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Designing a Global Energy System based on 100% Renewables for 2050

GENeSYS-MOD: An Application of the Open-Source Energy Modeling System (OSeMOSYS)

Session 3, Alternatives to Fossil Fuels in Future Energy Supply
11/13/2017

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Agenda

1) Introduction

2) Model Setup and Key Assumptions

3) Results

4) Conclusion and Further Research

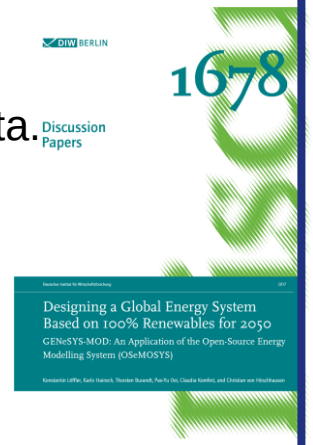
From OSeMOSYS to GENeSYS-MOD

OSeMOSYS (Open Source Energy Modeling System):

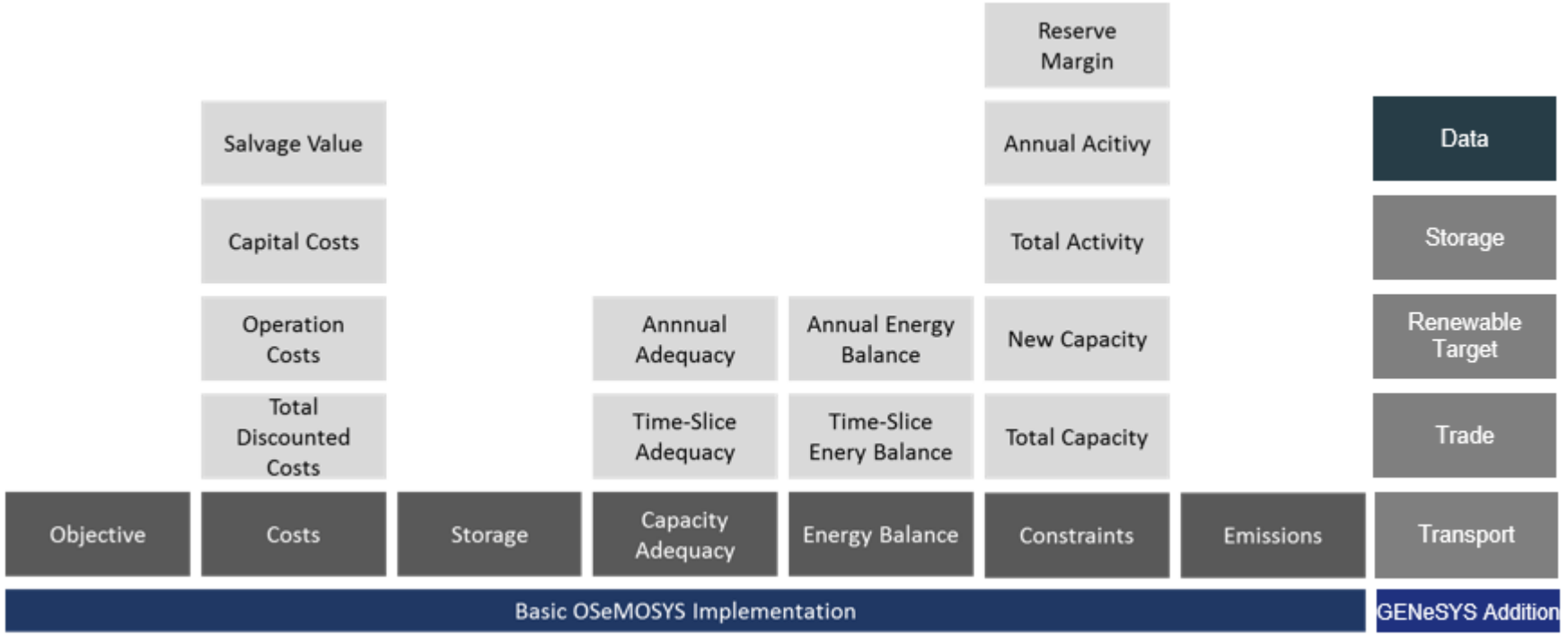
- **Cost-optimizing Linear Program** (LP)
- **Open-source** energy systems model
- Written in GMPL using a free GNU solver
- Mainly developed by KTH in Stockholm
- Available under: http://users.osemosys.org/

