SPATIO-TEMPORAL ANALYSIS OF SECTOR COUPLING PATHWAYS:

Combining top-down and bottom-up approaches for the German case

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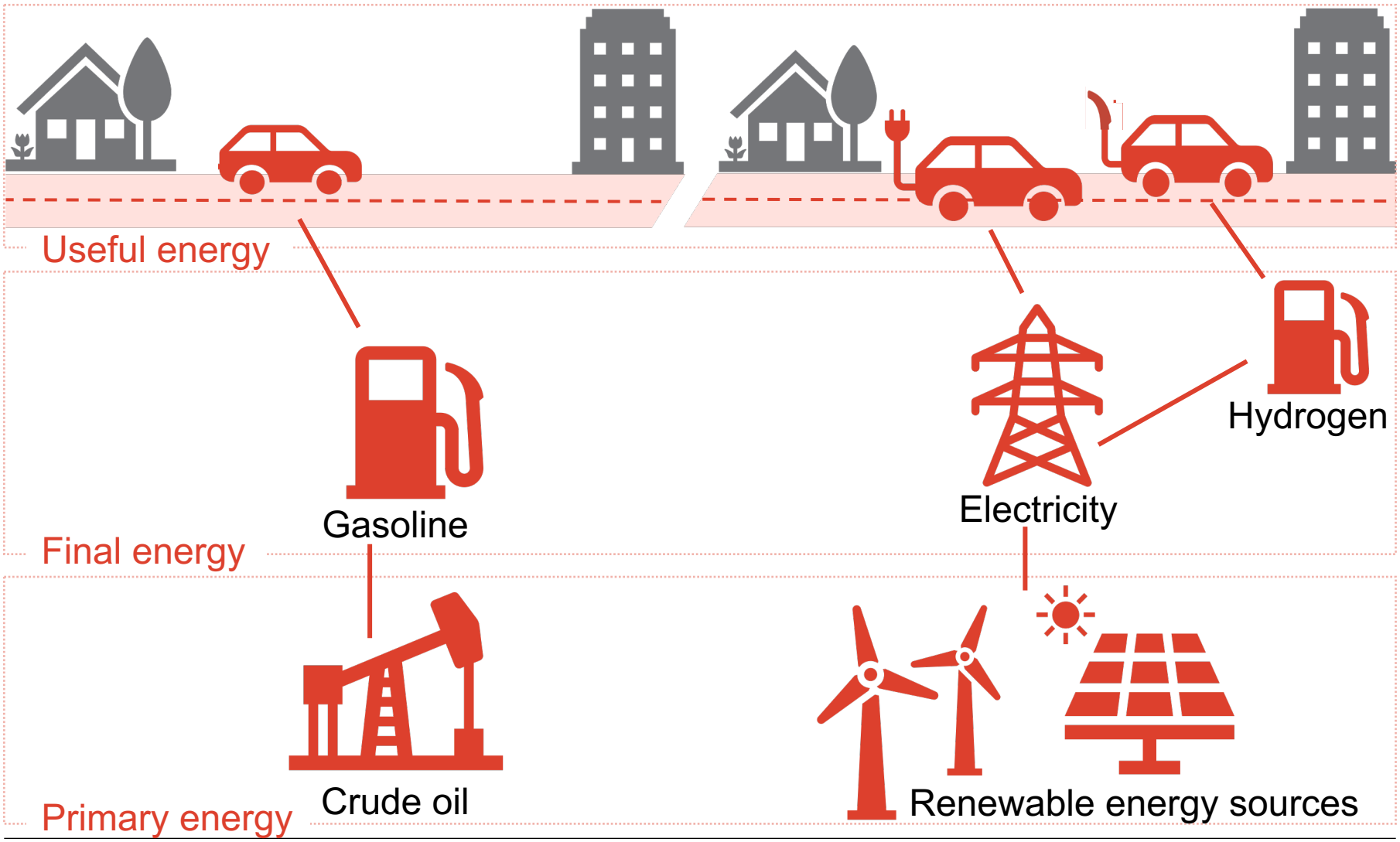
FCN | Future Energy Consumer Needs and Behavior | E.ON Energy Research Center | RWTH AACHEN UNIVERSITY

Sector coupling enables the possibility of transferring decarbonization potential from the power sector to other sectors



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Spatio-temporal resolved useful energy consumptions are required for essential energy system analysis

Supply side:

- **Expansion** of renewable energy source-based capacities
- Energy output and **generation profile** depend on geographical locations
- **Weather-depended** feed-in

Demand side:

- **Sector coupling** results in **uncertainty** how **useful energy consumption** is met by which **final energy carriers**
- **Final energy carriers** can be provided by **different primary** energy carriers

Research question

*How can **demands** for **useful energy** be estimated based on available data in a **temporally and spatially** highly disaggregated resolution?*

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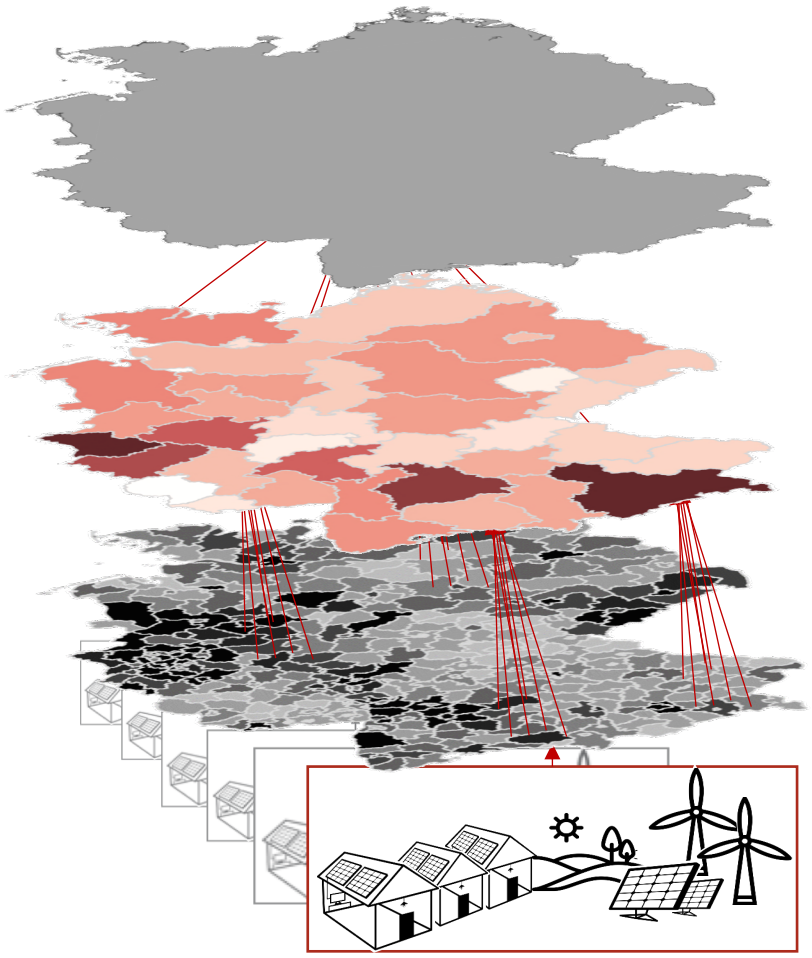
Spatio-temporal disaggregation and aggregation



