Universität Stuttgart
IER Institut für Energiewirtschaft
und Rationelle Energieanwendung

"Energiewende" in Germany – overview and model analysis

Mines ParisTech
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Markus Blesl

Outline

- Energy- and Climate Policies
- Modeling in TIMES
- Scenario definition an Analysis
- Some conclusions

Energy and climate policy vision in Germany by the “Energiewende” or Energy Transition concept 2011

- **Renewable energies** are to provide the **main share** of German energy supply in the future.
- **Energy consumption** should be significantly **reduced** and energy efficiency should be increased.
- The energy supply is to be **safer**, more **affordable** and **environmentally friendly** until the year 2050.
- Germany is to become one of the **most energy-efficient and environmentally friendly** economies in the world in the future with **competitive energy prices** and a high level of prosperity.

Energy and climate policy objectives in Germany

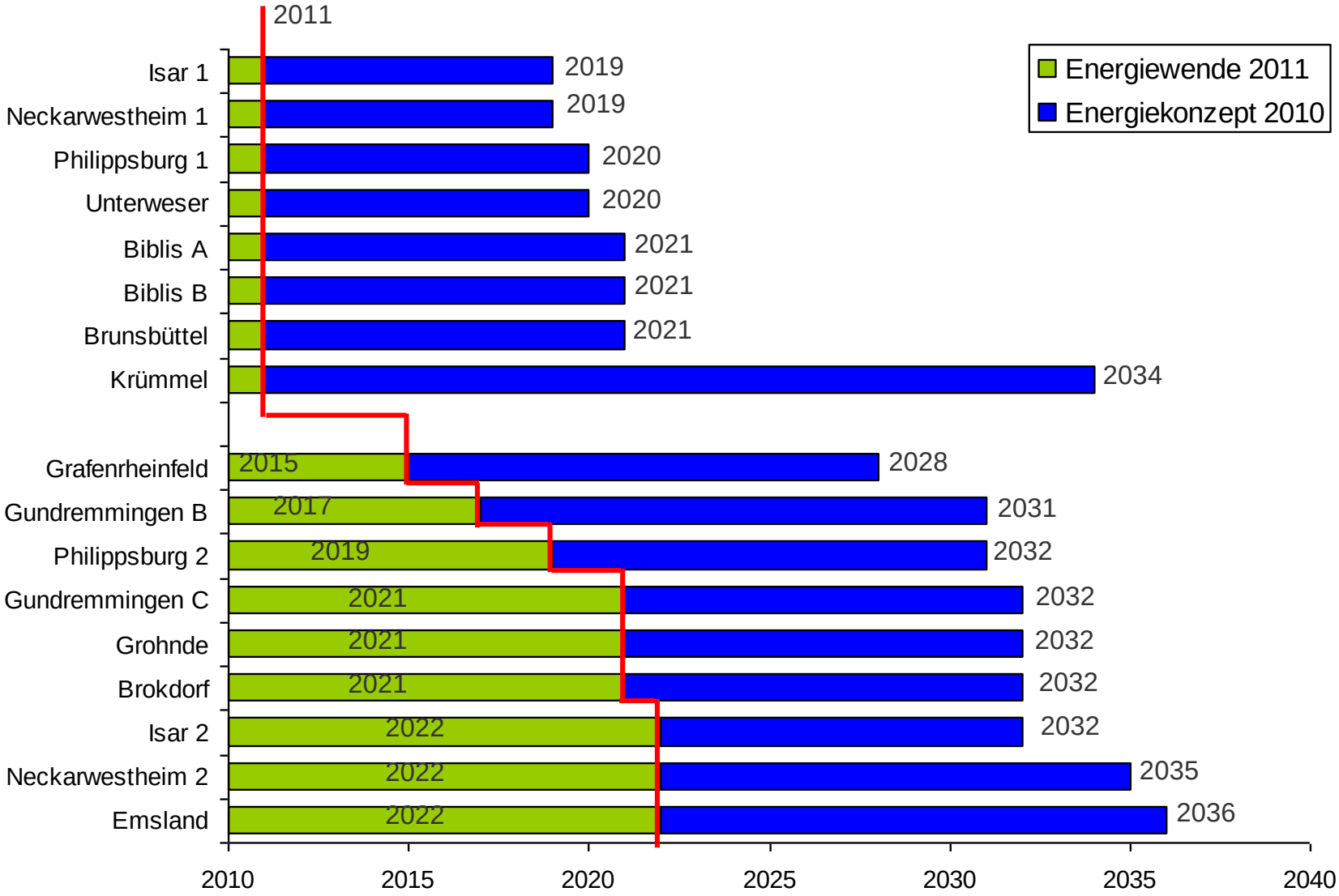
- The future **share of renewable energies** should be
  - **35%** of gross electricity consumption by 2020 and **80%** by 2050
  - **18%** of gross final energy consumption by 2020 and **60%** by 2050.

- **Reduction of greenhouse gas emissions by 40%** by 2020 and by **80 to 95%** by 2050 (compared to 1990)

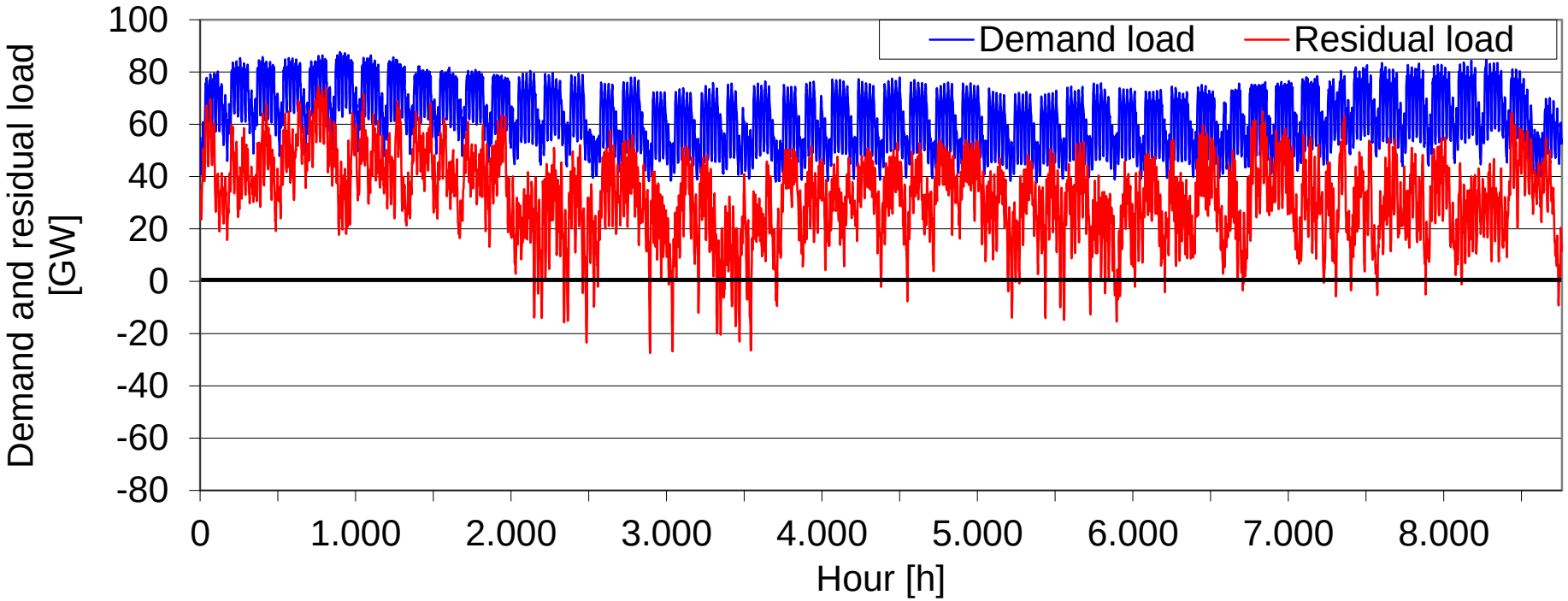
- **Energy consumption** should be **significantly reduced** and **energy efficiency** should be **increased**.
  - **Reduction of primary energy consumption by 20%** by 2020 and **by 50%** by 2050 (compared to 2008)
  - **Reduction of electricity consumption** by approx. **25%** to 2050

