11. Internationale Energiewirtschaftstagung (IEWT) Wien 2019

Session: Energiepolitik IV

Challenges for the European Low-Carbon Transition

A Quantitative Assessment of the Stranded Asset Problem

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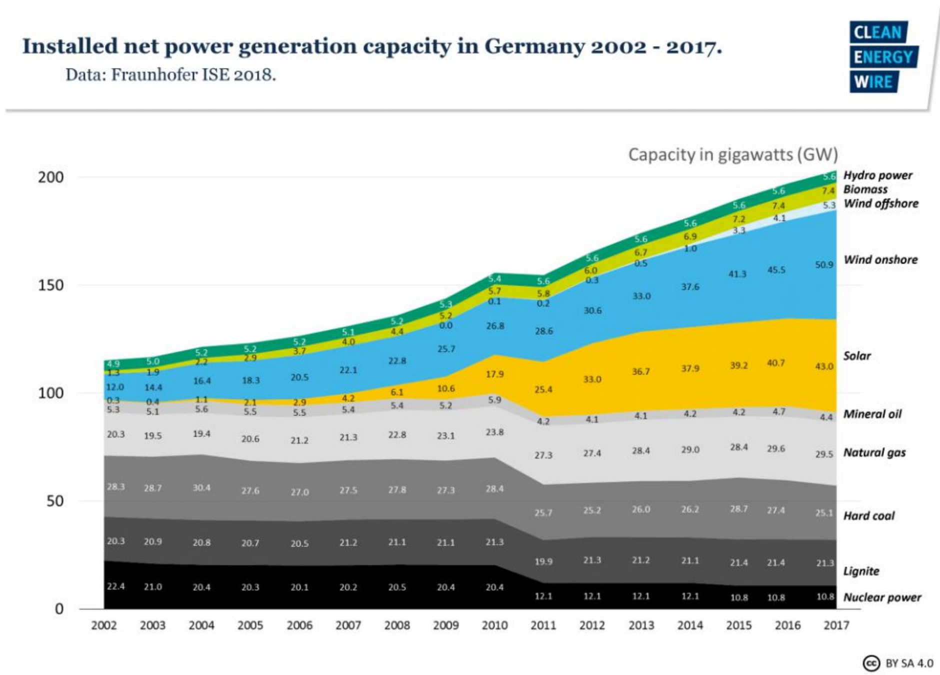
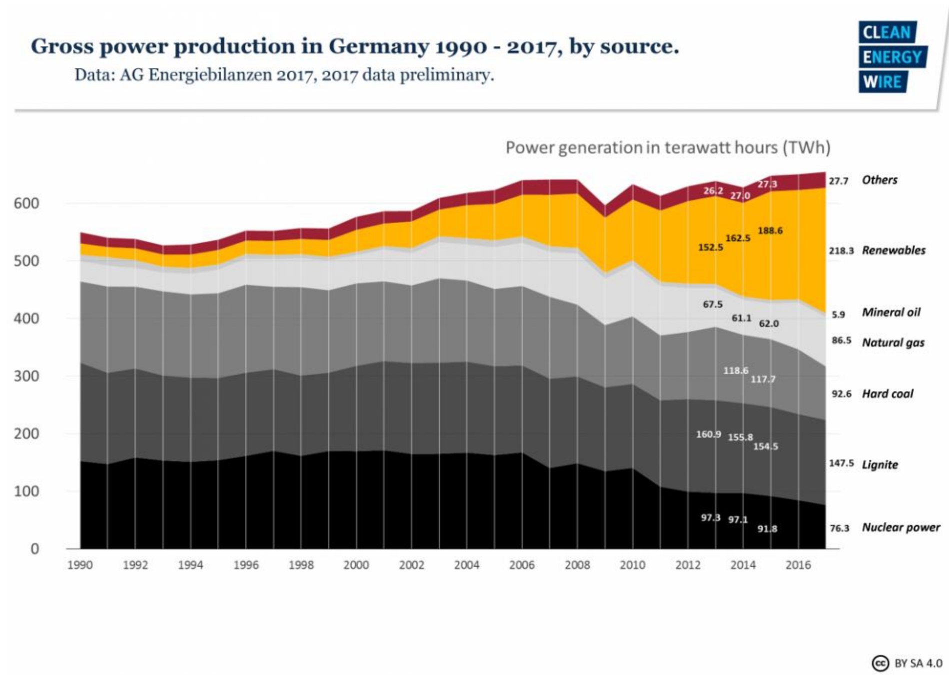
Motivation

Germany as an Example:

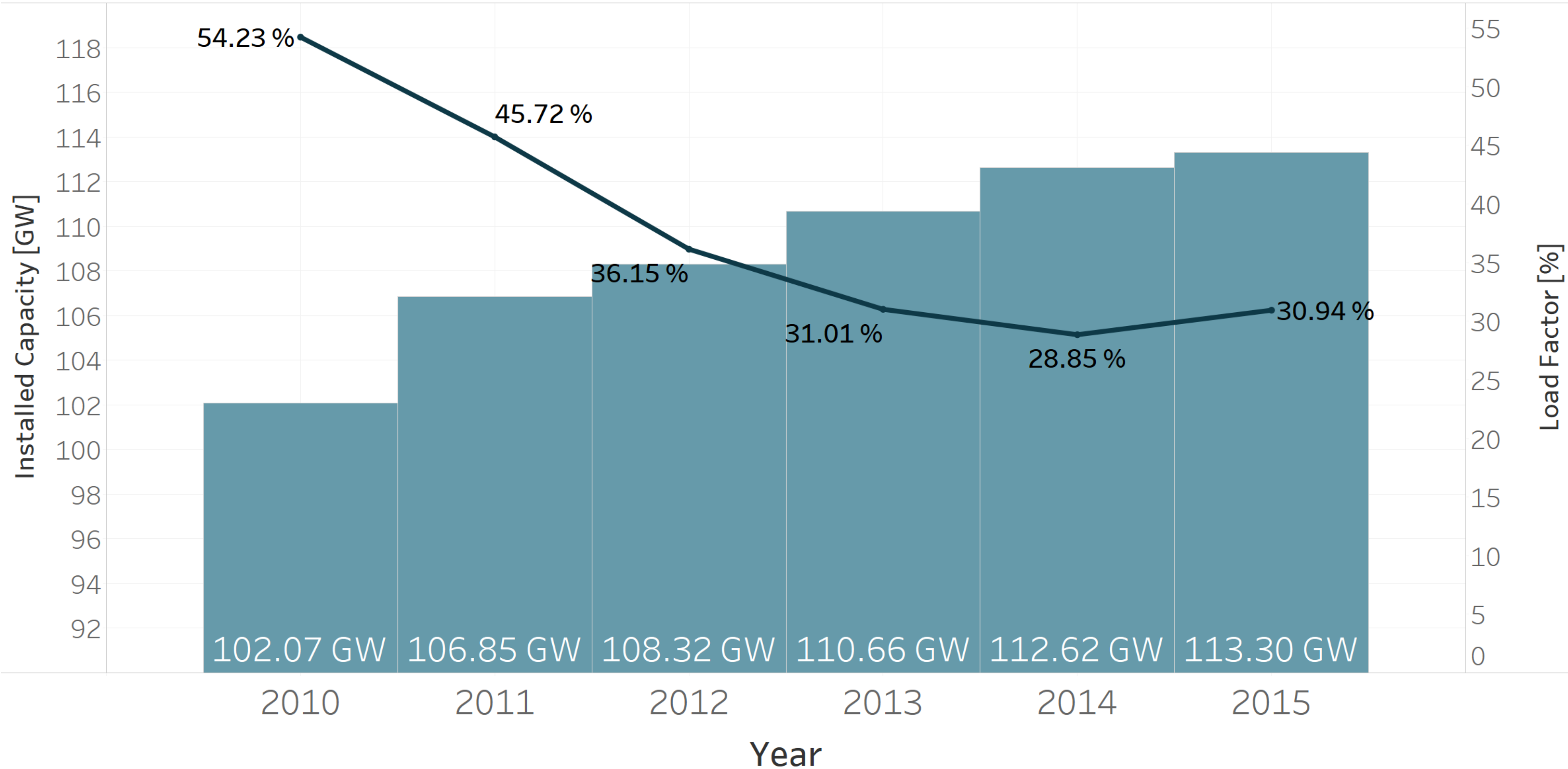
- The power production from fossil fuels is decreasing
- Capacities of conventional power plants remain mostly stable





