Best practice - Green Hydrogen plant with high performance

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GEFÖRDERT DURCH
Bundesministerium für Wirtschaft und Energie
Bundesministerium für Bildung und Forschung
AUFGRUND EINES BESCHLUSSES DES DEUTSCHEN BUNDESTAGES

Green Hydrogen for energy transition

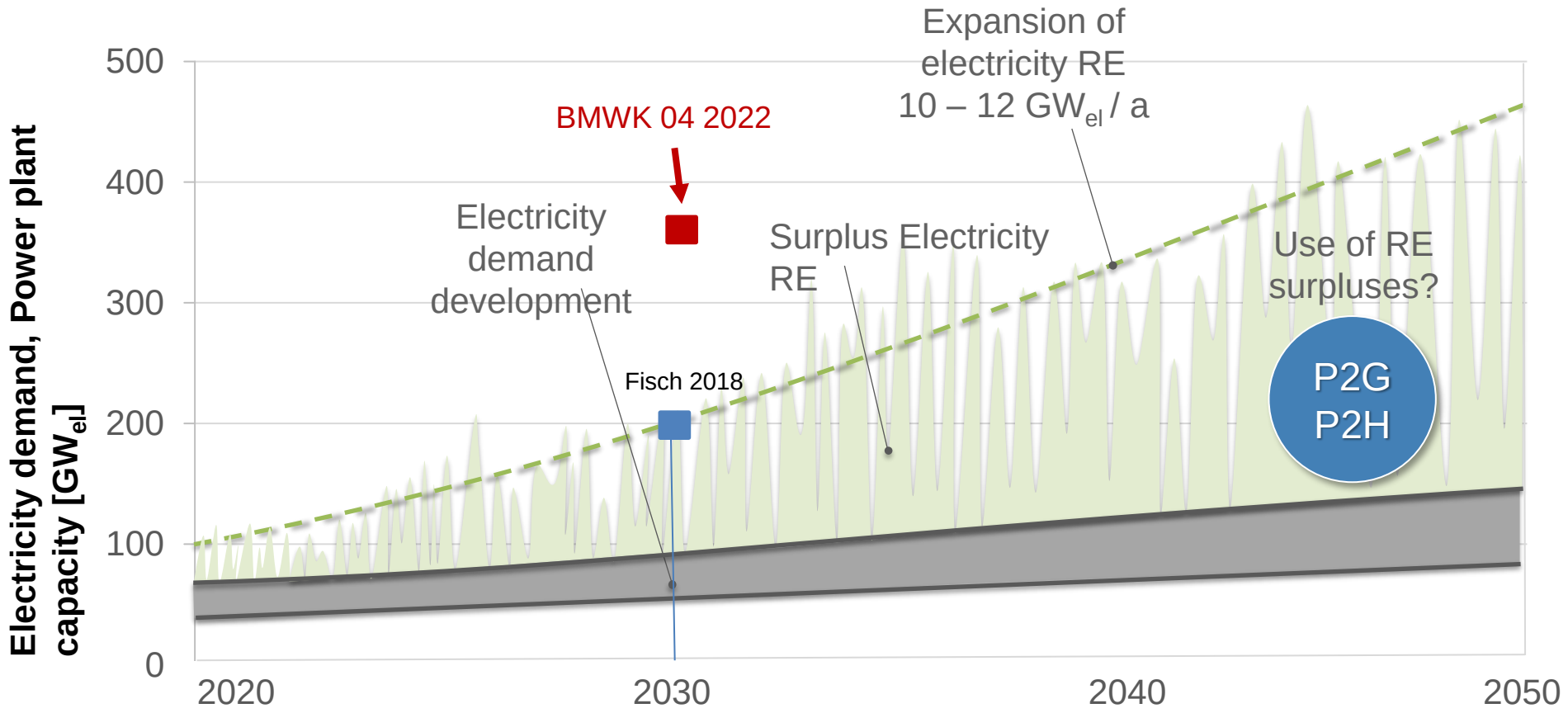
„Renewable Energy storage is the challenge for implementing energy transition “

„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

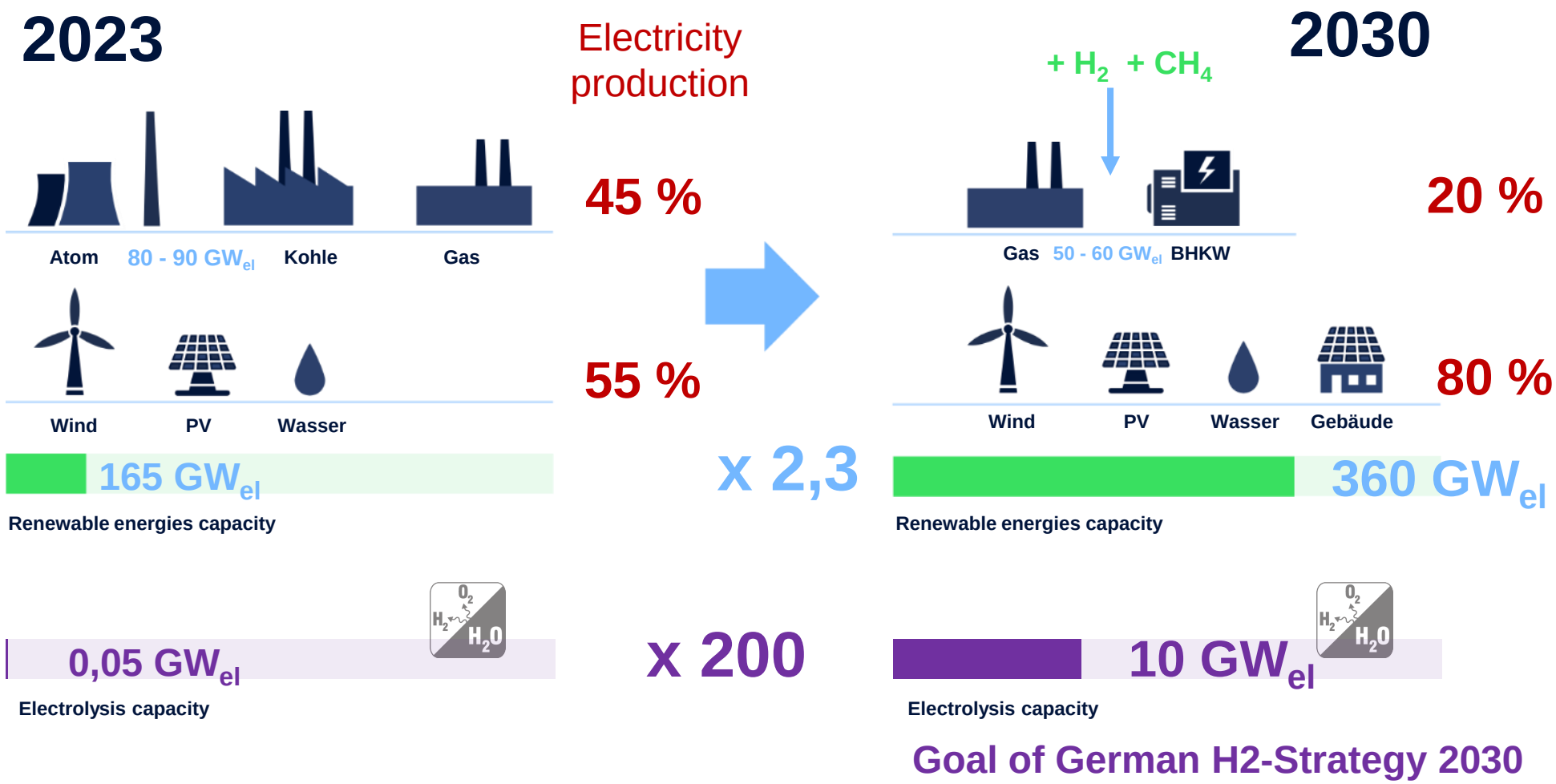
> 800 TWh/a (2050)

(2018, MNF)

