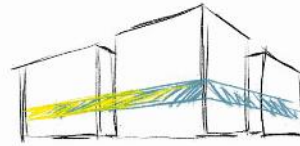


- **Electrolysis > 10 ...100 MW_{el}**
- 100% waste heat can be used
 - Seasonal heat storage + High temperature heat pump
- Use of hydrogen via logistics (central H₂-HUB)
 - Transport to industry
 - Gas station for heavy traffic

Project: Hydrogen districts H₂Q

H₂Q

Wasserstoff
Quartiere
by siz energieplus



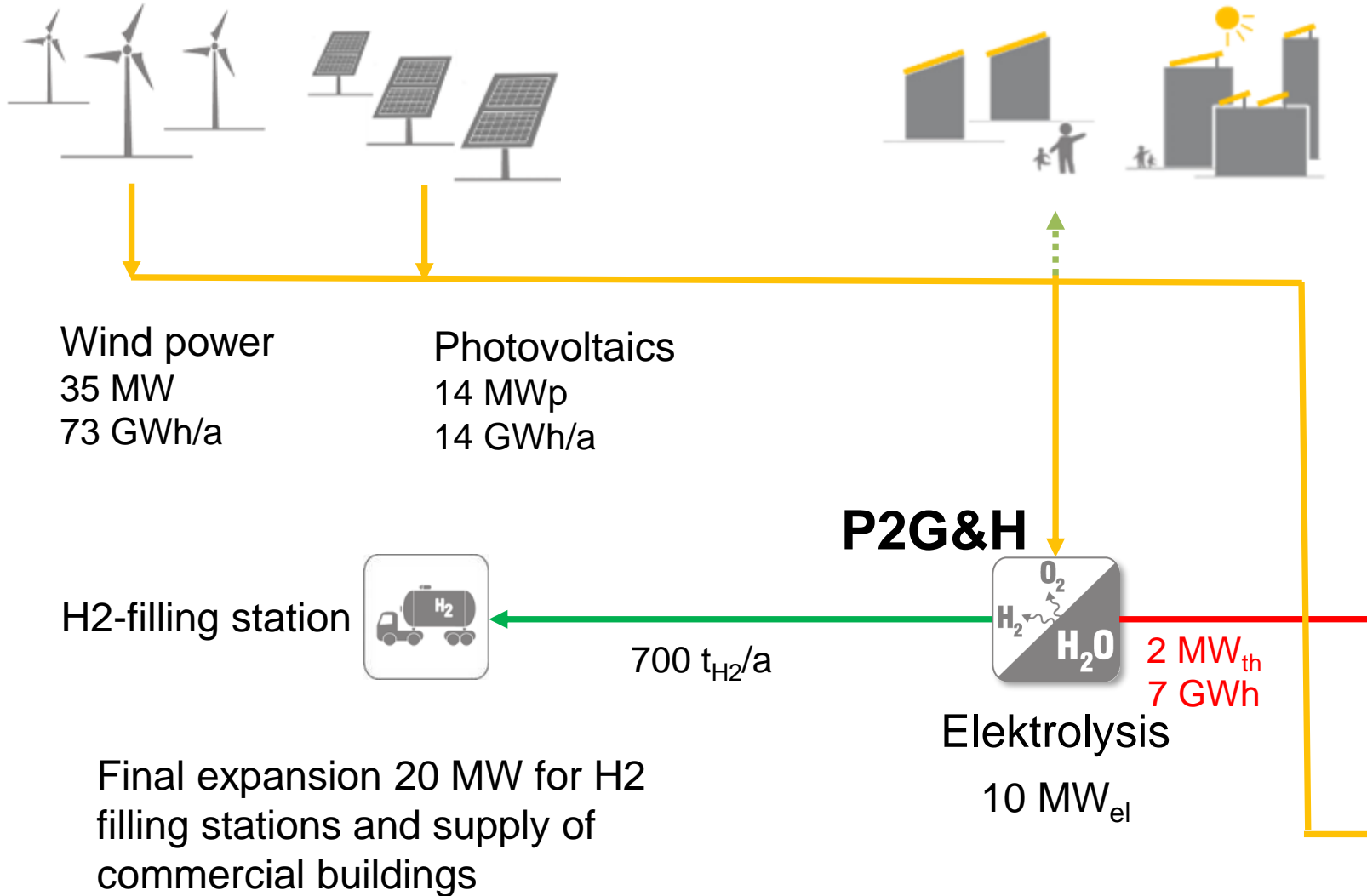
Gefördert durch:



Bundesministerium
für Wirtschaft
und Klimaschutz

aufgrund eines Beschlusses
des Deutschen Bundestages

Wertheim-Autohof – time horizon 2026/27



„Machen statt Reden! - Doing instead of Talking!“

We don't have a
knowledge deficit

but rather

an implementation
deficit & a lack of
information!

**Everything is happening far
too slowly!**

