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The role of hydrogen in a decarbonised energy system in Germany

Jonas Lotze
TRANSNET BW

May-09-2023, Santiago de Chile

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At the heart of the European transmission grid

Who is TransnetBW?

Energy system planning

Systemsecurity

Grid expansion & optimisation

Innovator & partner for sector coupling

Business model:

Certified Independent Transmission Operator (ITO)

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Sector coupling and a cost-optimised energy system

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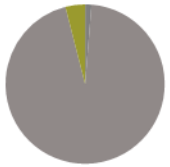
In Germany, fossil fuels dominate today:[1]

Power generation

Transport
(29 % share of final energy consumption)



Heat
(54 % share of final energy consumption)

Electricity
Fossil fuels
Renewable energies
Nuclear Energy
"Green" gas
Other

[1] Source: AGEB 2018

Three ways how the energy transition can be achieved by 2050 with renewable energies (RE):

100 % RE — **Electrification & grid expansion** — **Expansion of gas infrastructure for "green" gas**

e.g. organic fuels — **100 % RE**

e.g. battery electric vehicles — **"All Electric"** — e.g. fuel cell vehicles — **"Green" Gas**

e.g. local district heating sytems — **100 % RE**

e.g. heat pumps — **"All Electric"** — e.g. gas boiler — **"Green" Gas**

A **Sector-autonomous energy system transformation**

B **Sector coupling** Electricity

C **Sector coupling** "Green" gas

The path for a cost optimised energy transition lies somewhere in the combination of these three paths.

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The future vision of Europe in two scenarios

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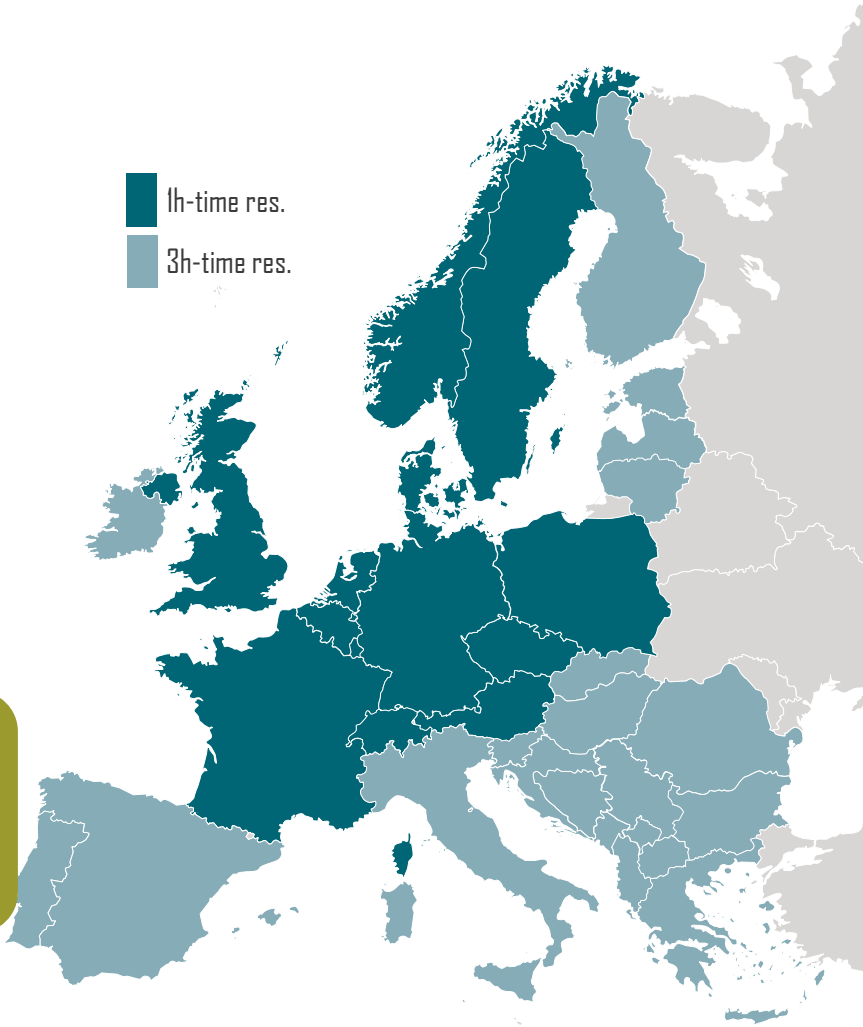
EU Green Deal CO_2 reduction targets
-55%* by 2030 and -100% by 2050

Cost-optimised energy system considering the sectors electricity, heat, industry and transport



Global Markets
Optimistic hydrogen import price from outside Europe

Energy Resilient Europe
More pessimistic hydrogen import price from outside Europe

*compared to 1990 levels

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Development of the European hydrogen system: Two pathways, one Target

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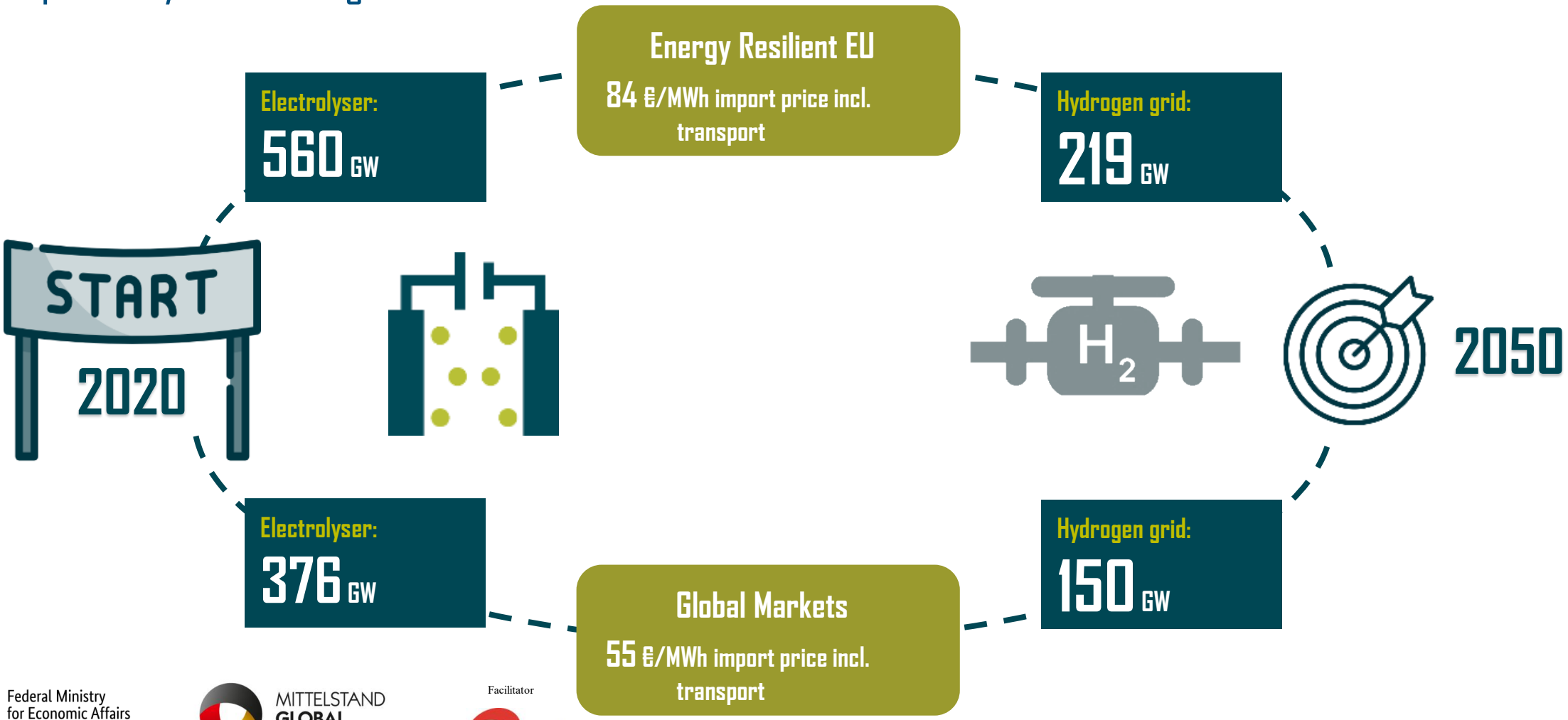