RE : Renewable Energy

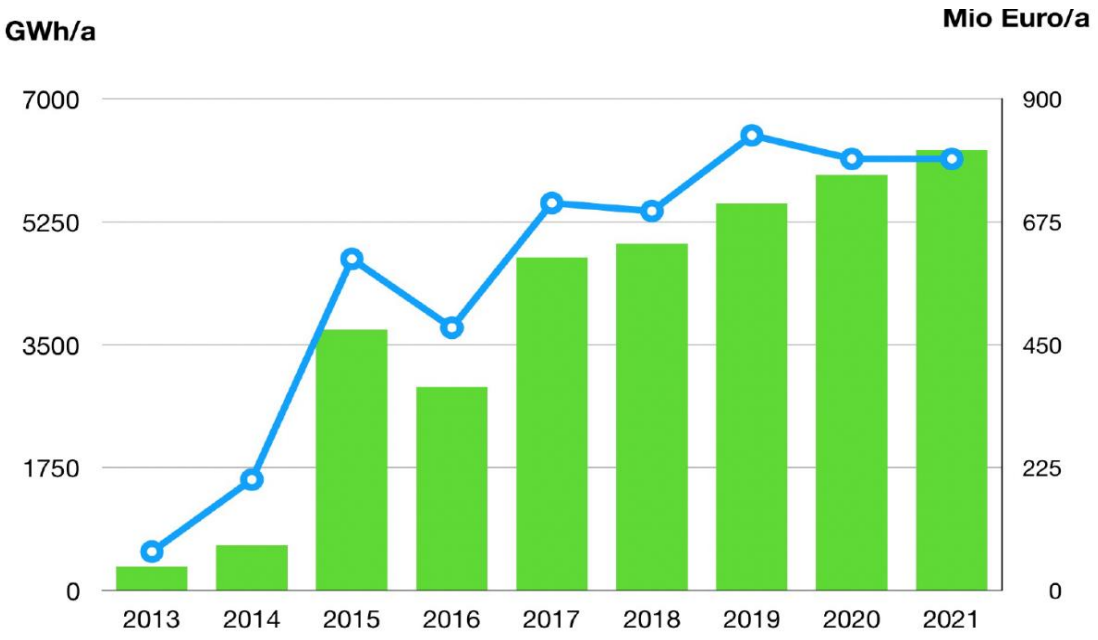
Political Hydrogen goals

Electricity system in transition



Sector Coupling is the key

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



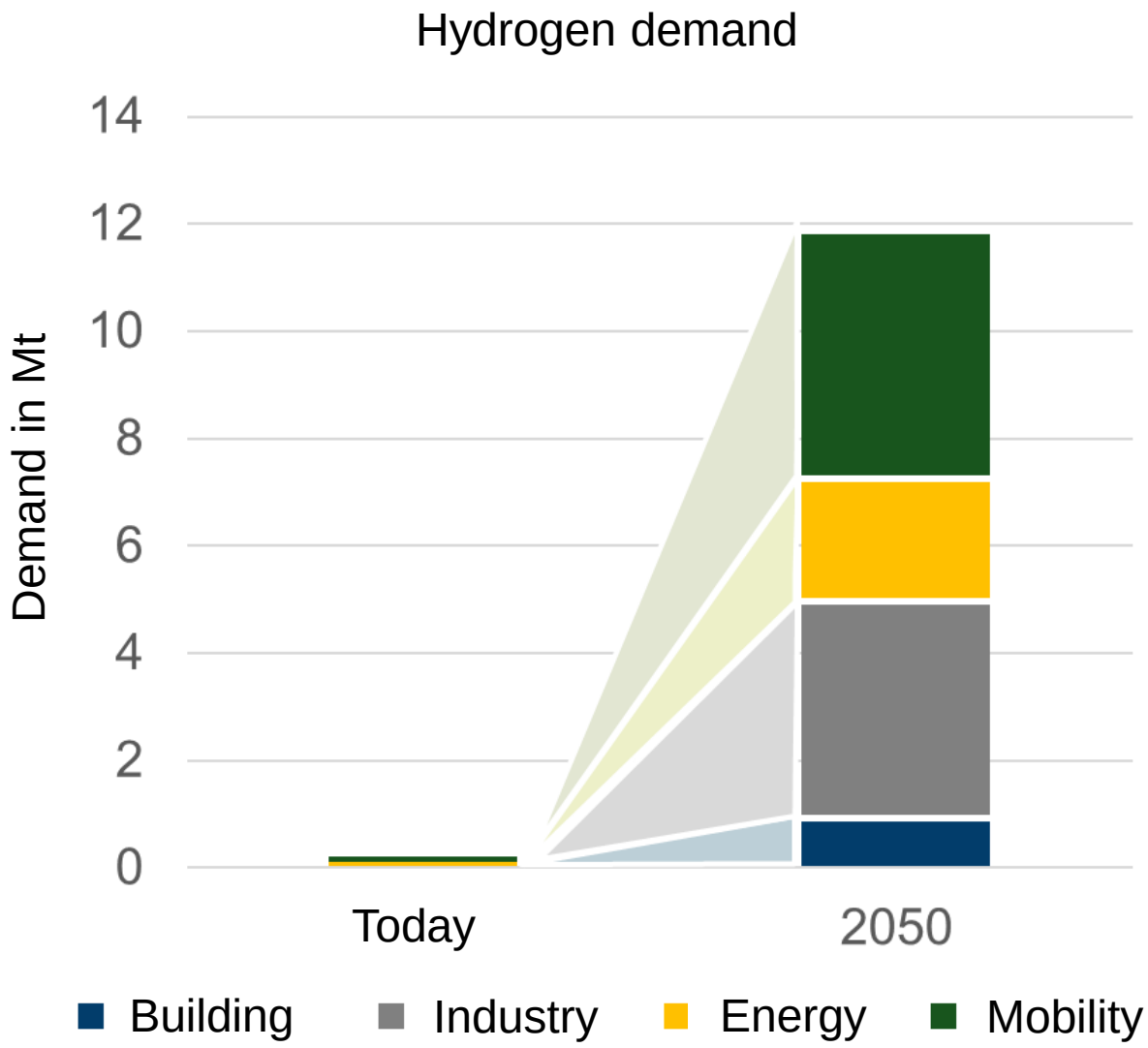
Payment to operators for shutdown
Wind and PV systems

2023: > 8 TWh/a > 1 Billion €

Sector coupling by PtH or PtG as key elements requested!

German „Energiewende“ until 2050

Hydrogen demand

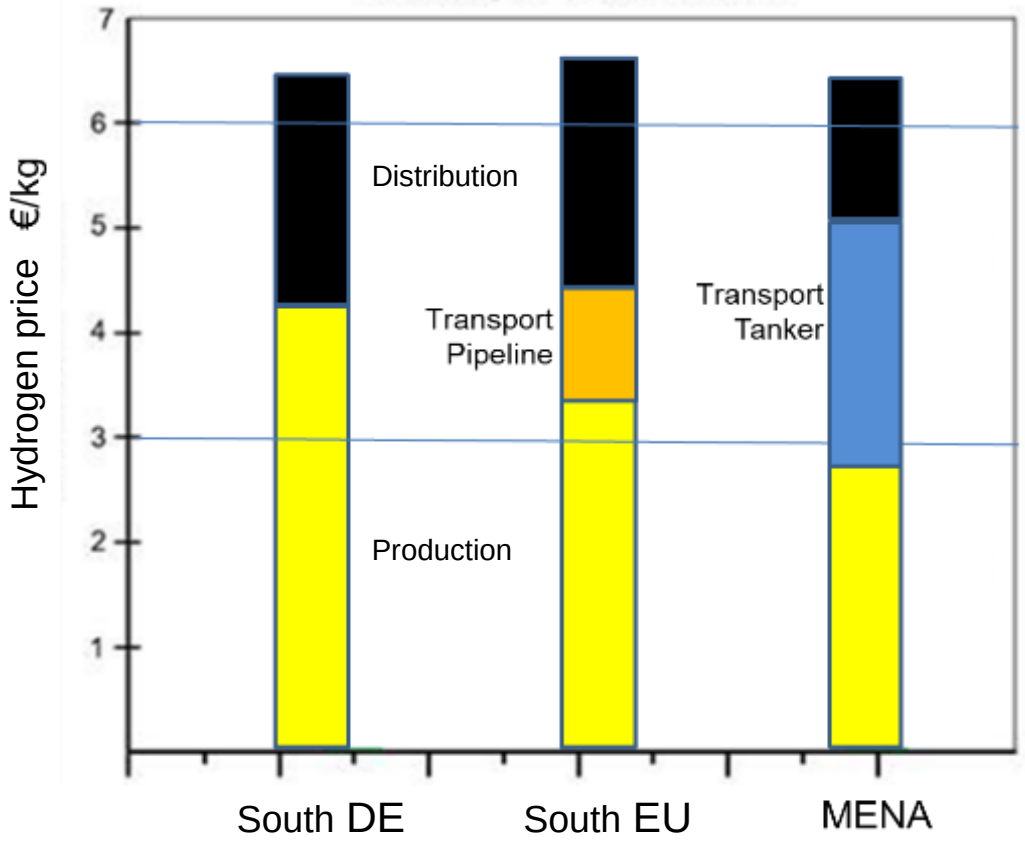


- H_2- Demand in 2050: 12 Mio.t
- 50% produced locally in Germany
- approx. 60 GW_{el} Ely- Capacity req.
- Priority use in **Mobility and Industry**

