

Flexible spatial distribution of electricity demand for energy system models

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Chair of Renewable and Sustainable Energy Systems

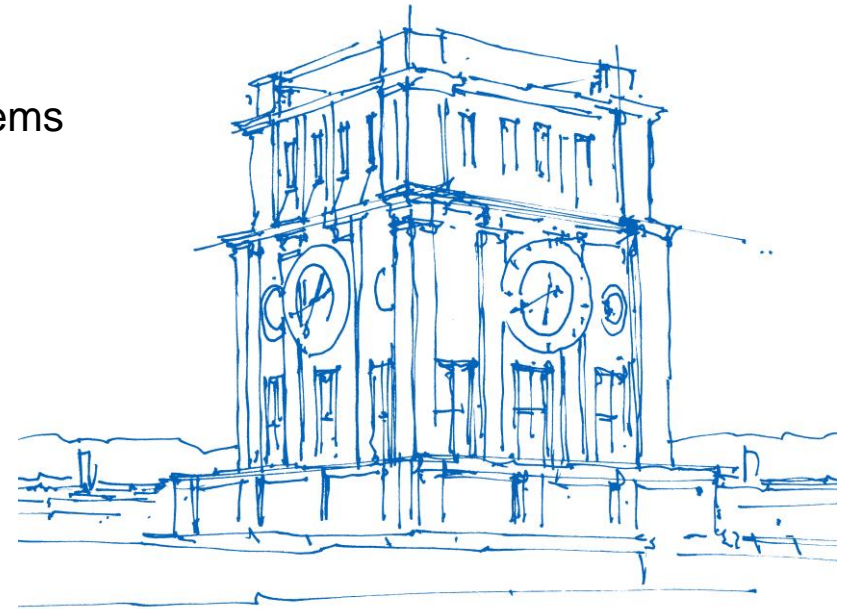
38th IEW @IEA, Paris, June 5, 2019

Supported by:



Federal Ministry
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Uhrenturm der TUM

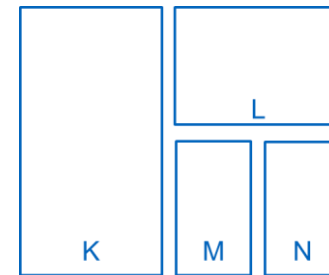
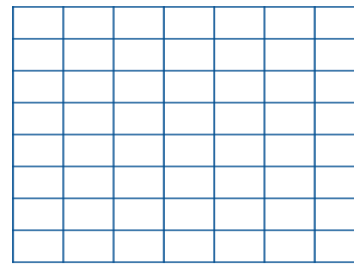
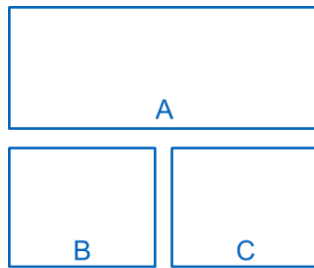
- Electricity system optimization models require information about the load, usually in the form of time series.
 - Such information is usually available on a country level or on a sub-national level (federal states, counties, or balancing areas of utilities).
 - However, this data resolution might not be adequate for research questions where the desired model region is different.
- Method to distribute the electric load spatially, while preserving the important characteristics for energy system models (total demand, profile shape, peak)?

Proposed workflow

In the general case:

DIVIDE

CONQUER



Resolution of
input data

High resolution

Desired
resolution

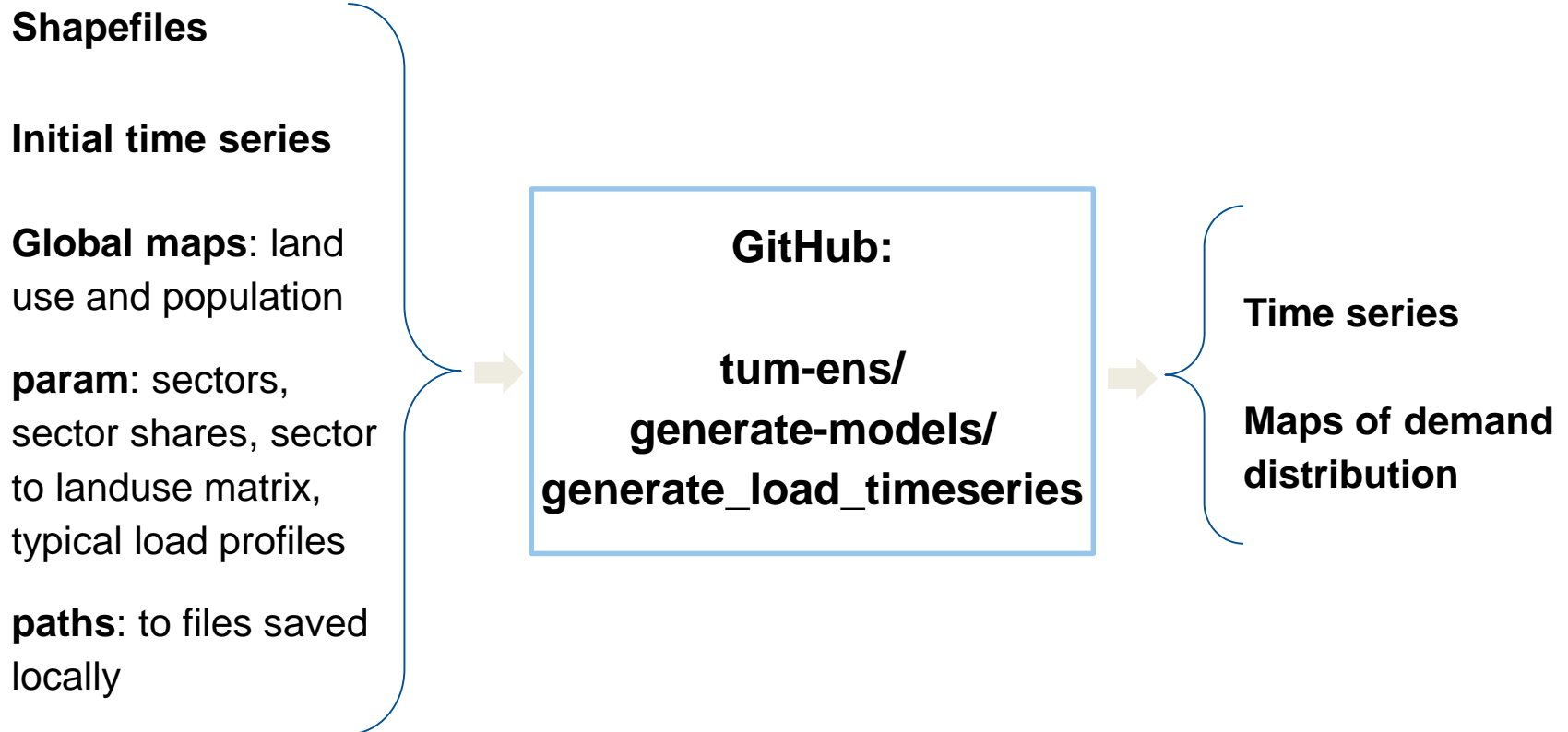


GitHub tools:

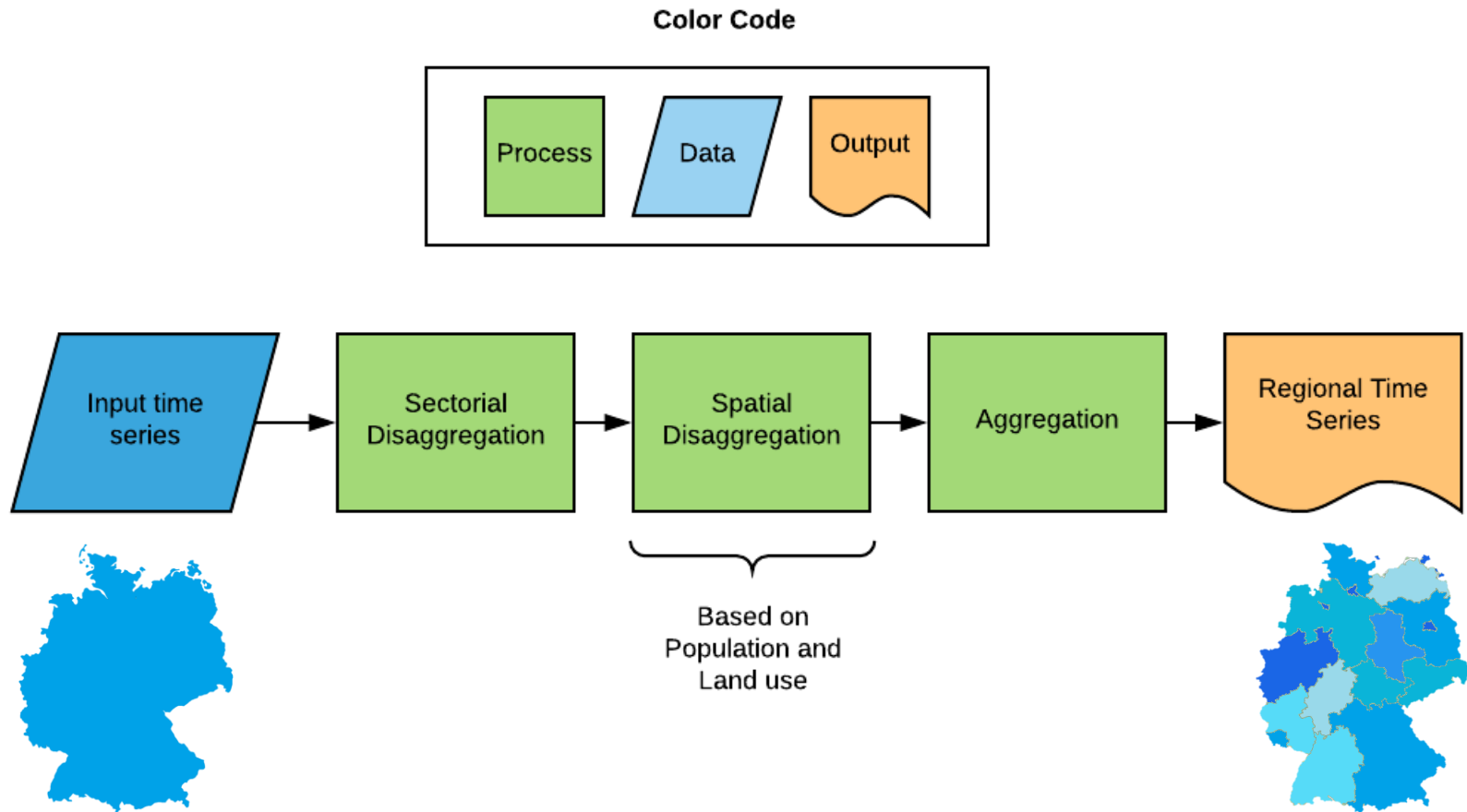
- tum-ens/
renewable-timeseries
- tum-ens/
generate-models/
generate_load_timeseries