- **Phase out** from the use of **nuclear power**

Phase out of nuclear plants in Germany

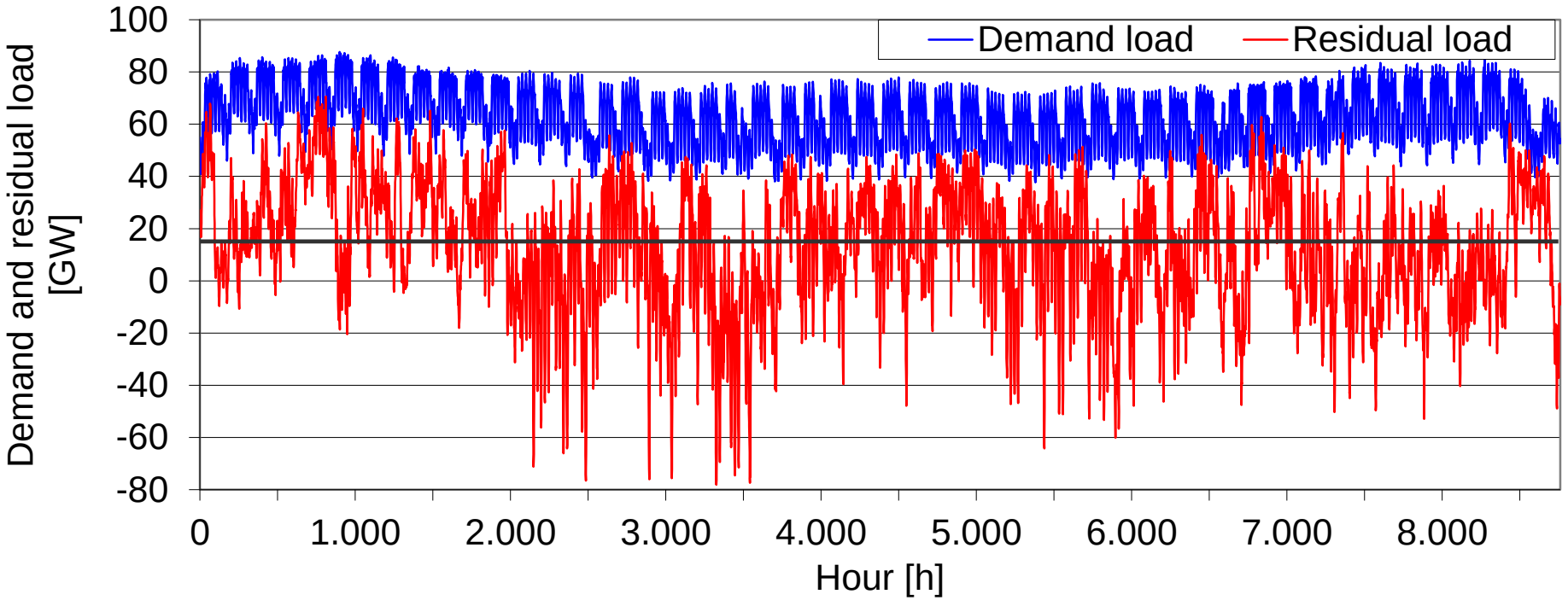


Demand load and residual load - 50 % share of RES



- Excess renewable power up to 27 GW
- Renewable surplus production ~ 2 TWh, about 1 % of the electricity production by wind and photovoltaics
- Storage capacity requirement ~ ? / Power –to x capacities ?

Demand load and residual load - 80 % share of RES



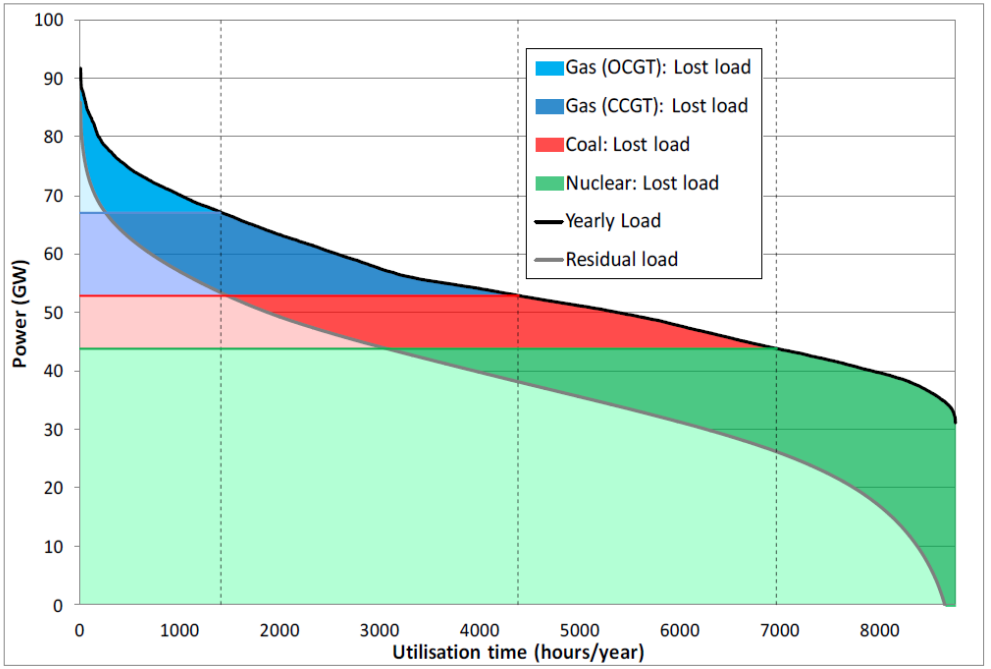
- Excess renewable power up to 78 GW
- Renewable surplus production ~ 43 TWh, about 13 % of the electricity production by wind and photovoltaics

Short-run Effects

In the **short run**, renewables with nearly zero marginal costs replace technologies with higher marginal costs. This means:

- Reductions in electricity produced by dispatchable power plants (lower load factors, *compression effect*)
- Reduction in the average electricity price on wholesale power markets

		30% Penetration level	
		Wind	Solar
Load losses	Gas Turbine (OCGT)	-87%	-51%
	Gas Turbine (CCGT)	-71%	-43%
	Coal	-62%	-44%
	Nuclear	-20%	-23%
Profitability losses	Gas Turbine (OCGT)	-87%	-51%
	Gas Turbine (CCGT)	-79%	-46%
	Coal	-69%	-46%
	Nuclear	-55%	-39%
Electricity price variation		-33%	-23%



- Together this means declining profitability especially for gas (nuclear is less affected)
- No sufficient economical incentives to build new power plants
- Security of supply risks as fossil pants close

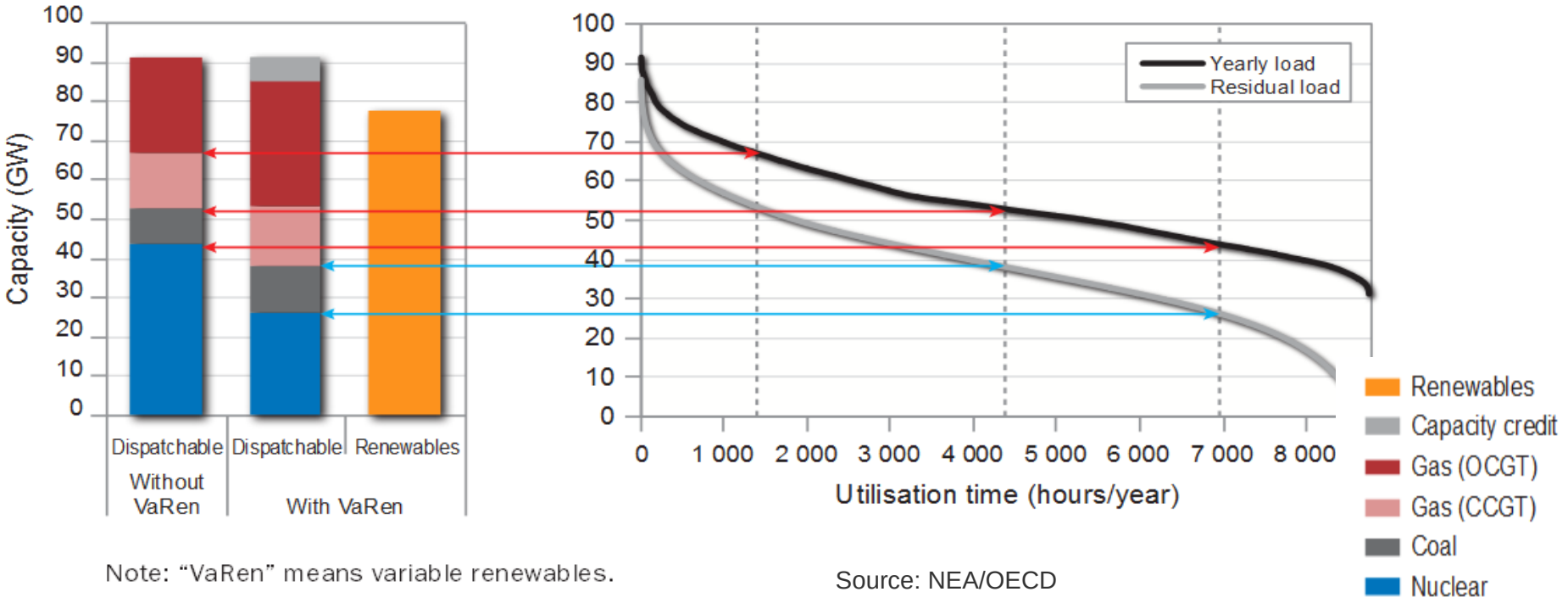
Source: NEA/OECD

Long-run Effects

In the **long run** the reduction in load factors will lead to declining shares of high-fixed cost technologies.

- New investment in the presence of renewable production will change the generation structure
- Renewables will displace base-load on more than a one-to-one basis

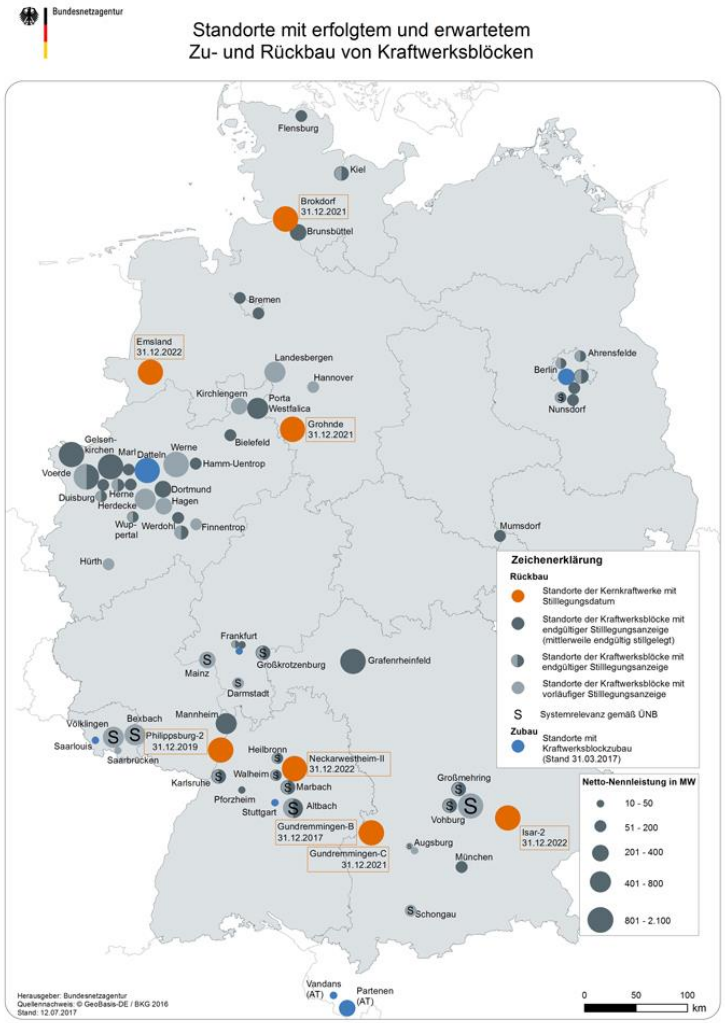
→ Declining profitability will increase the risks of new investment