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

Production Costs- „Green Hydrogen“

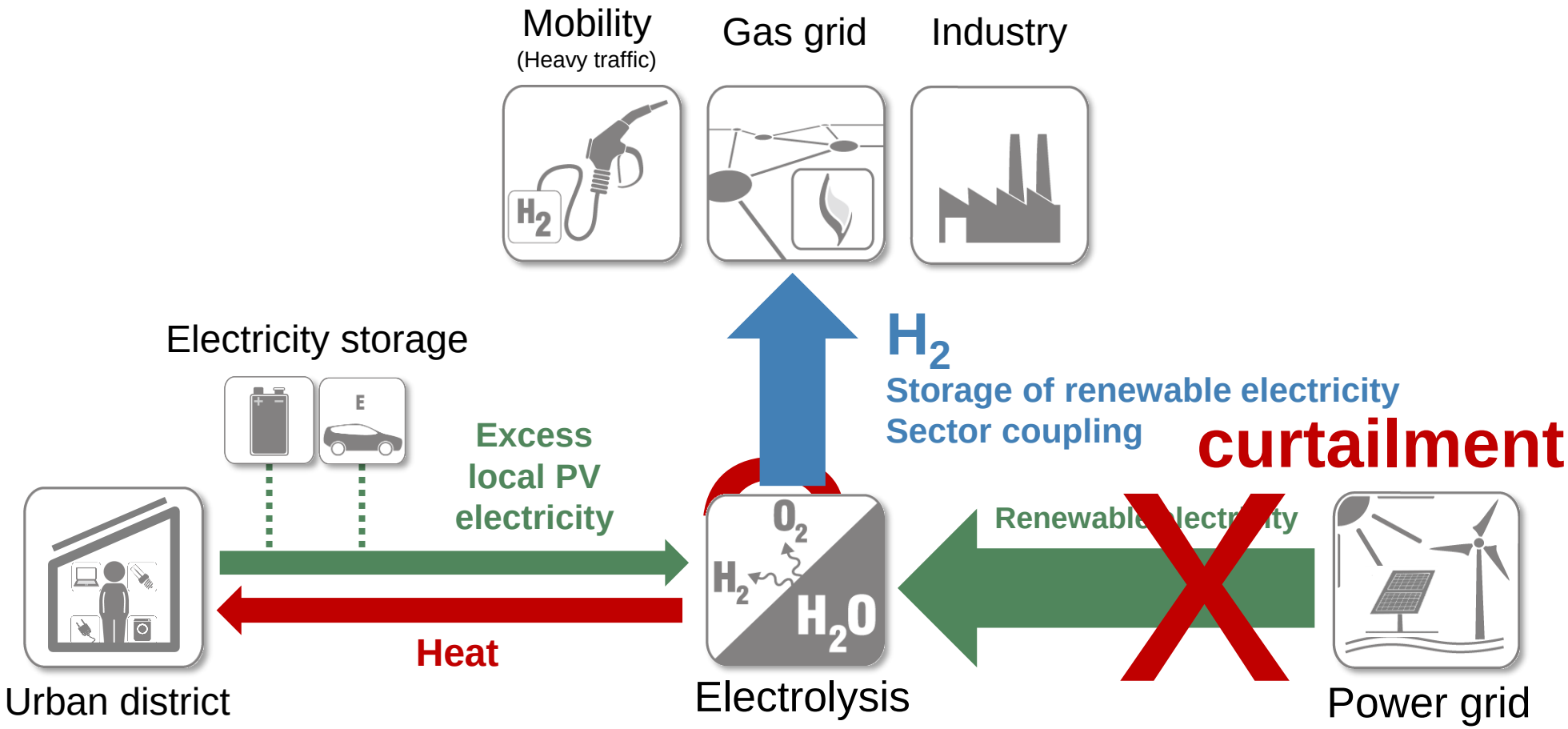
Location	Global radiation	Electricity yield / Electricity price		H_2 – Production costs		
	kWh/(m²a)	*kWh/(kWp a)*	*ct/kWh*	**OPEX** *€/kg*	**CAPEX** *€/kg*	**Total** *€/kg*
South Germany	1.100	1.250	5,0	2,8	1,2	4- 4,5
South Europe	1.800	1.700 *)	3,8	2,1	1,2	3,3- 3,5
MENA-Region	2.300	1.850 *)	3,0	1,9	1,1	2,8 - 3,0



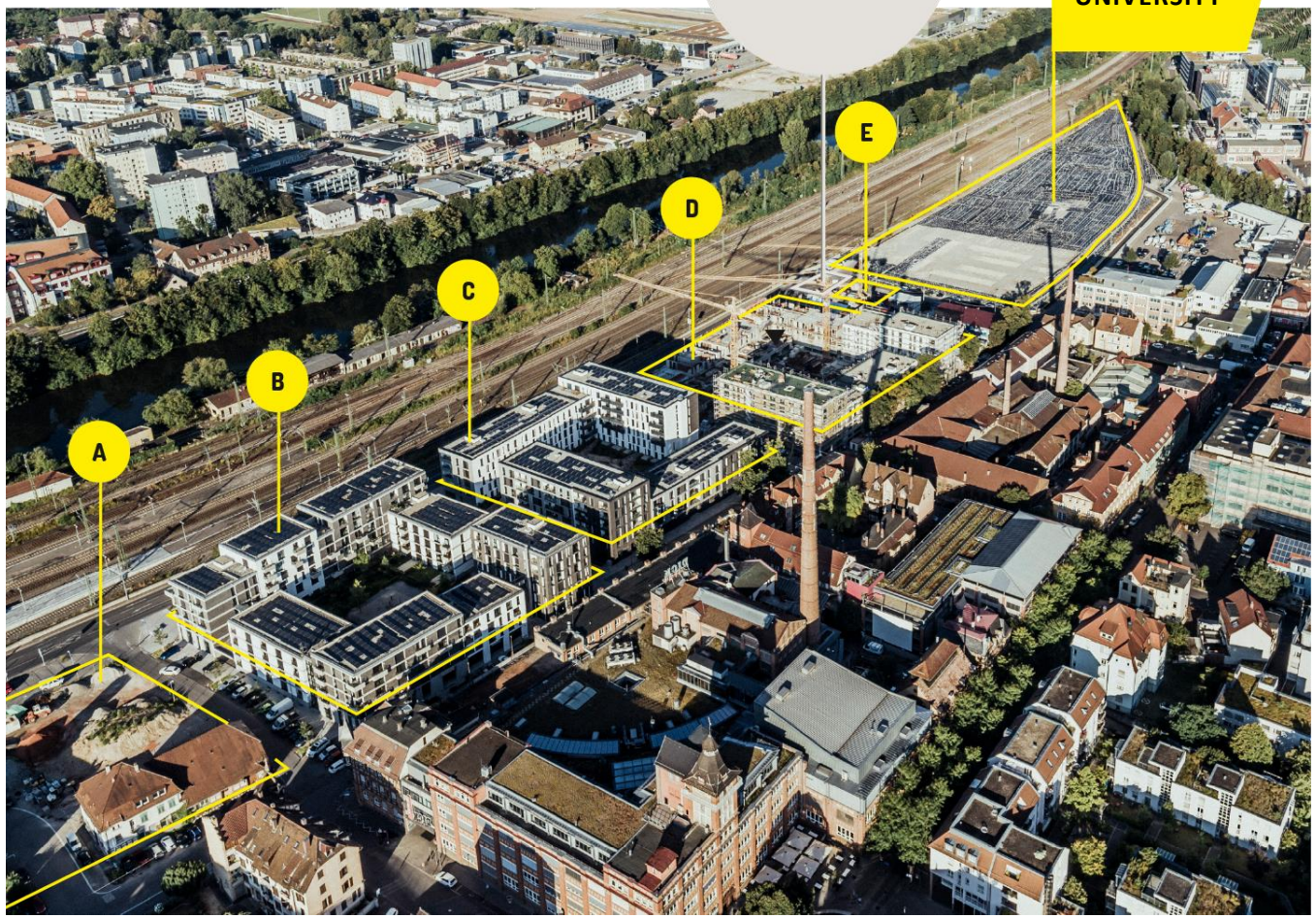
Quelle: SIZ energieplus, 2021

M.N.Fisch, 2020

Hydrogen in the city – why?

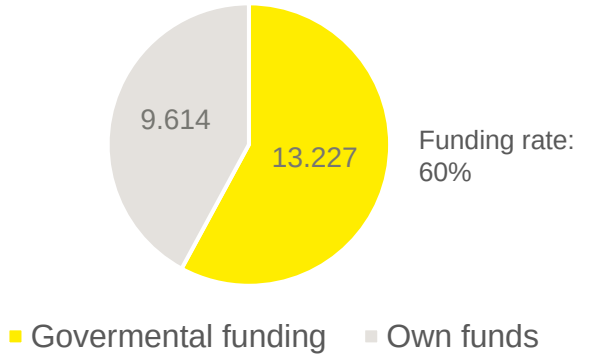


Urban district – Neue Weststadt Esslingen



Keyfacts

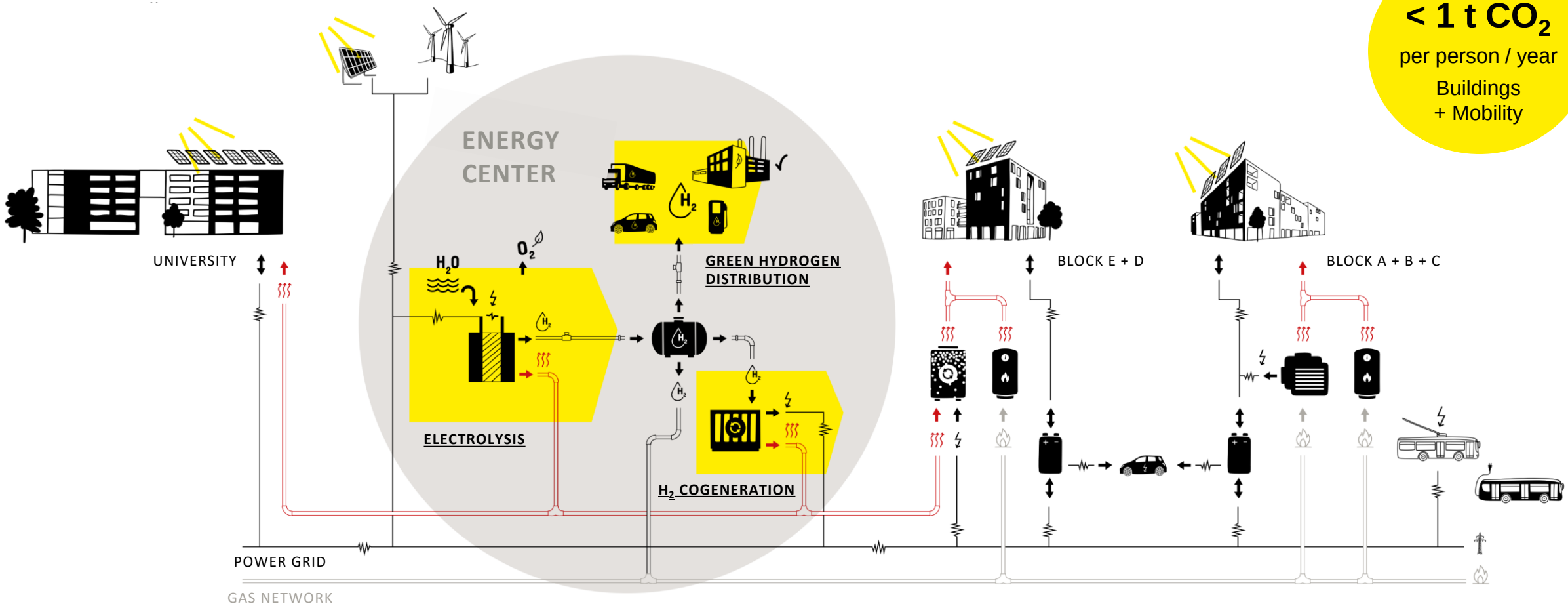
- 12 ha, 85.000 m^2_{BGF}, 80% Living (> 550 RU)
- Project duration: 2017 – 2024
- 13 interdisciplinary partners (City of Esslingen, research and science, real estate project development, energy suppliers, investors)
- Funding-relevant costs (T€)