tum-ens/
geoclustering

How the tool works

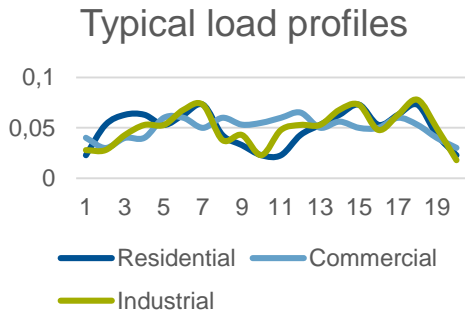


generate_load_timeseries

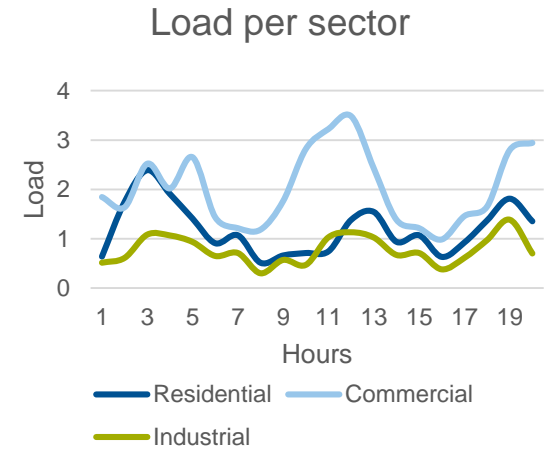
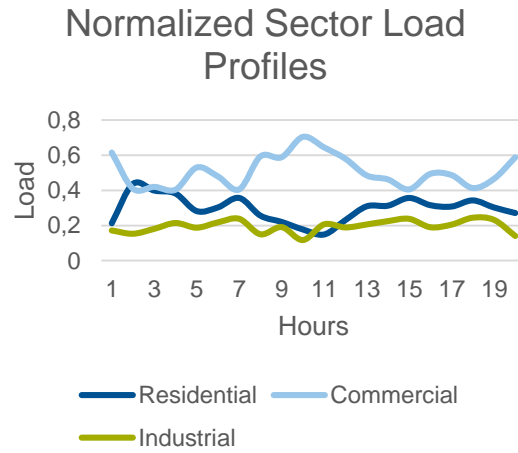
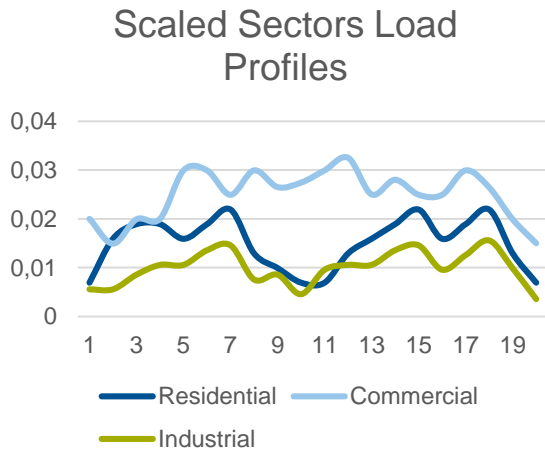
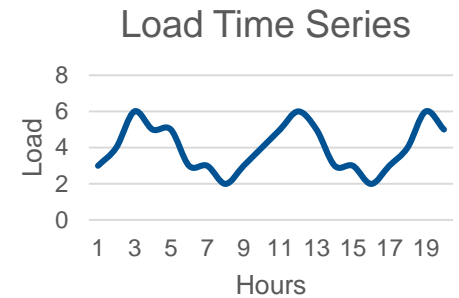
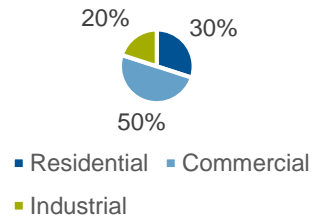