Disaggregation

Top-down approaches

Raw data on NUTS0 (national level)

E.g., annual energy demand and supply based on energy balances, input-output-tables, GDP

Level of our analyses: NUTS2

- 38 counties within Germany

Aggregation

Bottom-up approaches

Raw data on NUTS3 level (401 regions in Germany)

E.g., number of employees, number and type of houses

Geo-referenced data

E.g., location and feed-in potential of a single wind power plant

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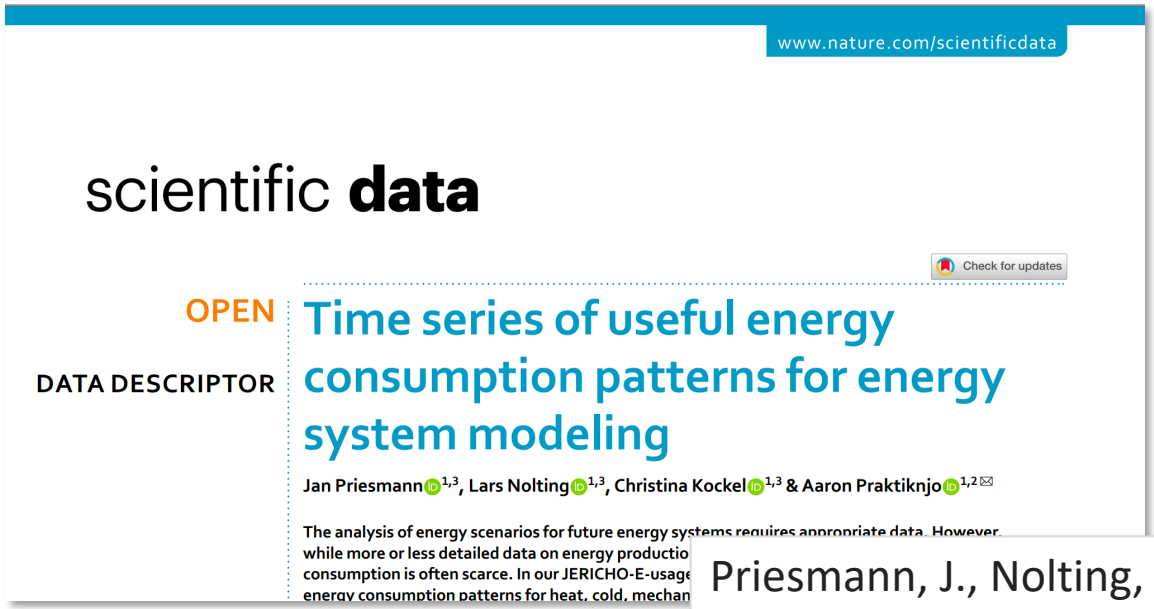
Methodology and data sets are available online open source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DATA DESCRIPTOR

Time series of useful energy consumption patterns for energy system modeling

Jan Priesmann[1,3], Lars Nolting[1,3], Christina Kockel[1,3] & Aaron Praktiknjo[1,2]

The analysis of energy scenarios for future energy systems requires appropriate data. However, while more or less detailed data on energy productio
consumption is often scarce. In our JERICHO-E-usage
energy consumption patterns for heat, cold, mechan

Priesmann, J., Nolting, L., Kockel, C., Praktiknjo, A. Time series of useful energy consumption patterns for energy system modeling. *Sci Data* **8,** 148 (2021). https://doi.org/10.1038/s41597-021-00907-w

Accessible online via this link or QR code:

https://www.nature.com/articles/s41597-021-00907-w

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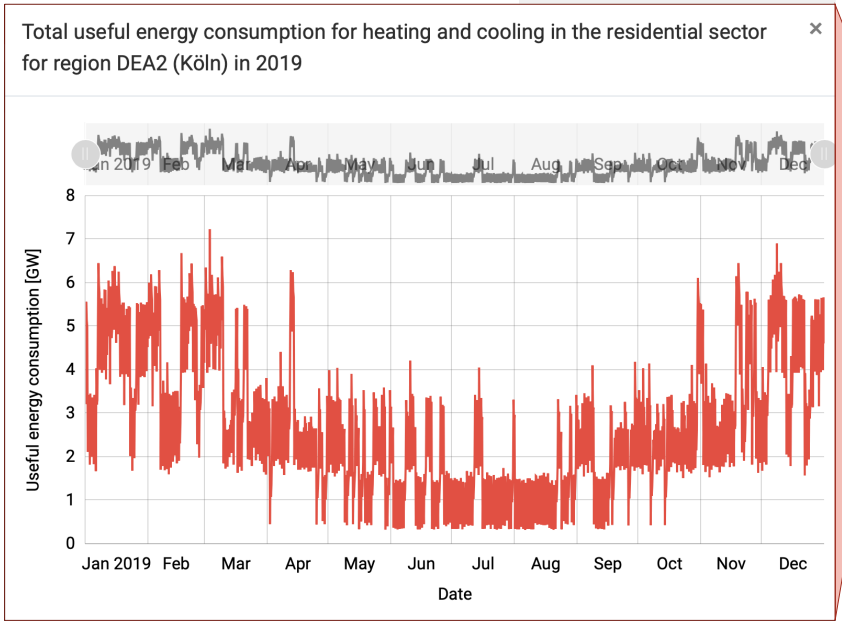
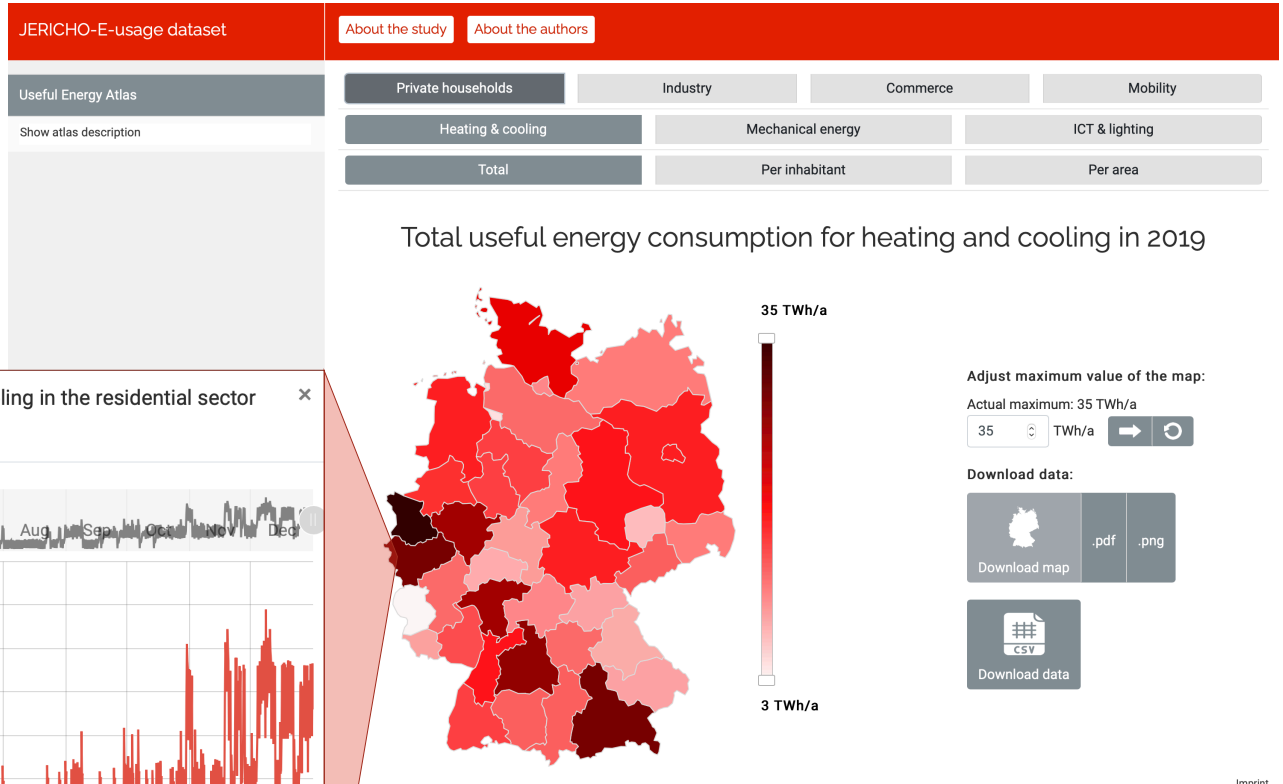
Hourly resolved time series for useful energy demand 38 regions in Germany

JERICHO-E-usage dataset is online available.

Example of a map and time series for heating and cooling demand in the residential sector.





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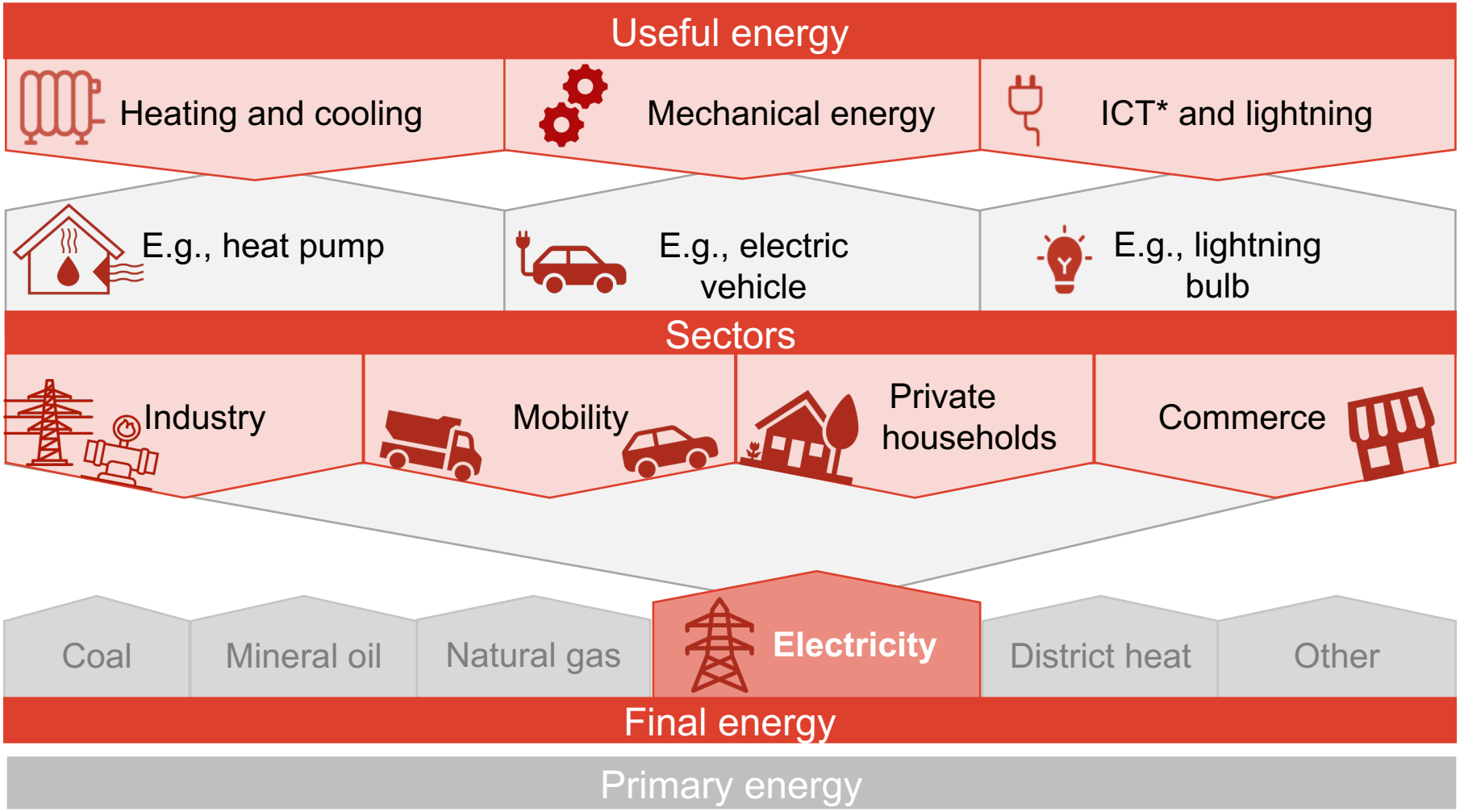
Final energy consumption including demand for sector coupling technologies can be estimated