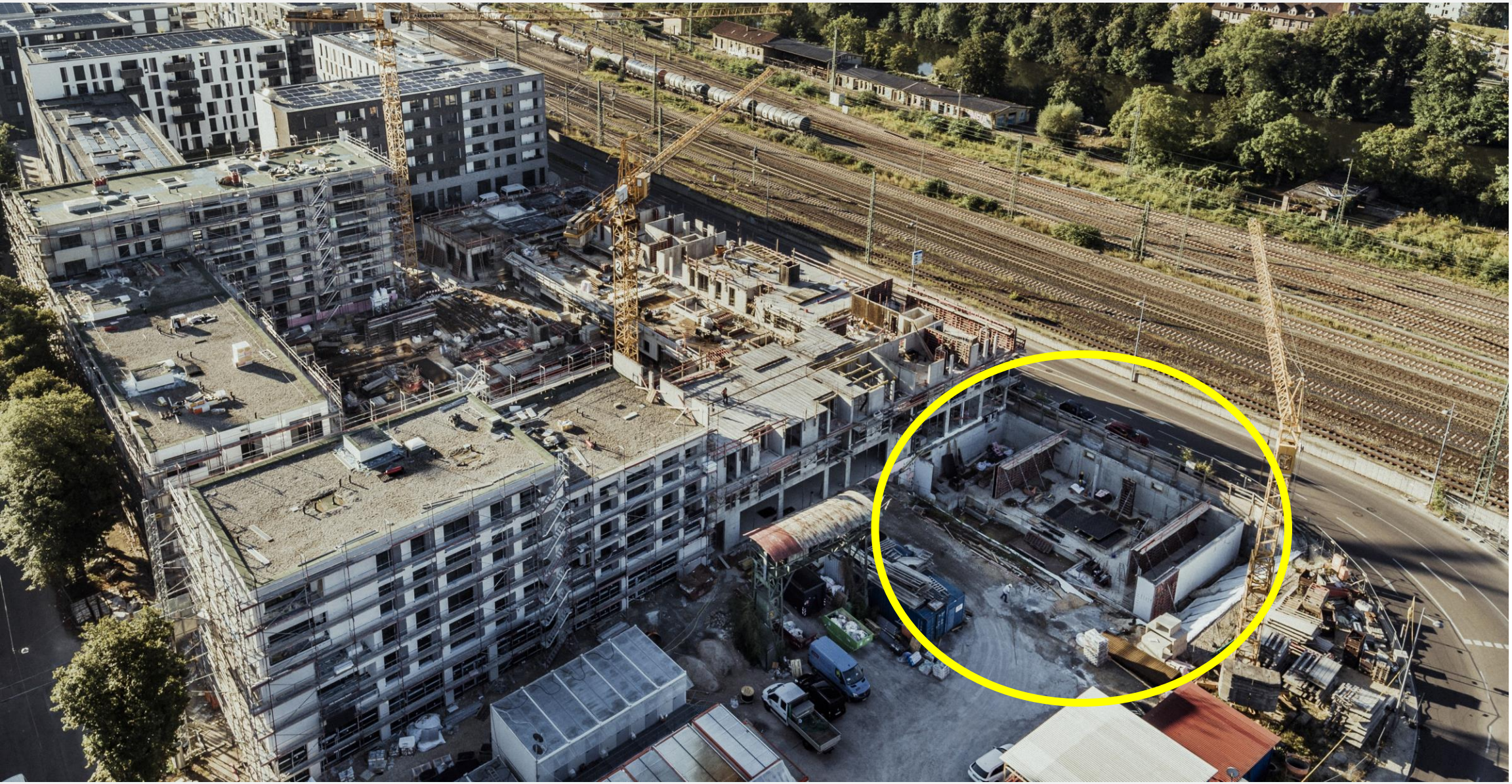
Supported by:
Federal Ministry for Economic Affairs and Energy
Federal Ministry of Education and Research
on the basis of a decision by the German Bundestag

Energy concept

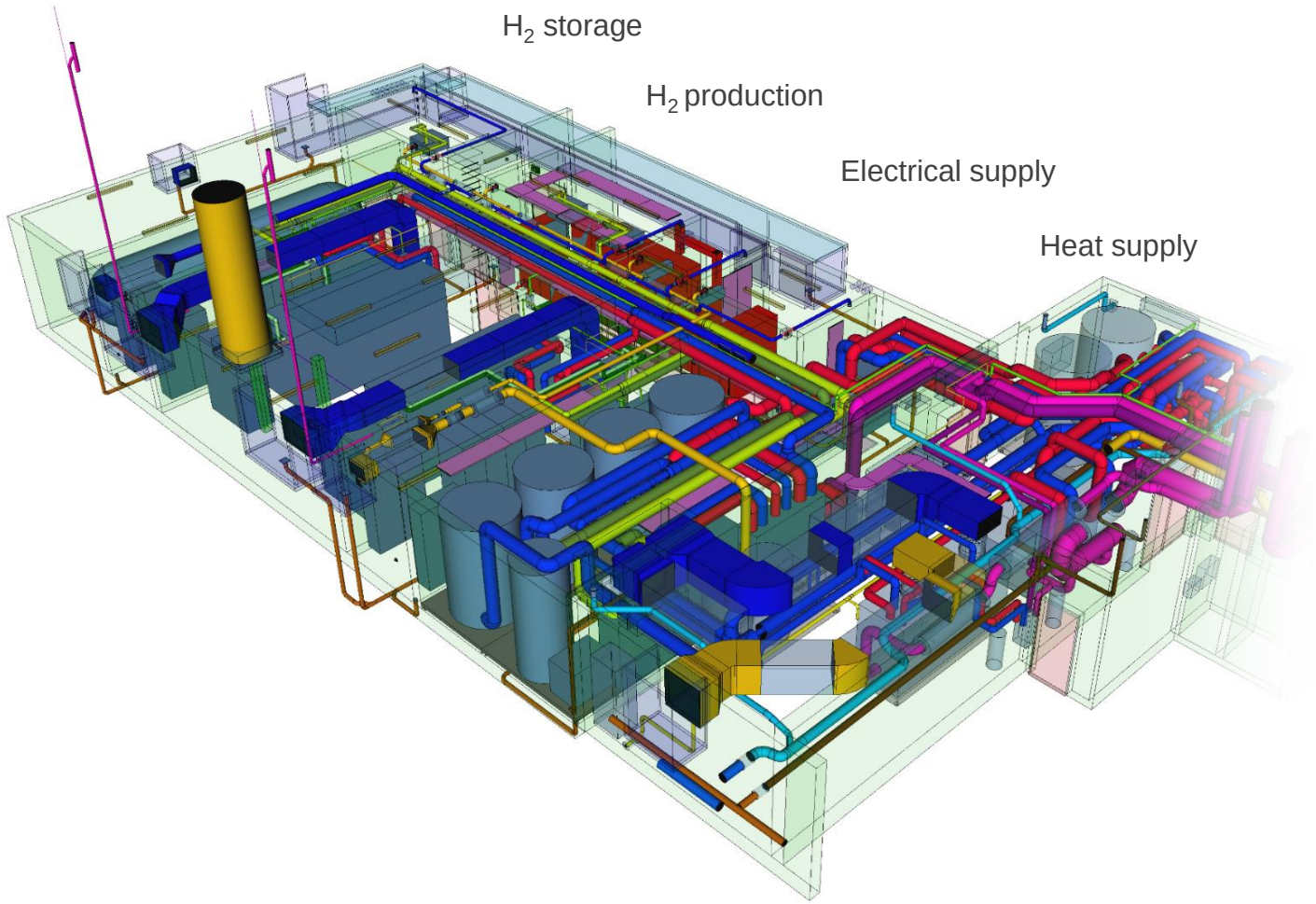
< 1 t CO_2
per person / year
Buildings
+ Mobility



