

COMPARISON OF DIFFERENT METHODS OF SPATIAL DISAGGREGATION OF ELECTRICITY GENERATION AND CONSUMPTION TIME SERIES

MODEX-Net

Join work with Thomas Dengiz, Wided Medjroubi, Chinonso Unaichi, Andreas Bruckmeier, and Rafael Finck

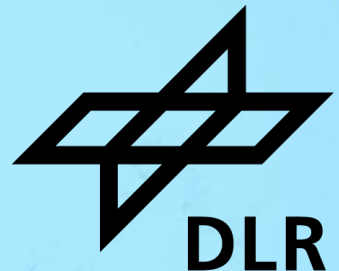


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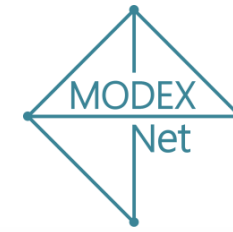
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Outline

1. The MODEX-Net project
2. Introduction to disaggregation
3. Methodology
 1. Comparison of disaggregation workflows
 2. Comparison of disaggregated output
4. Results
5. Conclusions



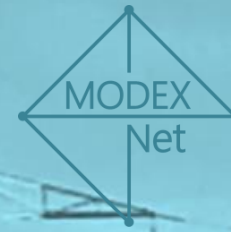
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The screenshot shows a web browser window with the URL <https://www.energiesystem-forschung.de/forschen/projekte/modex-net>. The page header includes the logo for "ENERGIESYSTEMFORSCHUNG" with the tagline "FORSCHUNG FÜR DAS ENERGIESYSTEM DER ZUKUNFT". Below the header, the navigation path "Forschen / Projektübersicht" is visible. The main content area features a large blue graphic with a world map and glowing nodes connected by lines. Below the graphic, the text reads "Projekt MODEX-Net" and "Verschiedene Modelle von Stromnetzen vergleichen". There are also social media sharing icons for email, Twitter, Facebook, and LinkedIn. The bottom part of the page contains a paragraph of text in German: "Der europäische Energiebinnenmarkt und die Beschränkungen des kontinentaleuropäischen Stromnetzes machen die Integration von erneuerbaren Energien zunehmend zu einer gesamteuropäischen statt einer rein nationalen Aufgabe. Damit die Energiewende in ganz Europa gelingt, wollen Forscherinnen und Forscher im Projekt MODEX-NET verstehen, was ein leistungsfähiges länderübergreifendes Stromnetz ausmacht."

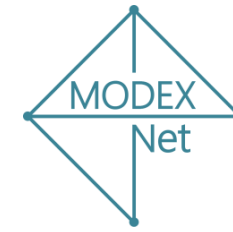


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THE MODEX-NET PROJECT

The MODEX-Net Project



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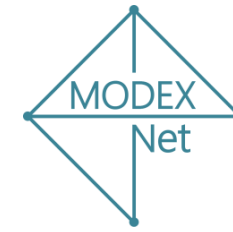
Project Aim:

Develop methods to compare transmission grid models

Output highlights:

- Comparison of models main features and harmonization proposal
- Comparison of disaggregation methods for RES and demand
- Comparison of market optimization: Price of electricity, energy mix and import/export
- Comparison of grid optimization: Redispatch, curtailment and line loading

The MODEX-Net Project



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Partners and Models



Institut für Vernetzte
Energiesysteme



technische universität
dortmund

PERSEUS/Tango

ELMOD

eGo/eTraGo

MILES

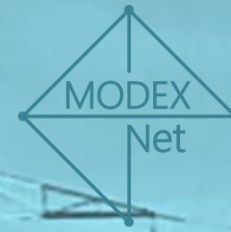


MarS/ZKNOT

EuroPower

ISAaR

PowerFlex-Grid-EU

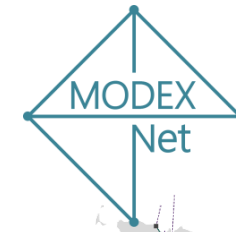


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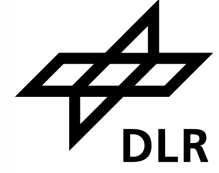


