open ENTRANCE

Uncertainty in Energy System Modeling

Lessons from case studies with GENeSYS-MOD

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 835896

Europa-Universität Flensburg

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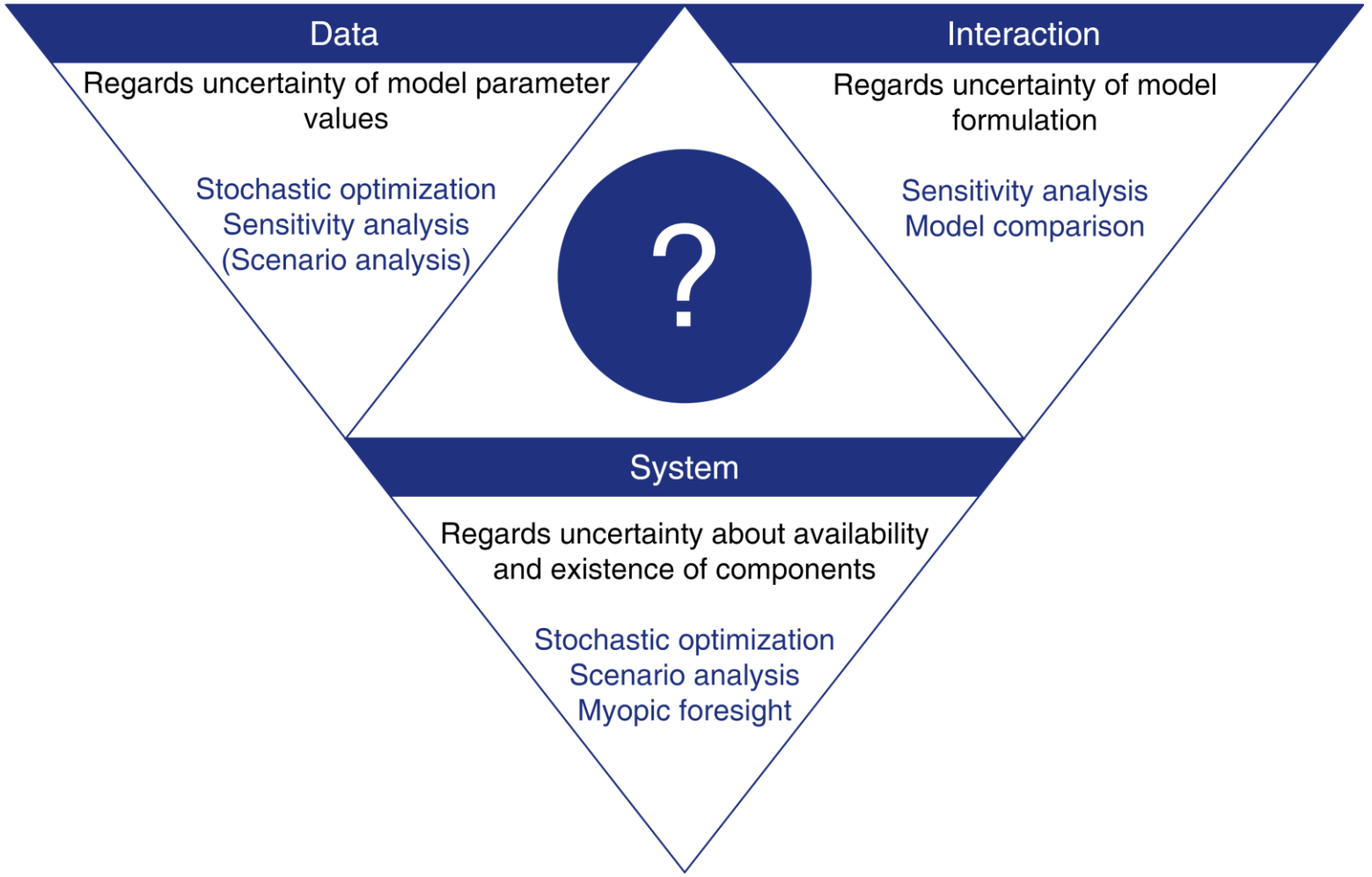
We deal with a lot of uncertainty in energy system modeling

- We face a lot of uncertainty in the energy system: past, present, and future
- Just to name a few:
  - Cost developments of batteries
  - Will nuclear fusion ever become viable?
  - How does the geopolitical landscape in 25 years look like?
- Different uncertainties require different methodologies to address them
- The question remains: In how far can we trust results from (deterministic) energy system models?