Construction phase



Underground energy center



Components

- Electrolysis: Cooling the stacks
  → 250 kW_{th} (~ 55-60°C)
- Heat pump: Rectifiers, inverters, transformer
  → 220 kW_{th} (~ 65°C)
- H_2/Biomethan CHP:
  → 190 $kW_{th\ (H2)}$
- Peak load boiler

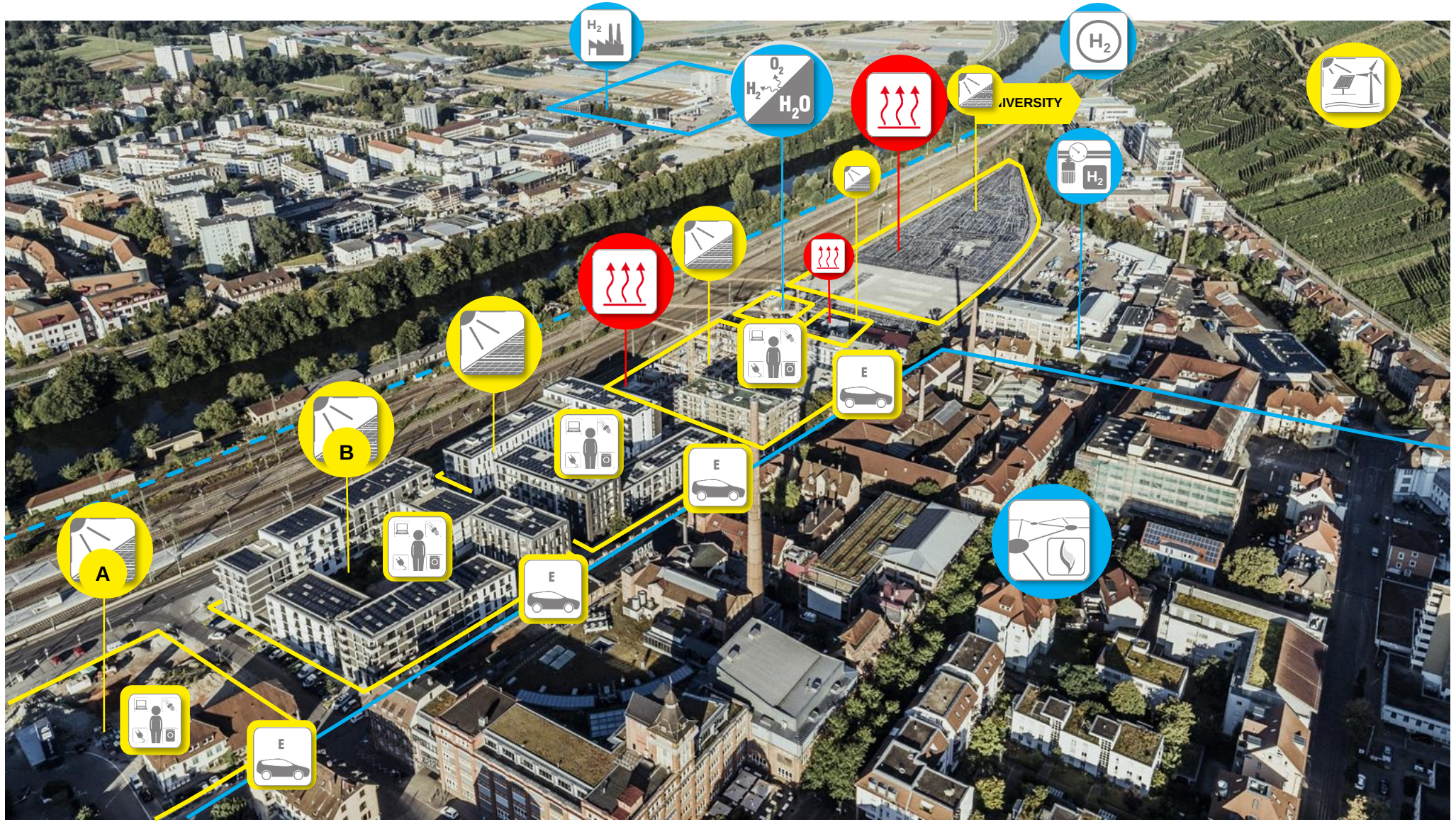
Heat distribution & consumers

- 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 Nm^3 H_2/h
- Operating pressure: 11,5 bar
- Elektrolyte: 30% Potassium hydroxide, 500 l
- Utilization rate: 5,2 kWh_{el} / m^3 H_2 (ca. 60%)
- Waste Heat: approx. 60 °C