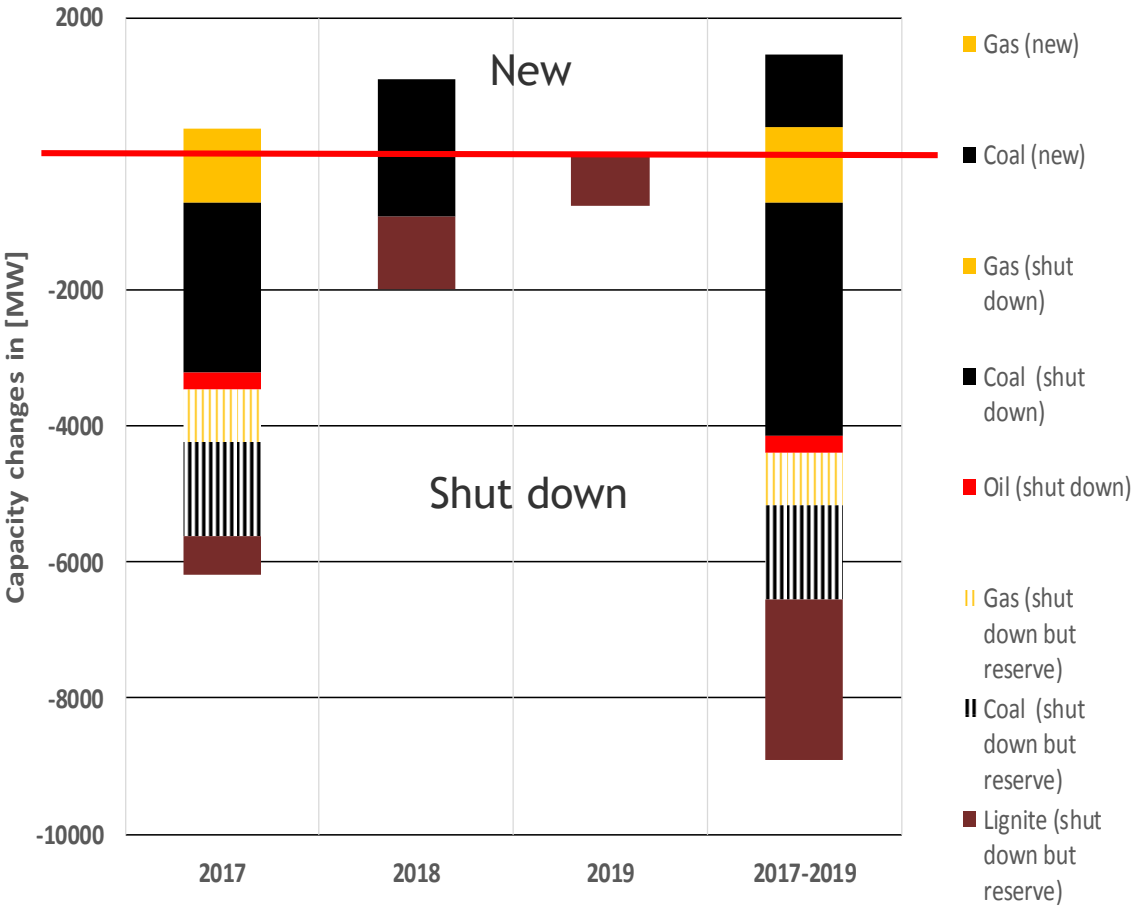


Note: "VaRen" means variable renewables.

Source: NEA/OECD

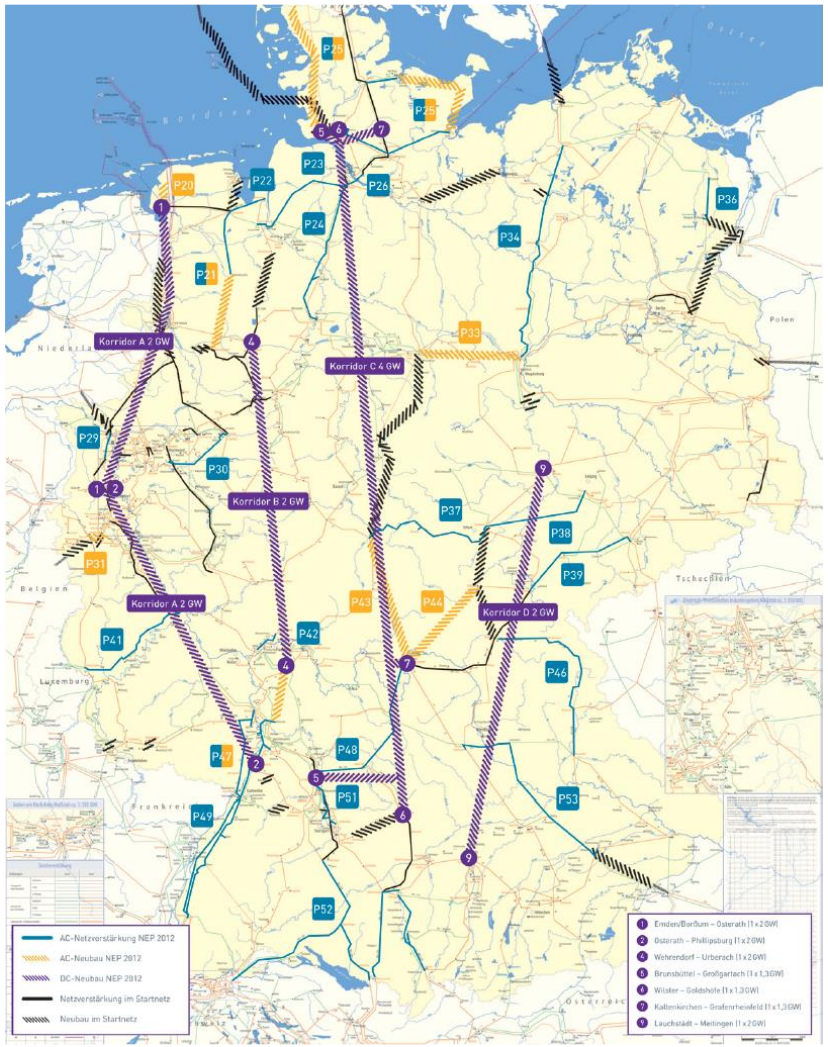
Changes in the installed electricity capacity by fossils already happen in Germany





Source: Monitoringrat der BenetzA

Necessary transmission-grid extension until 2022



- Grid extension:
  - AC-lines: 1,700 km
  - Additional AC-circuits: 2,800 km
  - Upgrading of AC-circuits: 1,300 km
  - DC-lines: 2,100 km
- Investment: 20 billion €
- Szenario 2022:
  - Wind offshore: 13.0 GW
  - Wind onshore: 47.5 GW
  - Photovoltaics: 54.0 GW
  - Share of renewable energies in electricity generation: 50 %

Source: TSOs, Netzentwicklungsplan , 2012

Additional topics in Germany

- Phase out of coal
- Reduction of the process specific emissions – Zero emissions of the energy related processes
- Discussion to forbid engines in cars
- Carbon emission free buildings
- …

Energy and climate policy objectives in the EU-28

- For energy conversion units covered by the ETS (Emission Trading System), a binding reduction of emissions by a total of 21% in relation to 2005 according to EU Directive 2009/29/EC. For the phase 3 of the EU ETS (2013-2020) a linear **reduction factor of 1.74%** of allowances, compared to 2008-2012 average is given.

