SECTOR COUPLING IN GERMANY
SCENARIO PATHS MODELLED WITH REMOD-D

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AGENDA

(1) Climate goals until 2050

(2) Energy sectors in 2016

(3) Approach: Energy system model REMod

(4) Scenario results for transition paths:
Role of sector coupling

(5) Conclusions

Link: www.energiesysteme-zukunft.de/themen/sektorkopplung/

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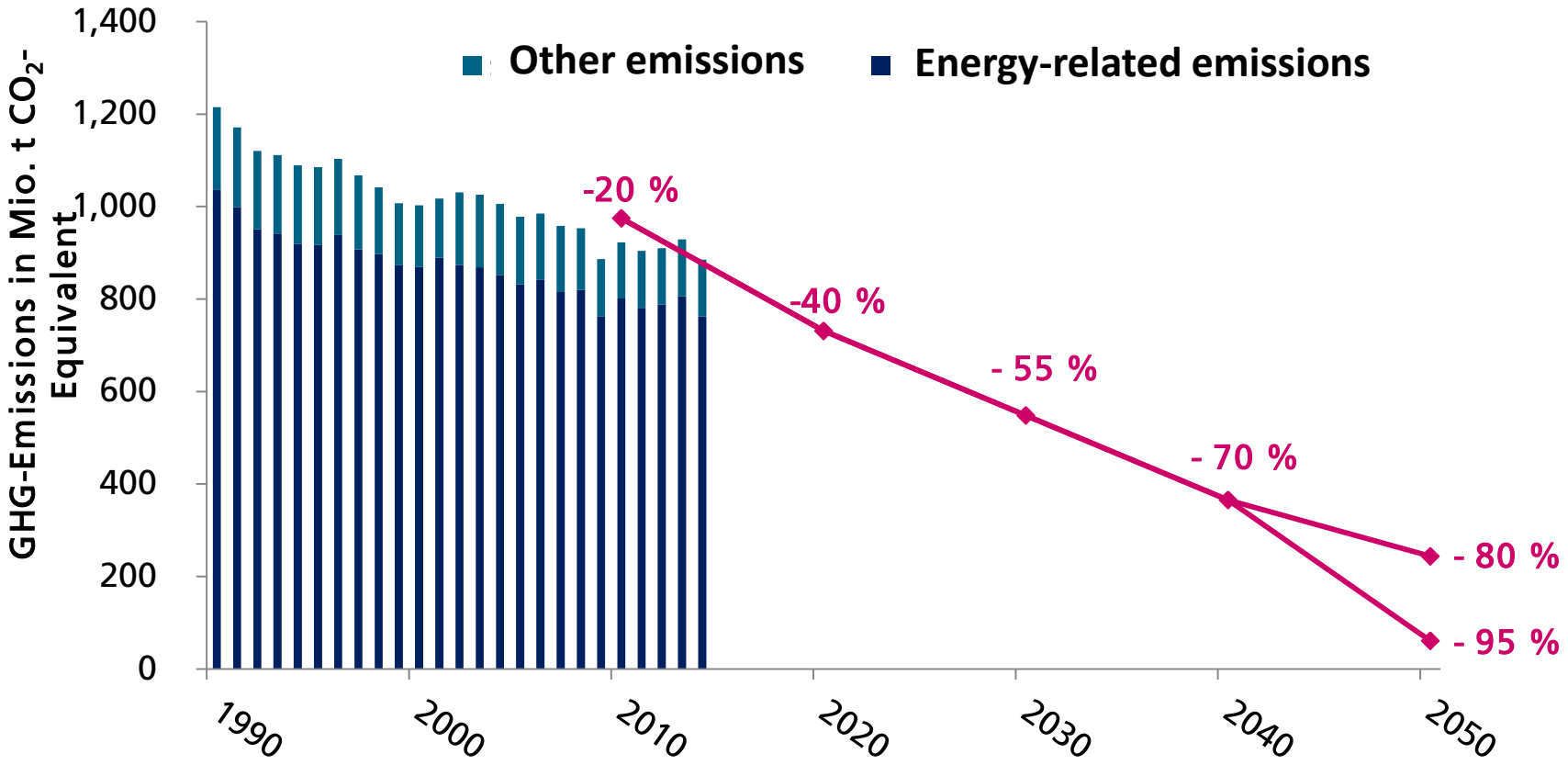
Initial position: Climate goals until 2050



Source: „Energiedaten, Gesamtausgabe“, BMWi, State May 2016

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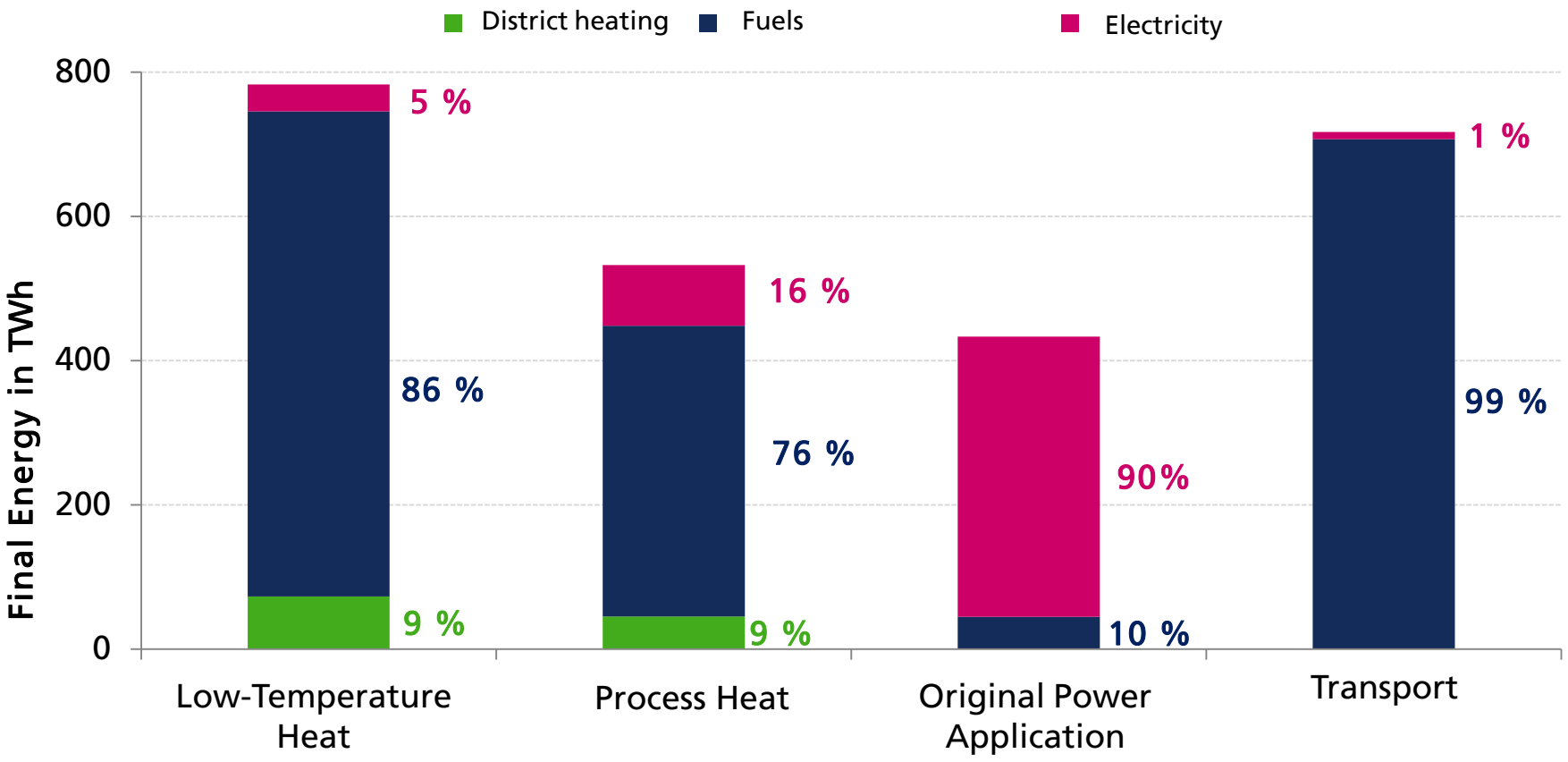
Distribution of energy sources in the four areas of use (2016)