*Information and communication technology

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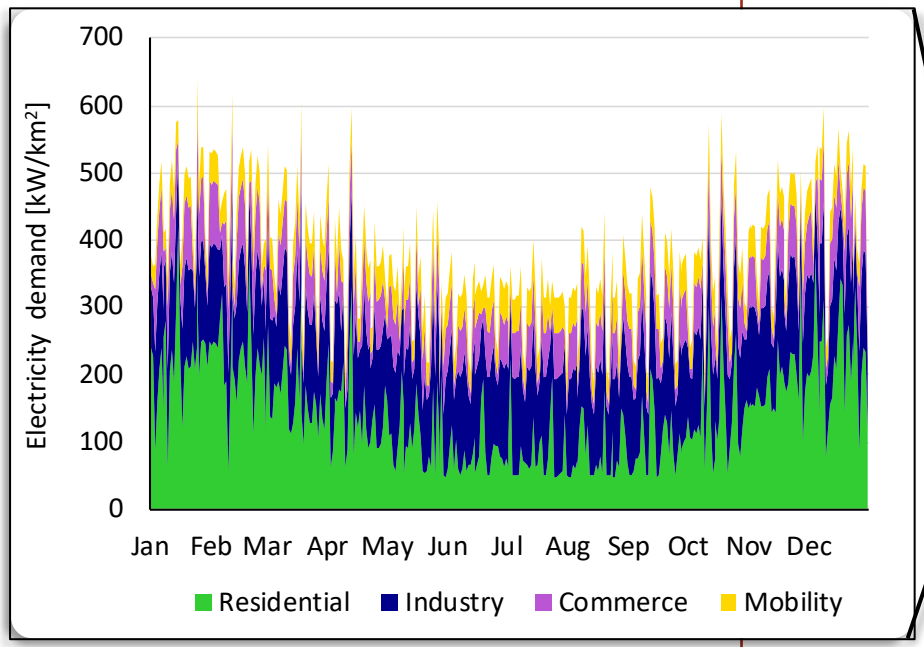
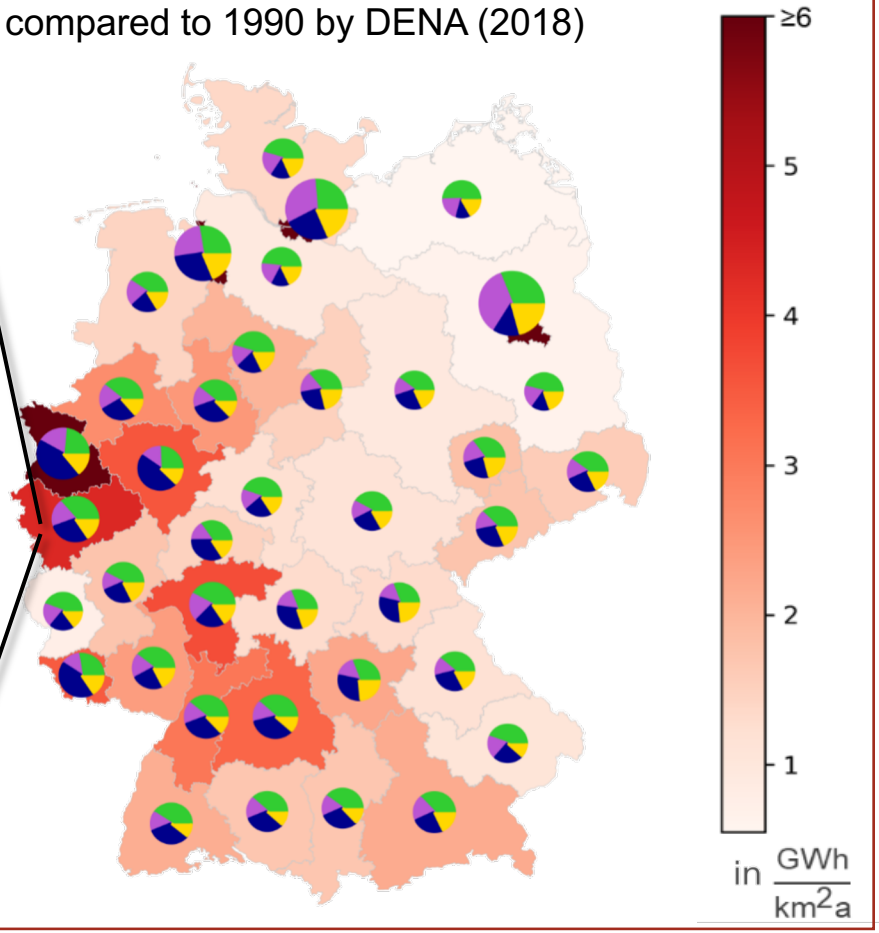
Resulting spatial and time resolved electricity demand for Germany

For a 95% GHG emission reduction scenario:

Based on technology-mix scenario for 95% GHG emission reduction compared to 1990 by DENA (2018)