- In March 2011, the European Commission made a **proposal for a reduction of 80-95% of greenhouse gas emissions** compared to 1990 by 2050 in its "Roadmap for the transition to a competitive low-carbon economy by 2050"

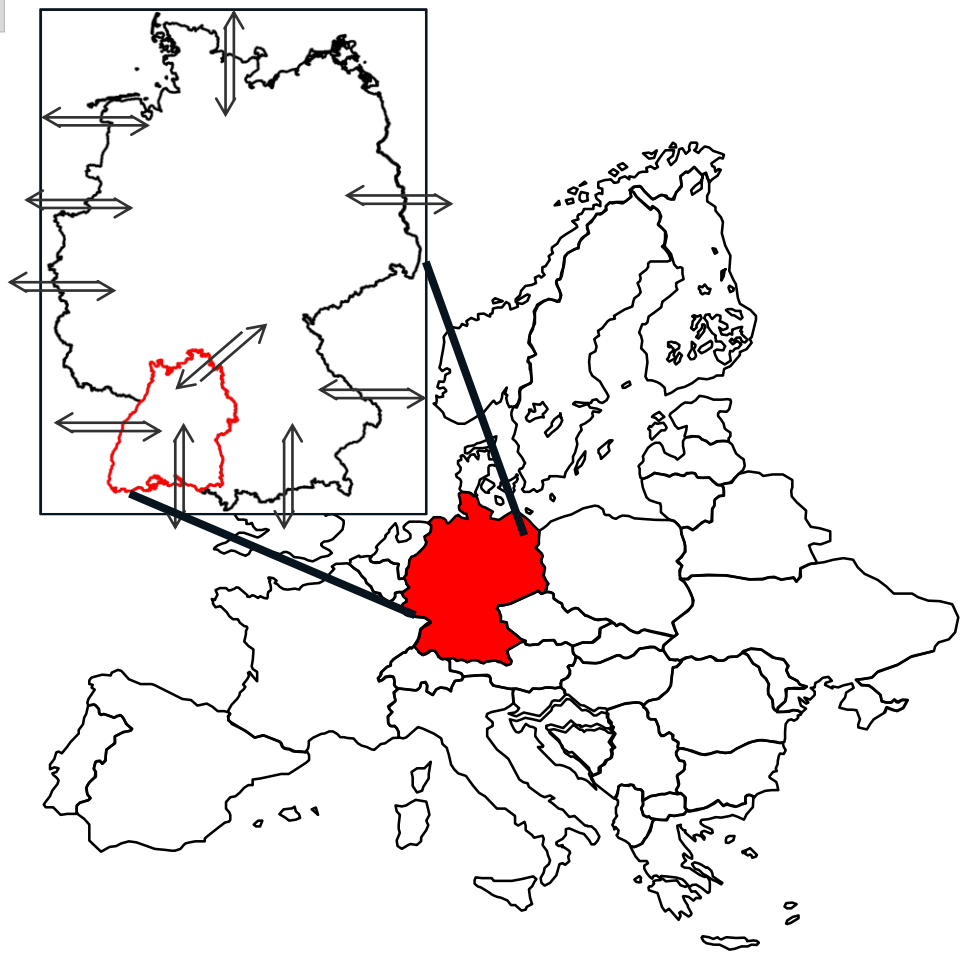
- In October 2014, the Commission adopted the Climate and Energy Package with the objectives for the year 2030. The targets are **40% greenhouse gas reduction, 27% renewable energy share** and the **reduction of primary energy consumption by 27%.**

Times PanEU Model

Energy System Model I/II

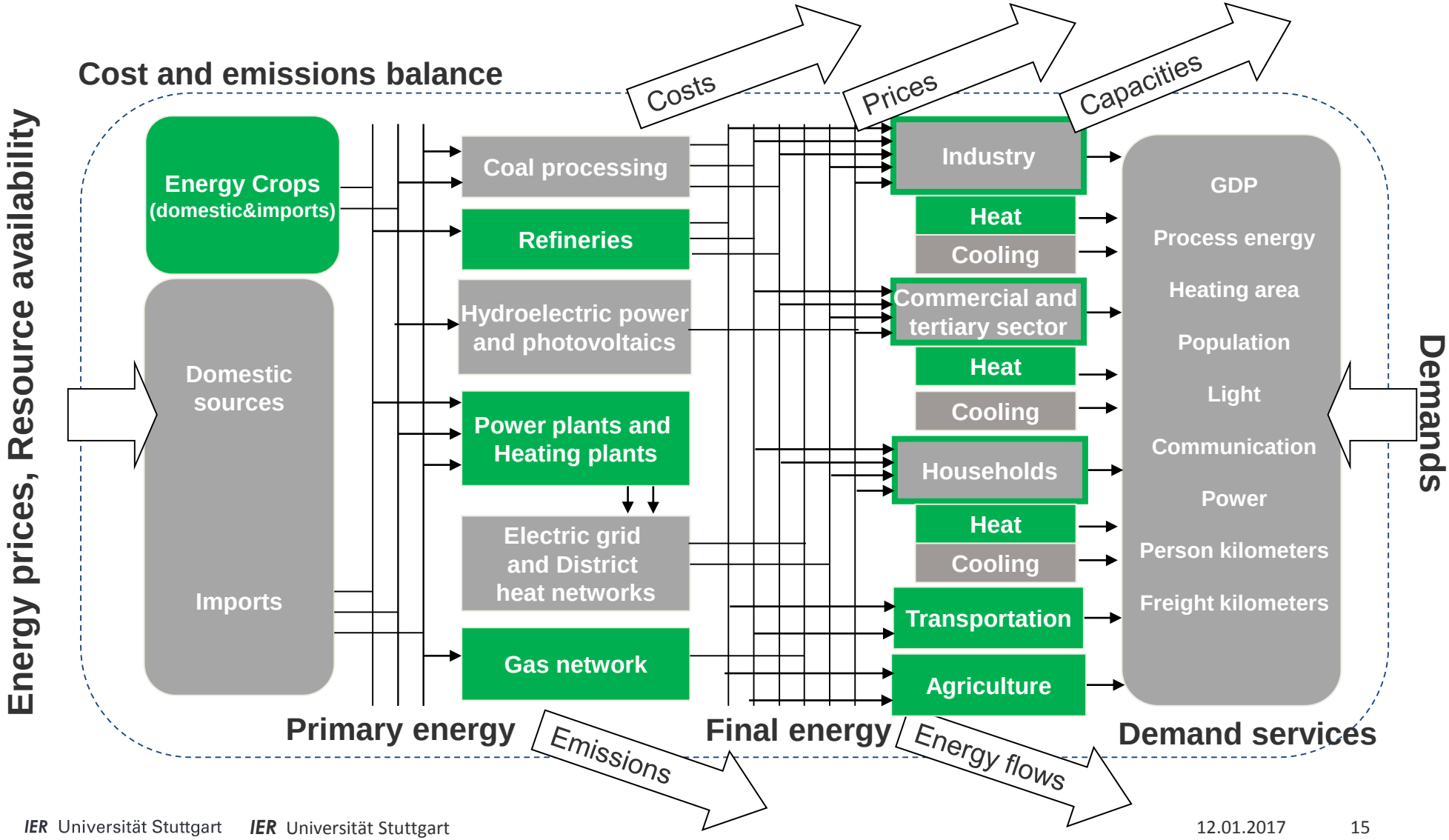
Characterization TIMES PanEU

- European energy system model
  EU28, Norway, Switzerland, **Baden-Württemberg**
- Technology-oriented, bottom-up optimization model with perfect foresight
- Country-specific detailing of the energy generation and the demand sector, as well as detailed mapping of the boundary coupling line capacities according to ETSO
- Intertemporal optimization in the period 2010 – 2050
- 12 sub-annual time segments (four seasonal and three daily segments)
- Emissions: Greenhouse gases (CO2, CH4, N2O)
- Sector-based: public and industrial energy supply, industry, households, Commercial and tertiary sector, transport, agriculture and refineries
- **Objective function:** minimization of the total costs (optimization model)