4 Source: „Energiedaten, Gesamtausgabe“, BMWi, State February 2017

Research Question

- What does an integrated sector coupling model such as REMod propose regarding:
  - Potential options for sector coupling?
  - Expansion options in the power sector?

- How does the specific drivers such as the range in the decarbonization target and efficiency influence the degree of sector coupling?

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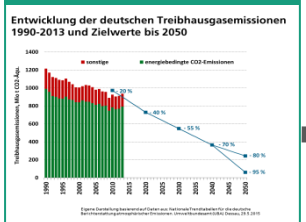
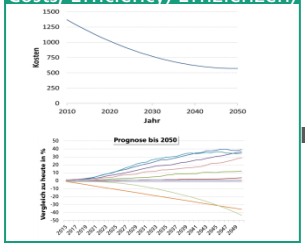
REMod – Energy System Model

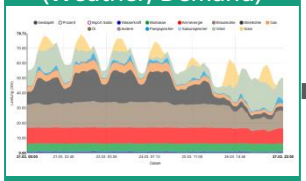
CO_2 Target(-80 -95%)



Prognoses (Demand, Costs, Efficiency) Effizienzen)



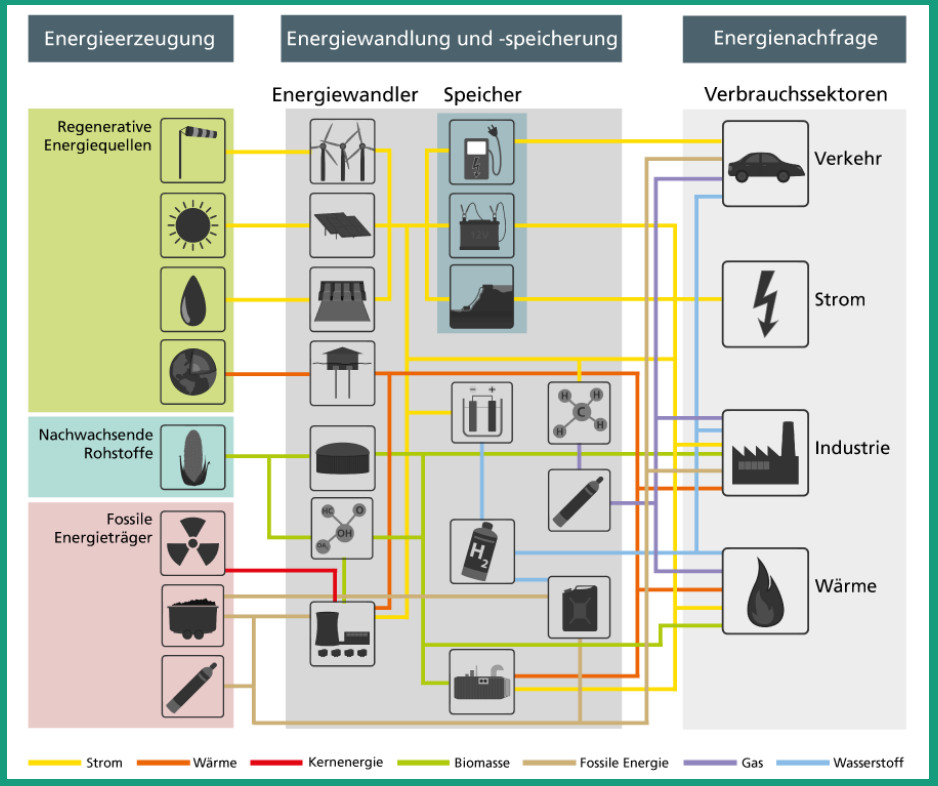
Hourly Profiles (Weather, Demand)



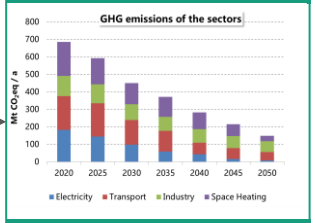
Stock today (all sectors)

Model

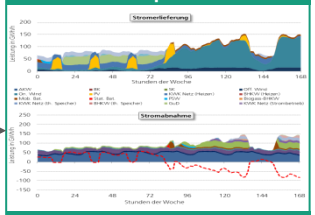
Hourly Simulation. Non-linear. Optimization.
All energy carriers, convertors, energy storage, demand sectors.
Objective: minizing total system cost
Constraints: Energy security and CO_2 emissions