Already existing overcapacities of power plants in Europe pose significant questions about the future of current and planned fossil fuel-based power plants and their economic viability.

Motivation



Load factors for gas-fired power plants have been decreasing heavily over the last few years, while new capacities have been constructed

Source: Eurostat, opsd

Agenda

1) **Introduction**

2) **Model Setup and Key Assumptions**

3) **Results**

From OSeMOSYS to GENeSYS-MOD

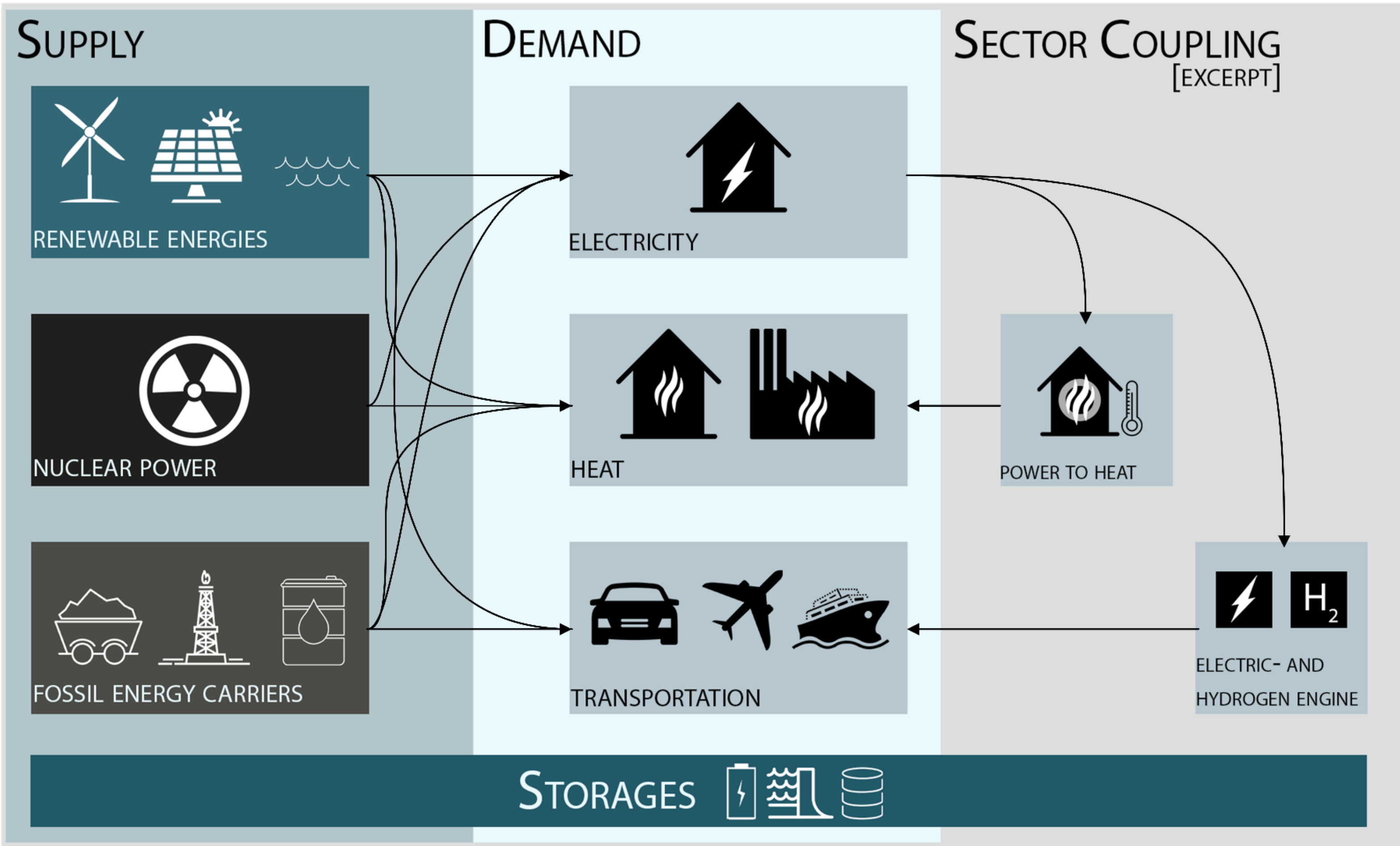
OSeMOSYS (Open Source Energy Modeling System):

- **Cost-optimizing Linear Program** (LP)
- **Open-source** energy systems model
- Written in GMPL using a free GNU solver
- Mainly developed by KTH in Stockholm
- Available under: http://users.osemosys.org/

GENeSYS-MOD (Global Energy System Model)…

- …offers a fully translated **GAMS version of OSeMOSYS**.
- …enhances the OSeMOSYS framework with multiple **additional features**.
- …is being made **publicly available** to the community with both code and data.
- For further information on GENeSYS-MOD see: Löffler et al. (2017): https://www.mdpi.com/1996-1073/10/10/1468 and Burandt et al. (2018): https://www.diw.de/sixcms/detail.php?id=diw_01.c.594278.de

Model Design & Technologies



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Model Setup: Key Assumptions and Disaggregation