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 model data.
- For further information on GENeSYS-Mod see: Löffler et al. (2017): https://www.diw.de/documents/publikationen/73/diw_01.c.563040.de/dp1678.pdf



GENeSYS-MOD: Blocks of Functionality



Main improvements of GENeSYS-MOD include:

- a fully reworked trade system
- a new transportation block, introducing a modal split
- endogenous calculation of storage capacities

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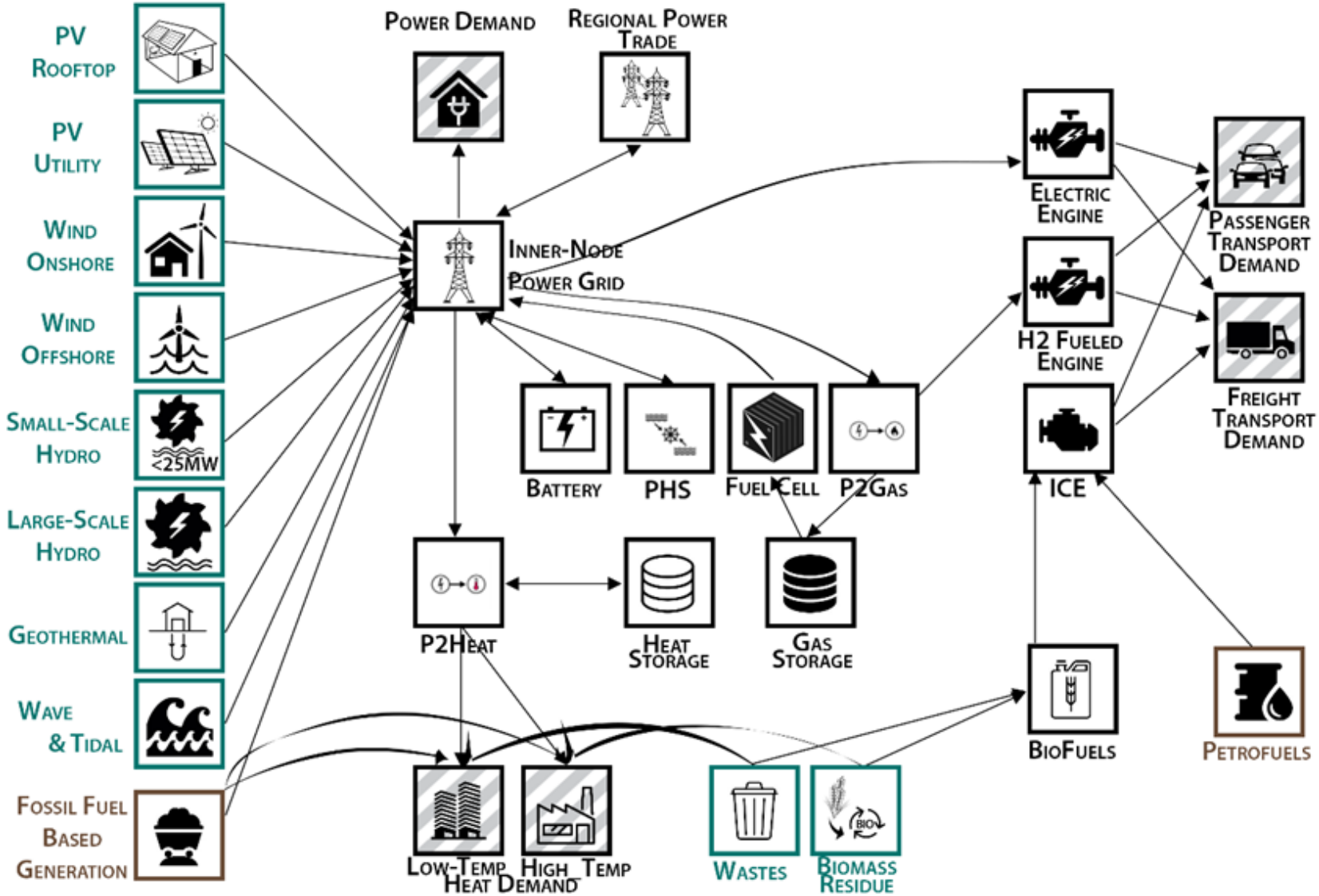
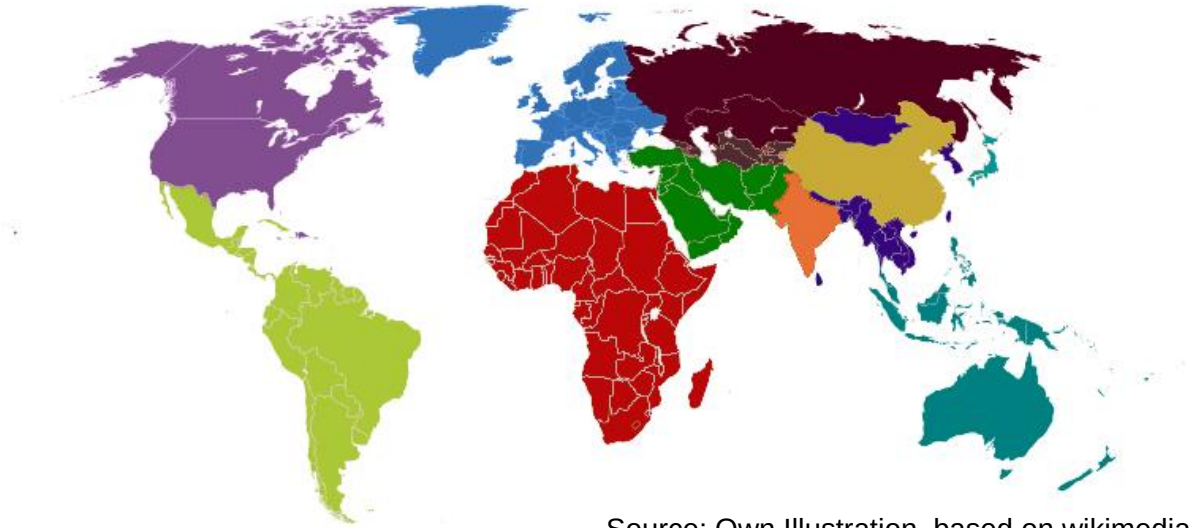
Model Design & Technologies