Decarobonization of all sectors

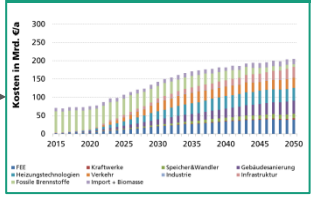


Operation is sector coupled



Stock until 2050 (all sectors)

System cost of transformation



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Methodology REMod

Optimization of new installations, retrofit and replacement

goal function: minimal cumulative total cost 2015-2050

Stock, age

1990	1991	1992	…	2012	2013	2014

- Thermal power plants, CHP
- Renewable energies (PV, wind, bio…)
- Buildings and building energy systems
- Car fleet (private, commercial)

New installations, retrofit, replacements

2015	2017	2018	…	2048	2049	2050

- Thermal power plants, CHP
- Renewable energies (PV, wind, bio…)
- Storage (electricity, heat)
- Buildings and building energy systems
- Car fleet (private, commercial)
- Power-to-X-technologies

Simulation (1 h time step) of the entire system from 2015 to 2050

CO_2-limits (for all years) met?

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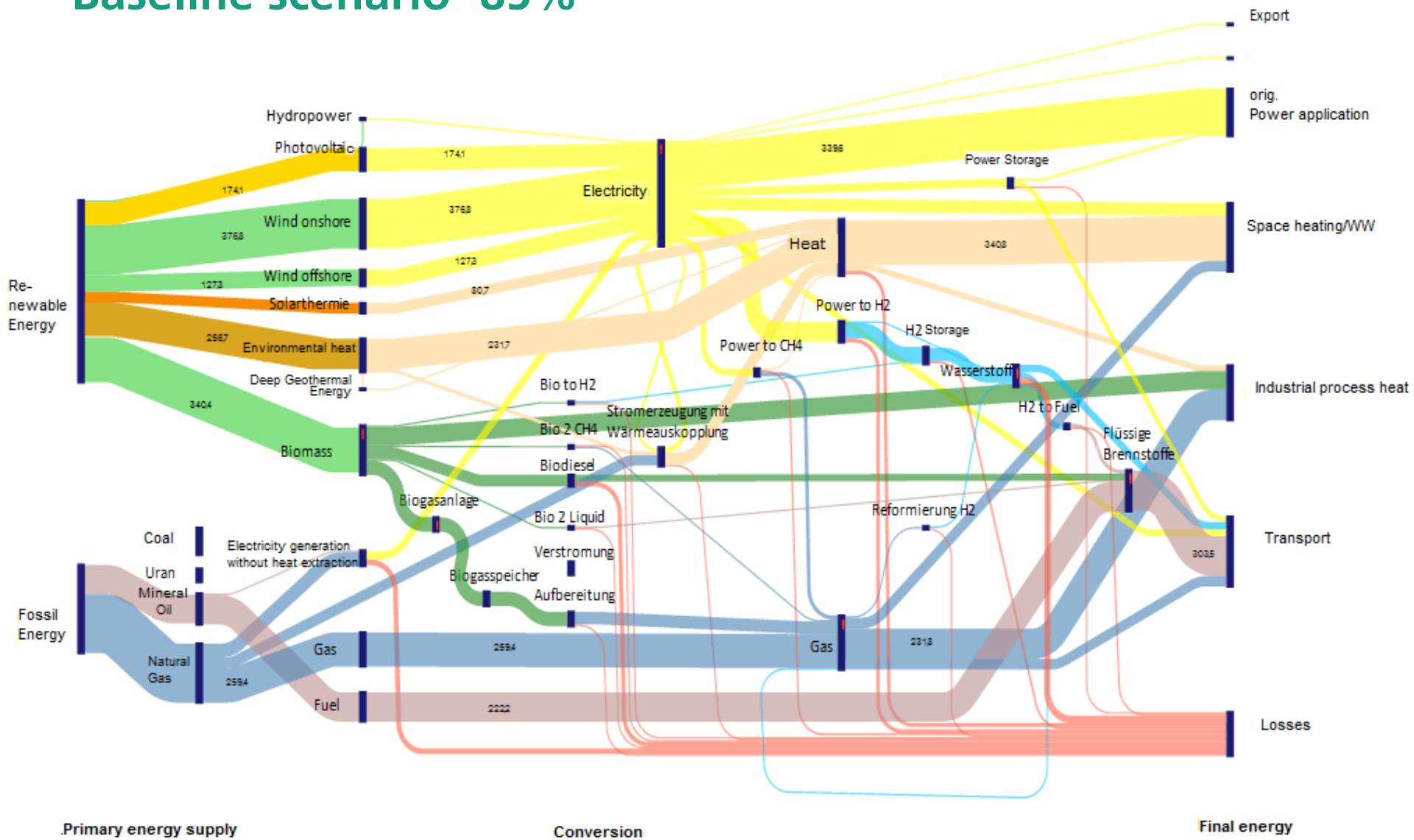
Key assumptions in the Acatech study

- Reduction of energy related CO_2-Emissions: -85 % compared to 1990
- Demand development of process heat in industry, electricity consumption in today's applications, number of car fleet & houses almost constant compared to today
- Biomass: ca. 290 TWh/a
- Nuclear phase-out: 2022
- No CCS

Sector coupling in 2050 in one figure!