Types of uncertainty in modeling



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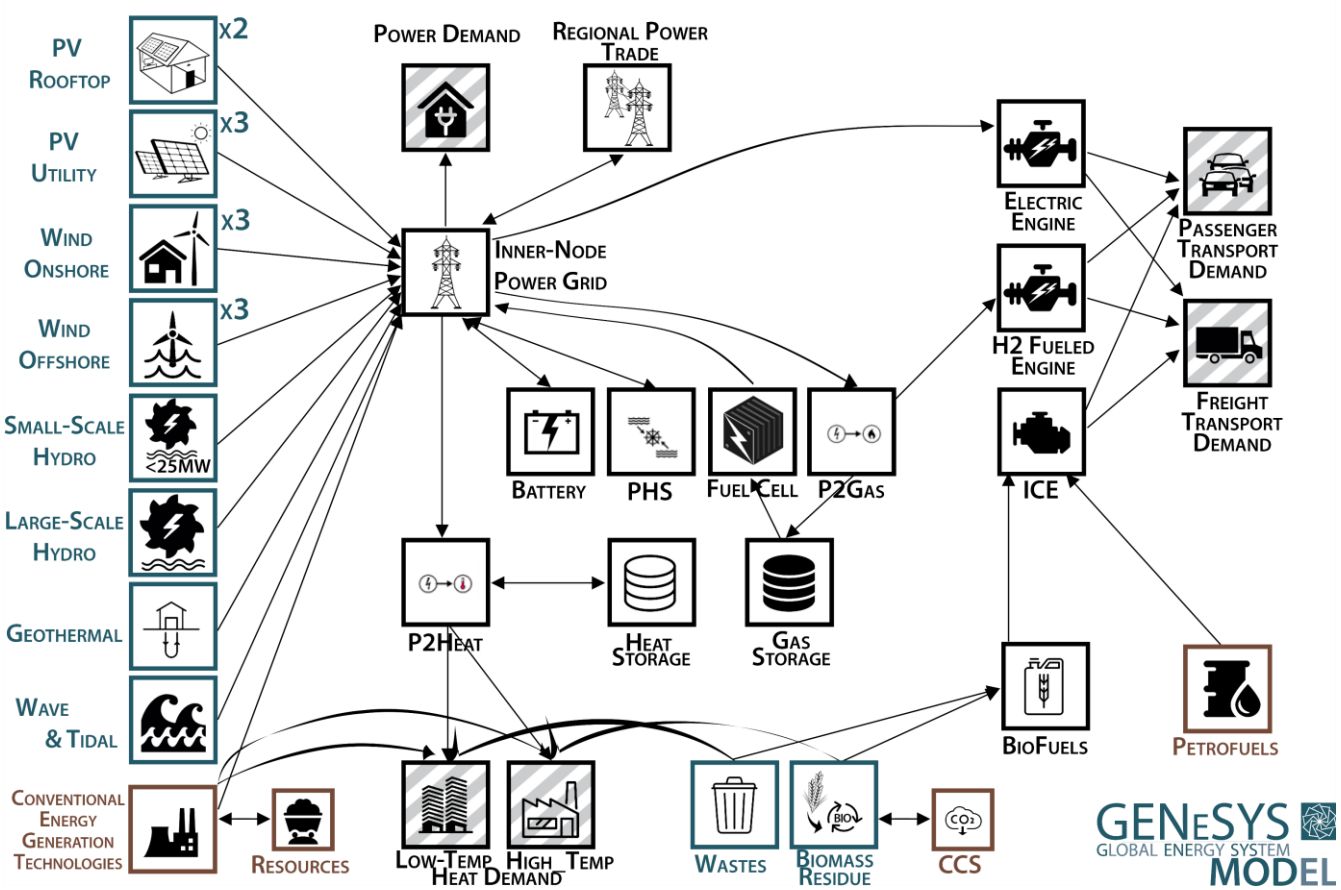
GENeSYS-MOD…

- … based on OSeMOSYS and developed since 2016
- …publicly available with model, data, and manual[1]
- Results in this presentation (mainly) based on European and German case-studies



[1] https://git.tu-berlin.de/genesysmod/genesys-mod-public

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Open-science as a major cornerstone

- Goes beyond open-source – data, source code, methodology, publications, etc. should all be publicly available
- Work benefits from higher exposure, possibility to get validated, and others can build upon it
- Most crucially: adequate result communication requires the possibility to replicate not only the results but also methodology and assumptions
- However: barriers are still high when trying to use other developer's frameworks