Model Specification and Implementation

Key Data and Constraints

- **10 regions** are considered which mostly consist of an aggregation of countries.
- The years 2020 - 2050 are modeled in **5-year steps**, with 2015 as a baseline.
- Demands and fossil fuel prices are fixed and based on the IEA 450ppm scenario datasets (World Energy Outlook 2015).
- The model considers **six time slices** in total: three seasons, each with a day/night cycle.
- The model sets a **renewable target of 100%** at the end of the modeling period (2050).
- Also, a global carbon budget in line with the Paris Agreement (**650 $GtCO_2$**) is set.



Source: Own Illustration, based on wikimedia

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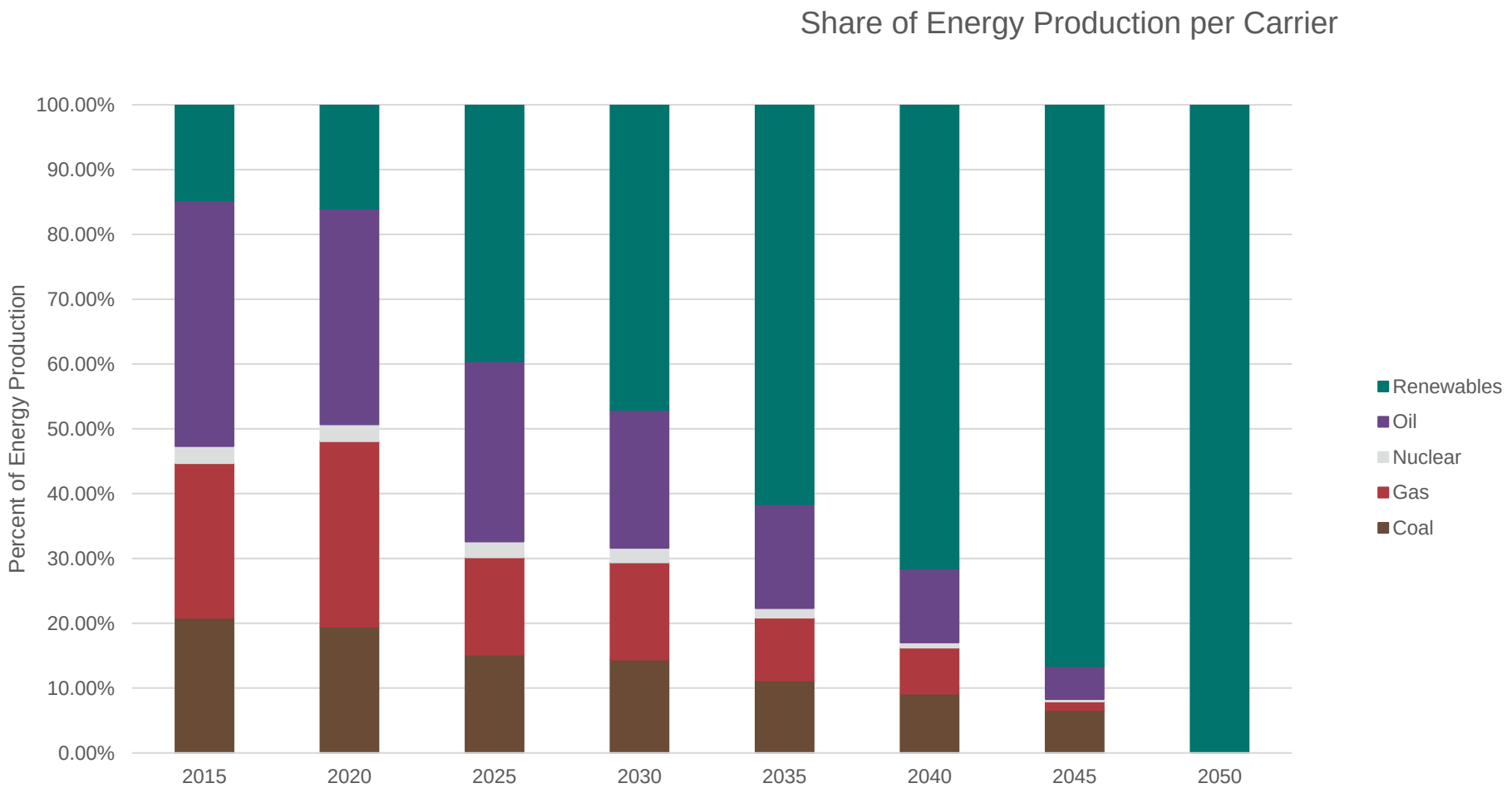
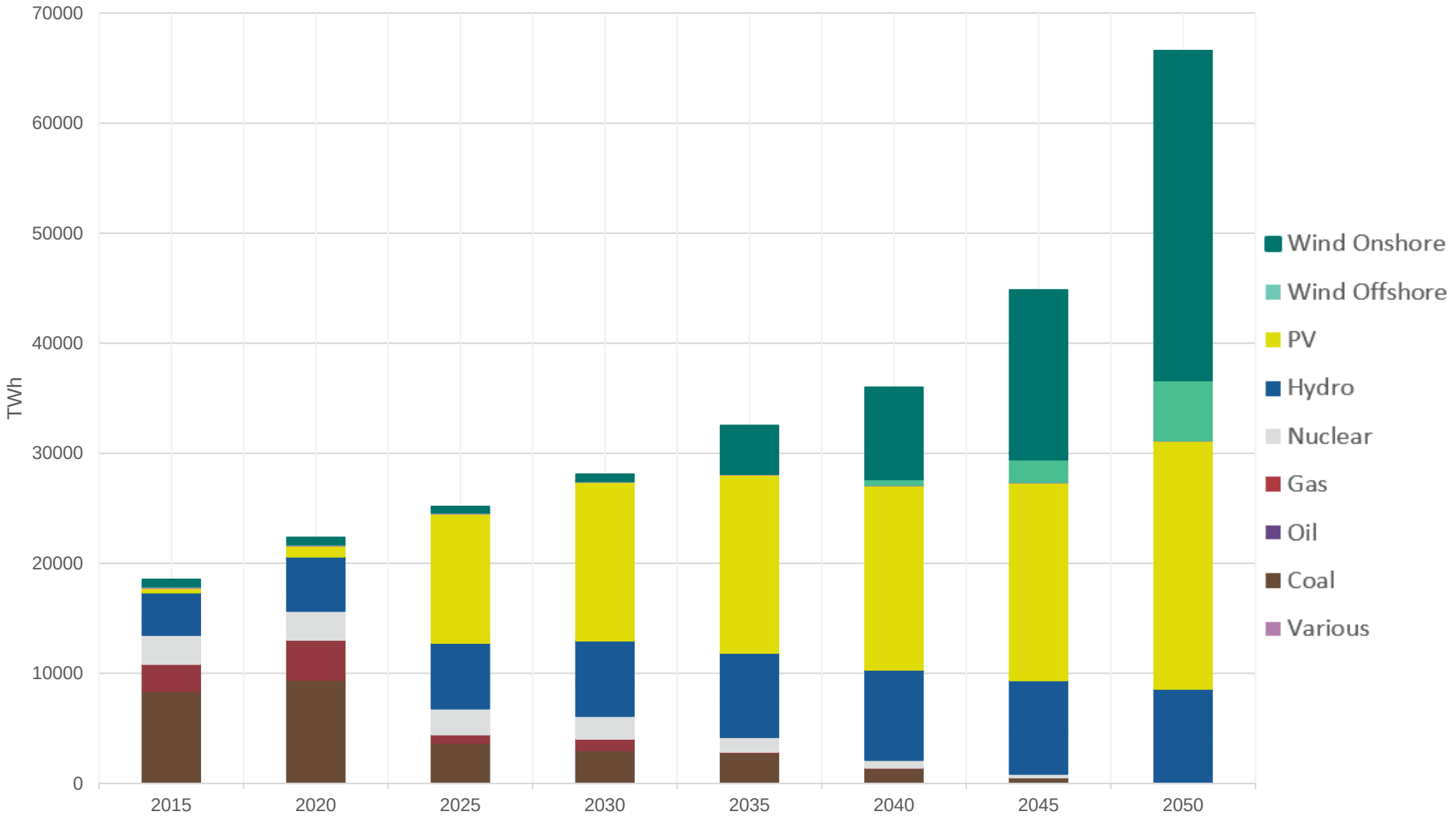
Energy Produced per Carrier in %