generate_load_timeseries

Sectorial disaggregation



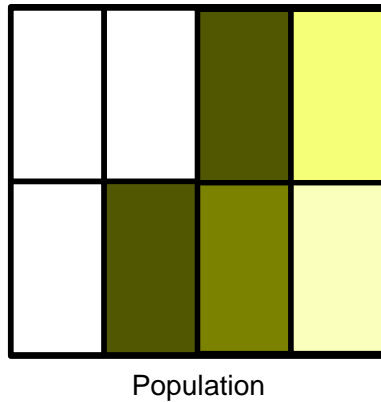
Sector Share



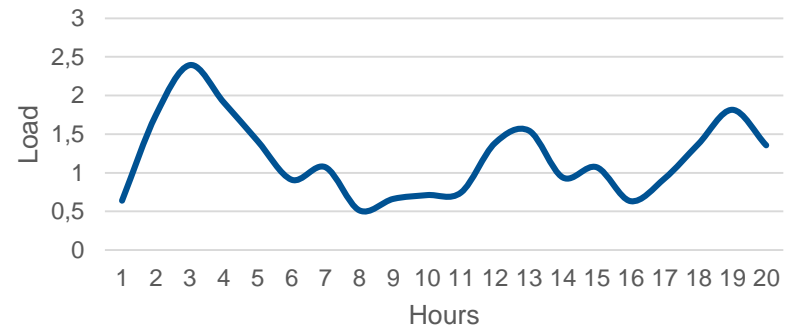
generate_load_timeseries

Spatial disaggregation

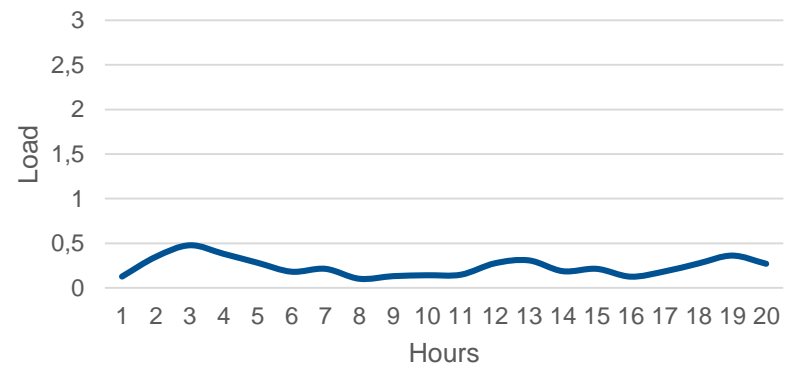
Raster



Residential Load



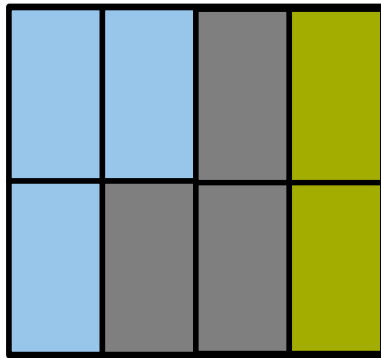
Load per person



generate_load_timeseries

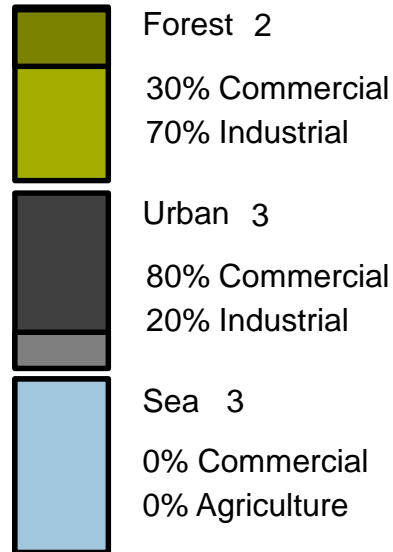
Spatial disaggregation

Raster

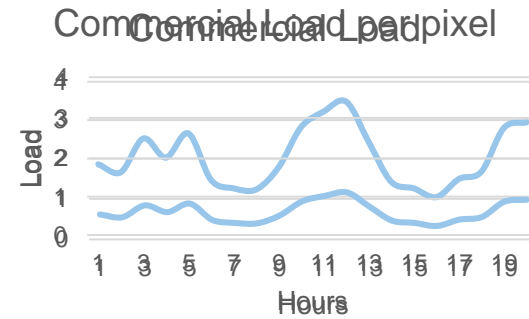


Land use

Assumptions



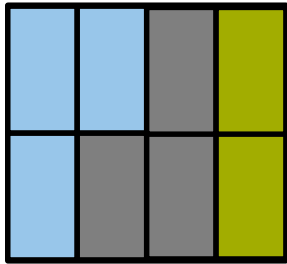
$$C. \text{ pixels} = 0.3 \times 2 + 0.8 \times 3 = 3$$



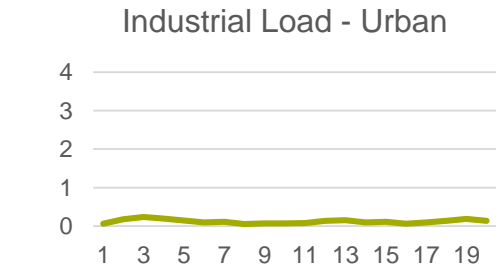
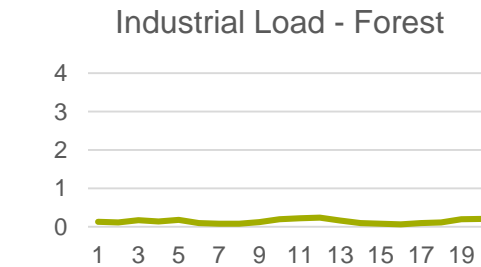
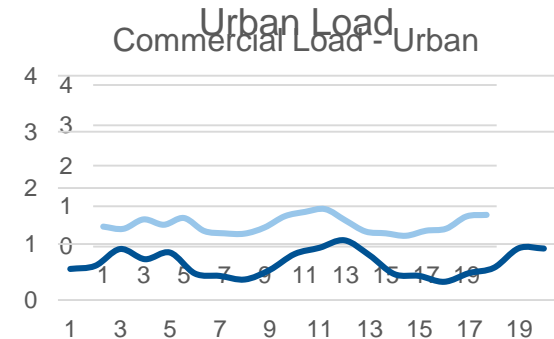
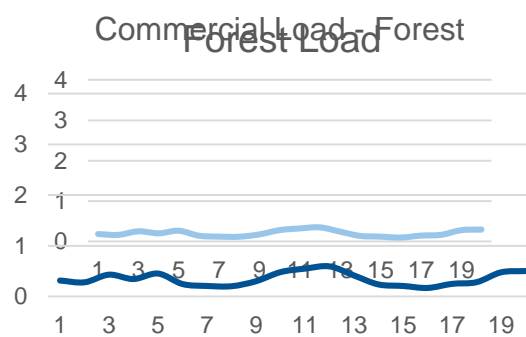
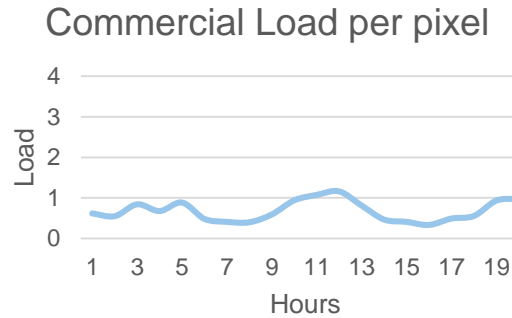
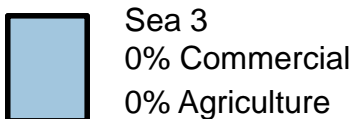
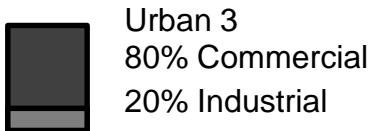
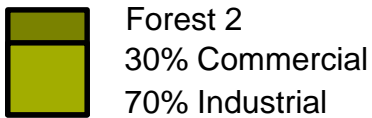
generate_load_timeseries