Open-science as a major cornerstone

- Goes ations, etc. s
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Key takeaways and messages

- Accounting for uncertainty adds layers of robustness to analysis and is crucial when communicating these results to policy and decision makers

- No-regret options:
  - No new fossil fuel capacities required, they rather put the decarbonization at risk
  - No room for delayed action
  - Electrification is key, hydrogen most likely only in a complementary role
  - Focus on energy demand reduction measures in the long-term, carbon price in the medium-term

Energy demand important factor in decarbonization's success

- Reducing energy demand shows the strongest effect on many indicators like emissions, installed capacities and system costs
- These effects are most pronounced in the long-term (2040-2050)
- While efficiency improvements can play a role in reducing energy demand, sufficiency proves to be more effective but also more difficult to target as a policy or decision maker

Energy demand important factor in decarbonization's success

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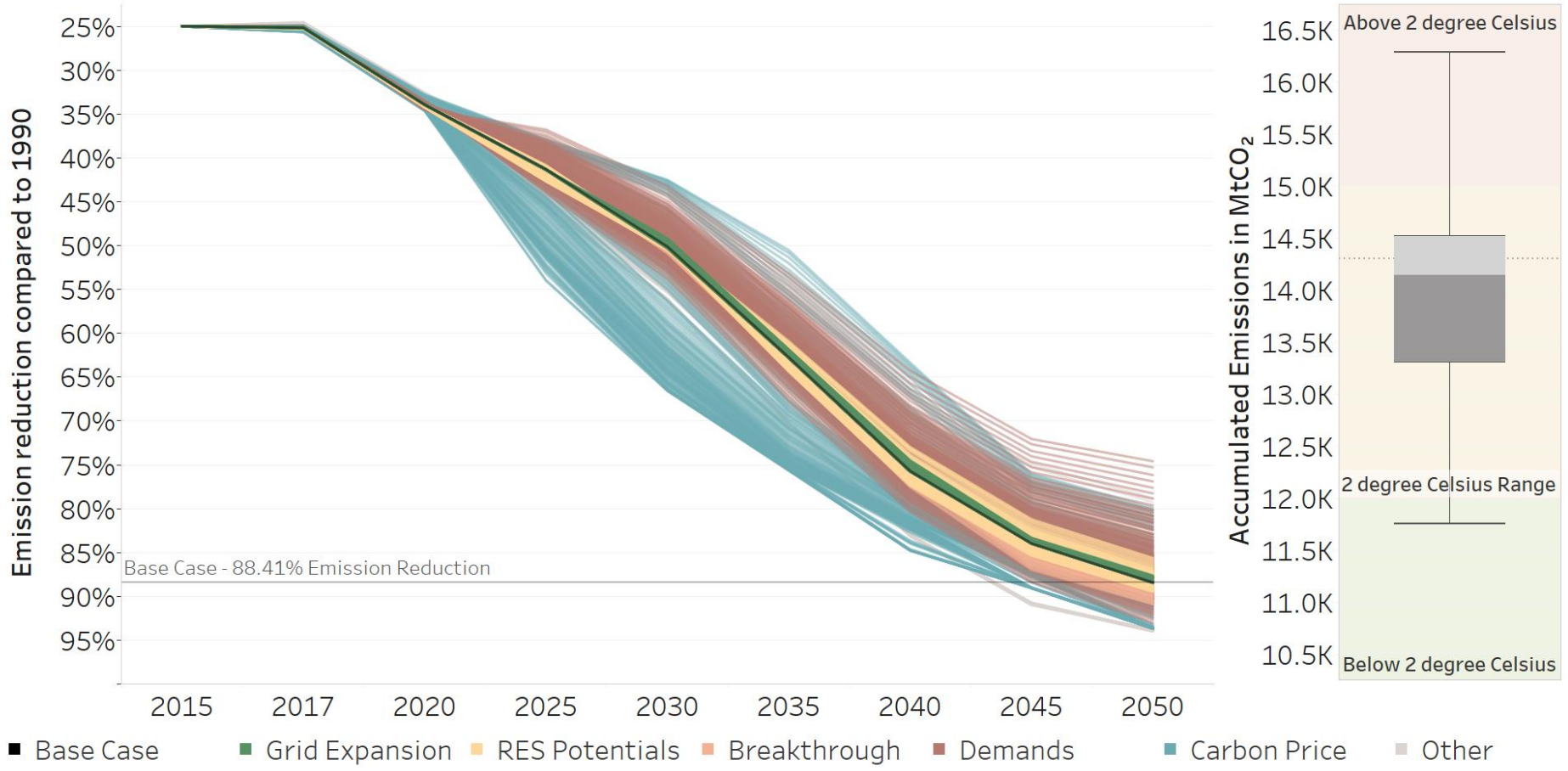