Source: Own Illustration

Global Development of Power Generation



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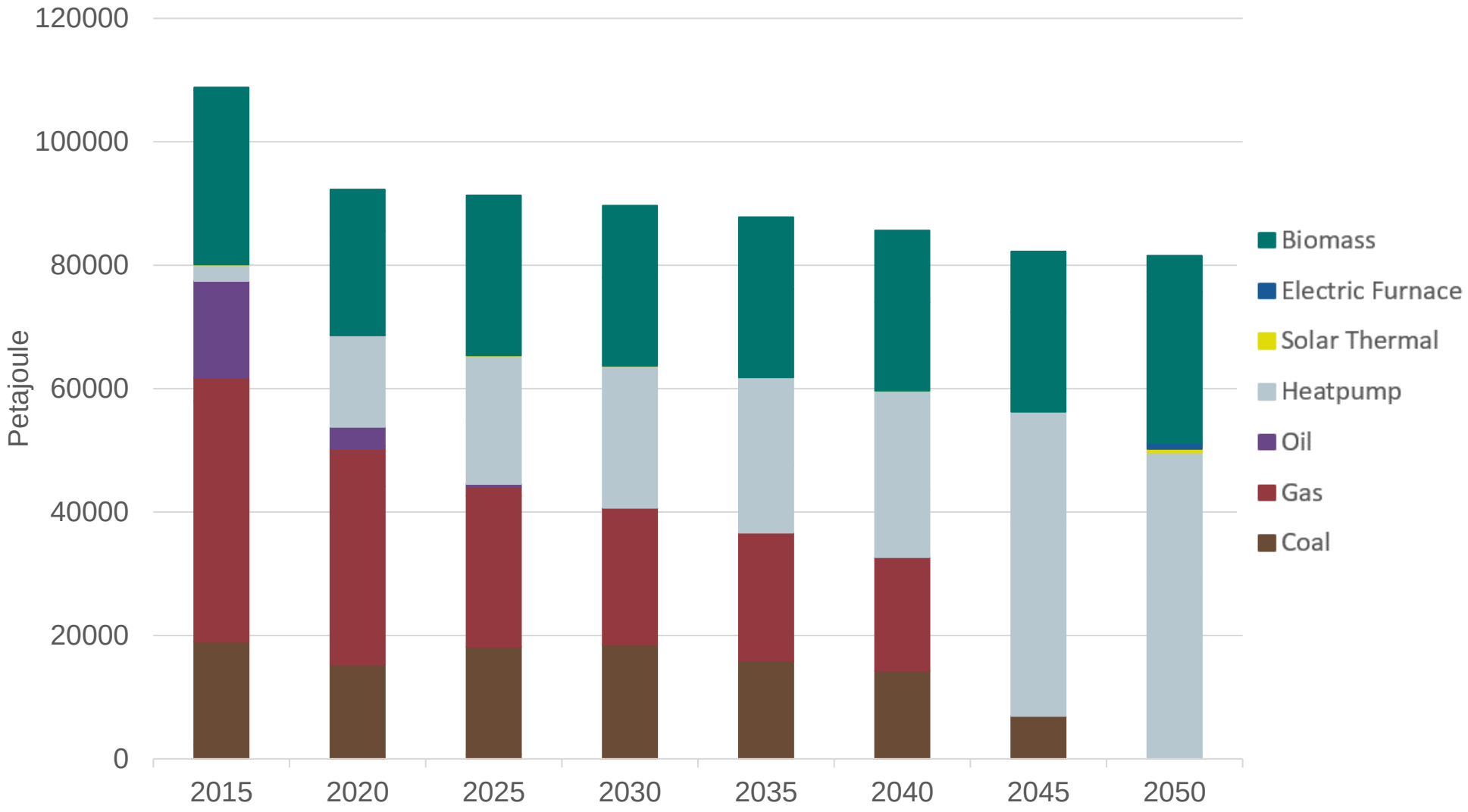
Global Development of Low-Temperature Heat Generation