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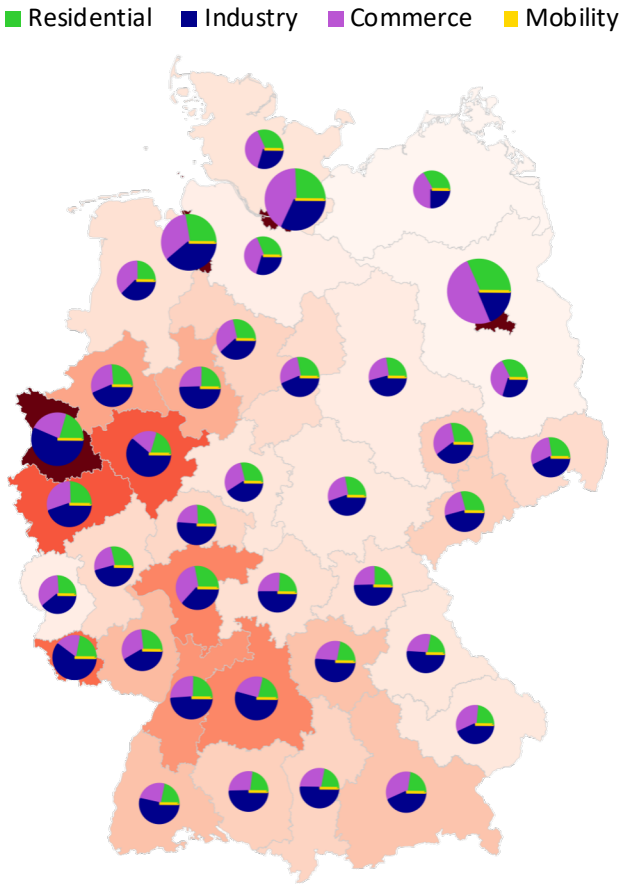
Status Quo:

For the year 2019



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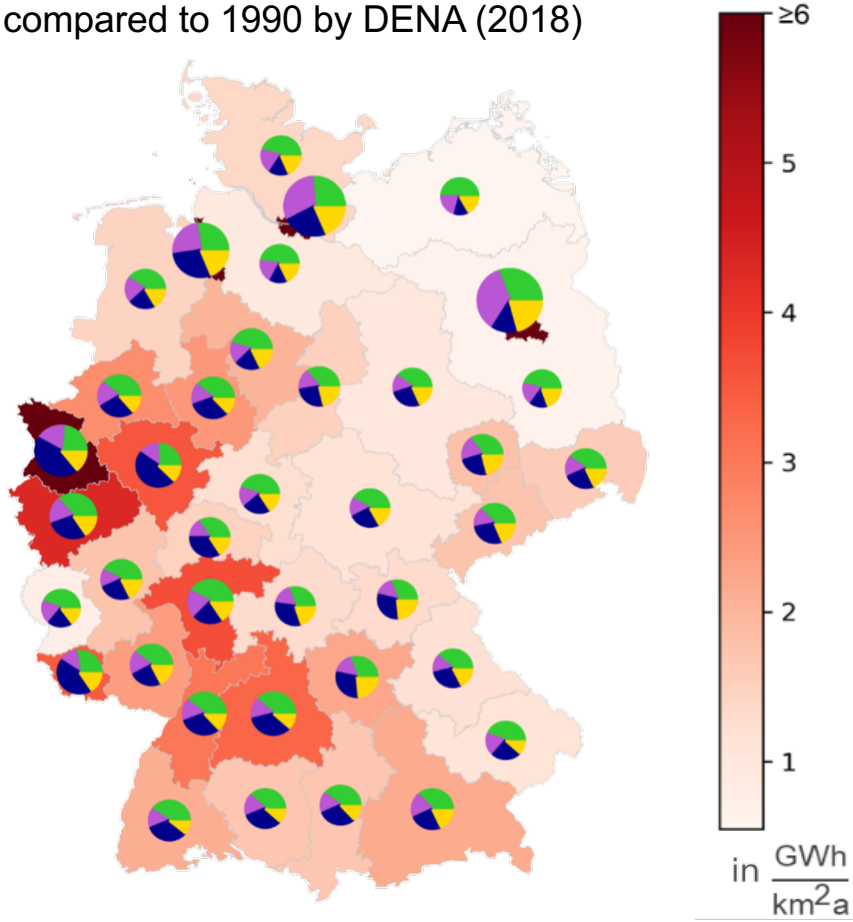

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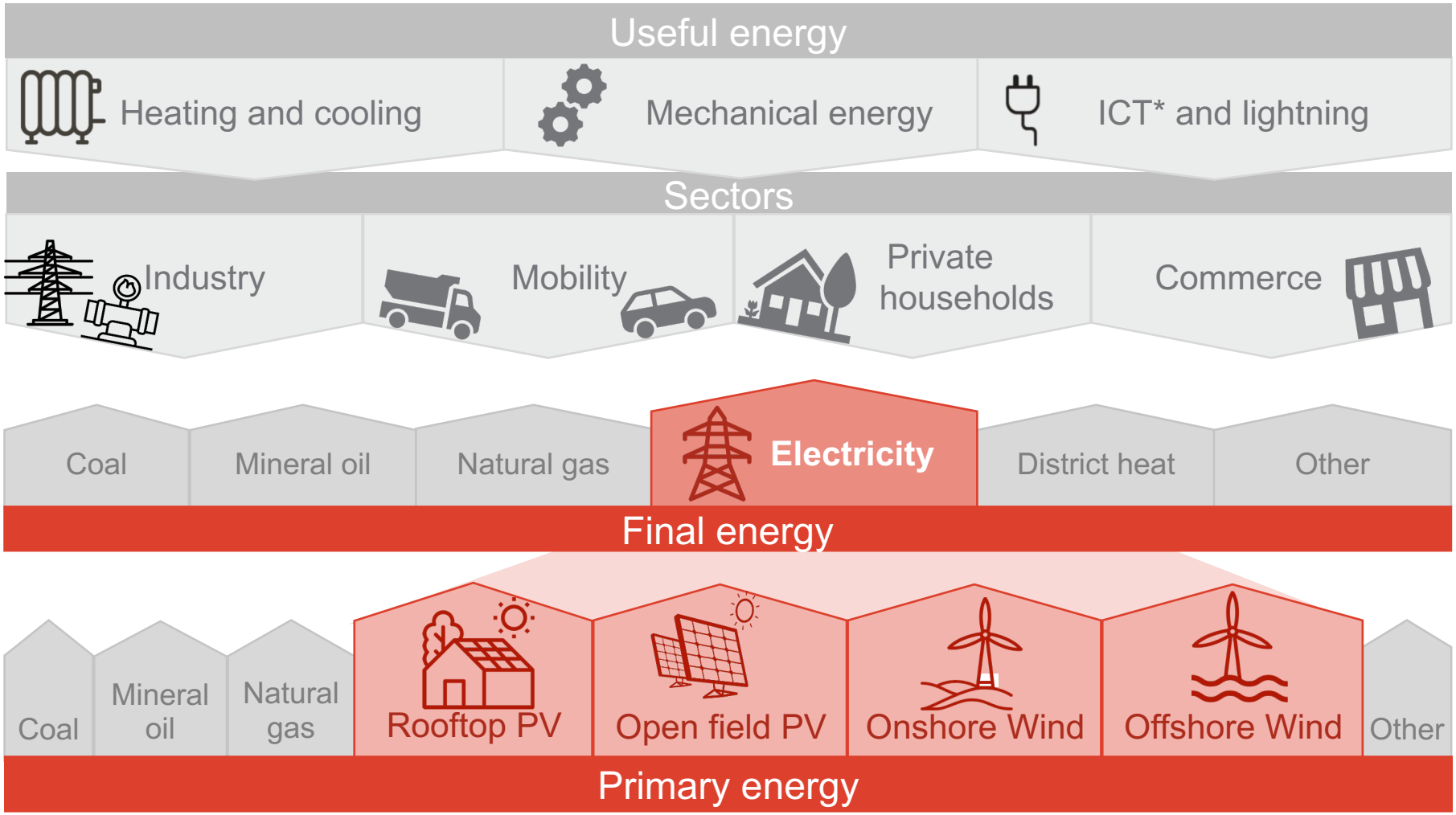
Analyses for renewable resources based on the demand-oriented final energy data