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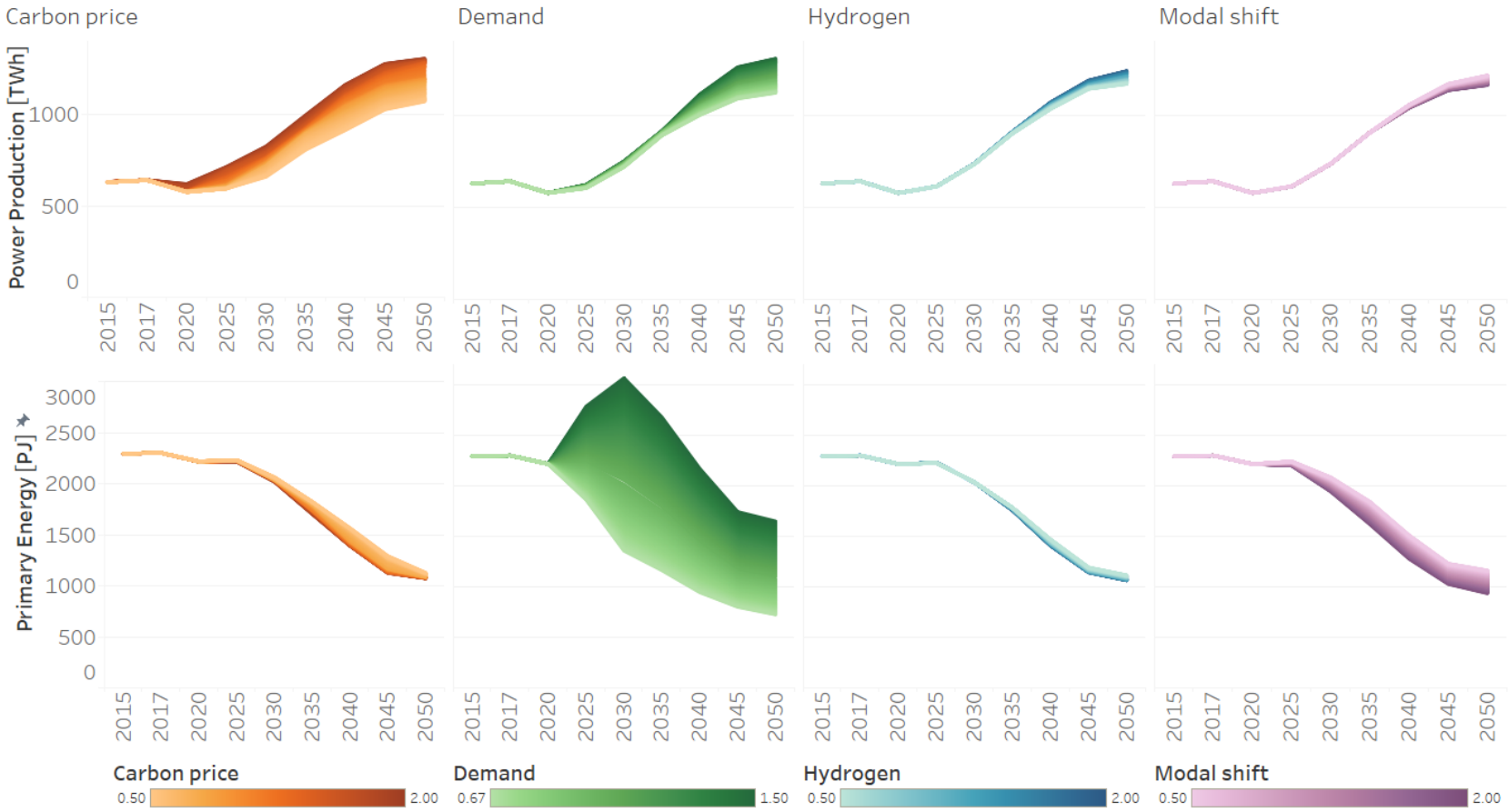
Carbon price effective, but mostly in the medium-term



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Additional fossil capacity expansions most likely end up being stranded