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Electrification boosts electricity demand

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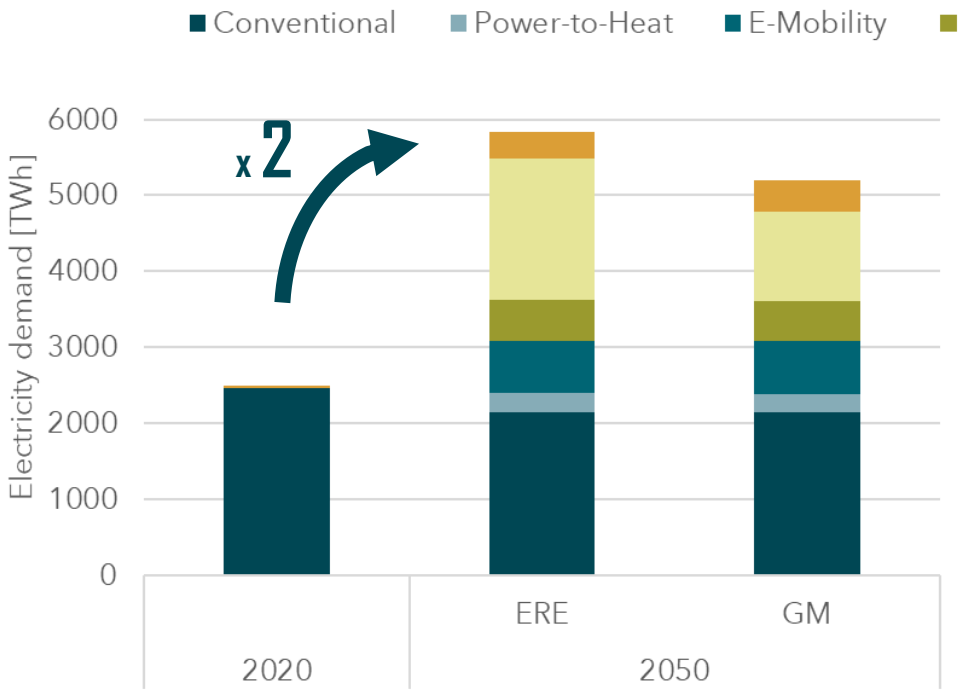
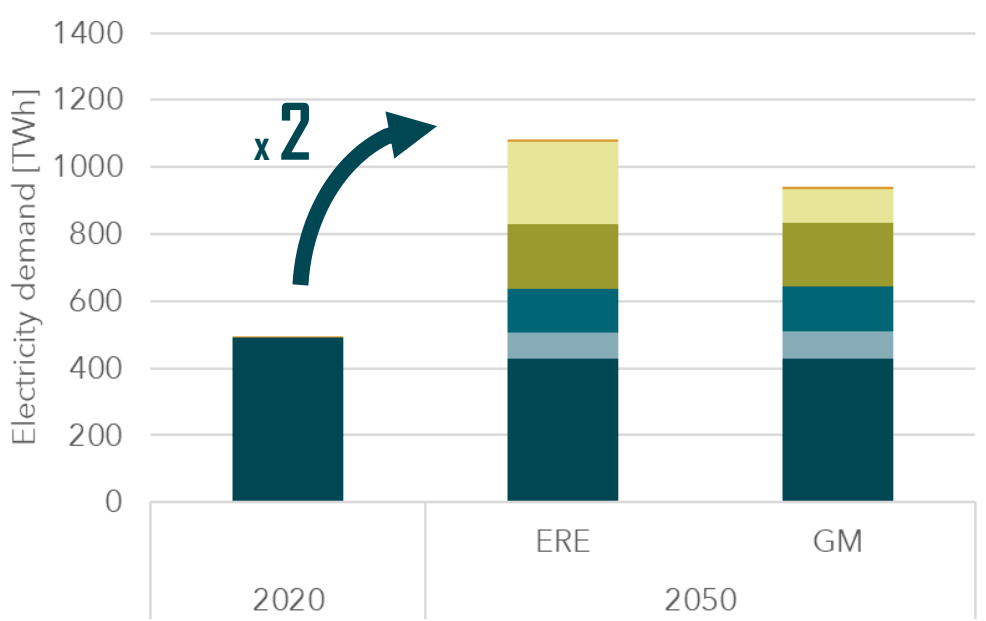
ELECTRICITY DEMAND EU27



ELECTRICITY DEMAND GERMANY



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PV and wind dominate power generation

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RENEWABLE CAPACITY EU27

Wind:

177GW

GM: 844GW

ERE: 969GW

~5-fold increase

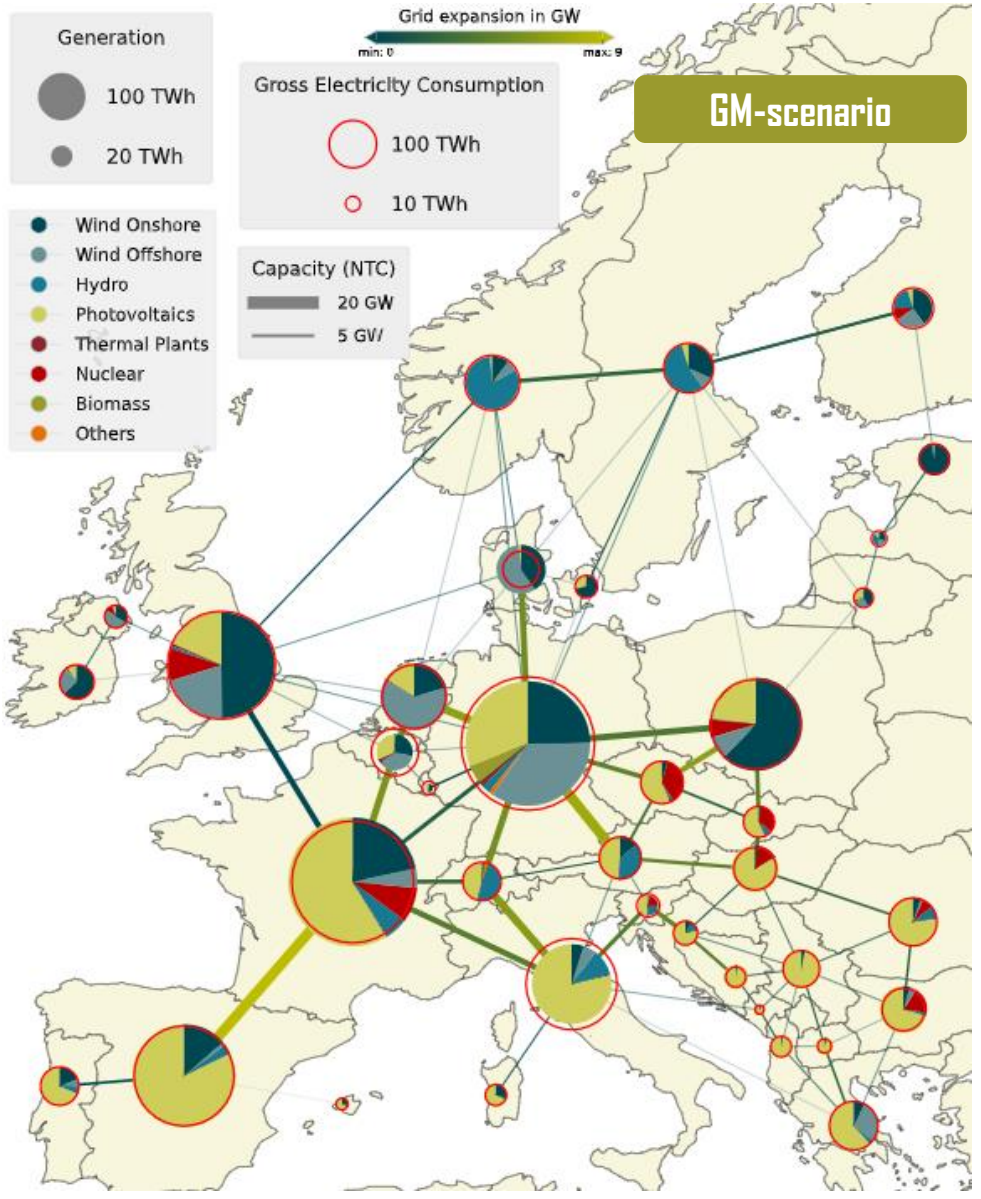
PV:

139GW

GM: 2136GW

ERE: 2462GW

~17.8-fold increase



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The big picture

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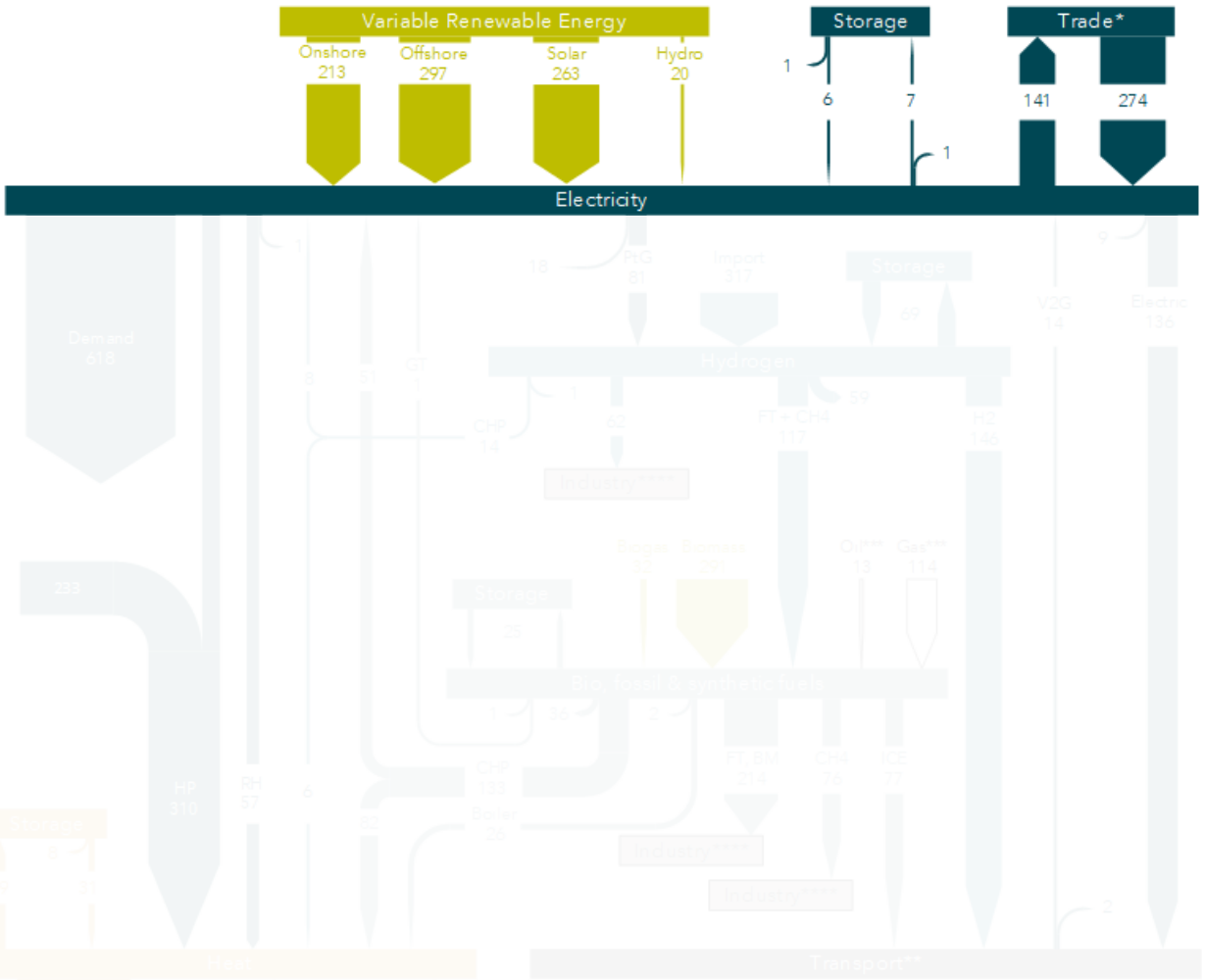
GM-scenario

How could Germany's climate-neutral energy system look like in 2050?



CH4	Methane (fossil or synthetic)
CHP	Combined Heat and Power
FCEV	Fuel Cell Electric Vehicle
FT	Fischer-Tropsch product
HP	Heat Pump
ICE	Internal Combustion Engine
PtG	Power-to-Gas
RH	Resistive Heater
V2G	Vehicle-to-Grid

* The trade also contains transit flows across non-EU27 regions like Switzerland and UK, e. g. power transmitted from Germany to Italy via Switzerland is accounted twice. First as export, then as import.

** The emission reduction of international transport is outside the scope of this study and has been only taken partially into account. Therefore, all fossil based fuel demand of the international transport is not shown.

*** Even in a fully decarbonized energy system, small amounts of fossil energy carriers are used. Their emissions are fully captured by existing Carbon Capture technologies or encountered with negative emissions.