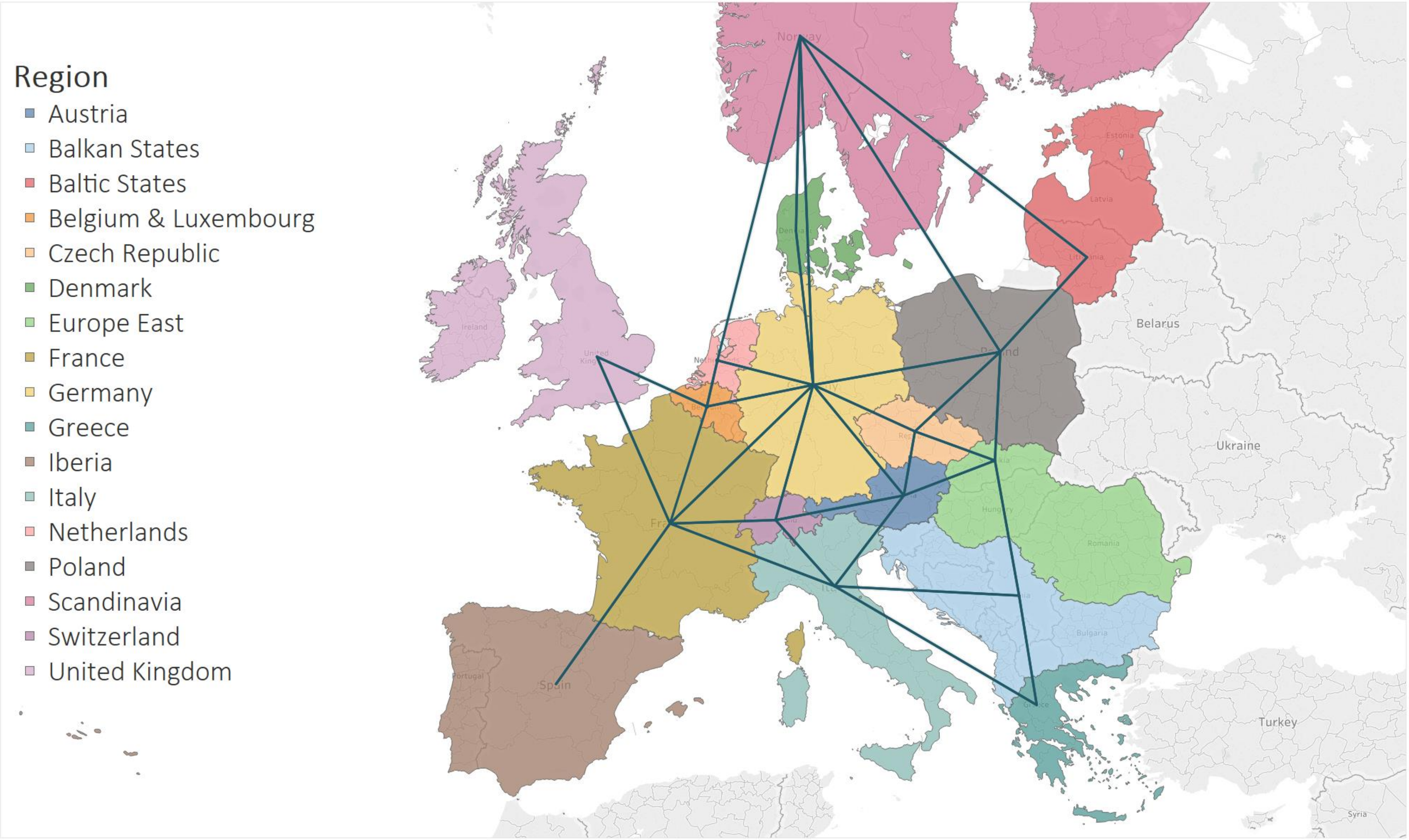
Key Data and Constraints

- **17 regions** are considered.
- The years 2020 - 2050 are modeled in **5-year steps**, with 2015 as a baseline.
- The model considers **16 time slices per year**: four seasons, each with four daily time slices.
- Electricity demand based on the EU Reference Scenario (PRIMES, EUREF).
- Heat and transport demands (2015) based on recent literature and data.
- Demand development and fossil fuel prices are fixed and based on the IEA 450ppm scenario datasets (World Energy Outlook 2016).
- Residual capacities for supply technologies are taken from Farfan and Breyer (2017).
- CO_2 storage potential taken from Oei et al. (2014).

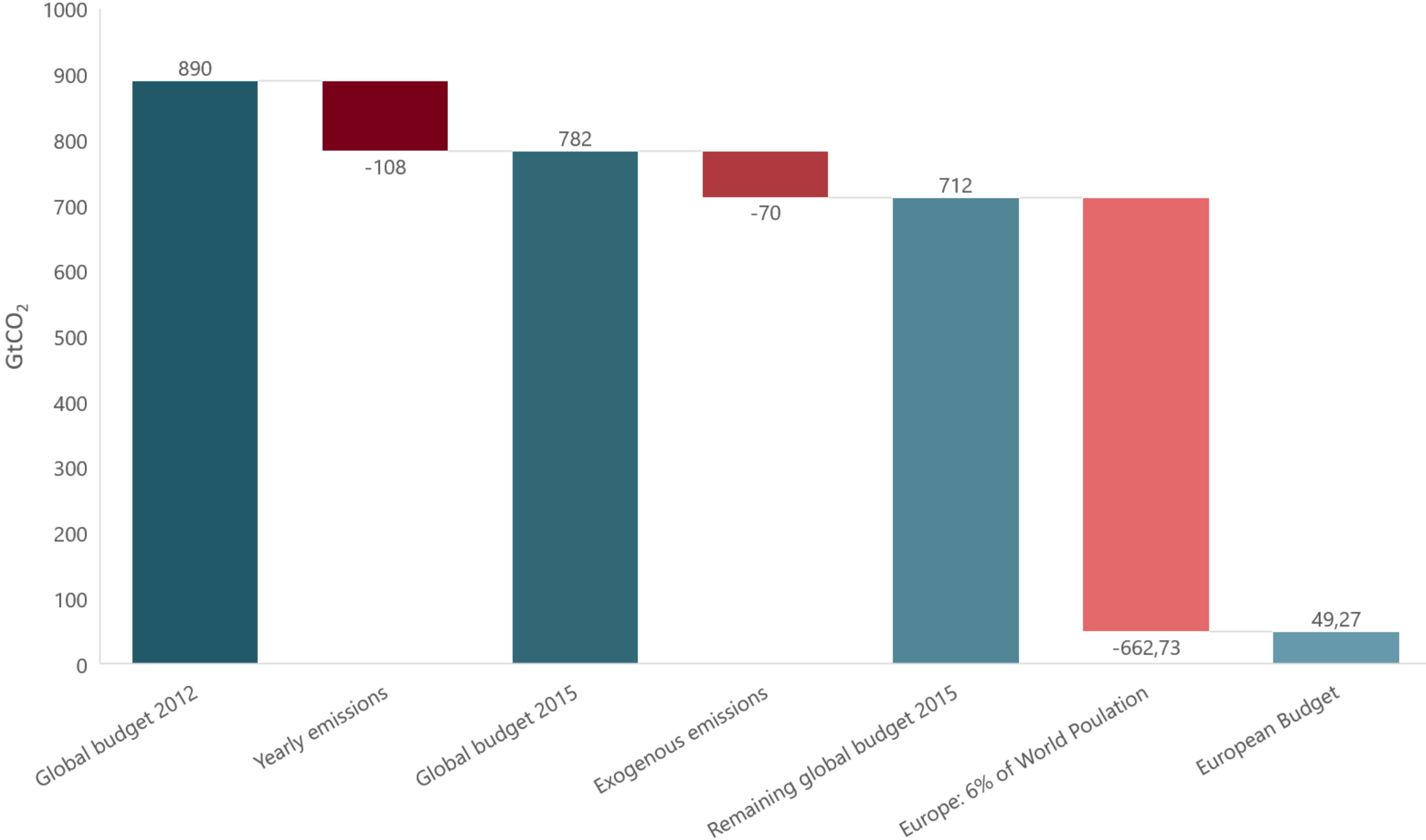
- A carbon budget representing an achievement of the 2° C target is implemented.