- Short-sighted decision making can put the decarbonization's success at risk
- Case-study focusing on Europe with three scenarios, simulating myopic foresight
- If long-term requirements and developments are ignored, significant stranded assets as a result
- Of course we face short-term problems, especially nowadays – but long-term goal should has to be considered when solving them

Additional fossil capacity expansions most likely end up being stranded

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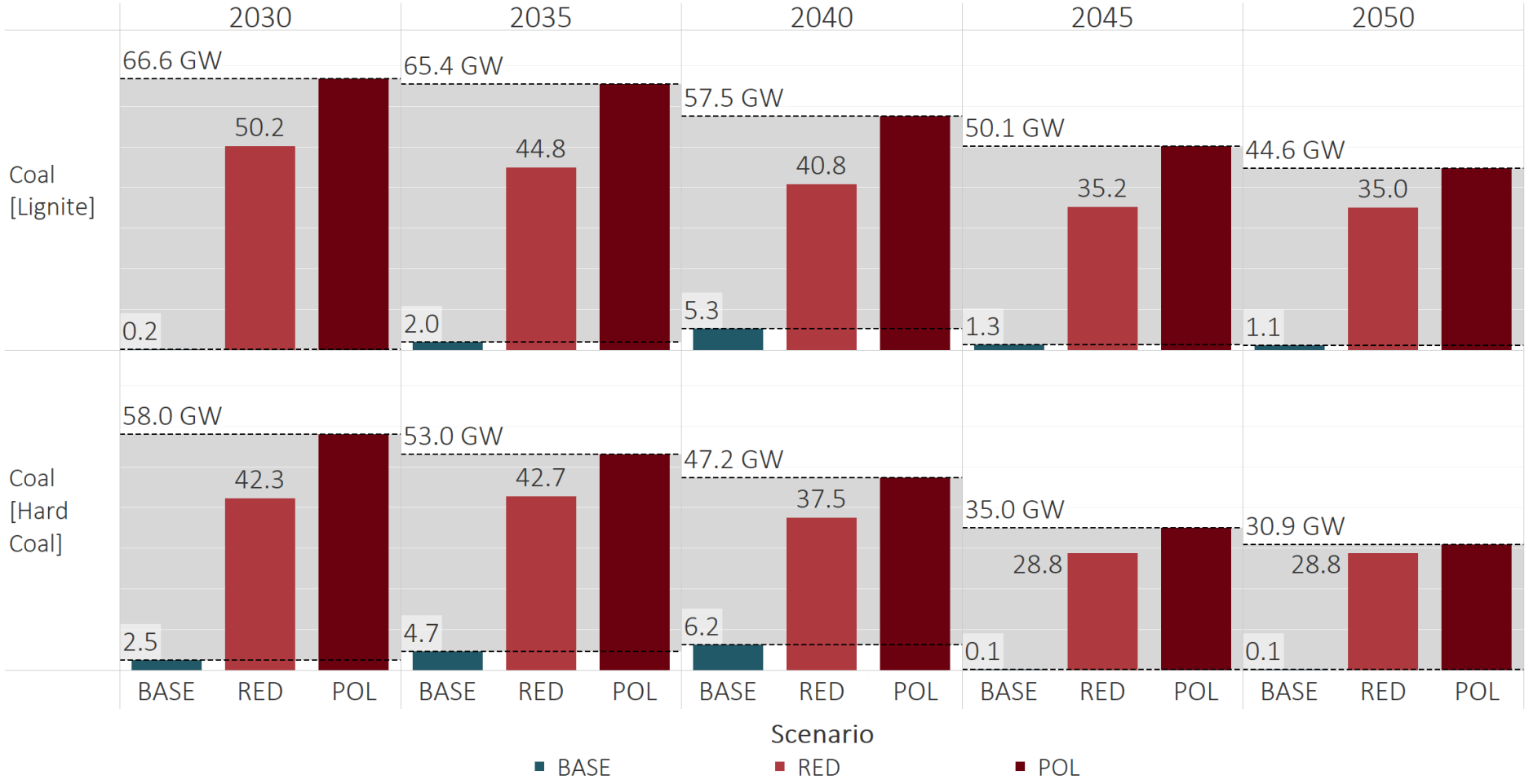

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Electrification is key, cheap hydrogen can play an important role in certain industries

- Cheap and available hydrogen will play a role mainly in industry, while recent trends in transportation showcase a declining role
- A limited reliance on hydrogen will also result in reduced import dependency for many countries
- Including stochasticity into energy system modeling and imperfect foresight can lead to substantially increased requirements on the system: in terms of overall costs, capacity levels, etc.