Concept map and H_2 usage



i. Short-term

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

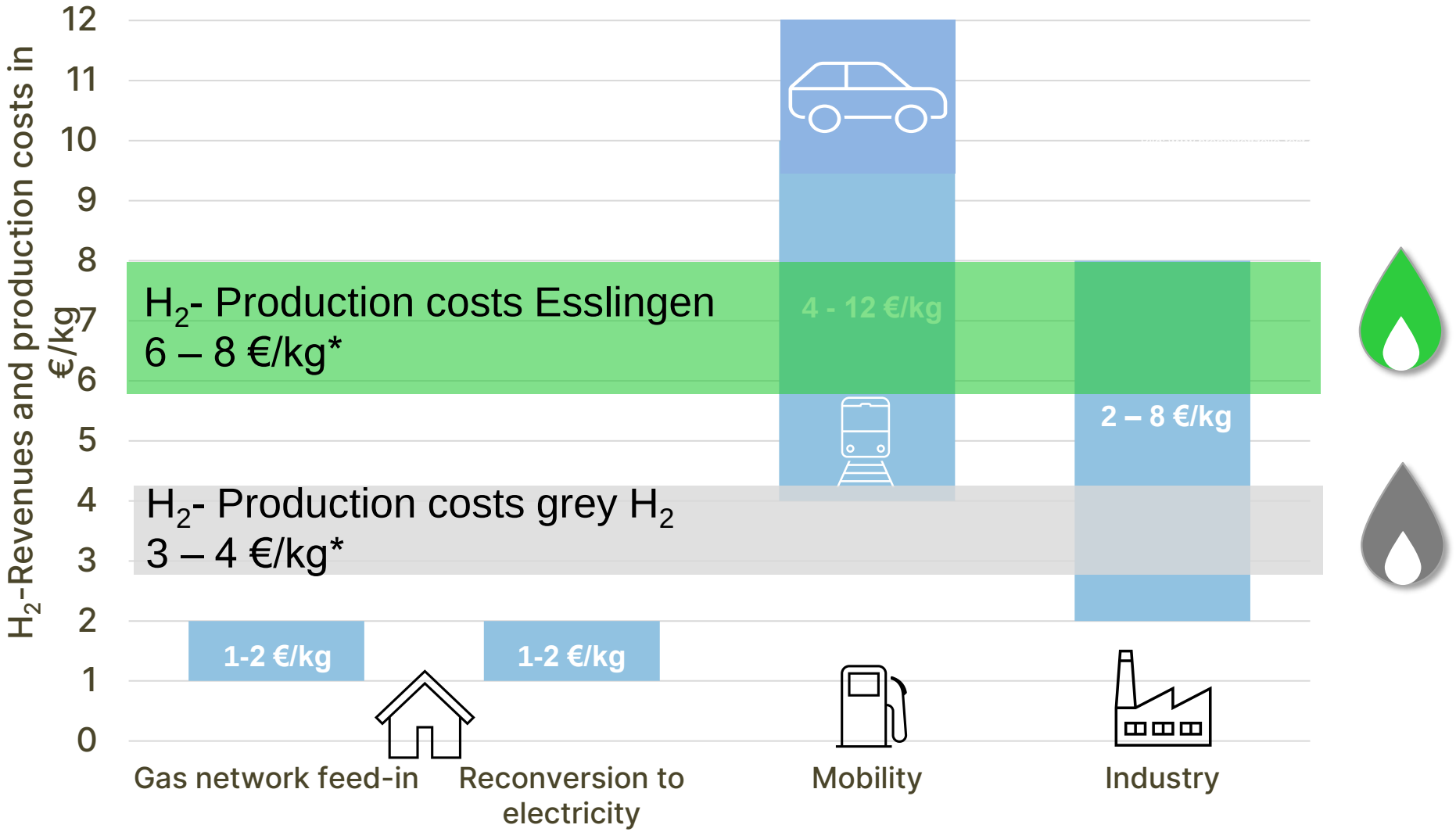
ii. Medium-term

Industry/Mobility: Fuel cell test stands

iii. Long-term

H_2 Pipeline: Scaling the hydrogen economy in the region

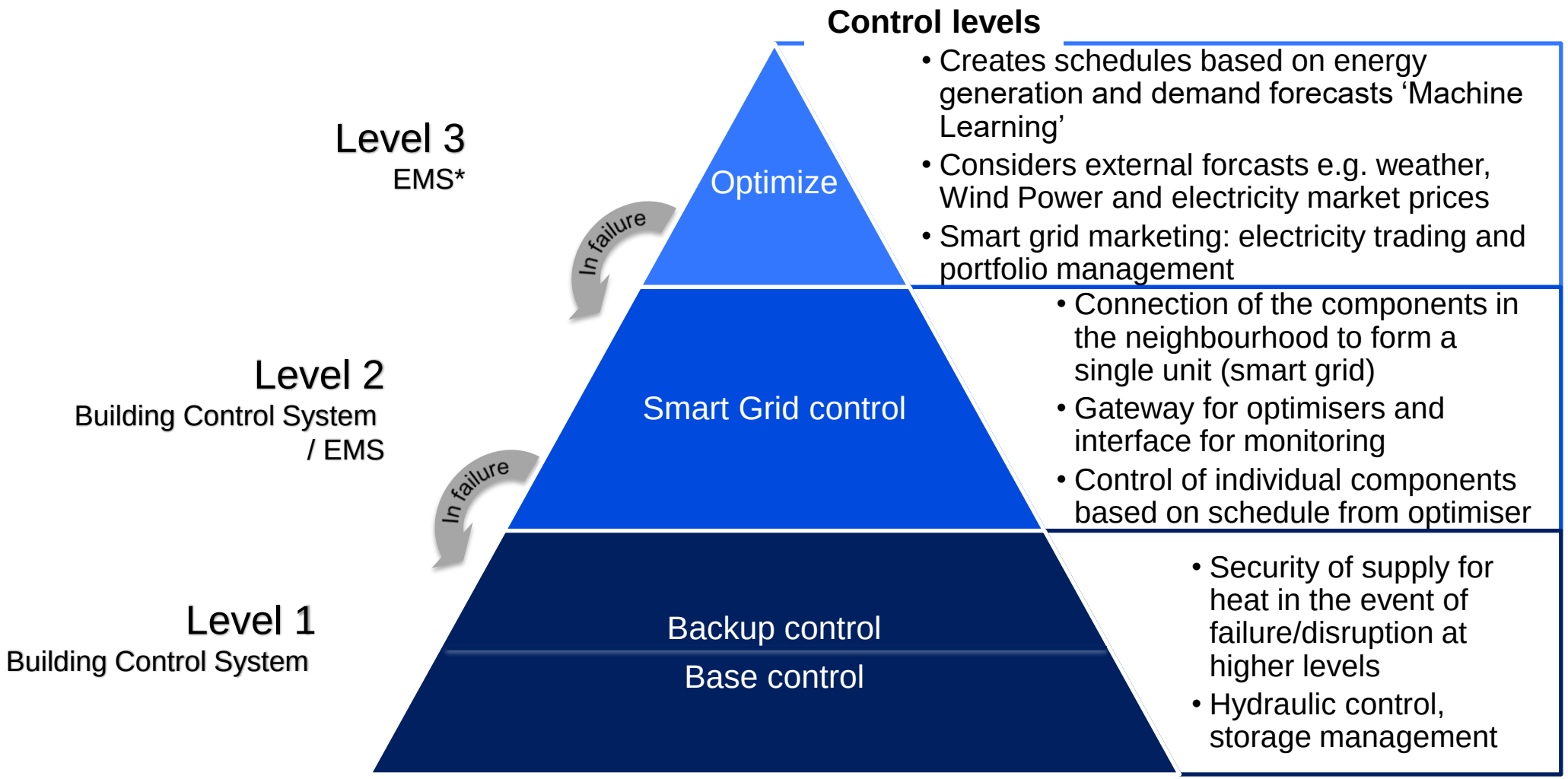
H_2-Disabler
Sales market for green hydrogen



*Costs before the crisis - status 2019

Energy Management System

Control levels



* EMS: Energy Management System

Using renewable electricity at low prices

Energy management system

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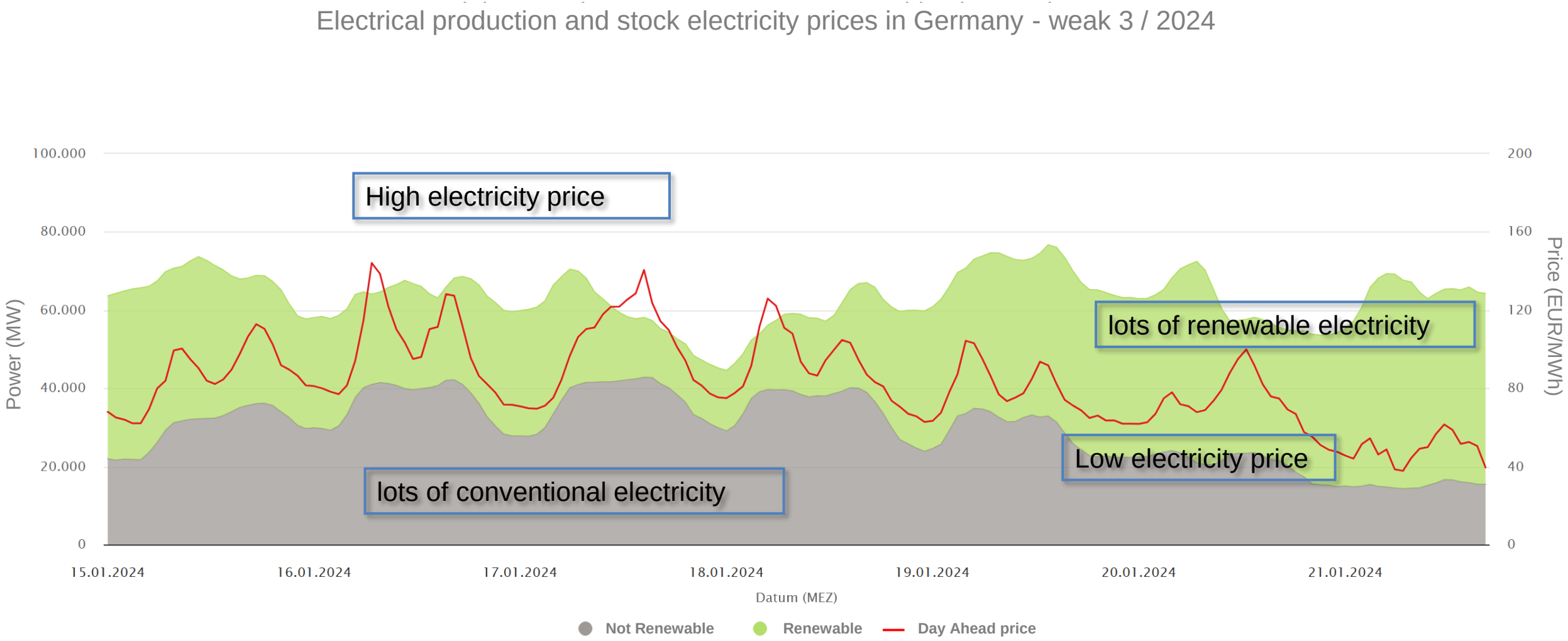
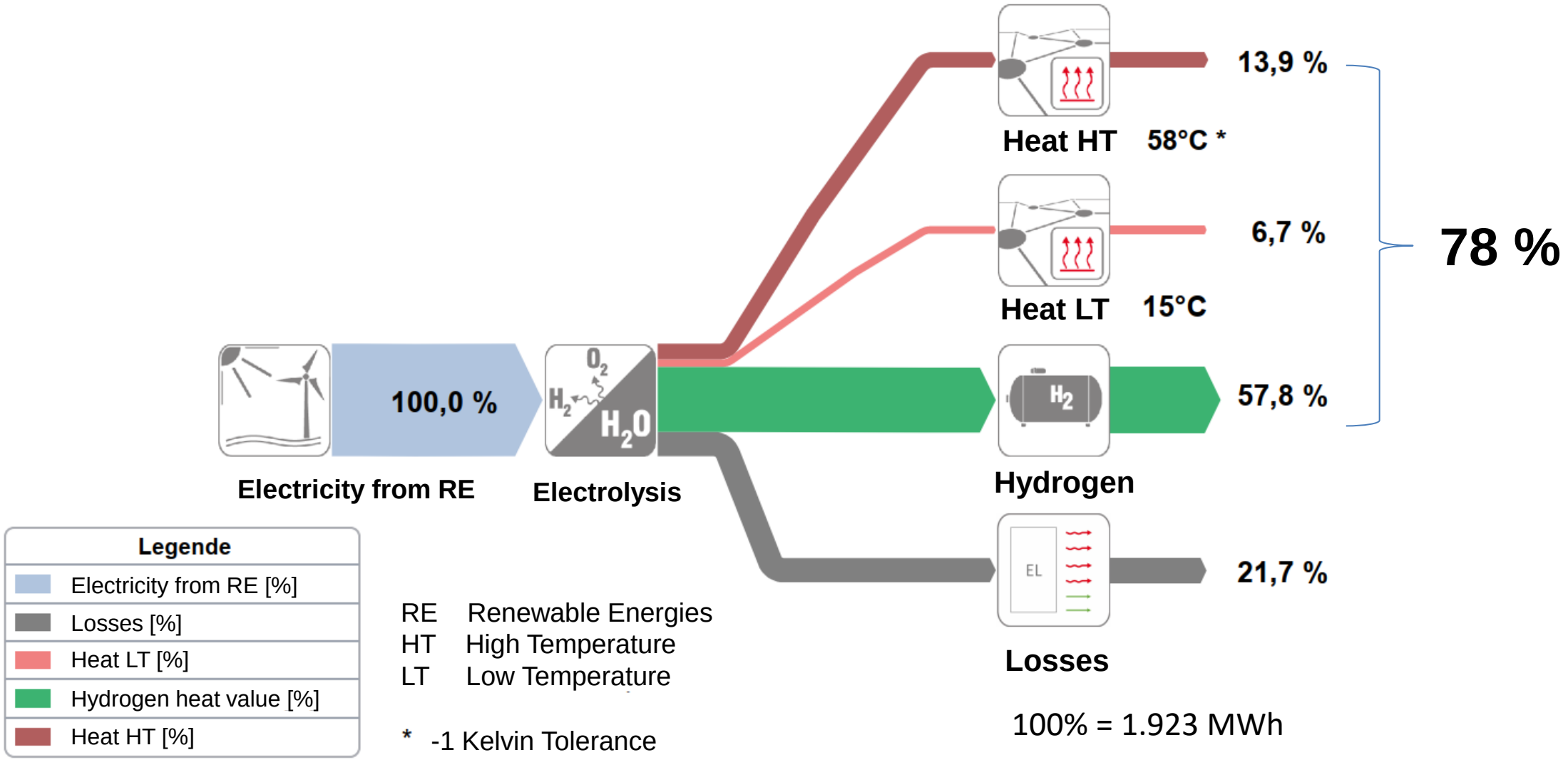
EGS plan