Times PanEU Model

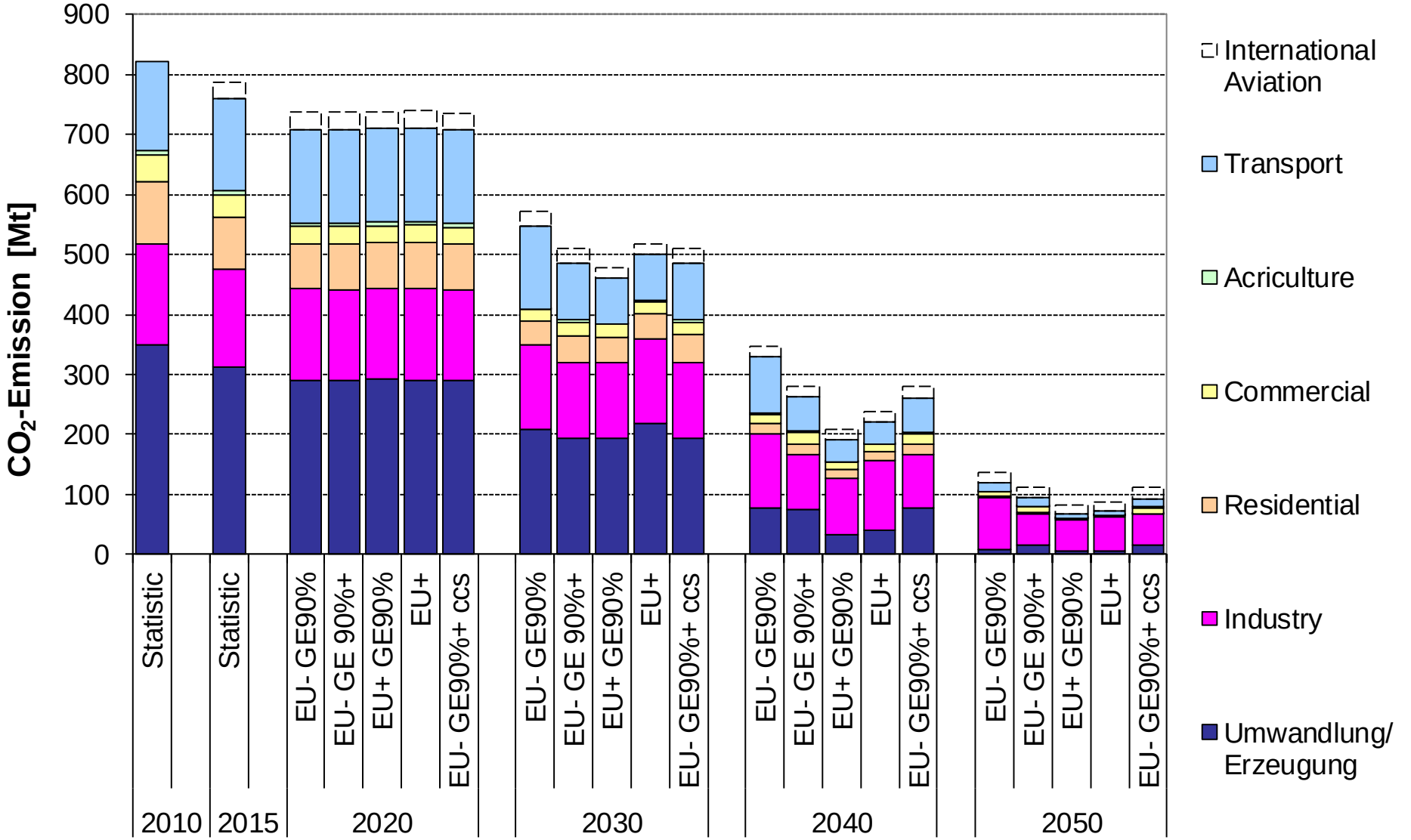
Energy System Model II/II



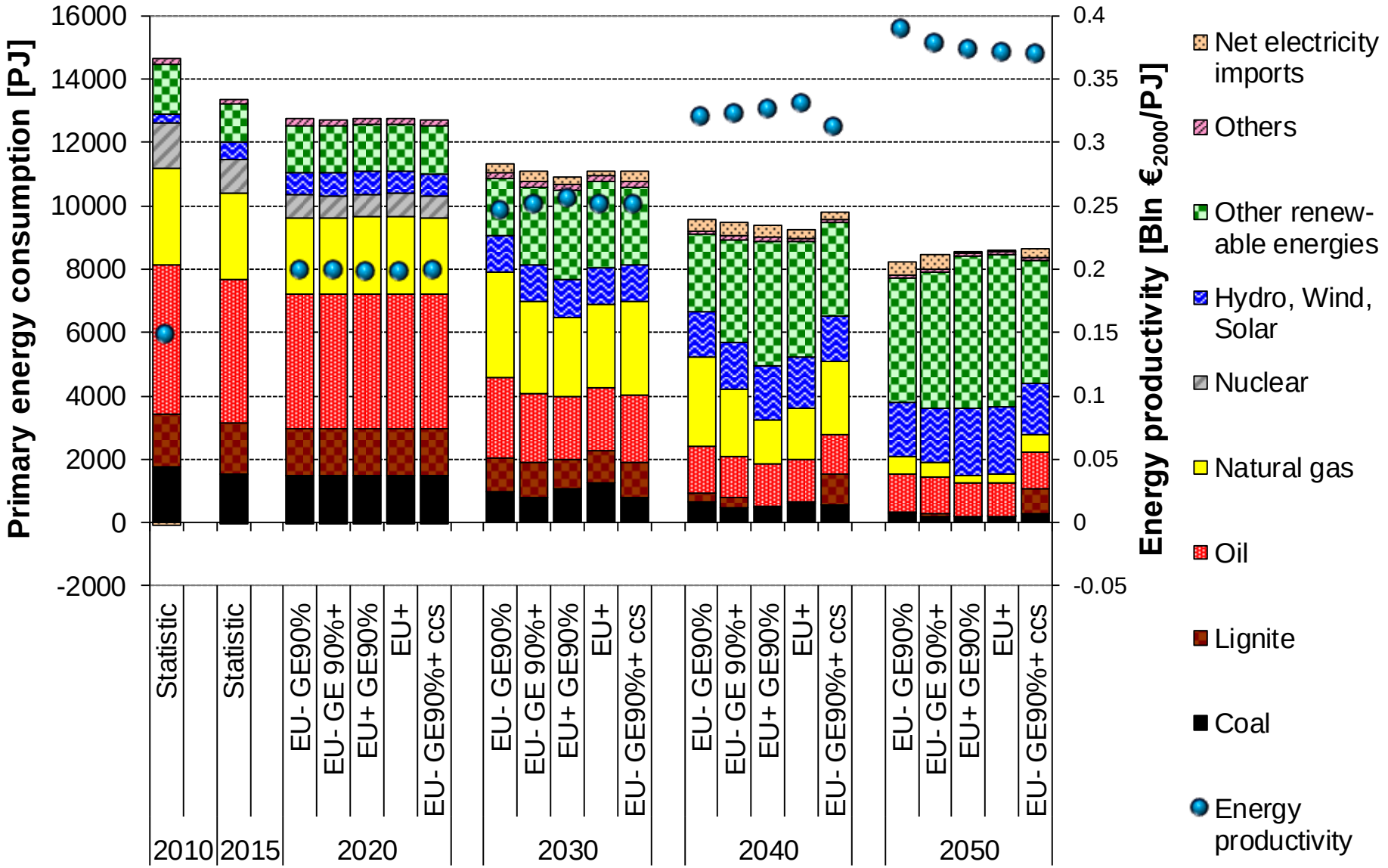
Scenario definition

	EU- GE90%	EU- GE 90%+	EU+ GE 90%+	EU+	EU- GE 90%+ CCS
ETS (65 %)	✓	✓			✓