GENESYS
GLOBAL ENERGY SYSTEM
MODEL

Model Setup: Spatial Resolution



Model Setup: Carbon Budget



Model Setup: Scenarios

BASE: Baseline-Scenario, enforcing a carbon budget for a 2° C target

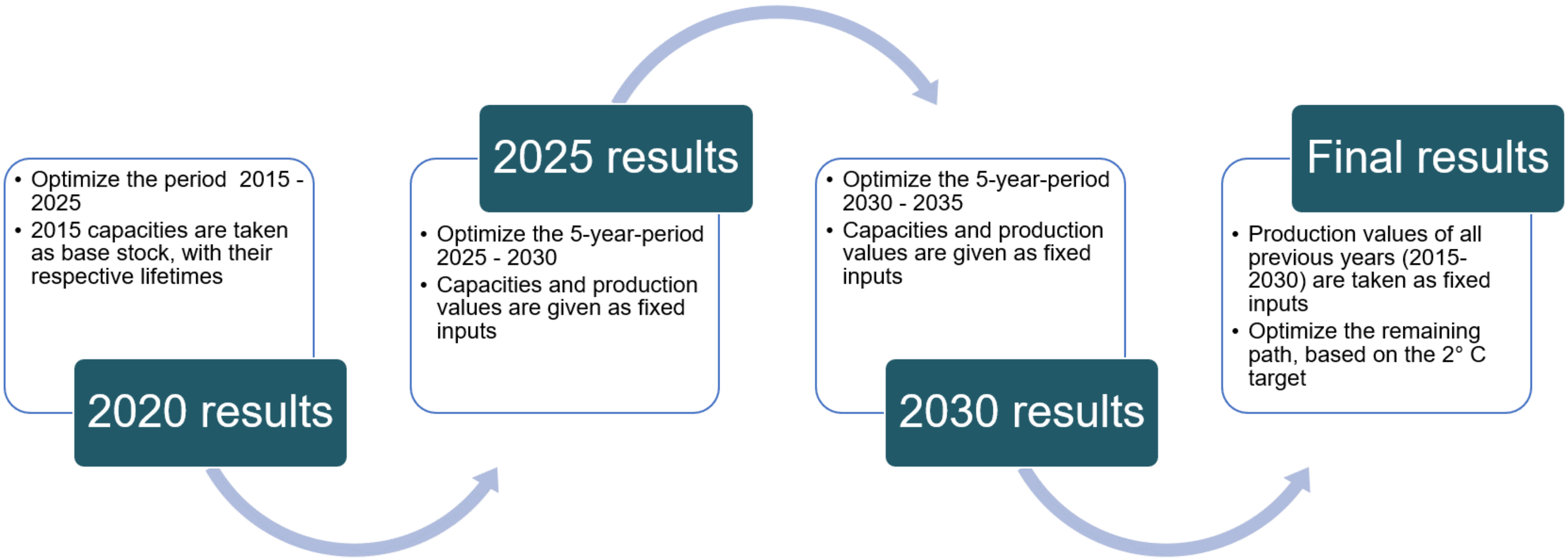
RED: Introduces reduced foresight, simulating limited planning horizons of businesses and politicians

POL: Adds political boundaries to the RED scenario, representing the efforts of incumbent actors and interest groups

Model Setup: Analyzing Stranded Assets

Introducing reduced foresight…

- Variation of baseline model runs:



- By introducing the element of reduced foresight to the model, the stranded asset problem is highlighted due to worse investment planning.