Baseline scenario -85%



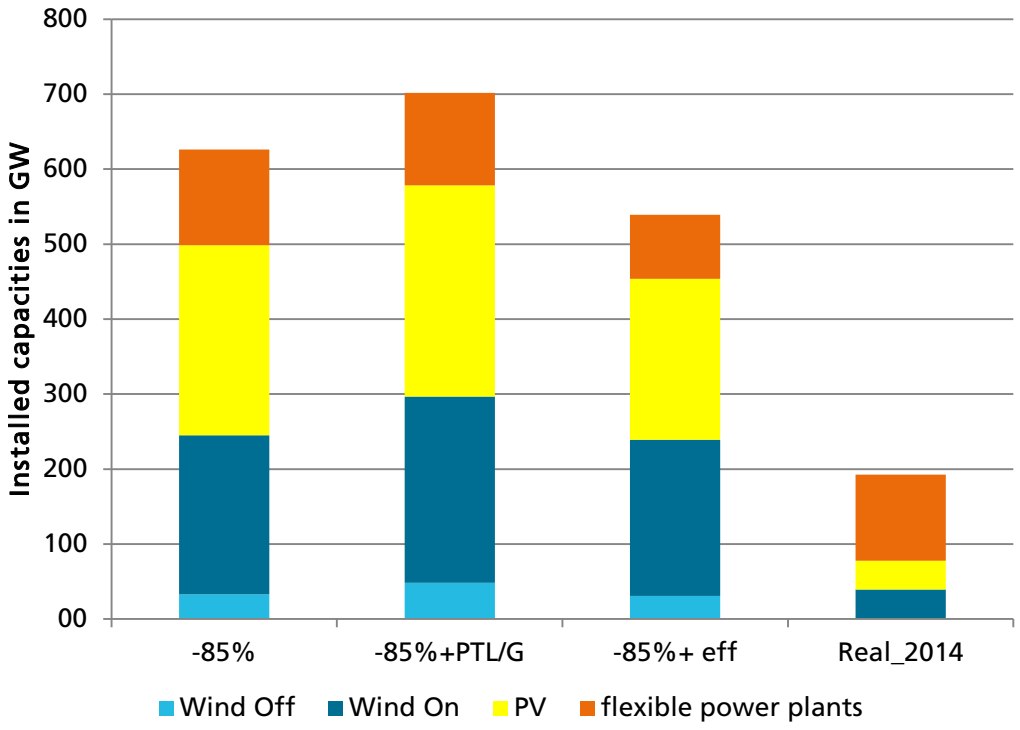
Scenario analysis

- Analysis of the configuration of potential German energy systems by analyzing three scenario paths
  - (1) -85% CO2 emission reduction, free optimization of all sectors **(-85%)**
  - (2) -85% CO2 emission reduction, with share of (synthetic) fuels **(-85%+PtL/G)**
  - (3) -85% CO2 emission reduction, free optimization of all sectors and ACTIVE coal phase-out in 2030, and strong efficiency measures **(-85% + eff)**

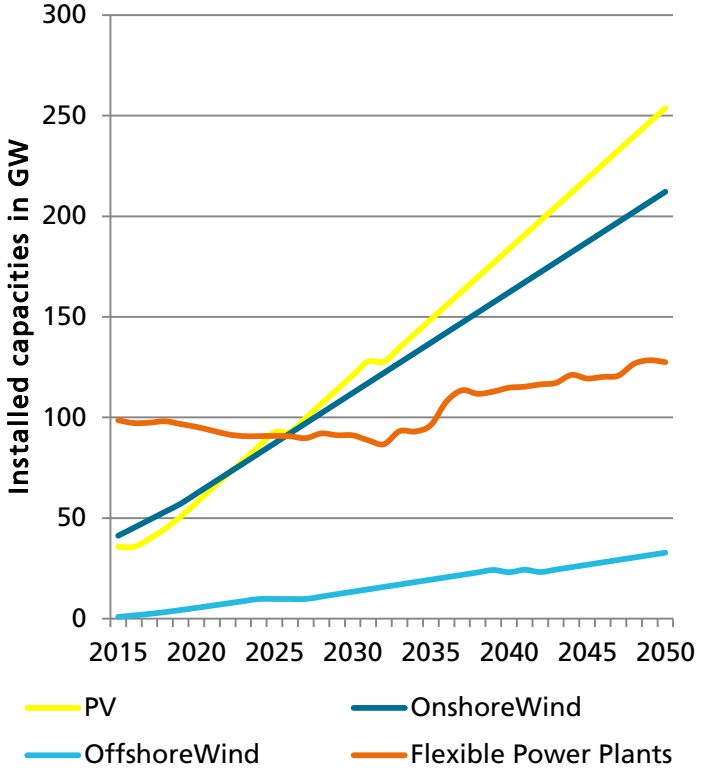
- In study: also other scenarios with change of CO2 targets

Electricity generation capacity is strongly depending on sector coupling and efficiency

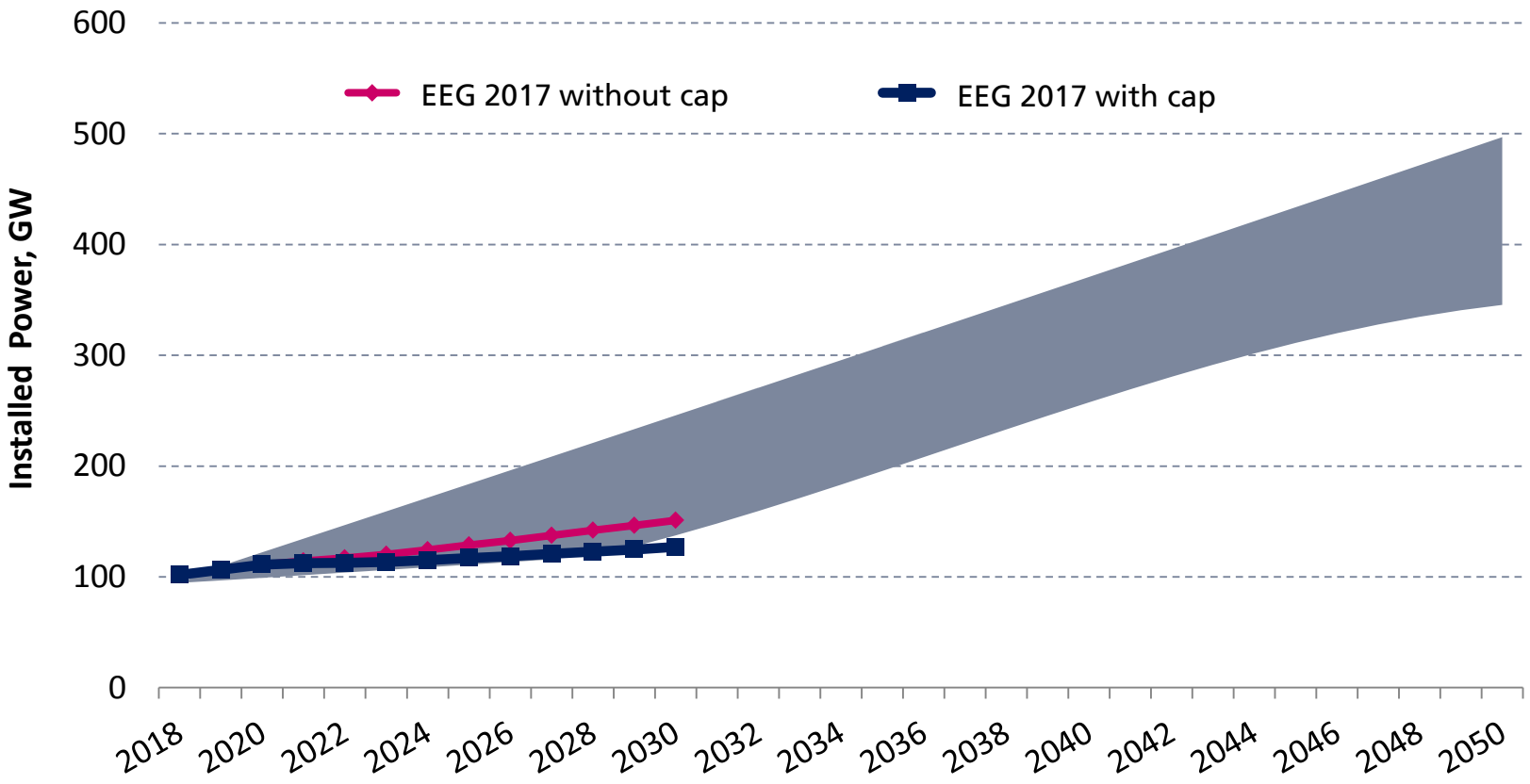
Installed electricity generation in 2050