EU länder- und sektorübergreifend (80 %)			✓	✓	
DE sektorübergreifend	✓				
DE Sektorziele gem. Klimaschutzplan (90 %)		✓	✓		✓

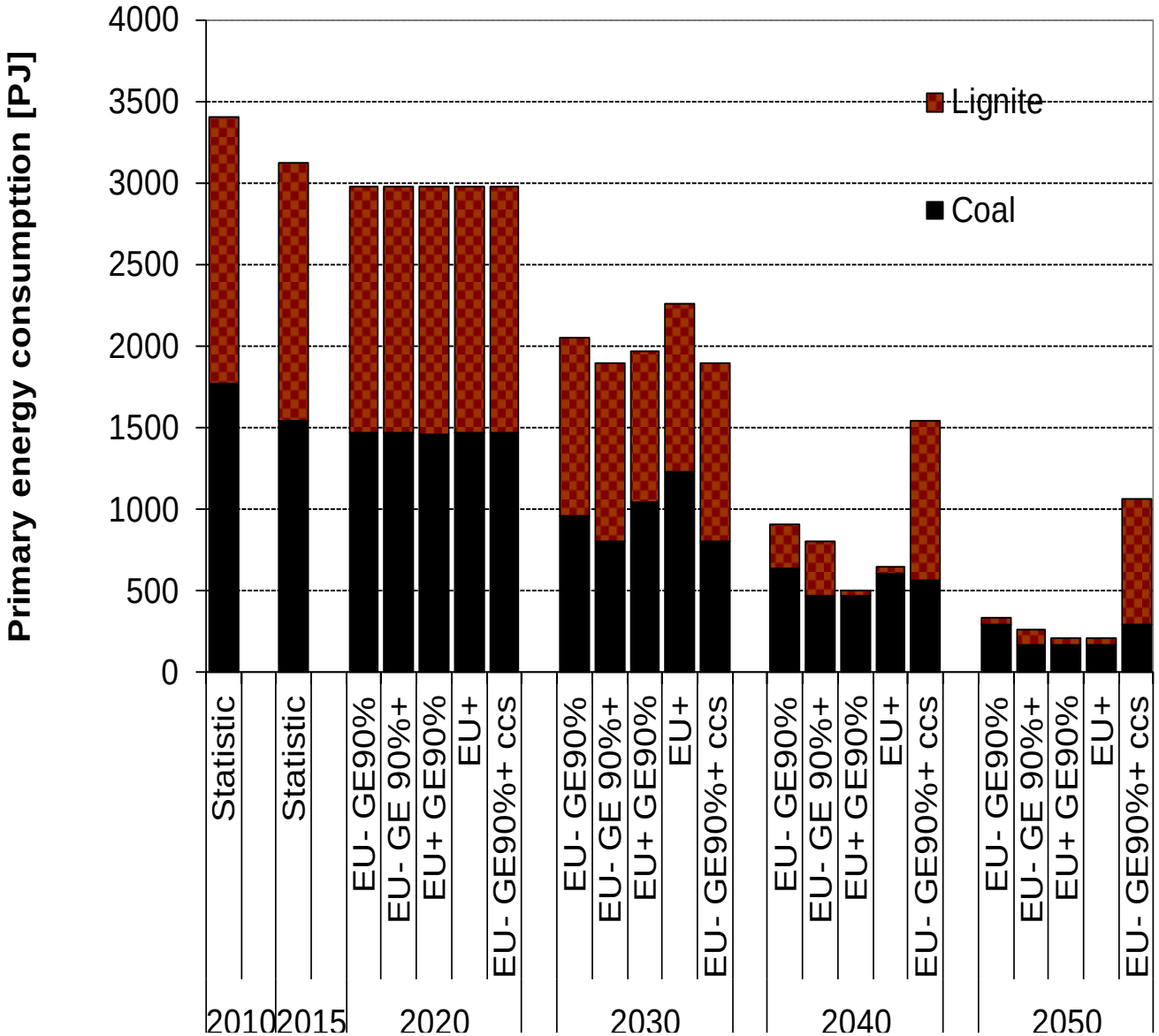
CO2 emission in Germany in a scenario comparison