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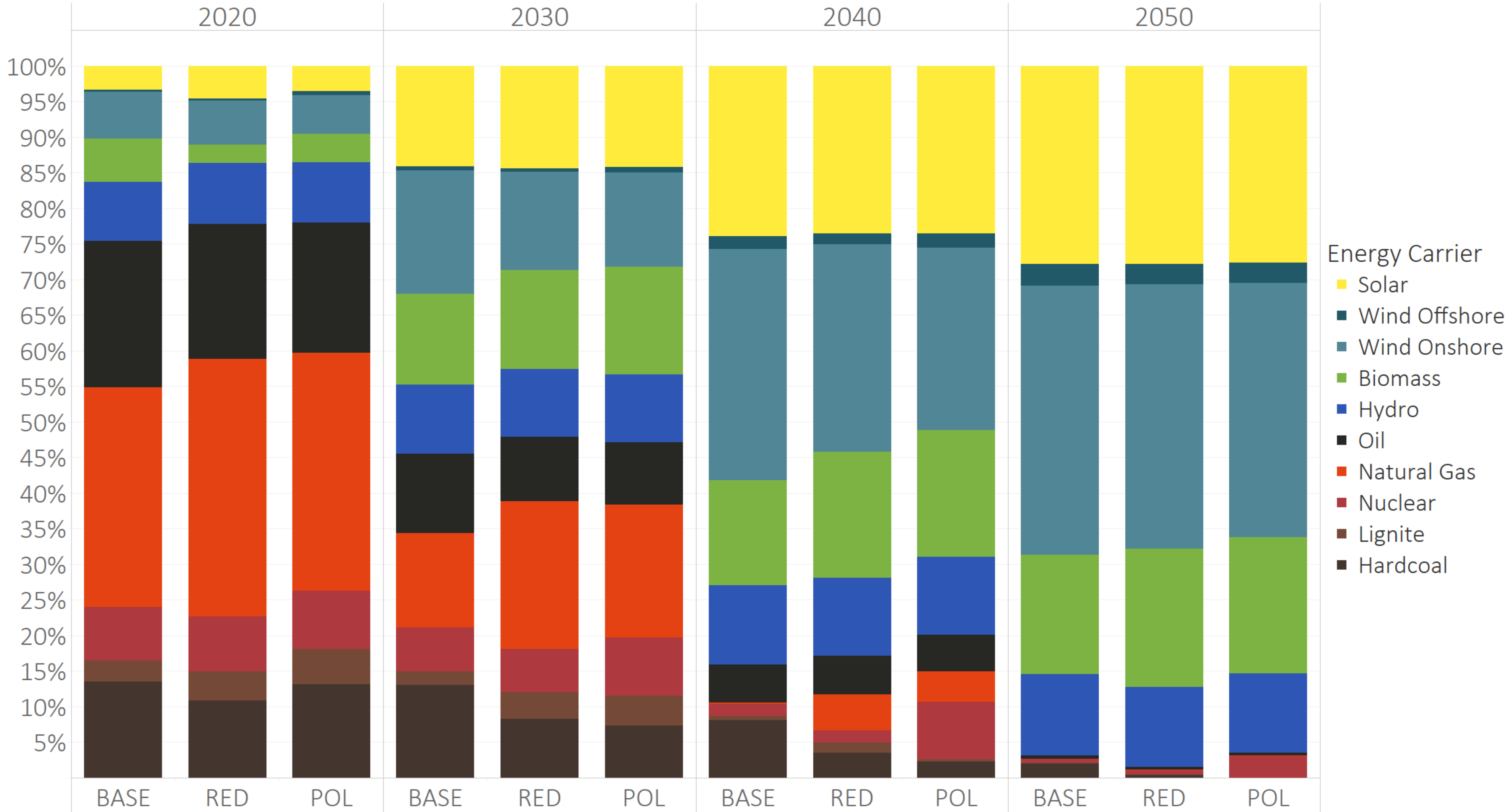
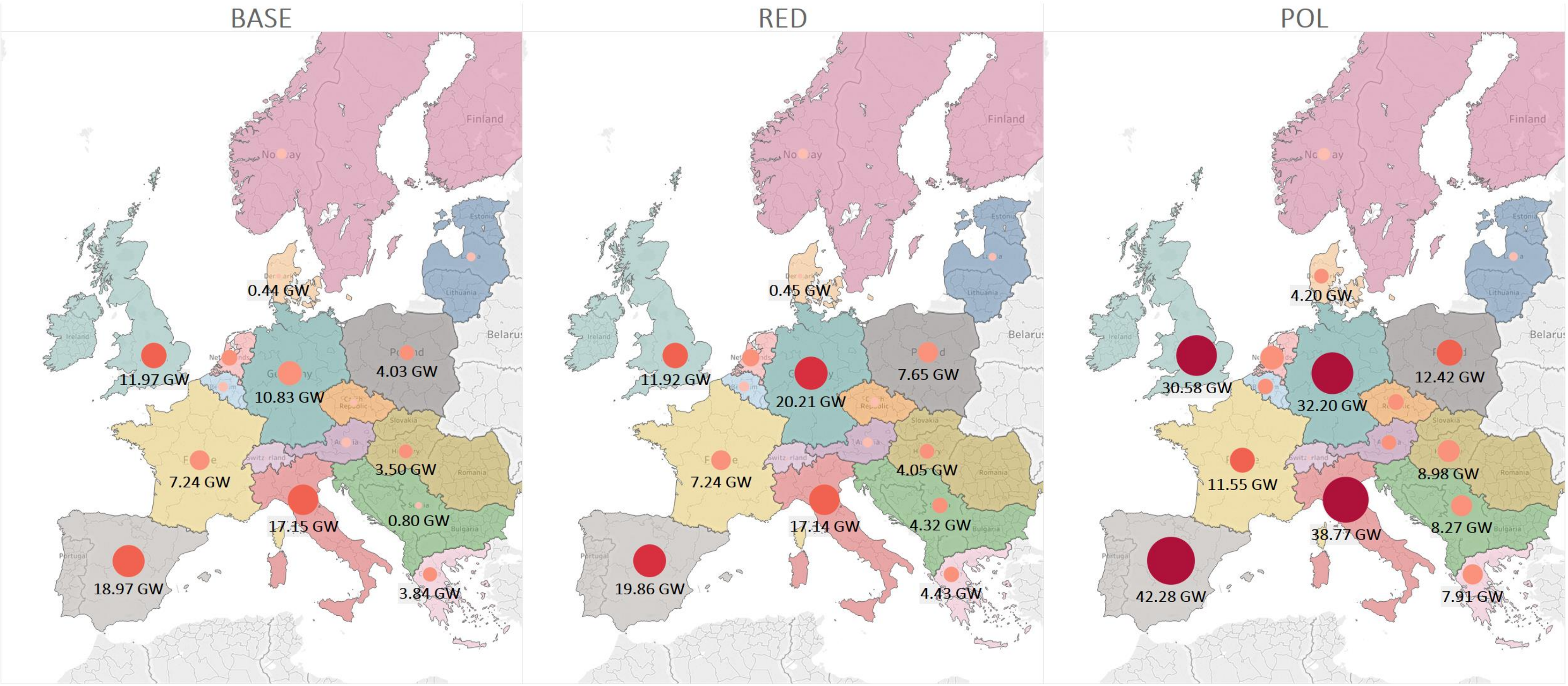
Development of the Final Energy Mix Across Scenarios