Spatial disaggregation

Raster



Land use



Validation

Regions studied:

Norway

- 5 Bidding zones

Sweden

- 4 Bidding zones

Denmark

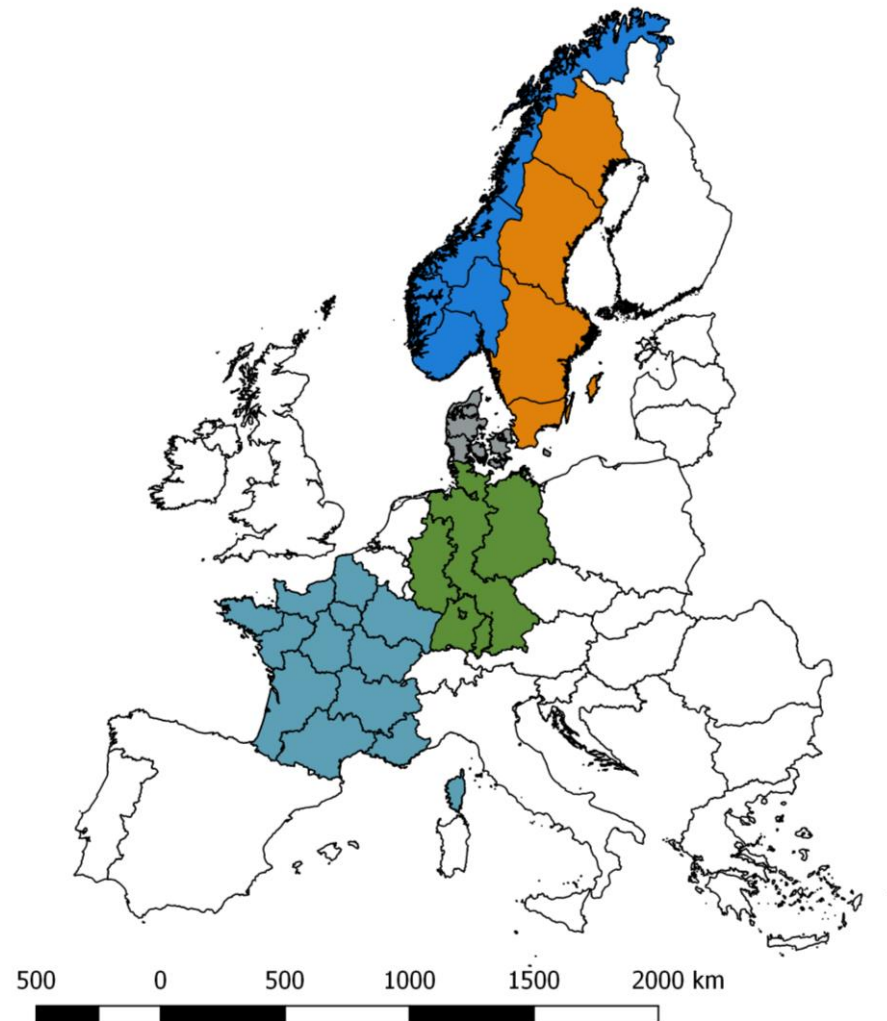
- 2 Bidding zones

Germany

- 4 Transmission Systems Operator

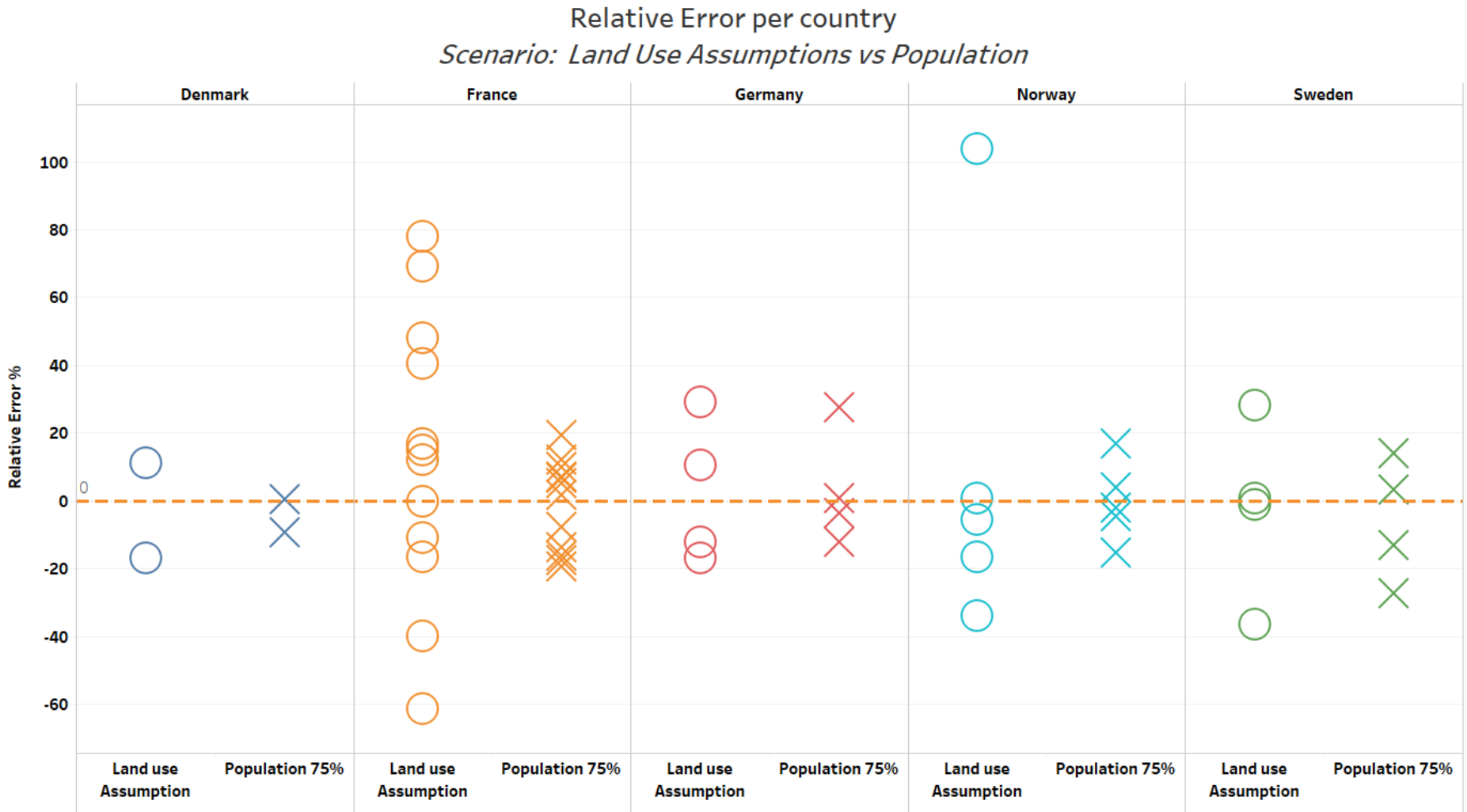
France

- 12 Administrative areas



Validation

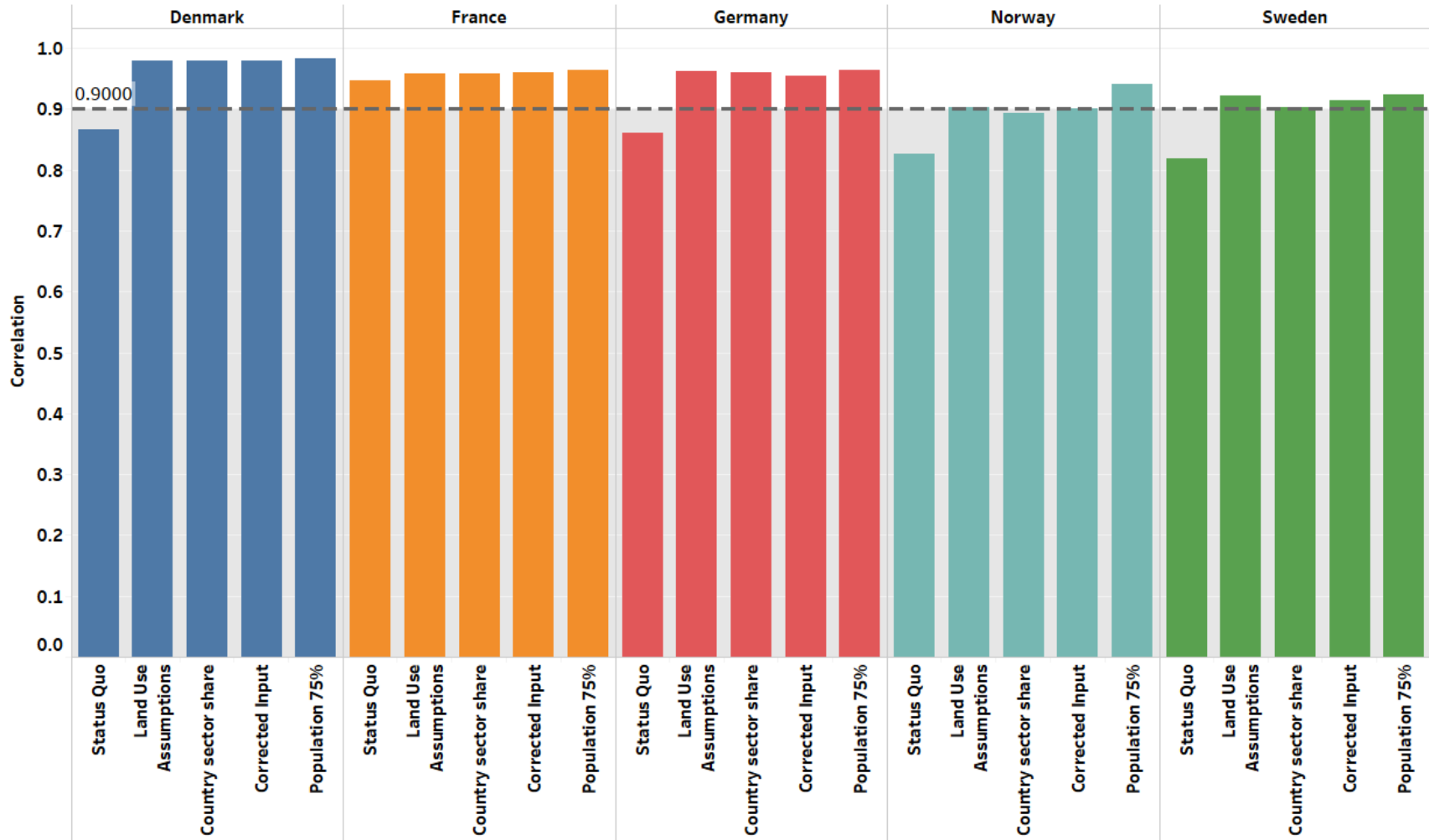
Yearly electricity demand