Quelle: Fraunhofer ISE / energy-charts.info

Electrolysis: Energy flow diagram

2023 Jan – Dec



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

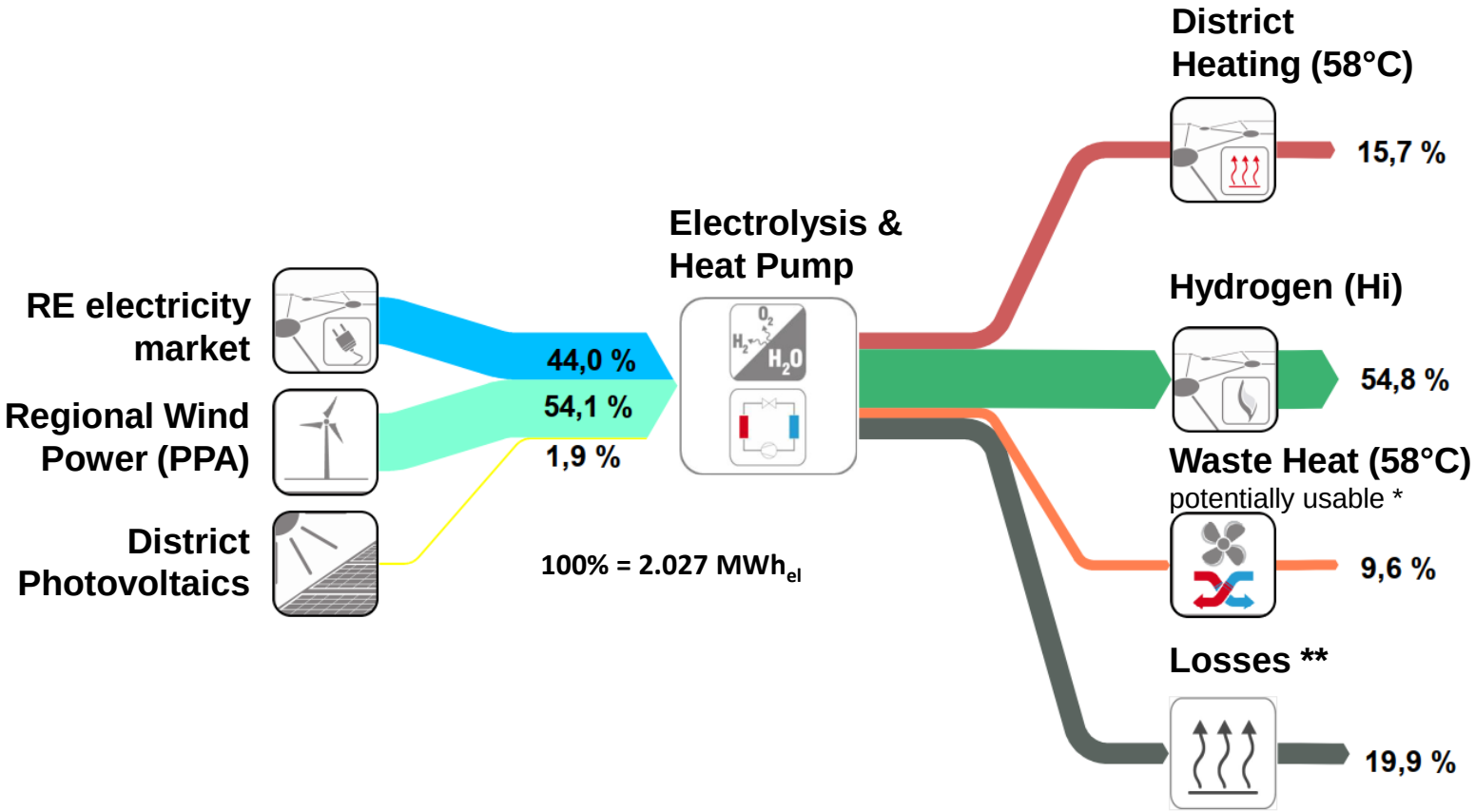
RE Renewable Energies
HT High Temperature
LT Low Temperature

* -1 Kelvin Tolerance

100% = 1.923 MWh

Green Hydrogen Energy-Center

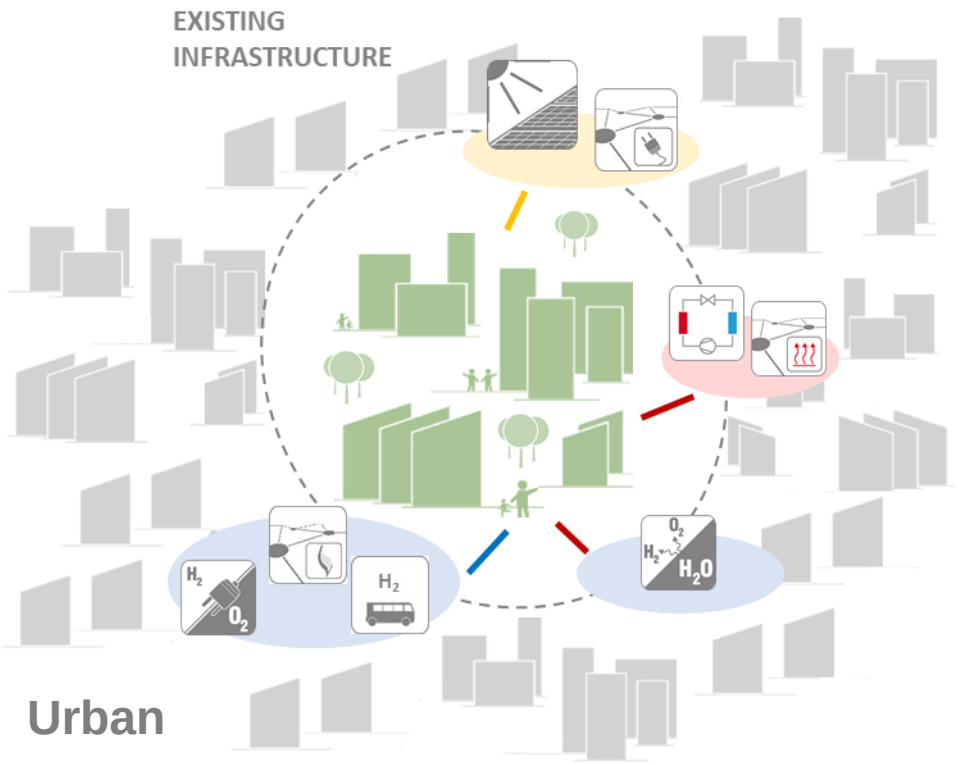
Energy flow diagram: 2023 Jan – Dec



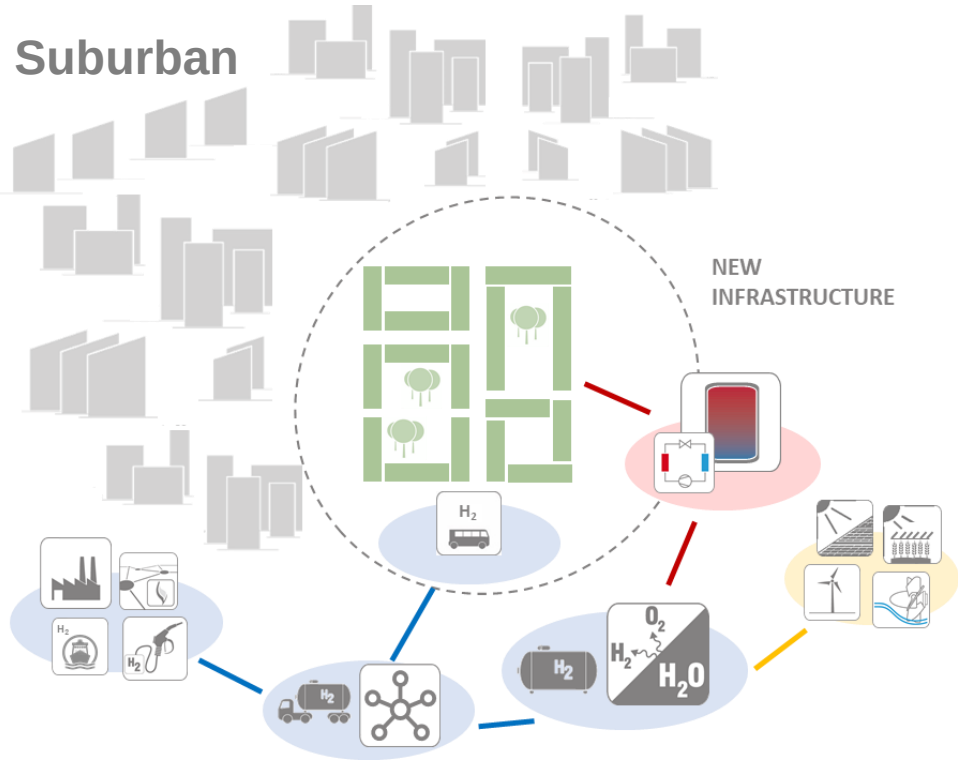
80 %
Potential efficiency

70 %
actual efficiency
in 2023

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)
  - H_2 Network (?)