Development Path (-85%)

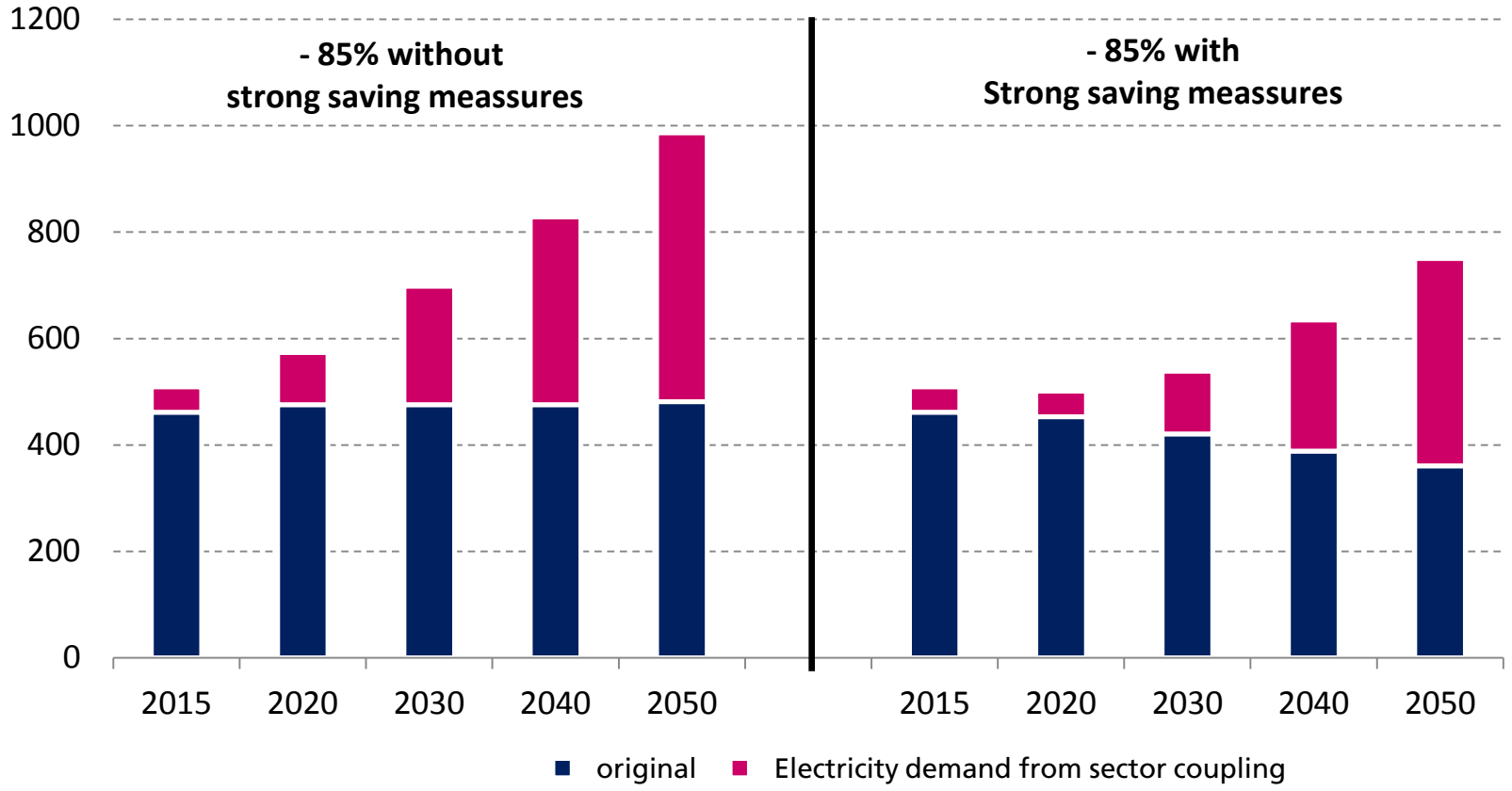


Corridor of necessary expansion for wind and PV



Development of electricity demand

Model output