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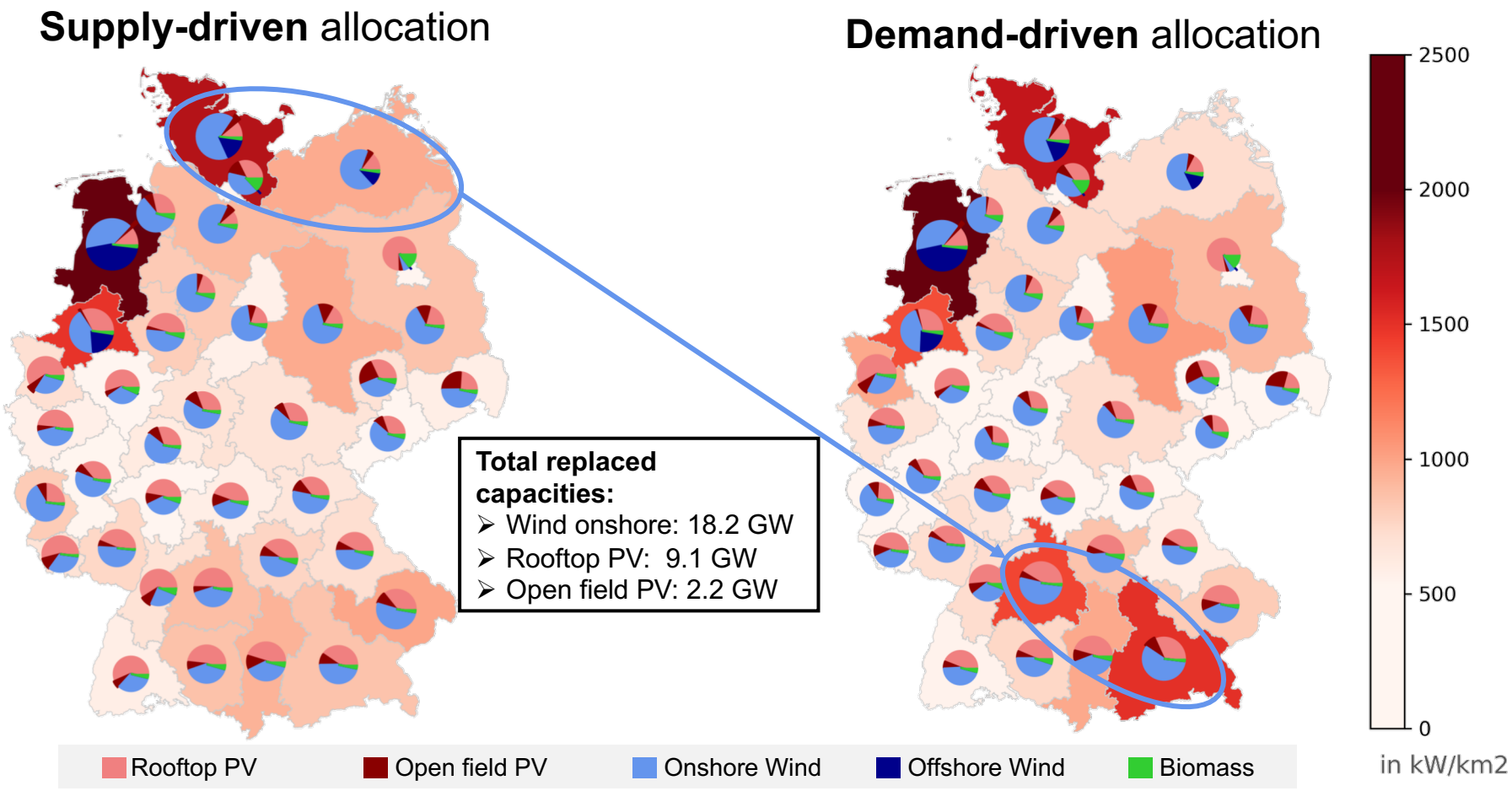
Difference demand- or supply-driven allocation of placement of RES-based capacities

Exemplarily shown for the expansion requirements of 95% GHG emission reduction scenario by DENA (2018)



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Contribution of our research can be twofold:

Data sets for German energy system analysis

- **Temporally and spatially** resolved useful energy consumption in Germany for the year 2019
- **Available** online

Methodology

- Methodology of **combining top-down and bottom-up approaches**
- Approach **transferable** to other regions

Level of detail for useful **energy demand** allows essential analysis for **current** and **future challenges** within the energy systems

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Thank you for your attention!