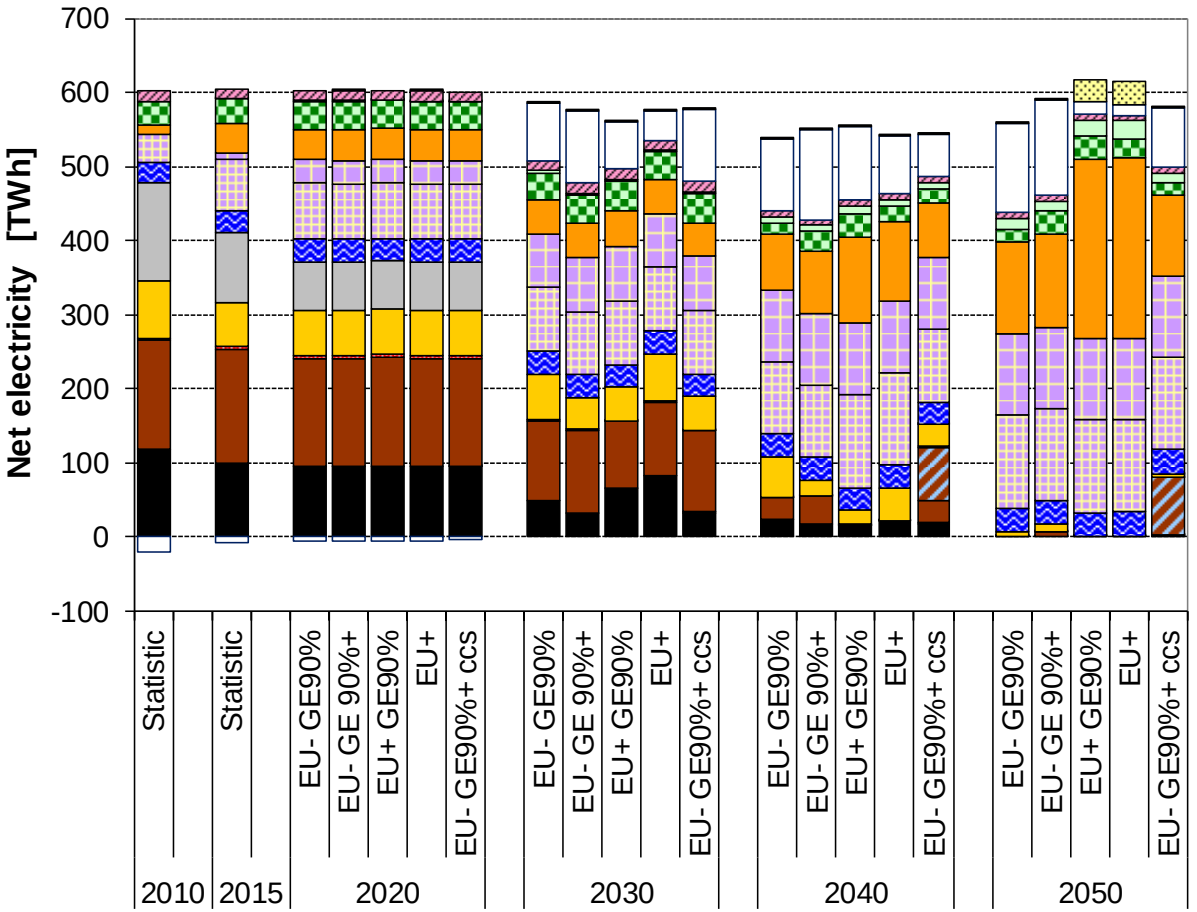
Primary energy consumption in a scenario comparison



Coal consumption in Germany in a scenario comparison

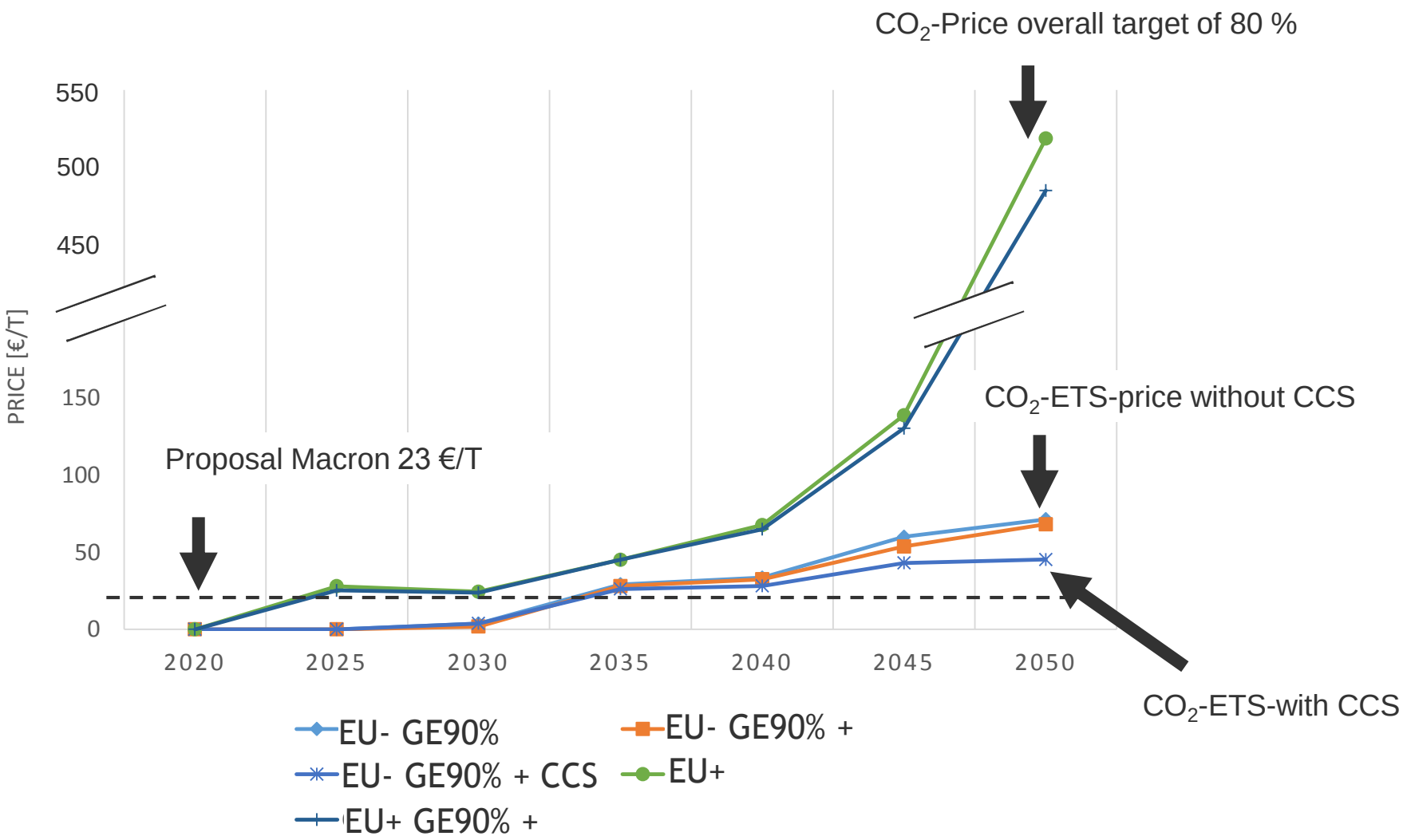


Electricity generation in Germany a scenario comparison



- No phase out of coal before 2040
- Import dependency on the GHG reduction target
- An European GHG reduction target have impact on the competitiveness of the German electricity generation

Marginal CO2 prices



Some Conclusion and Outlook

- We should be carful and avoid a related a single strategy without diversification of the energy system.

- The cooperation in the energy market over all kind of boarders is the only way to make it possible to achieve the 1.5 °C target achievable.

- The decarbonisation of the whole energy systems needs a new thinking – a combination between resource/energy efficiency and a digital world

Universität Stuttgart

Thank you for your attention !

PD Dr.-Ing. Markus Blesl

E-Mail Markus.Blesl@ier.uni-stuttgart.de
Telefon +49 (0) 711 685- 87 865

Universität Stuttgart

Institut für Energiewirtschaft und Rationelle Energieanwendung (IER)
Energiewirtschaft und Systemtechnische Analyse (SAM)