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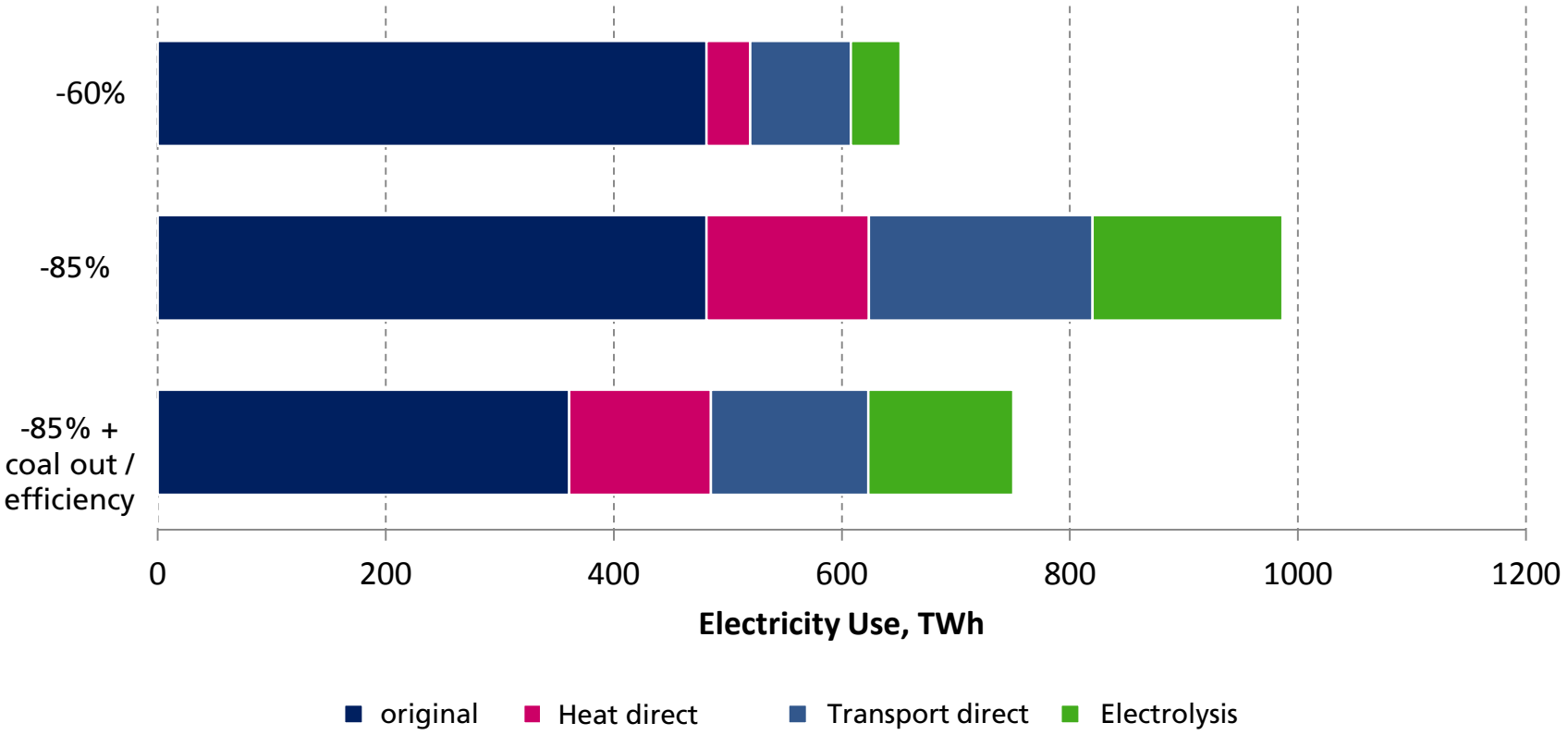
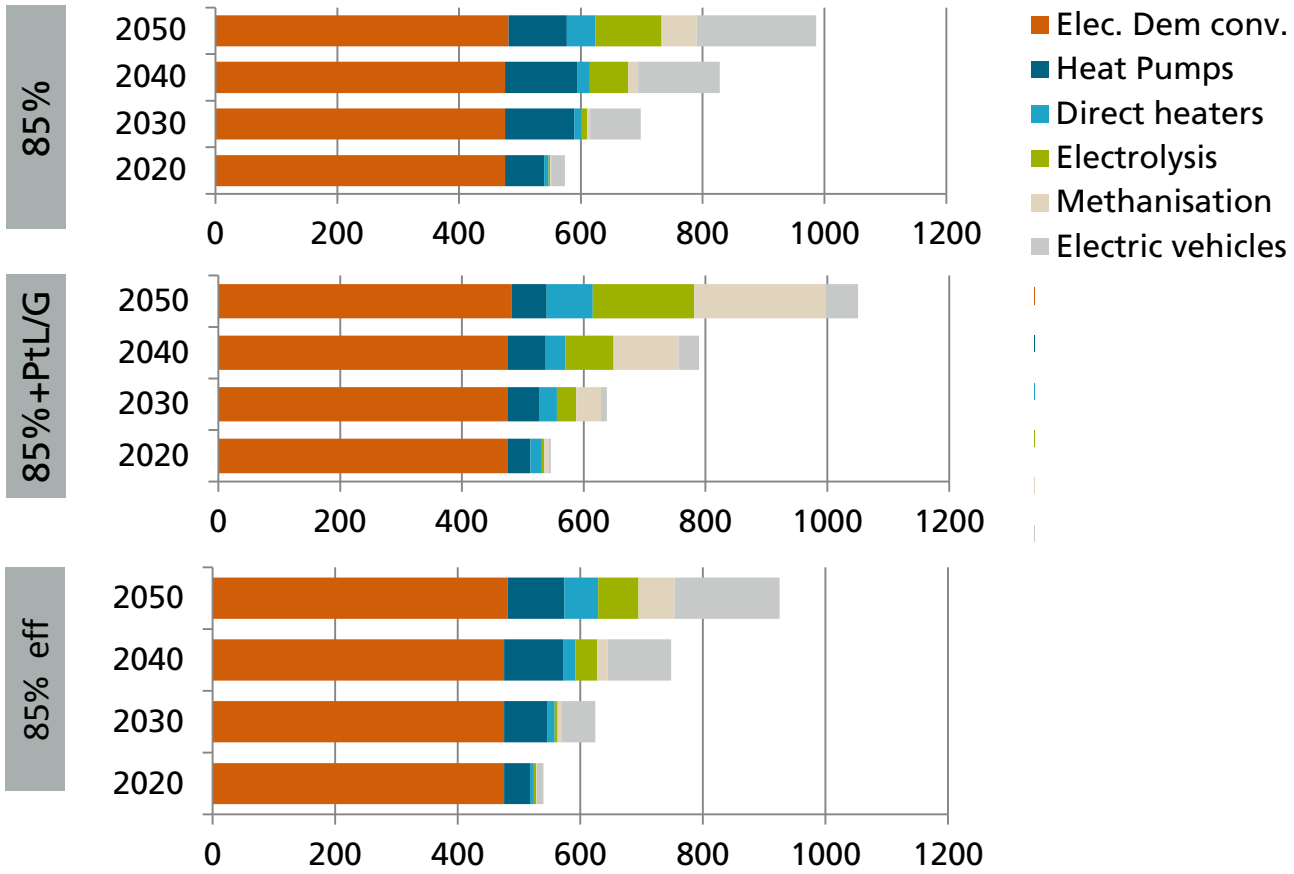
Electricity usage in the year 2050