Validation

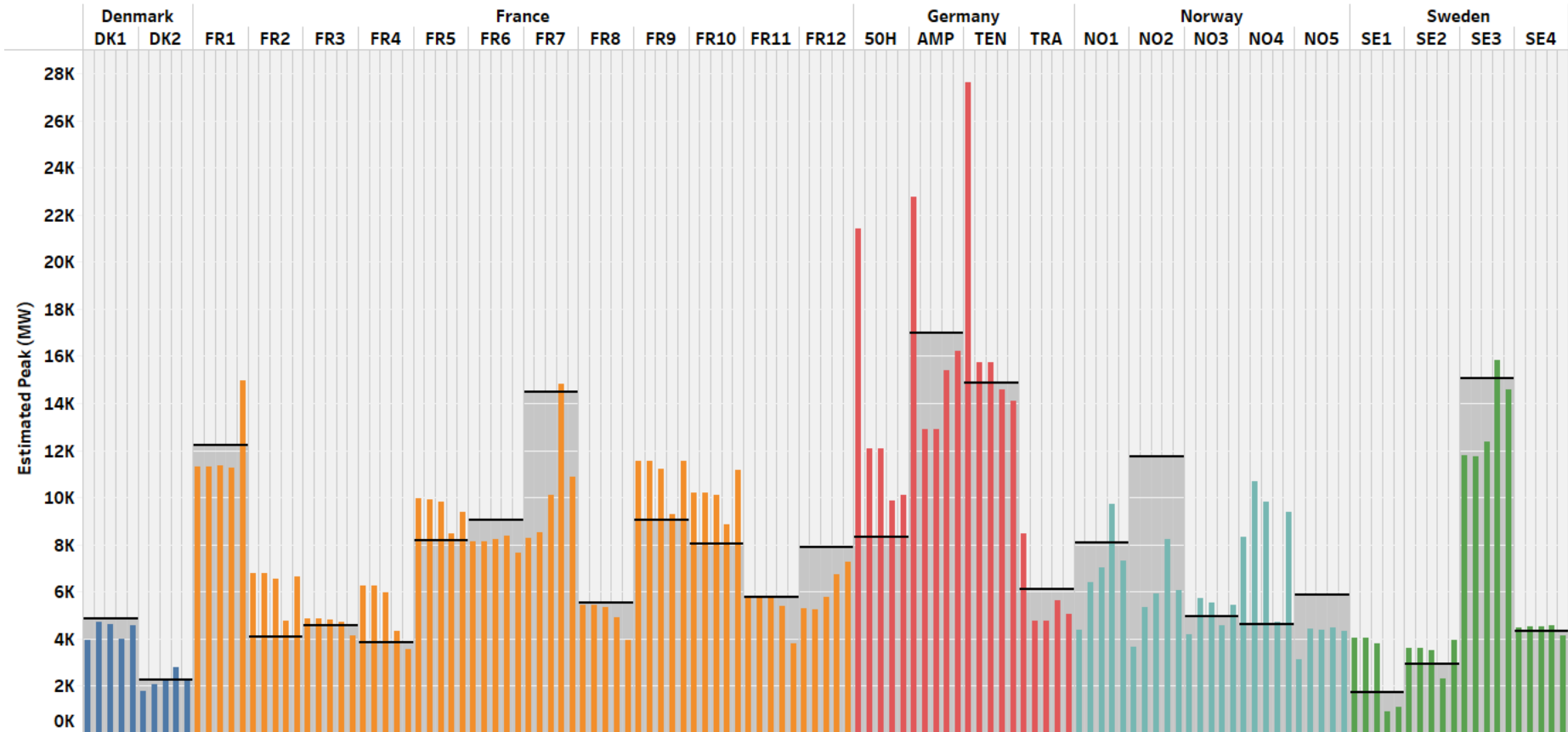
Load profile correlation

Correlation comparison



Validation Peak load

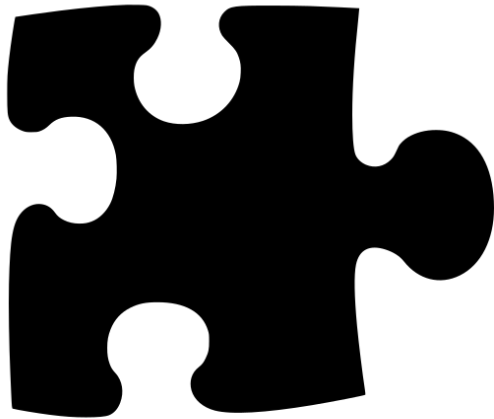
Peak Load Comparison



The order of the comparison scenarios are as follow for each region: Status Quo, Corrected Input, Country Sector Share, Land use Assumptions, Population 75%

The black line in each region represents the real peak value.

GitHub:
**tum-ens/
generate-models/
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- Generation of load time series for any user-defined regions, particularly cities
- Generation of high resolution electricity demand map
- Application of sector-specific assumptions, so that the total load, its peak and its shape can be varied for the future