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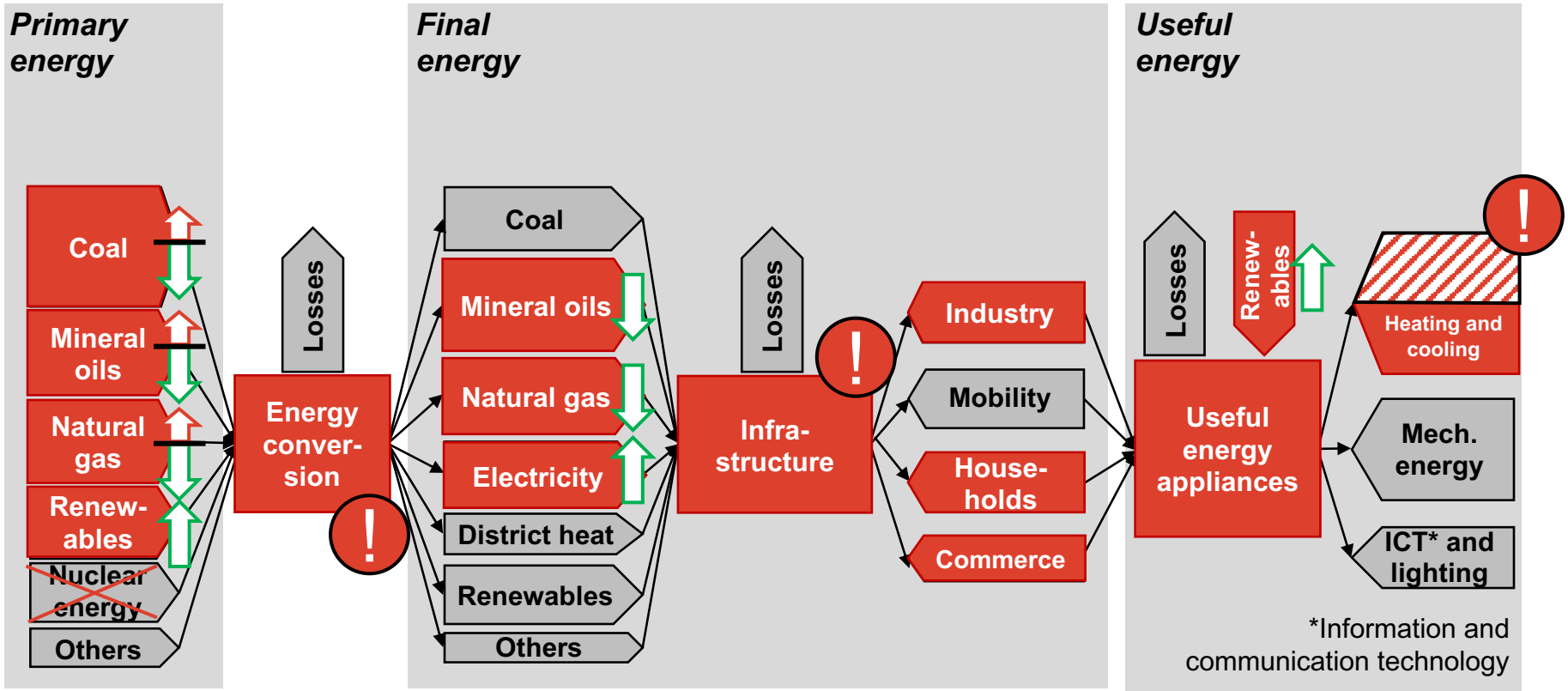

Overview of energy flow charts based on Zweifel et al. (2017)[1]

[1] *Zweifel, P., Praktiknjo, A., Erdmann, G., 2017. Energy economic – Theory and Applications, Springer*

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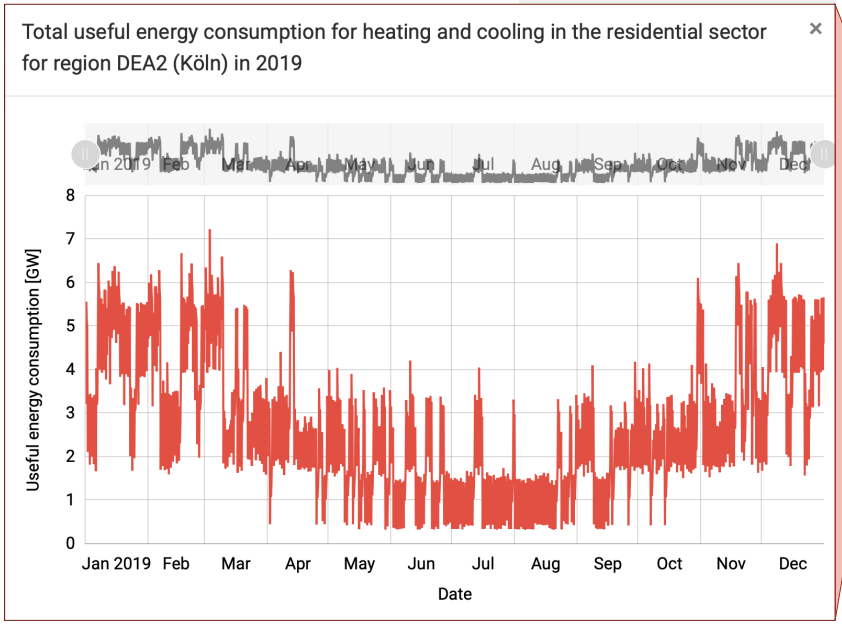