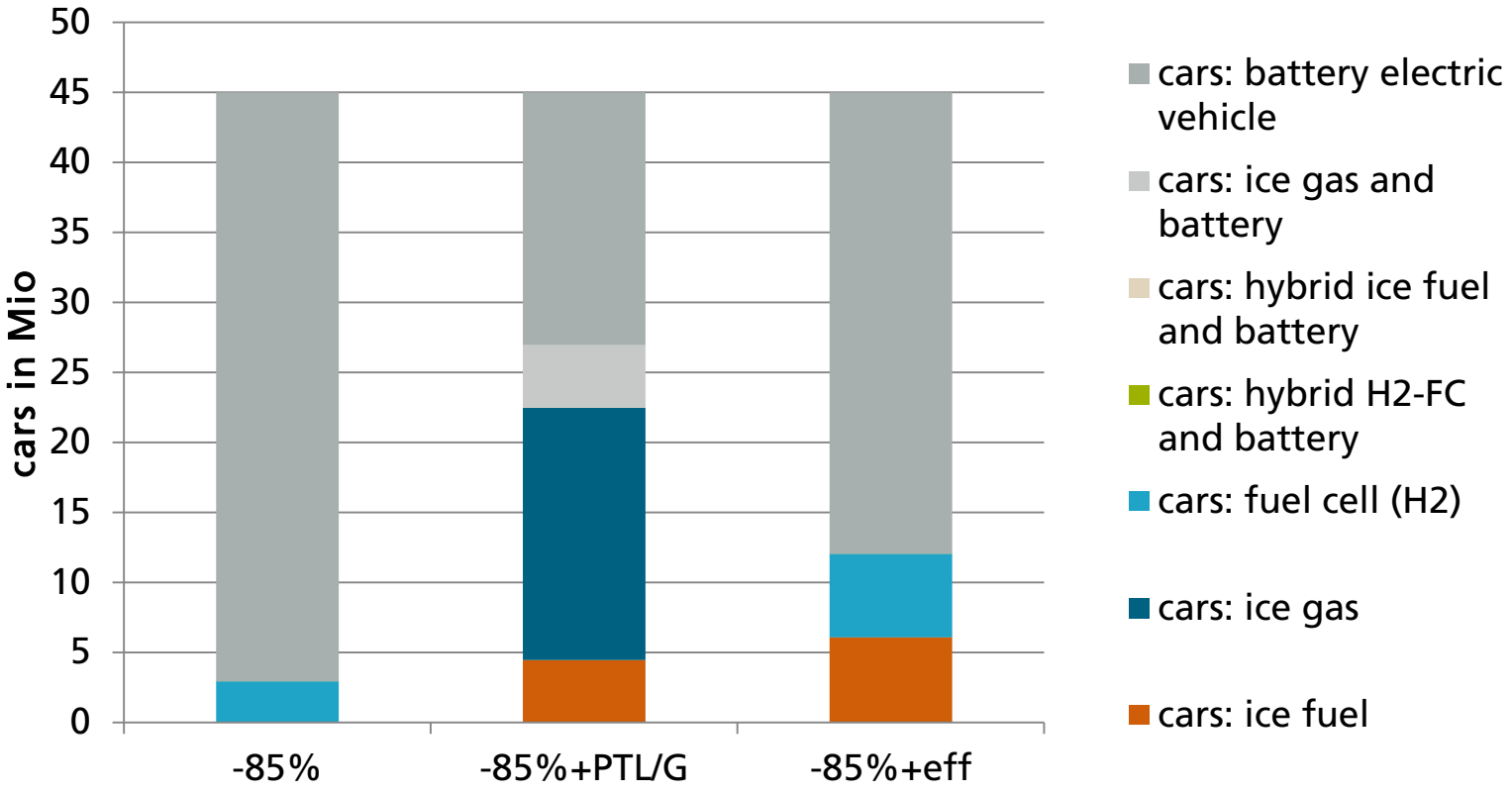


Electricity use increases strongly with sector coupling! Dependency on transport sector.



Transport sector as example for sector coupling

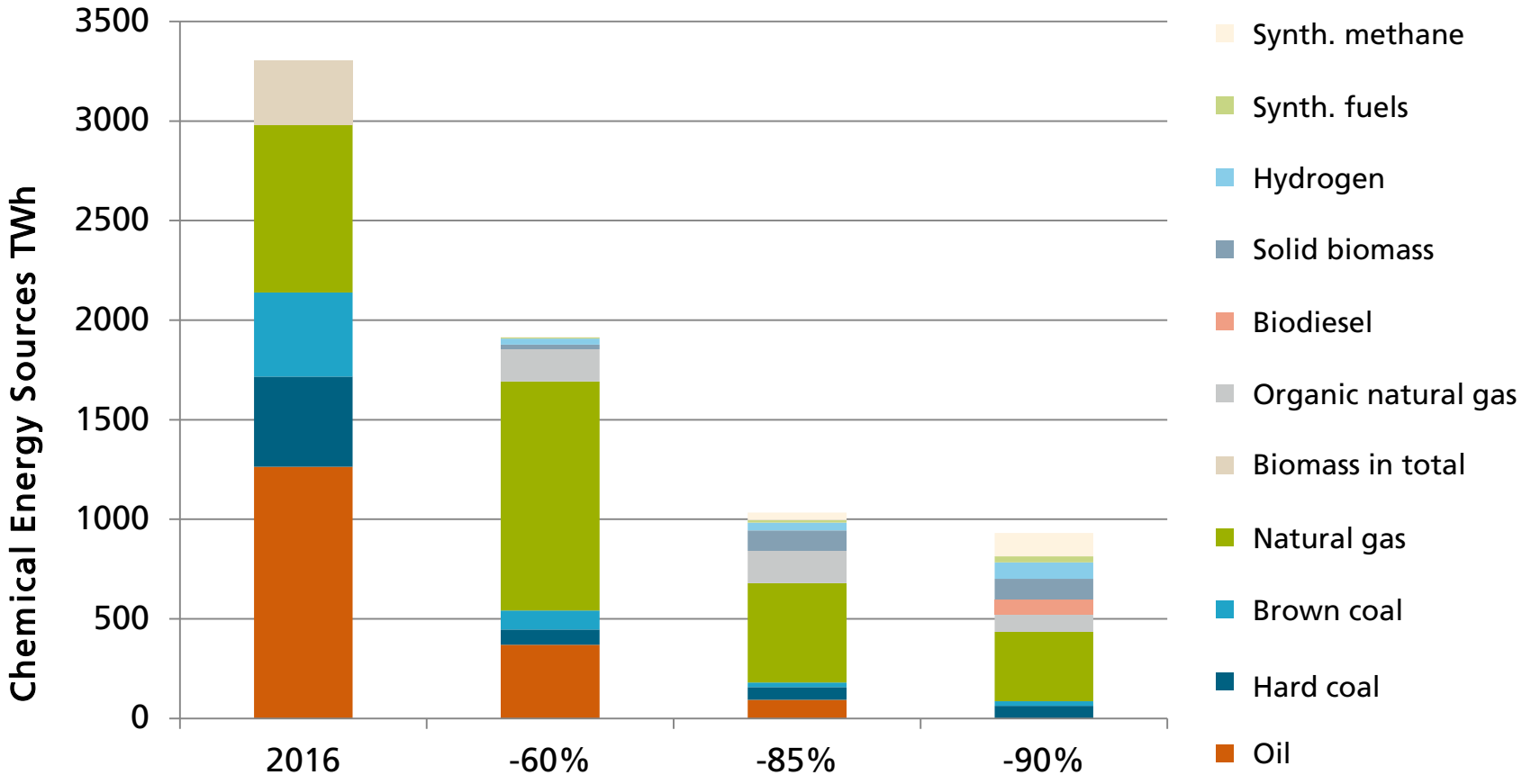
Car fleet in Germany, distribution of technologies in 2050