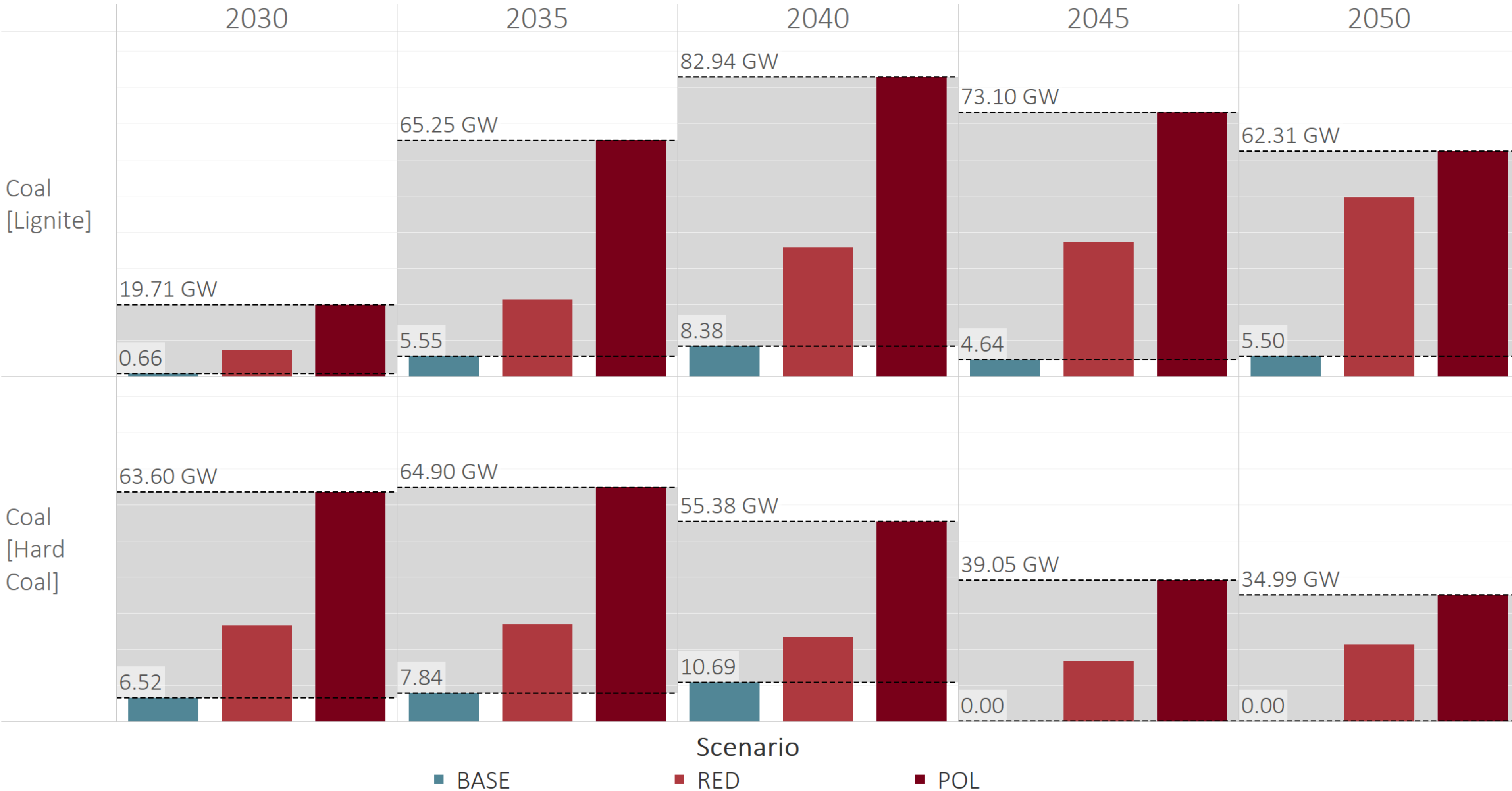


Source: Own Illustration

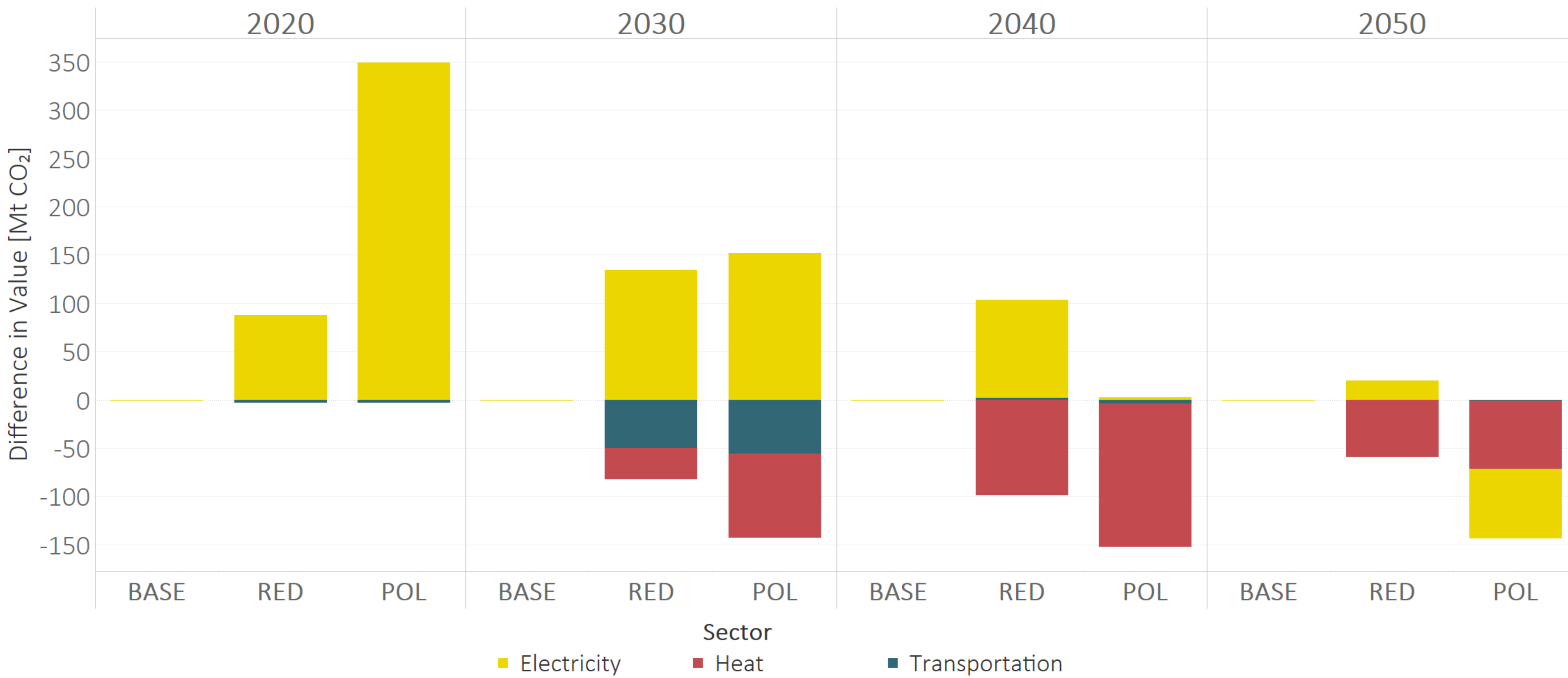
Stranded Capacities per Scenario in 2035



Total Stranded Assets in GW



Shifts in Emissions Across Scenarios
(BASE Scenario as Reference)



Conclusion of our Model Results

- Results show that there will be **massive amounts of unutilized** capacities in Europe in the upcoming years.
- This is due to **declining costs of renewables** and **strict climate targets**, which drive conventional energy generation out of the market.

- Introducing **reduced foresight** to the model **further increases this problem**, leading to new construction of fossil fuel plants in the 2020s that quickly become obsolete.
- The decreasing competitiveness of conventional energy generation poses difficult challenges for investors, owners, and policy makers.

- **Strong, clear signals from policy makers are needed to combat the threat of investment losses.**

Thank you for your Attention!

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Back-Up Slides

Introducing GENeSYS-MOD v2.0

Major Upgrade from the first version (2016/17):

- Introducing…

10 more time slices → More detailed regional disaggregation → Various new technologies → Performance optimization

- …and more

Temporal Disaggregation

N: Night; M: Morning; P: Peak; A: Afternoon

Model Formulation – Objective Function

- **Sets:**

y	*Year*	f	*Fuel*	s	*Storage*
t	*Technology*	m	*Mode of Operation*	e	*Emission*
r	*Region*	l	*Time Slice*		

- **Objective Function**

$$\min costs = \sum_{y}\sum_{t}\sum_{r} TotalDiscountedCost_{y,t,r} + \sum_{y}\sum_{r} TotalDiscountedTradeCosts_{y,r}$$

$$\begin{aligned} TotalDiscountedCost_{y,t,r} = {} & DiscountedOperatingCost_{y,t,r} \\ & + DiscountedCapitalInvestment_{y,t,r} \\ & + DiscountedCapitalInvestmentStorage_{y,s,r} \\ & + DiscountedTechnologyEmissionsPenalty_{y,t,r} \\ & - DiscountedSalvageValue_{y,t,r} \\ & \forall \quad y \in Y, t \in T, r \in R \end{aligned}$$