- **Electrolysis > 10 ...100 MW_{el}**
- 100% waste heat can be used
  - Saisonal heat storage + High temperature heat pump
- Use of hydrogen via logistics (central H_2-HUB)
  - Transport to industry
  - Gas station for heavy traffic

Project: Hydrogen districts H_2Q

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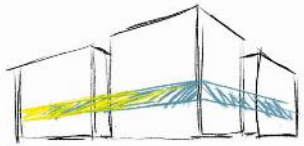
EGS plan

H_2Q Wasserstoff Quartiere
by siz energieplus



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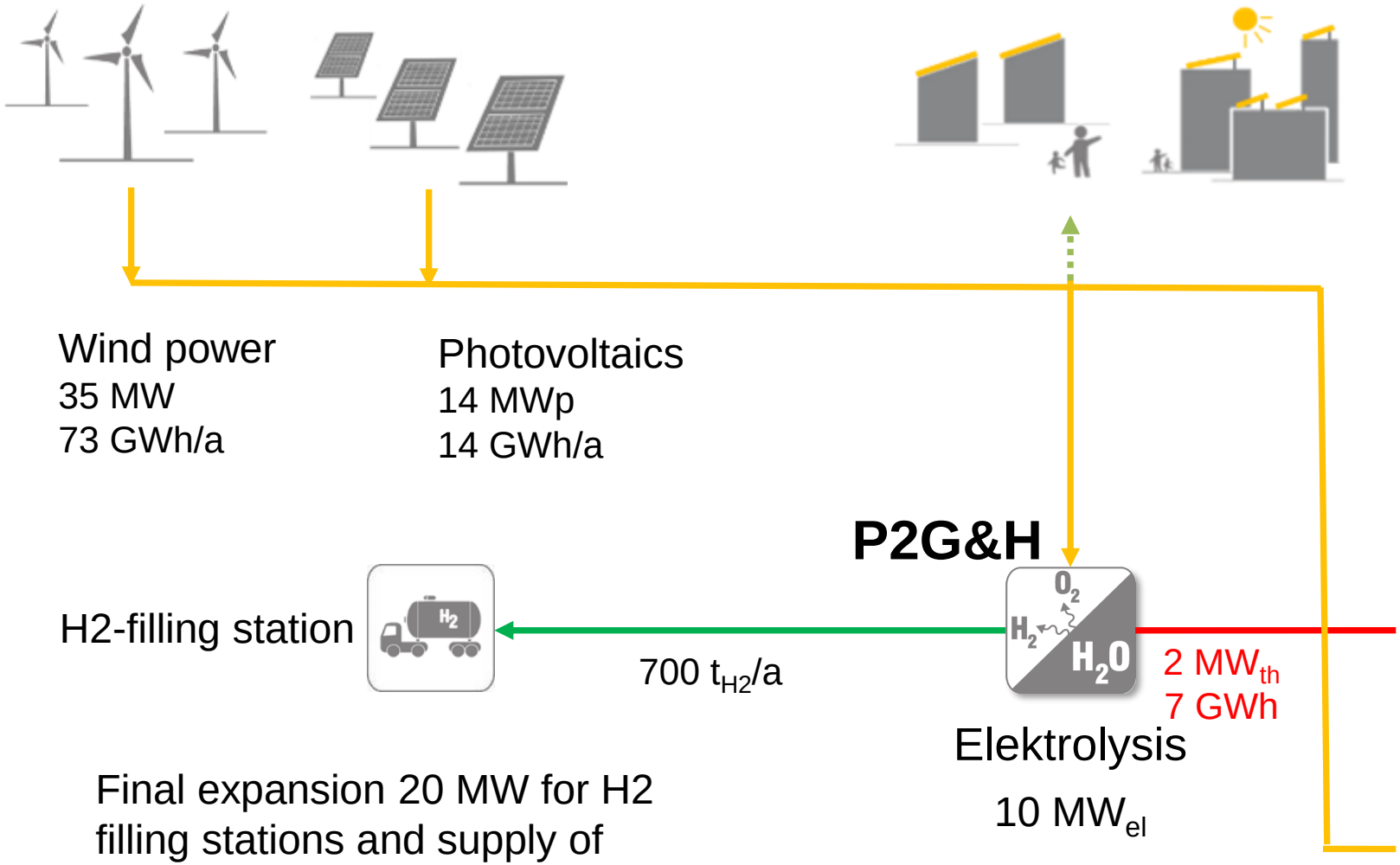
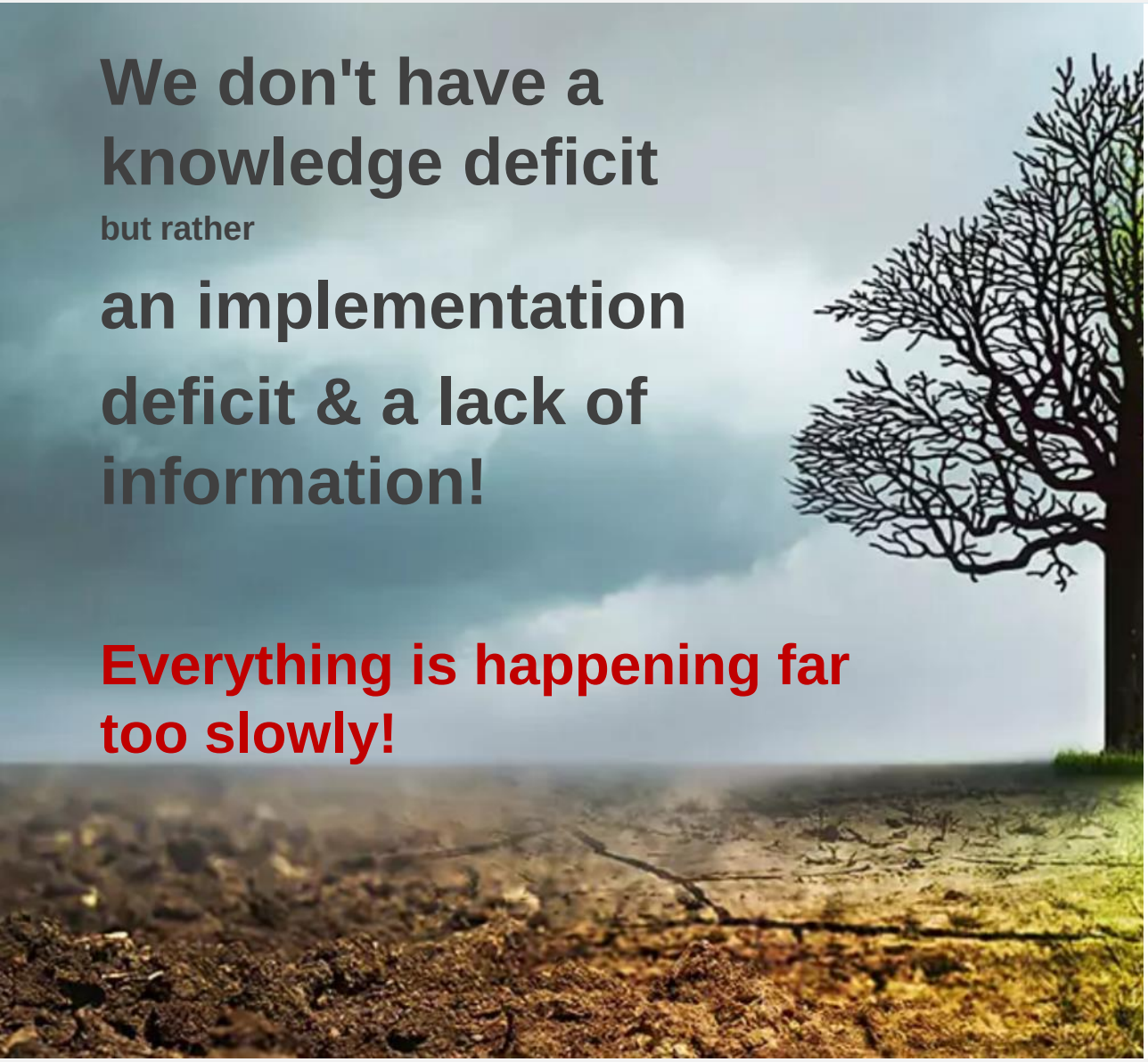
Bundesministerium für Wirtschaft und Klimaschutz

aufgrund eines Beschlusses des Deutschen Bundestages

Wertheim-Autohof – time horizon 2026/27



Final expansion 20 MW for H2 filling stations and supply of commercial buildings


We don't have a knowledge deficit
but rather
an implementation deficit & a lack of information!
Everything is happening far too slowly!