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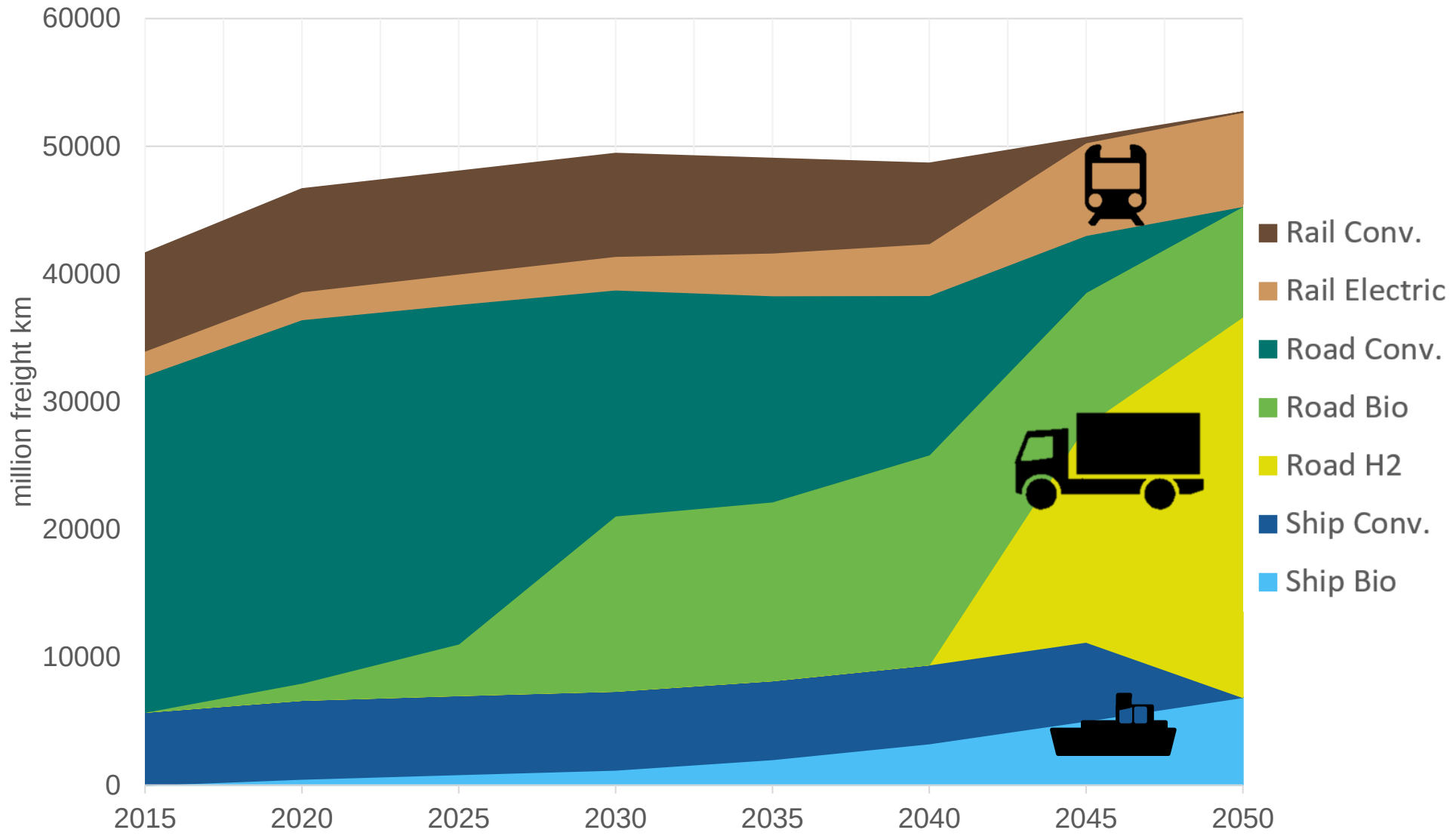
Global Development of Freight Transportation