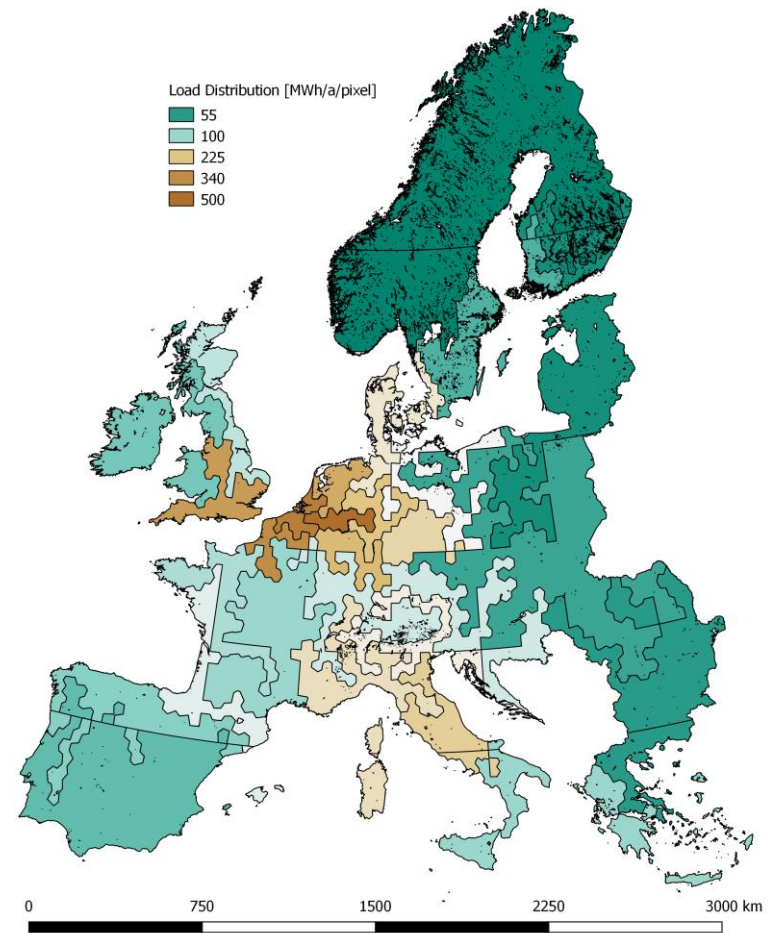
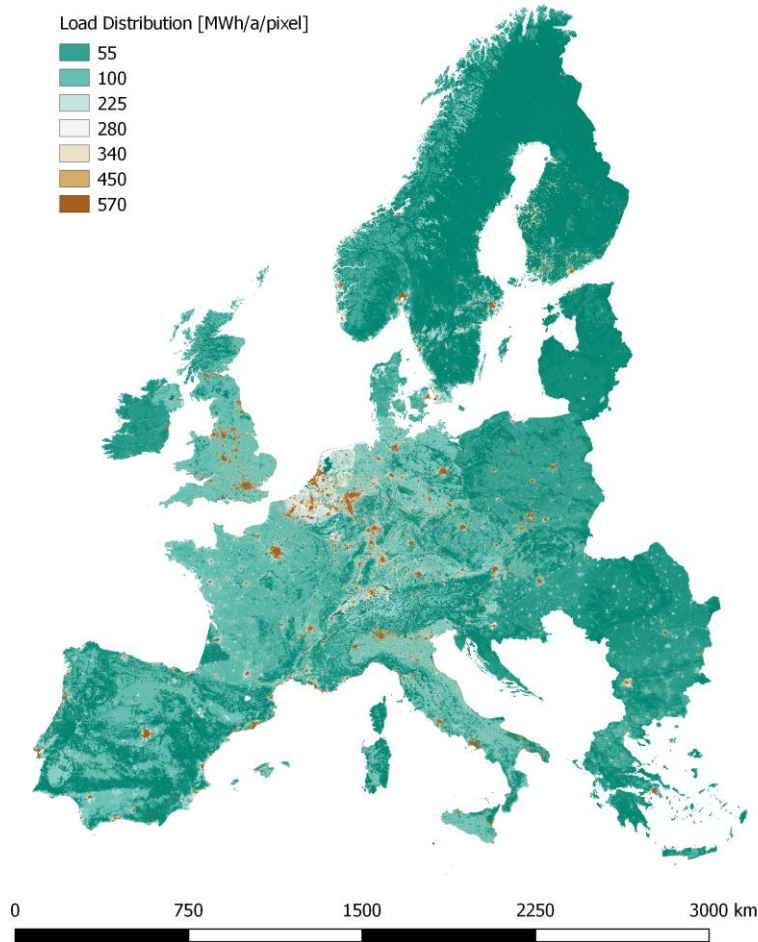
Impact of the Choice of Regions on Energy System Models

Kais Siala, Mohammad Youssef Mahfouz

Technical University of Munich, Chair of Renewable and Sustainable Energy Systems

Highlights

- We develop a spatial clustering method for high resolution data.
- We cluster rasters of load density distribution and solar and wind potentials.
- We create energy system models with different shapes for the regions in Europe.
- Comparison with models based on countries show large discrepancies for the future.
- We use the method for a geographic sensitivity analysis to derive robust results.



Summary and next steps

Empirical method allows the obtention of electricity time series for any region, provided that the input time series is provided for an overlapping geographic coverage.

Diversity in terms of peak load, profiles and sub-regional total demand, which was not possible with econometric methods.

Correlation factors $>90\%$ and relative errors for total demand below 20% .

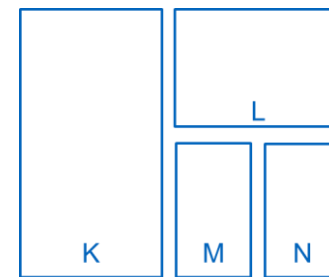
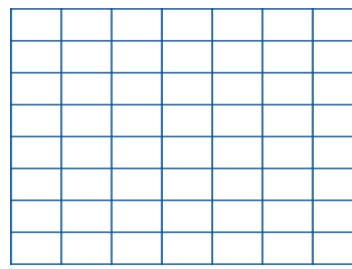
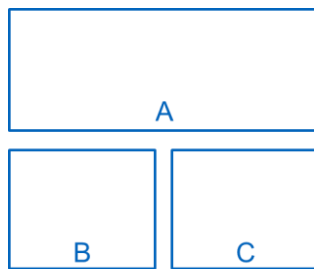
In the near future: comparison of performance with other disaggregation methods.

Summary and next steps

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Resolution of
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High resolution

Desired
resolution



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Back up