Model Equations

- **Capacity Adequacy**

$$\sum_{m} RateOfActivity_{l,m,r,t,y} = TotalCapacityAnnual_{r,t,y}$$
$$* CapacityFactor_{l,r,t,y}$$
$$* AvailabilityFactor_{r,t,y}$$
$$* CapacityToActivityUnit_{r,t}$$
$$\forall \quad y \in Y, r \in R, l \in L, t \in T$$

$$RateOfProductionByTechnologyByMode_{f,l,m,r,t,y} = RateOfActivity_{l,m,r,t,y}$$
$$* OuputActivityRatio_{f,m,r,t,y}$$
$$\forall \quad f \in F, l \in L, m \in M$$
$$\forall \quad r \in R, t \in T, y \in Y$$

Model Equations – Investment and Trade Costs

- **Investment Function**

$$TotalCapacityAnnual_{r,t,y} = ResidualCapacity_{r,t,y} + \sum_{yy} NewCapacity_{r,t,yy} \quad \forall \quad r \in R, t \in T, y \in Y$$

$$yy = \{y \in Y: yy > OperationalLife_{r,t} - y \wedge yy \geq y\} \; \forall \, r \in R, t \in T$$

- **Trade Costs**

$$\sum_{f} \sum_{rr \in R} Import_{f,l,r,rr,y} * TradeRoute_{f,r,rr,y} * TradeCosts_{f,r,rr} = TotalTradeCosts_{l,r,y} \quad \forall \quad l \in L, r \in R, y \in Y$$

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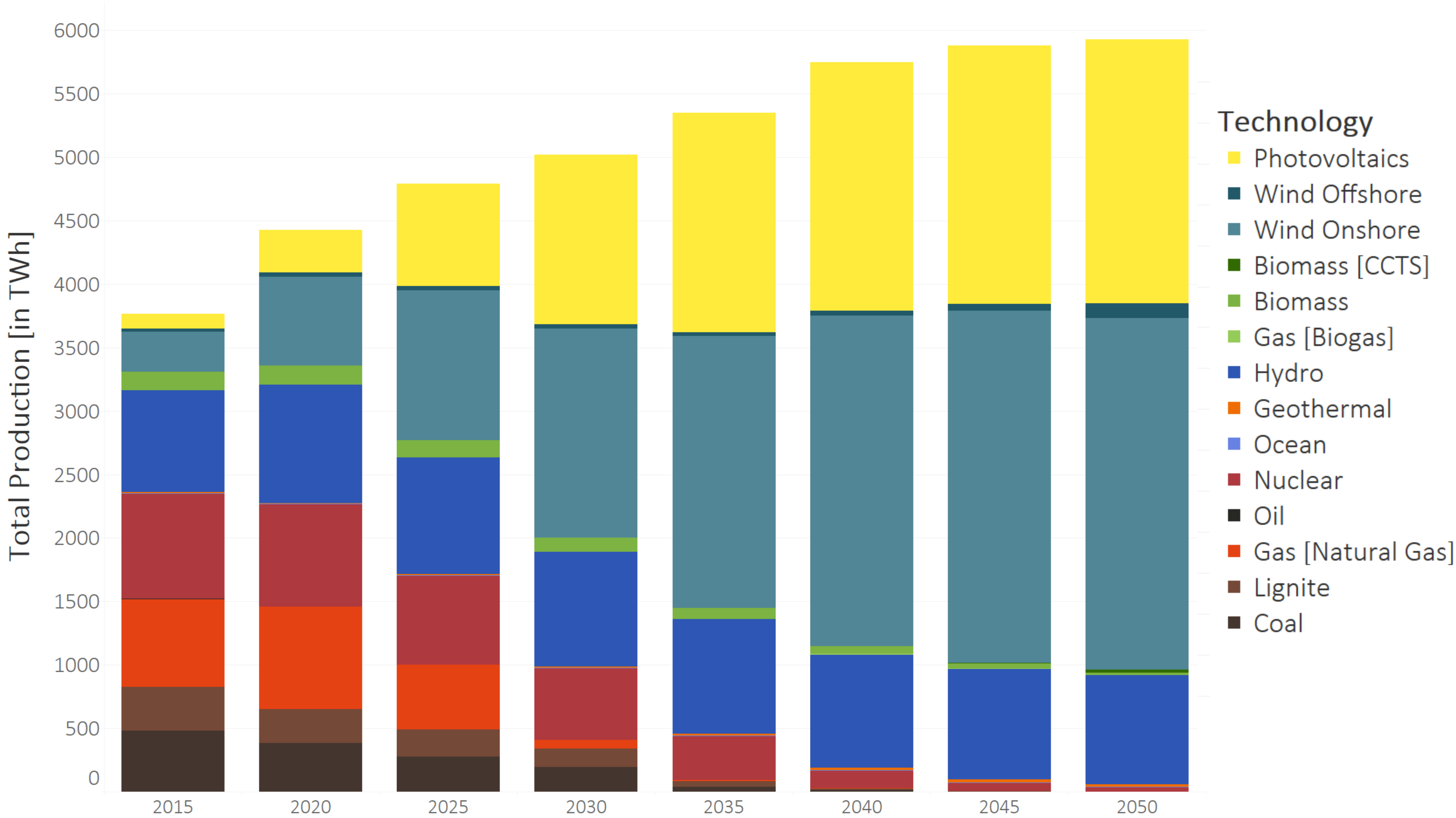
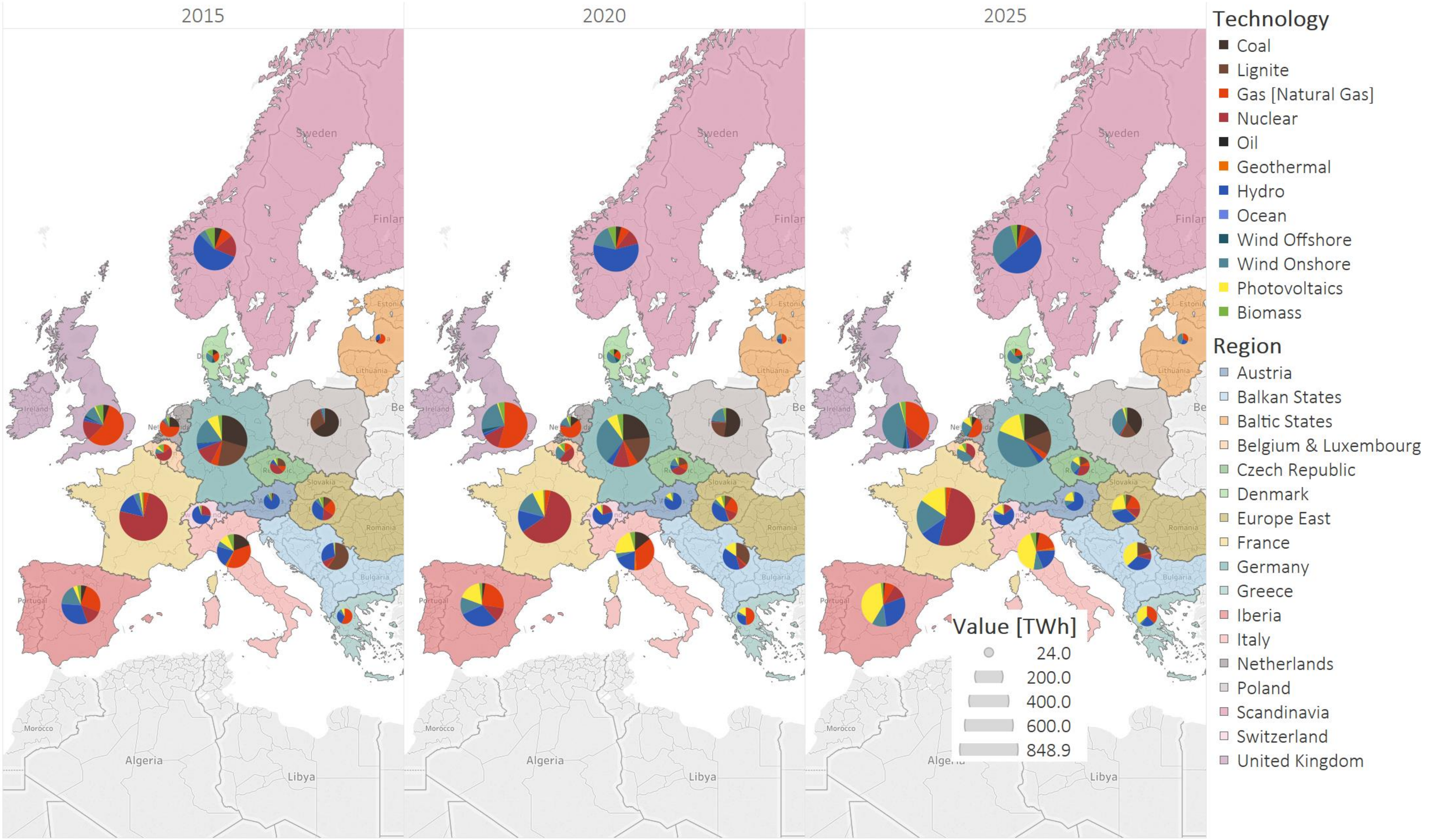
Base Scenario (2°, Perfect Foresight)