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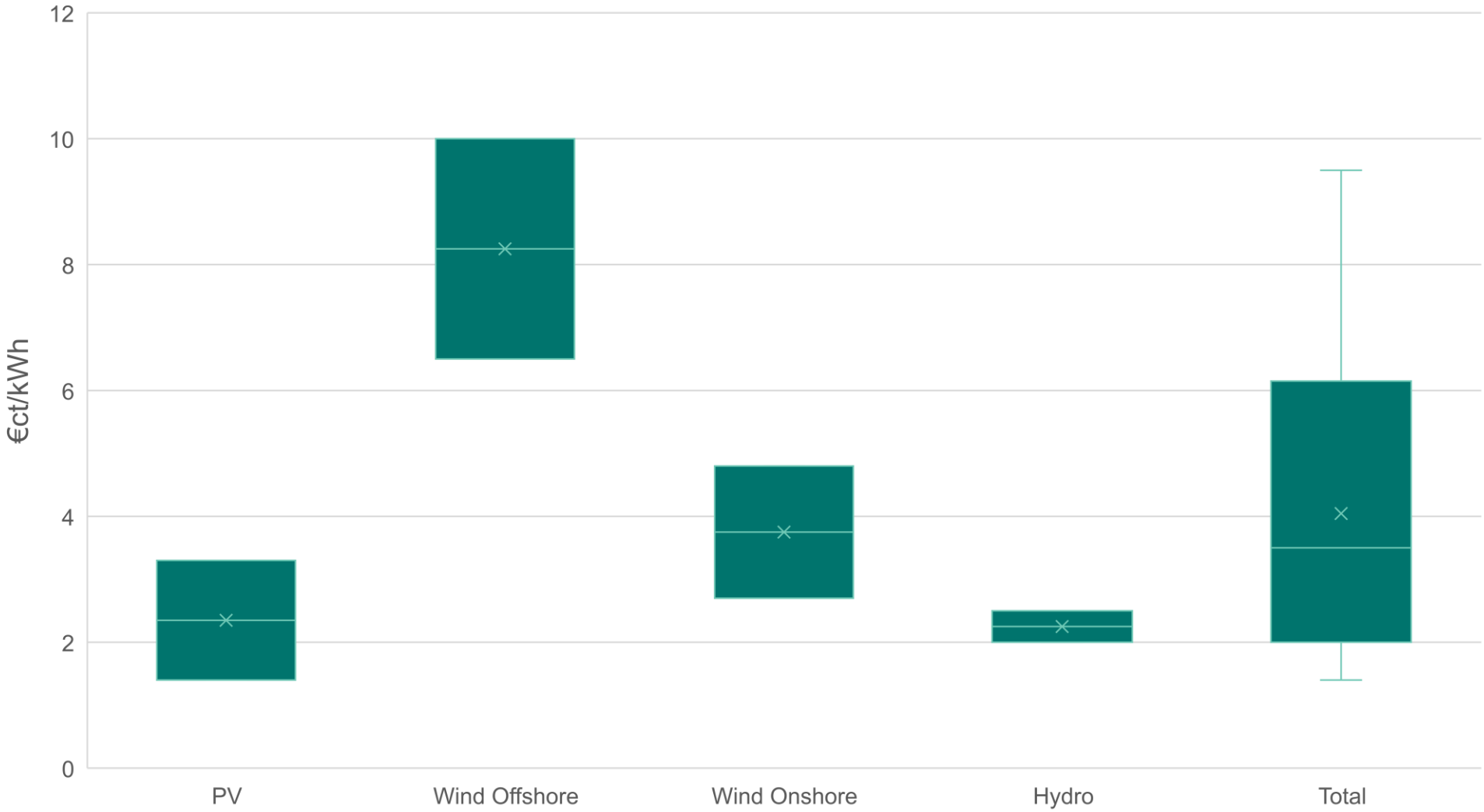
2050 Global Costs of Power Generation per Technology in €cents/kWh – Average of 4.04 €cents



Source: Own Illustration

Key Insigts from Sensitivity Analysis

- Fuel prices: Constant fuel prices, instead of rising prices as projected in IEA WEO 2015, are leading to a **higher share of natural gas** in the final energy mix.

- Storage costs: **Halved or doubled storage costs** have little to no impact on the optimal energy mix.

- PV prices: The **prices for PV modules are having a large impact** on the share of solar PV in the final energy mix. With double PV prices, offshore wind and biofuel based power generation are becoming the backbone of the energy system.

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Conclusion of our Model Results

Conclusion

- A global energy system largely based on renewable energy sources for the sectors power, heat and transport is technically possible and can be achieved at low cost.
- **Energy transformation in the power sector** is the easiest and cheapest, and it is thus the first to complete the shift towards renewables.
- A **strong sector coupling** between both the heat and transportation sectors with the power sector can be observed.
- Biomass is important for the **transportation and heating sector**, together with hydrogen.
- Wind is largely used as a resource in northern regions, while the south is dominated by PV coupled with more storage capacities.
- **But: we nee to get there ASAP!**

Further Research and Outlook

- Inclusion of infrastructure aspects, such as costs and endogenous grid expansions.
- Inclusion of Biomass in combination with carbon capture, transport, and storage (CCTS).
- Enhancement of the heating sector regarding available technologies.
- Better inclusion of local public transport in the transportation sector.
- Vehicle2Grid – inclusion of electric vehicles as a storage technology.

Thank you for your Attention!

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Article

Designing a Model for the Global Energy System—GENeSYS-MOD: An Application of the Open-Source Energy Modeling System (OSeMOSYS)

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