**** „Industry" contains energetic as well as feedstock usage. Fossil feedstock is not represented in this chart as its respective CO_2 content is not released into the atmosphere. Hence, all fossil based feedstock flows are excluded.

In general: Energy flows below 1 TWh are not depicted. Therefore, small imbalances between inputs and outputs may occur.

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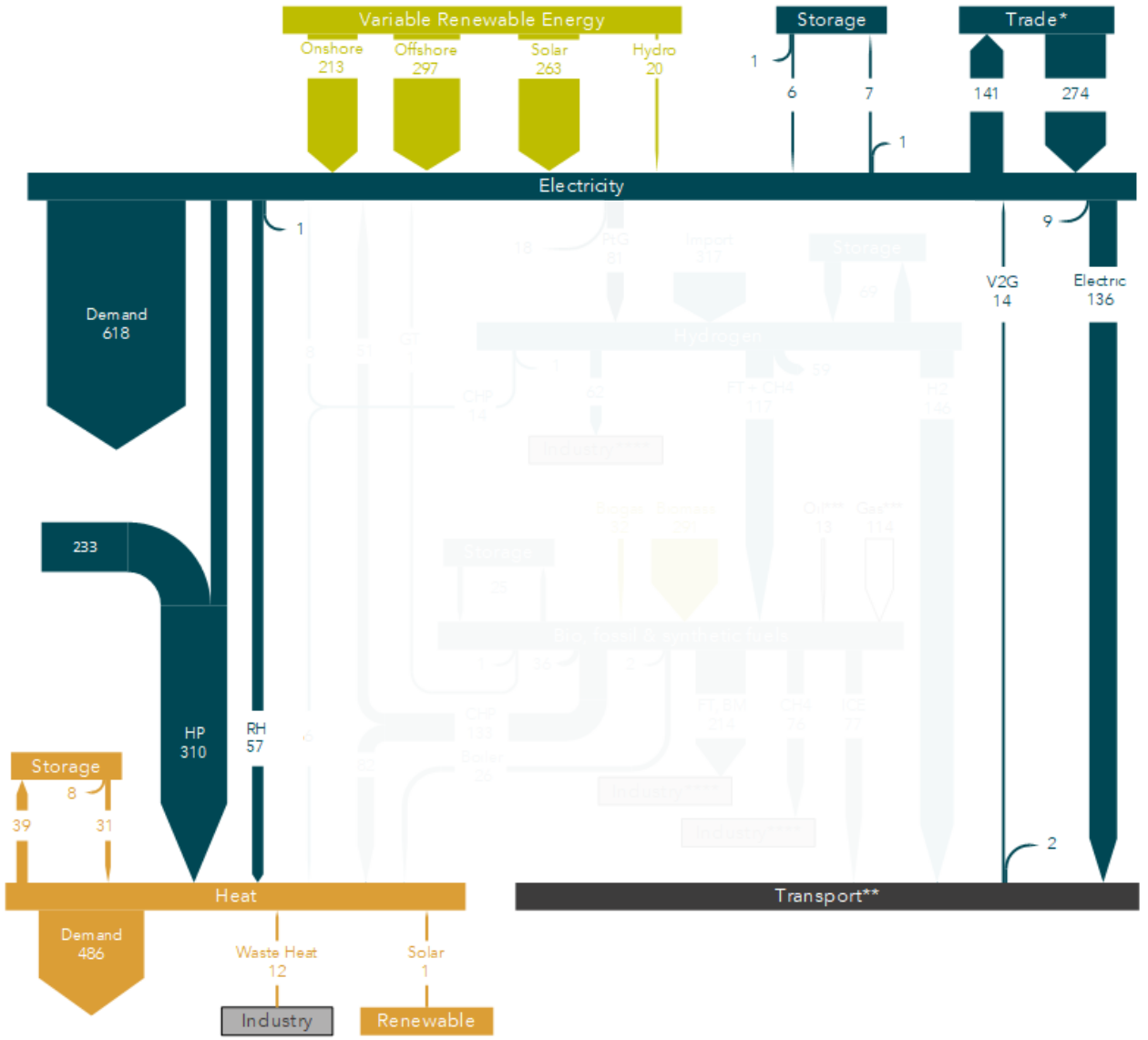

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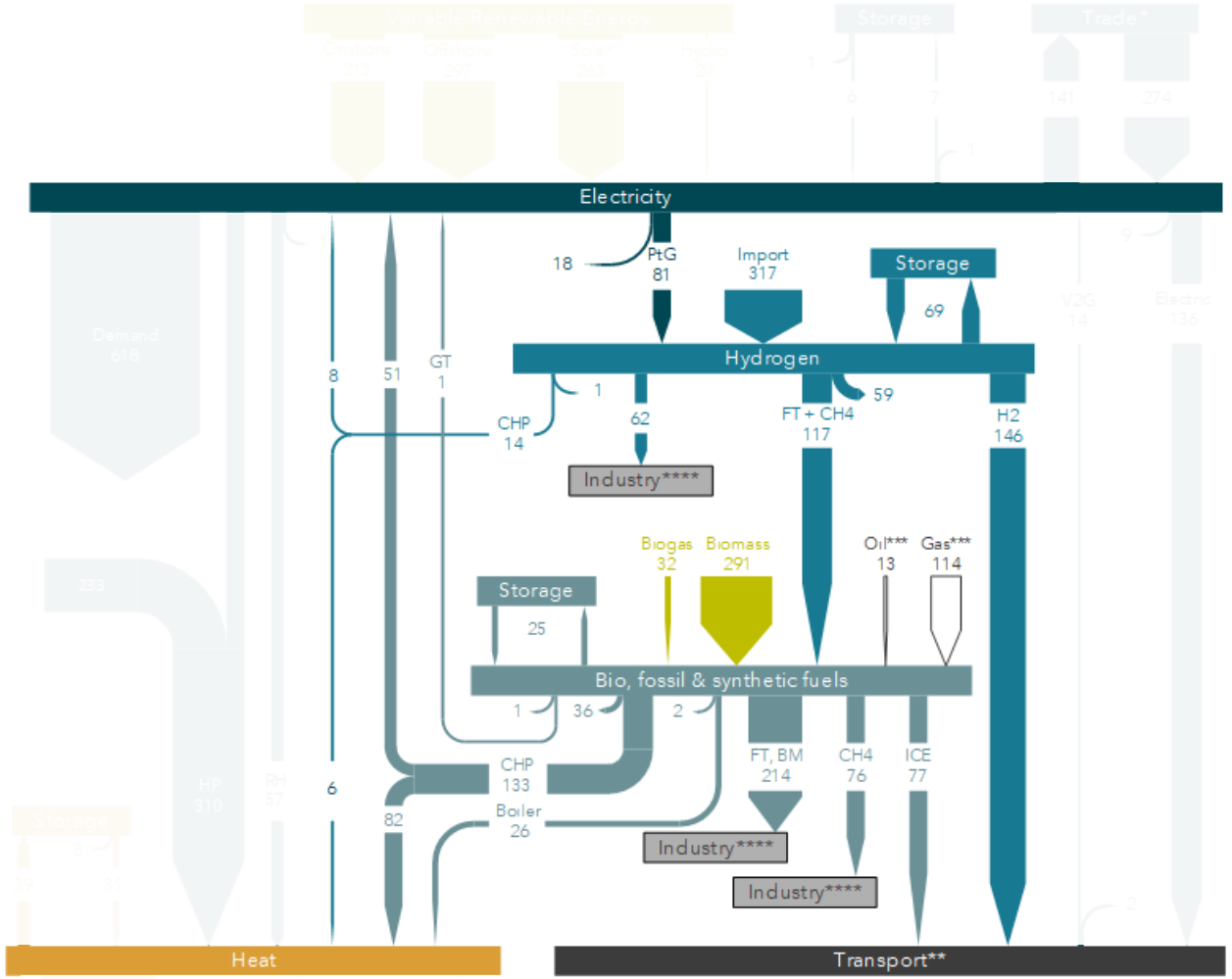