Development of Power Generation

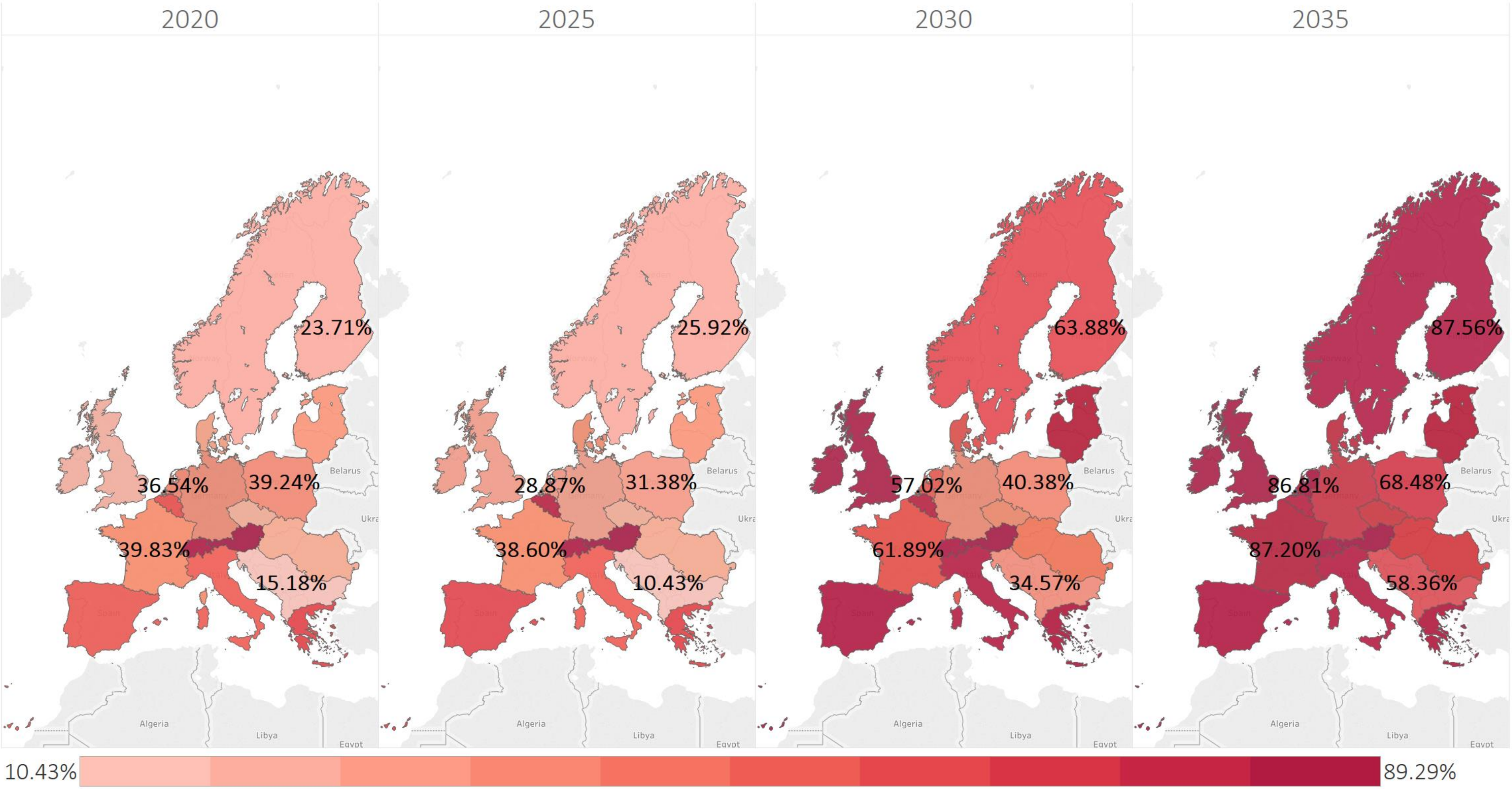


Source: Own Illustration

Regional Power Generation Profiles 2015 to 2025



Unused Capacities



2°, Reduced Foresight

Scenario Comparison

- Up to 6 GW (per region) of additional unused power plants are constructed under reduced foresight.
- The amount of renewables in the electricity mix stays about the same under reduced foresight, but is lightly shifted towards coal & lignite. This is due to cost reasons and limited awareness for emission reduction targets.
- The reduced foresight scenario induces a cost increase of about **2.5 %** in total system costs.

Load Factor for Installed Capacities (Gas & Coal) per Region