Energy sources in 2050

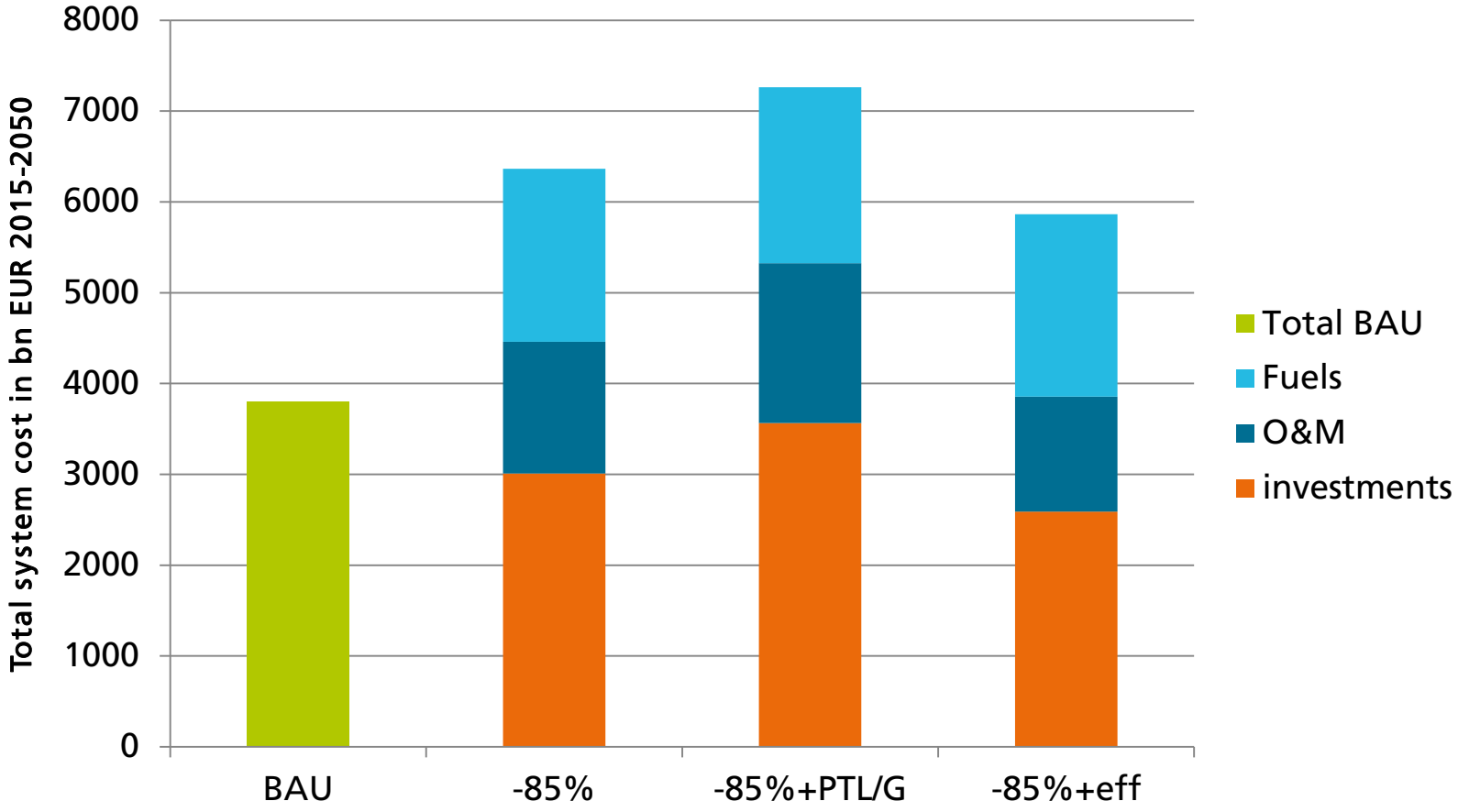
- **Electricity from renewables** will become the dominant energy source of the future
- The **selective use of biomass** in the heating and transport sectors as well as an expansion of geothermal and solar energy can help to limit the expansion of wind and PV and to secure public acceptance of the energy transition.
- **Natural gas** will continue to play an important role for a long time to come (fossil natural gas, increasing proportions of bio natural gas and, possibly, synthetic gases from renewable energy).
- **Hydrogen (H2)** plays a central role due to its versatile possible applications (options for use in transport, heat supply, power generation, use in industry, further conversion to hydrocarbons).
- **Synthetic fuels** are expected to be indispensable (long-term storage and security of supply during dark periods, use in shipping and air traffic and in special industrial processes).

Chemical energy sources in the model calculations



Cost of the development path depends a key drivers: decarbonization target, technology selection in all sectors and efficiency measures

Total system cost by 2050



Conclusions

- REMod approach shows impact between electricity sector and other sectors in a single model
- Huge changes in all sectors
- Critical drivers: decarbonization targets, coal phase out, imports, efficiency measures
- Electricity from renewables is key source, however deployment paths needs to be adjusted to fulfill our energy demand by 2050 (if we want to reach climate targets)

- If we want to get back on track for the climate targets, even until 2030 the changes in the energy system (which comes along with more sector coupling) are massive!

Thank you for your kind attention!

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