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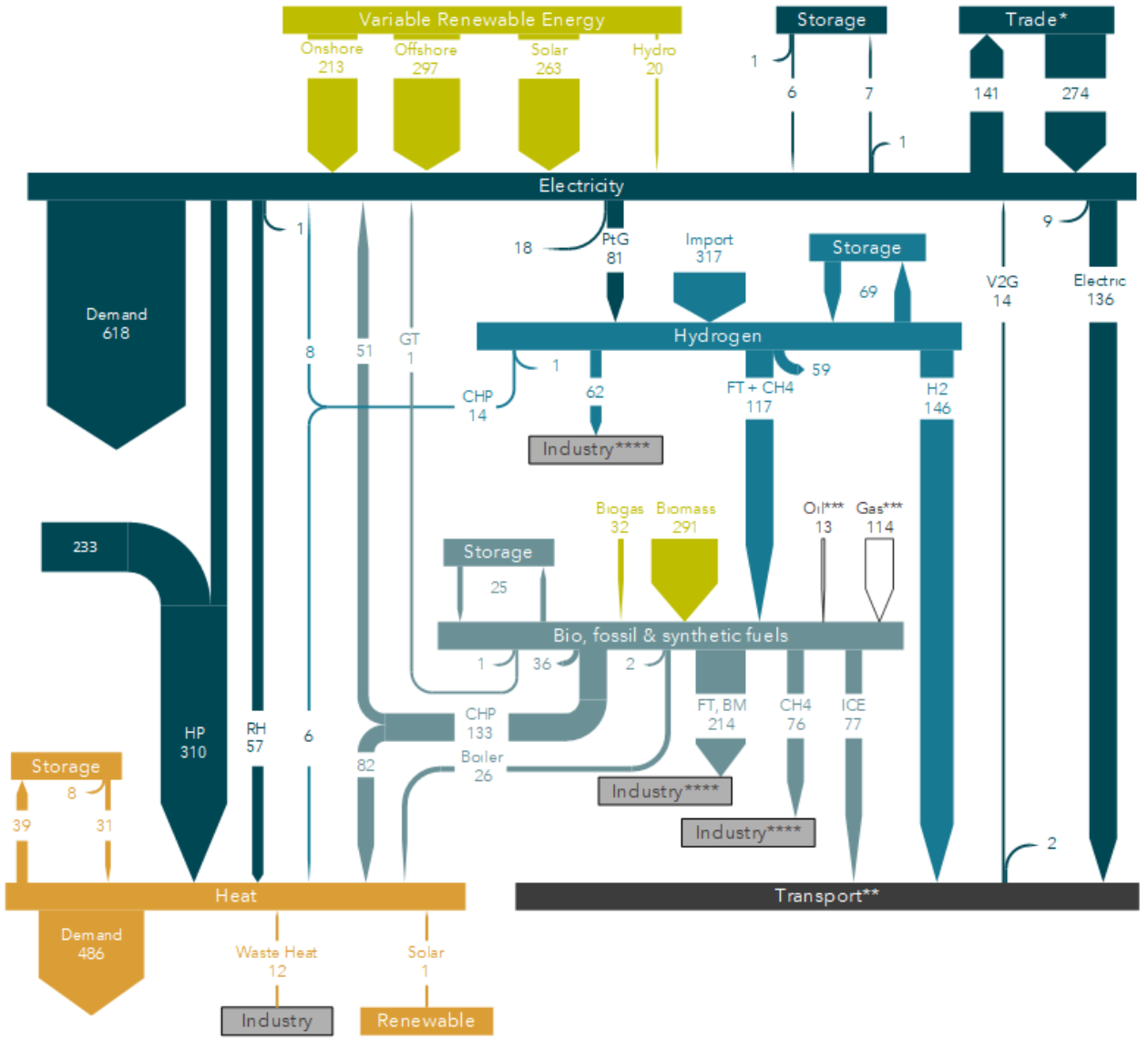
GM-scenario

How could Germany's climate-neutral energy system look like in 2050?

H_2-Import 317 TWh without international transport



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The energy transition reduces demand for gas and oil

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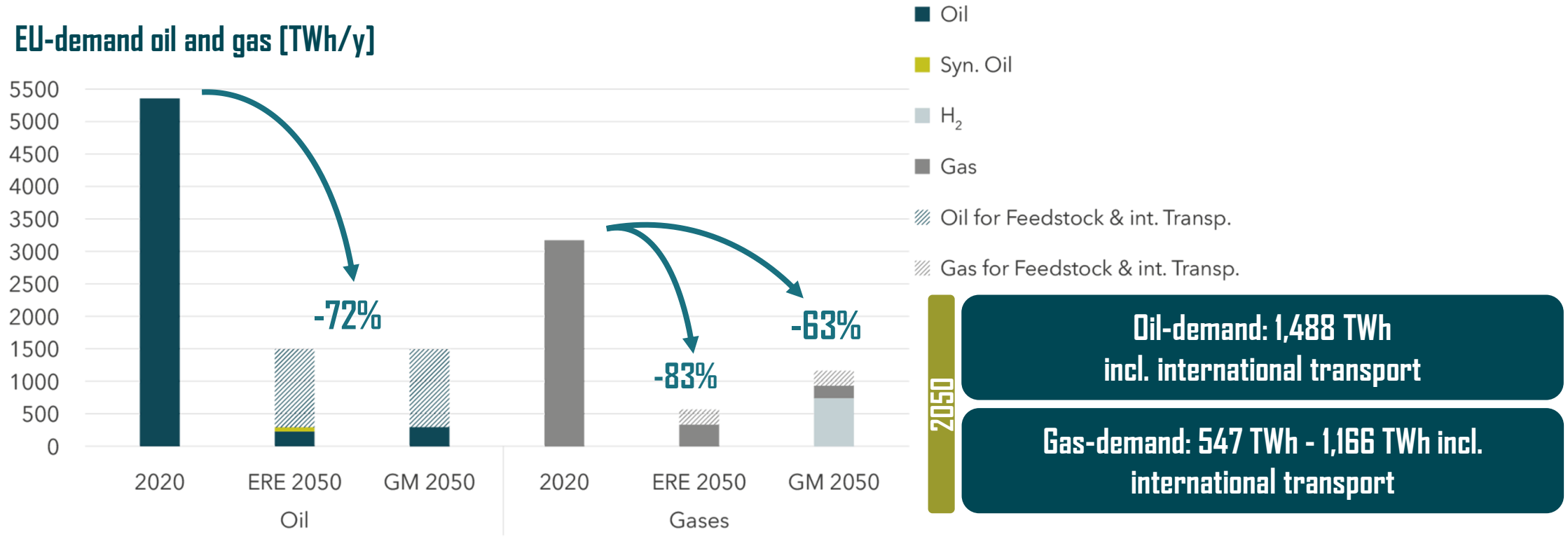

2050

Oil-demand: 1,488 TWh incl. international transport

Gas-demand: 547 TWh - 1,166 TWh incl. international transport

By 2050, there will be a need to import high-quality, green energy carriers. Which path Europe and Germany will take depends on the price of importable hydrogen and synthetic oils and gases.