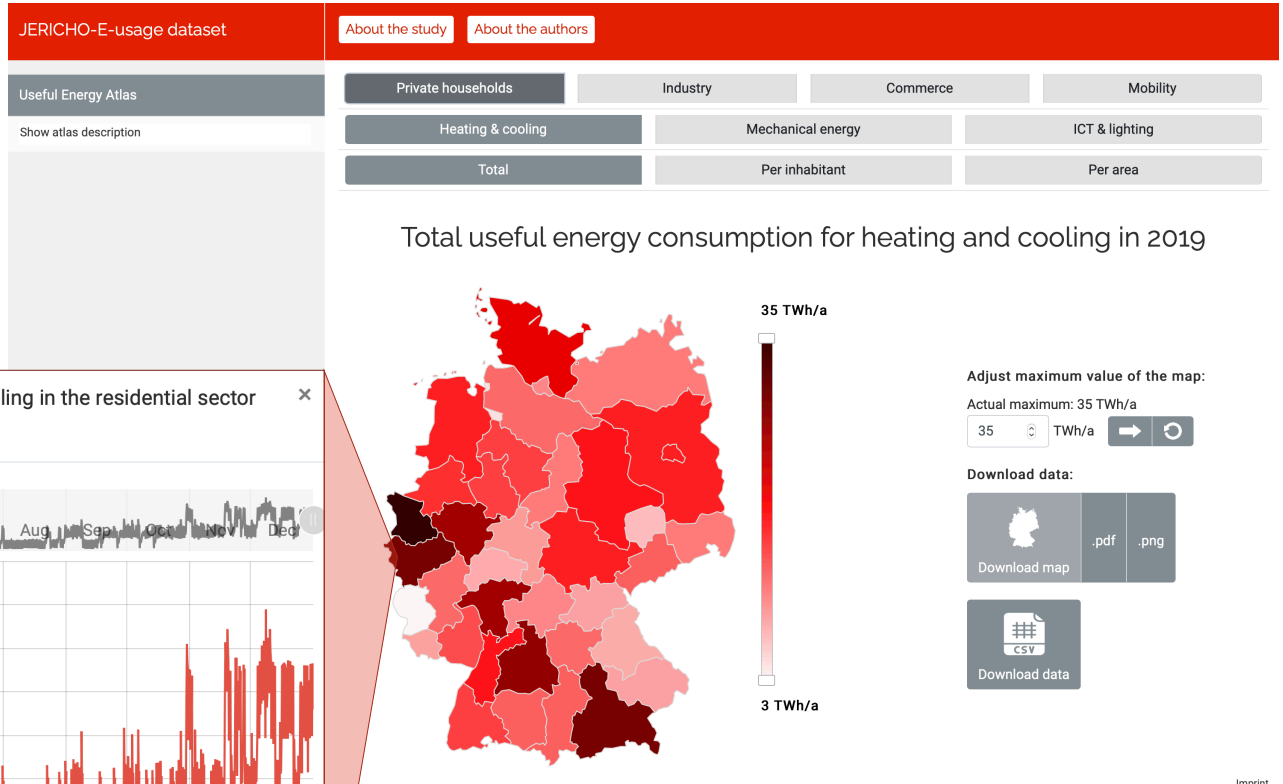

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Validation

Legend

Relative deviation	Absolute deviation [TWh/a]	Color
< 10%	-	
> 10%; < 20%	< 0.5	
> 10%; < 20%	> 0.5; < 3	
> 20%	< 0.5	
> 10%; < 20%	> 3	
> 20%	> 0.5; < 3	
> 20%	> 3	
Not applicaple		

		Useful energy								Final energy			
		Space heating	Hot water	Process heating	Space cooling	Process cooling	Mechanical	Information	Light	Mineral oils	Gas	Electricity	Biomass and waste
DEA*	Residential												
	Industrial												
	Commerce												
	Mobility												
DE3**	Residential												
	Industrial												
	Commerce												
	Mobility												
DE8*	Residential												
	Industrial												
	Commerce												
	Mobility												
DED*	Residential												
	Industrial												
	Commerce												
	Mobility												

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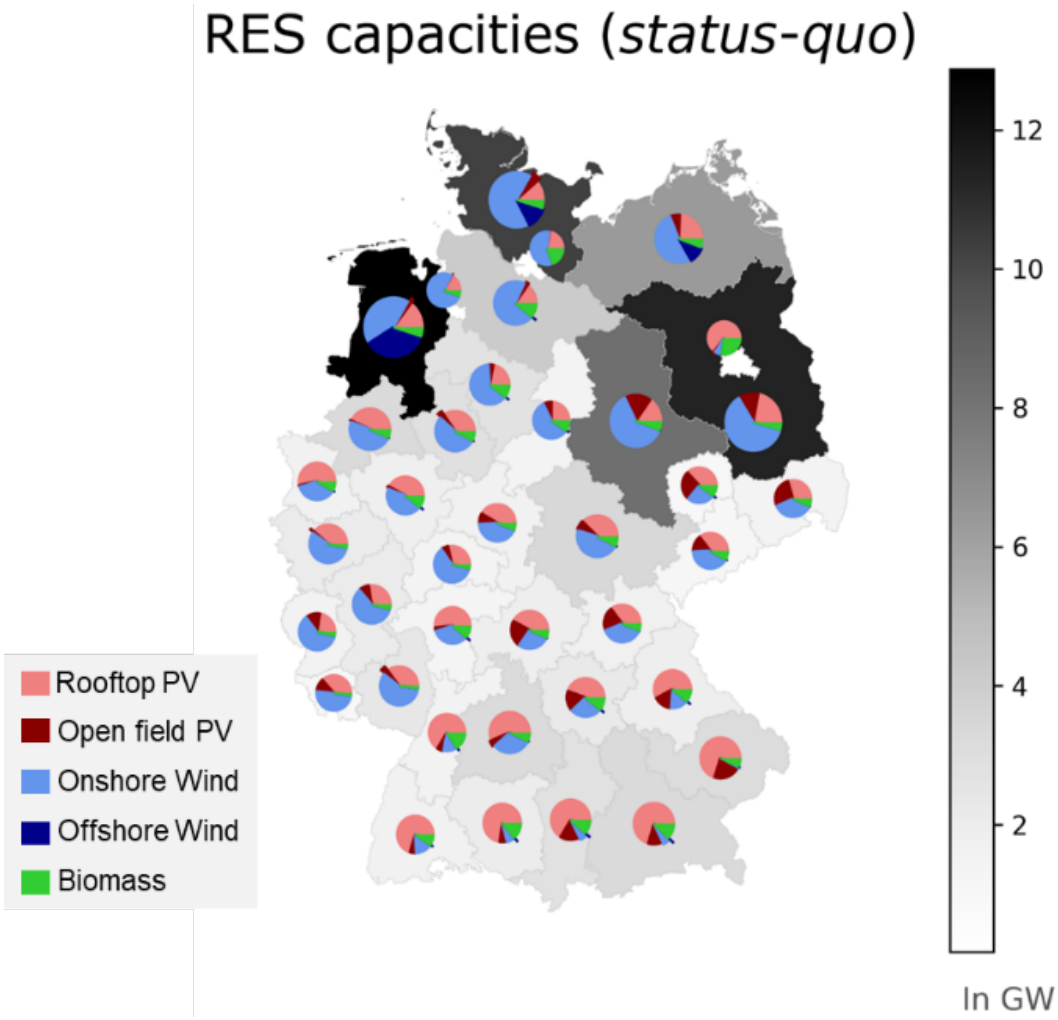
Renewable energy sources capacities – status quo



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