Burandt, Thorsten (2021): *„Analyzing the necessity of hydrogen imports for net-zero emission scenarios in Japan"* in Applied Energy 298 (2021); DOI: https://doi.org/10.1016/j.apenergy.2021.117265

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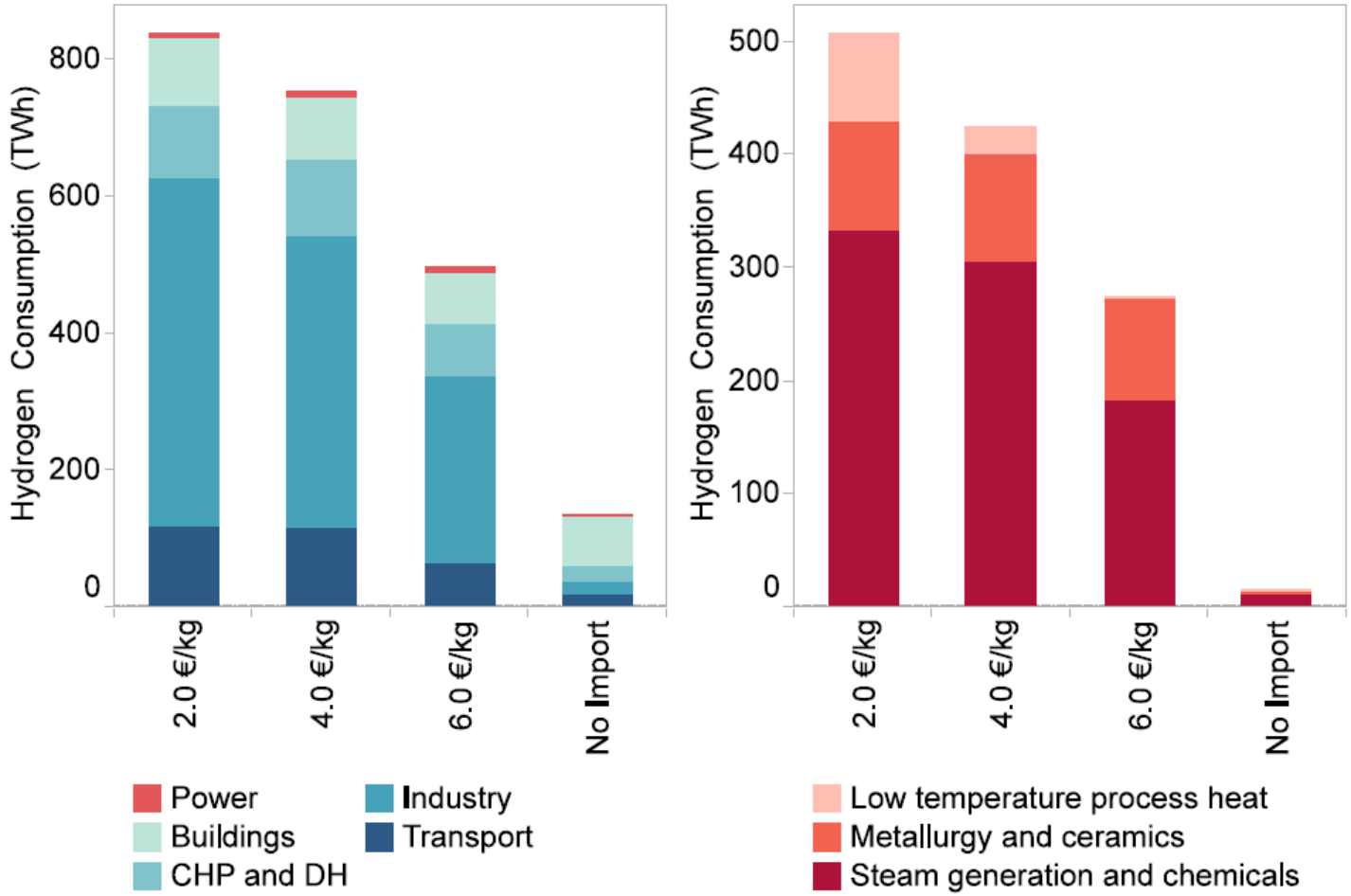

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Key takeaways and messages

Thank you for your attention!

Dr. Karlo Hainsch
k.hainsch@tu-berlin.de

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