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Further development of the power grid necessary

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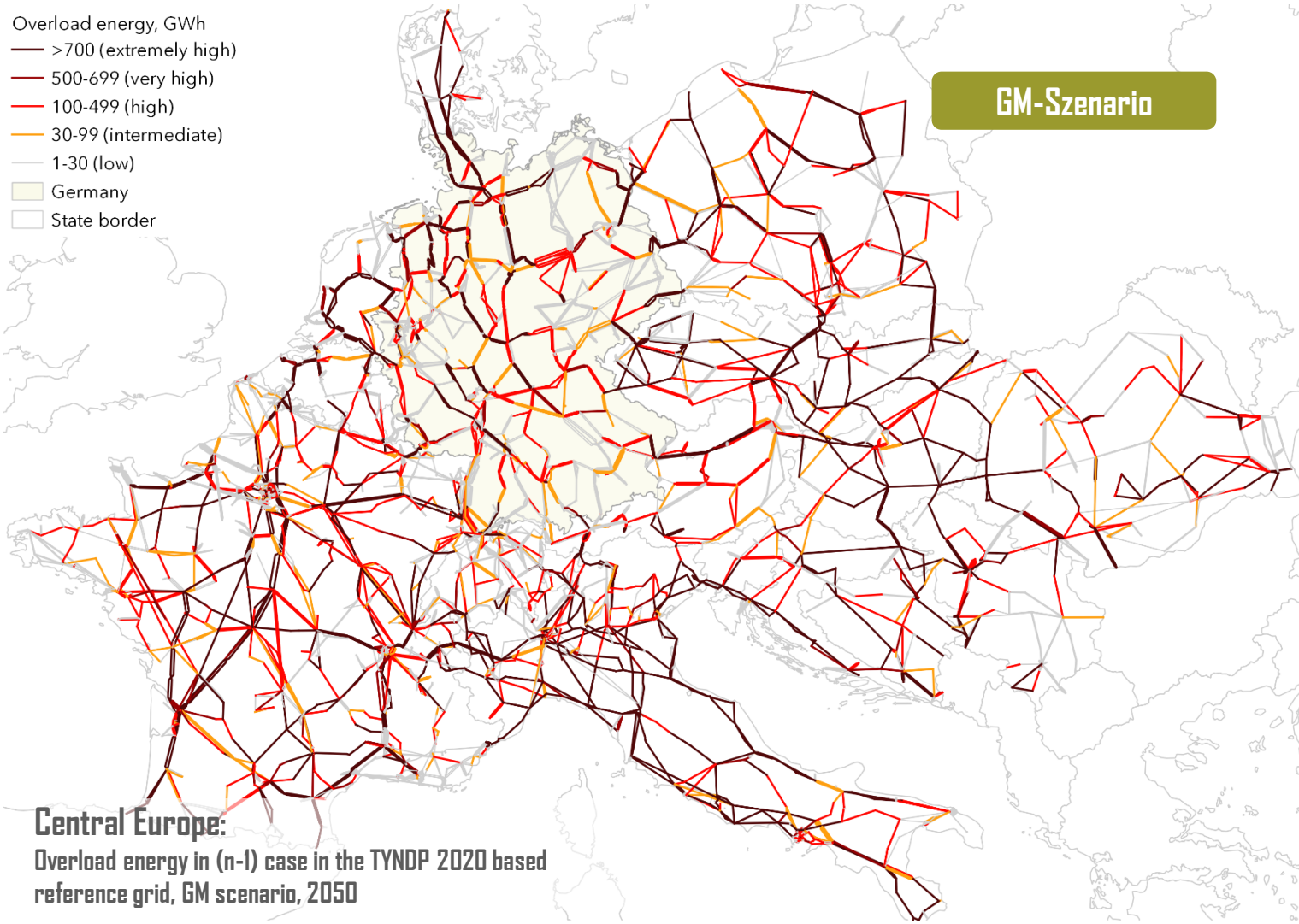
Gross electricity trade EU27:

1,600 TWh

Power grid interconnection capacity EU27:

2,8 increase in power grid interconnection capacity

70 GW → **200 GW**



Central Europe:
Overload energy in (n-1) case in the TYNDP 2020 based reference grid, GM scenario, 2050

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Thank you for your attention!

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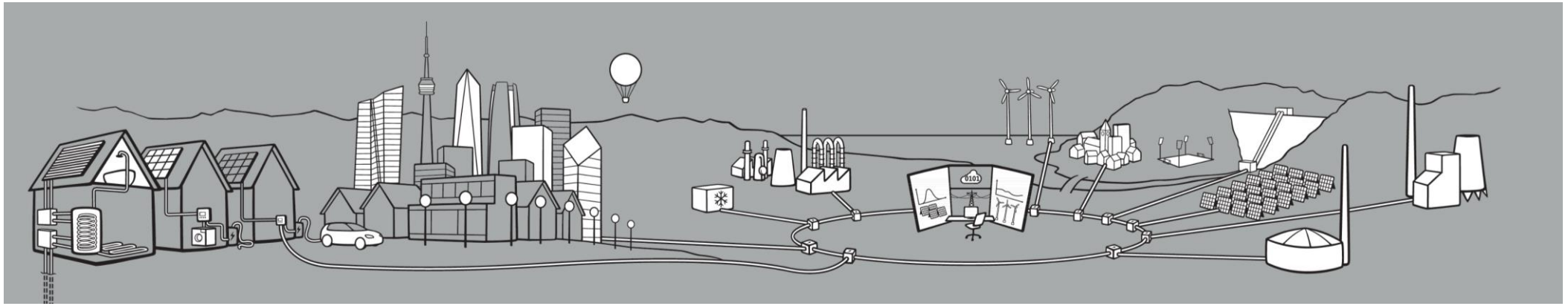
ENERGY SYSTEM 2050
Towards a decarbonised Europe

Download the Study Report at:
https://www.energysystem2050.net/



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Backup & additional information

The energy system model of TransnetBW

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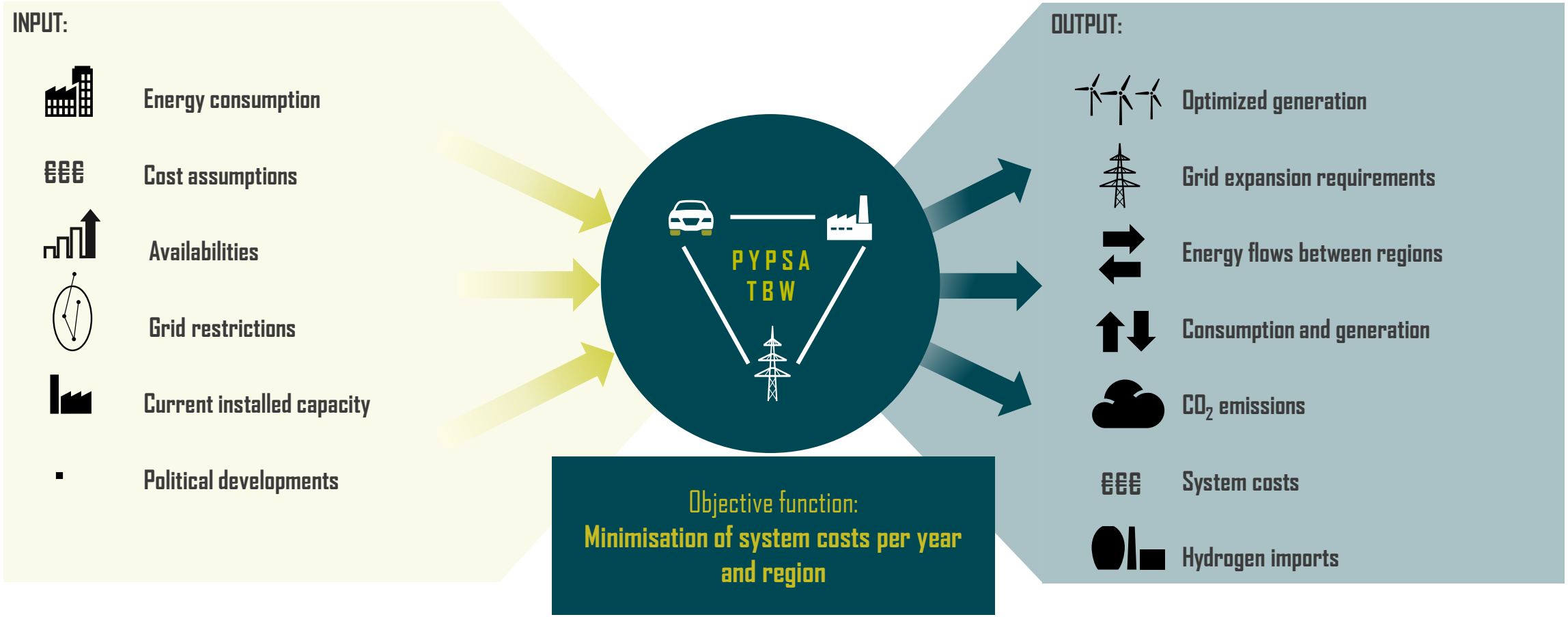

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Comparison of fuels – assumed production and transport cost

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Fuel	Global Demand (TWh/y)	Global Trading (TWh/y)	Production Cost (€/MWh)	Transport Cost (€/MWh)
e-Methane	8,590	4,100-5,700	37-81	4-15
e-FTL	12,650	8,200-9,400	55-112	3-10
e-Ammonia	3,340	800-1,460	45-82	7-19
e-Methanol	12,180	5,500-8,300	50-102	4-13
e-H2	9,640	2,060-2,900	29-51	10-49
e-LOHC		500-1,300	25-51	9-20

Scenario input: For detailed calculation of the hydrogen import cost from non-EU countries see *Energy System 2050* study, table 11, page 112.

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European CO2-Reduction pathway

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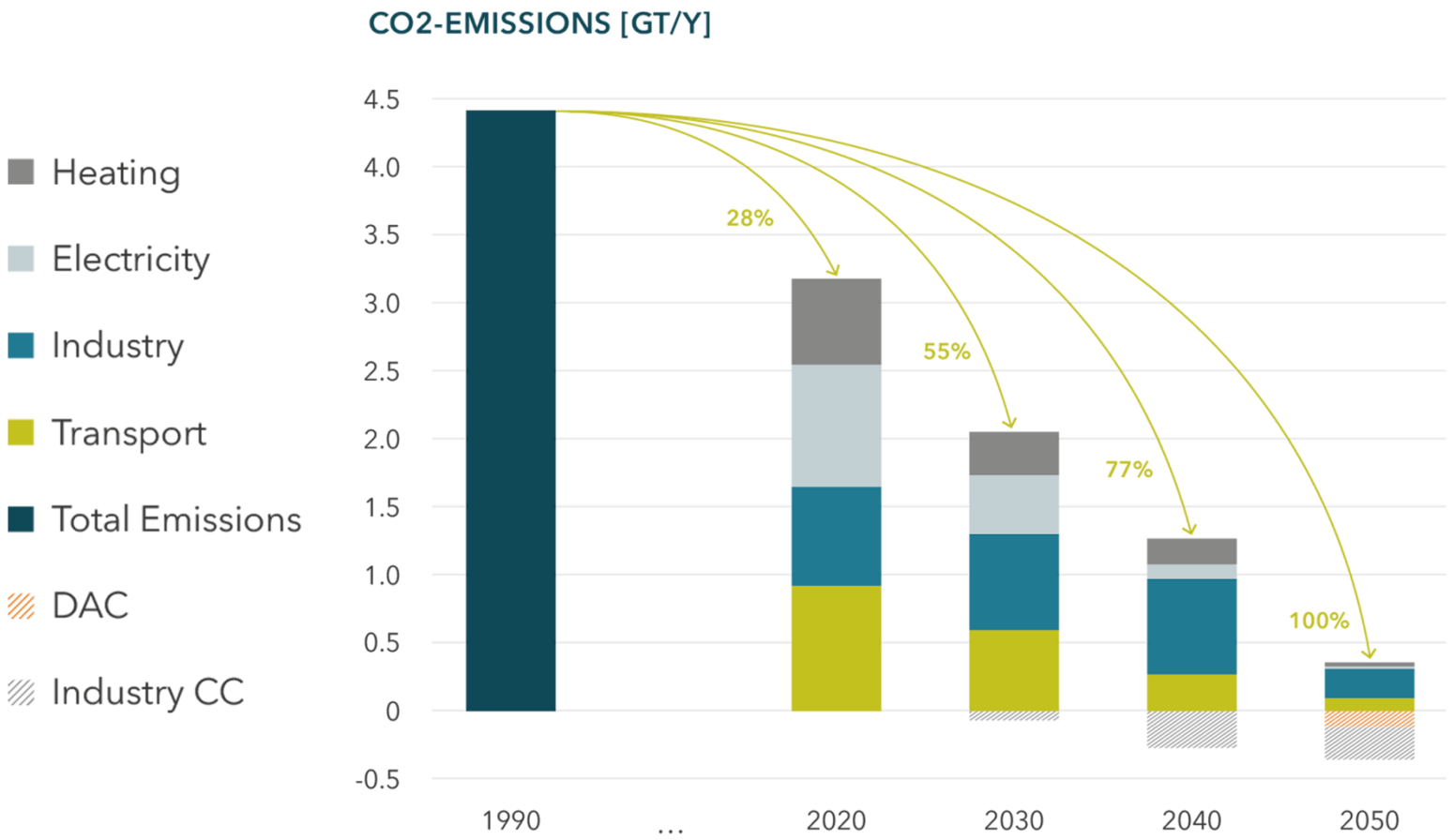

Emissions of CO2 must be reduced from 1990 (3.7 Gt/y) to **net zero by 2050**, according to the EU Green Deal. **CCS** (Carbon Capture and Storage) will be used in the industrial sector to reduce CO2 emissions, particularly beginning in 2030. **Direct air capture (DAC)** will also be a part of the energy system by 2050.

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Hydrogen as basis for industry and fuels for the transport sector

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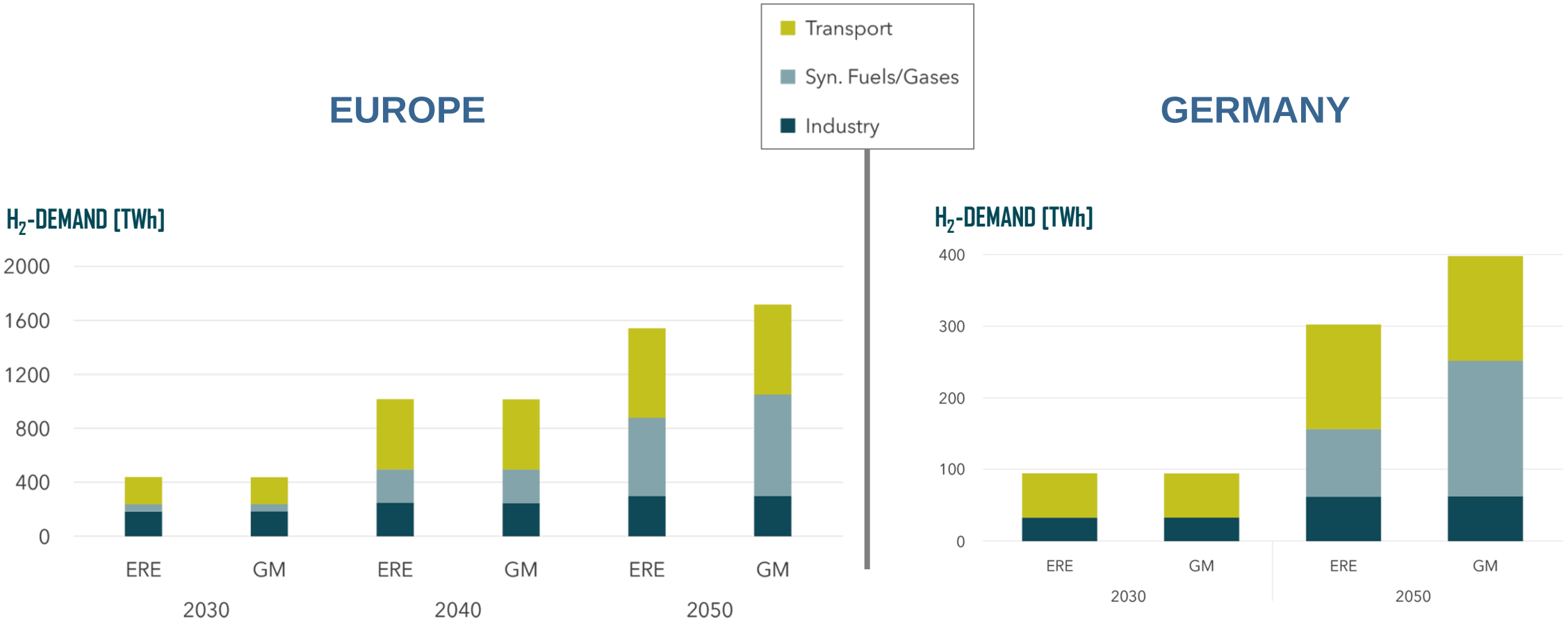

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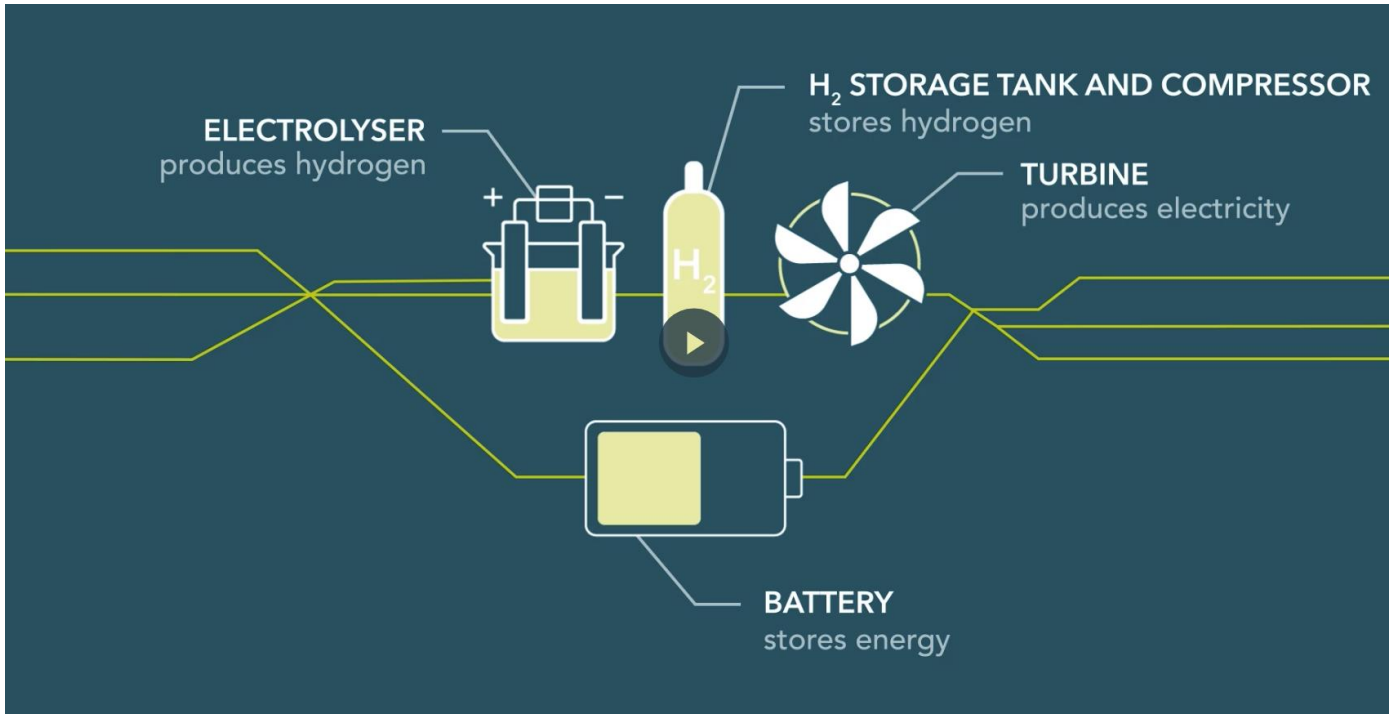
Excursus: hydrogen for grid stability
The HydrogREenBoost-project



Objective of the concept:
Higher utilisation and grid stabilisation

Possible areas of implementation:
- Regulating power (pos./neg.)
- Reactive power
- Black start capacity
- Redispatch (curative/preventive)
- Grid/capacity reserve

Link_HydrogREenBoost-project

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