INTRODUCTION TO DISAGGREGATION

Introduction

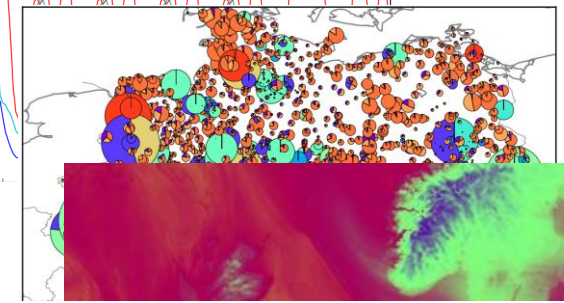
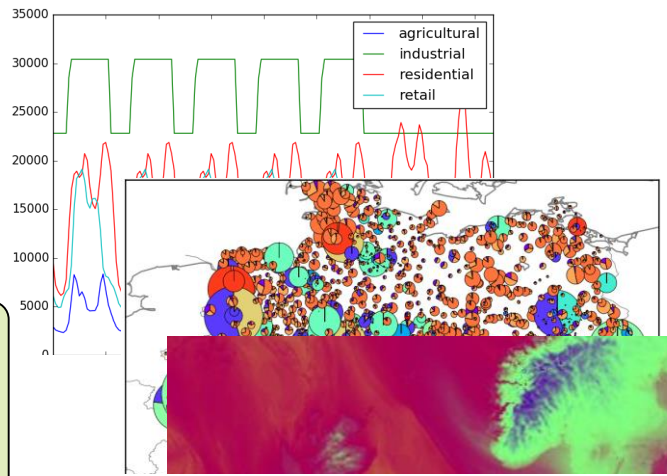


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Input data

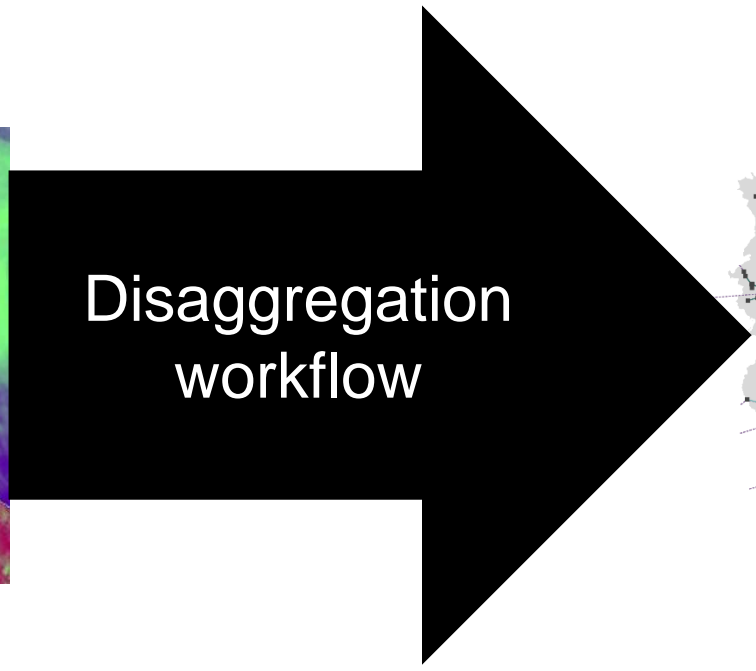
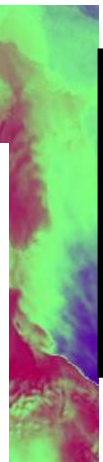
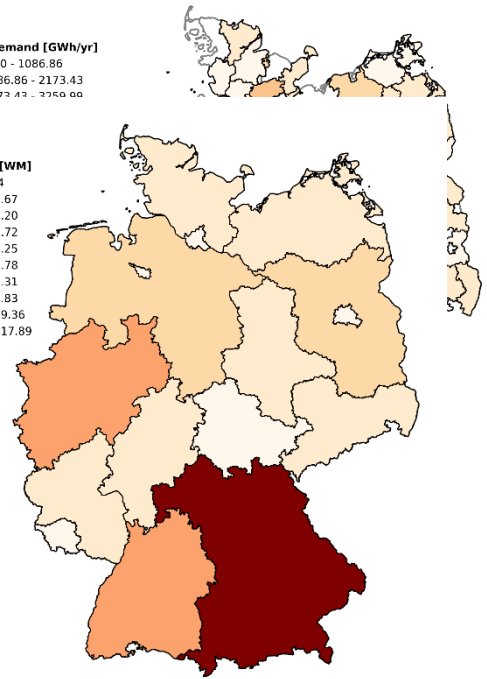


annual demand [GWh/yr]

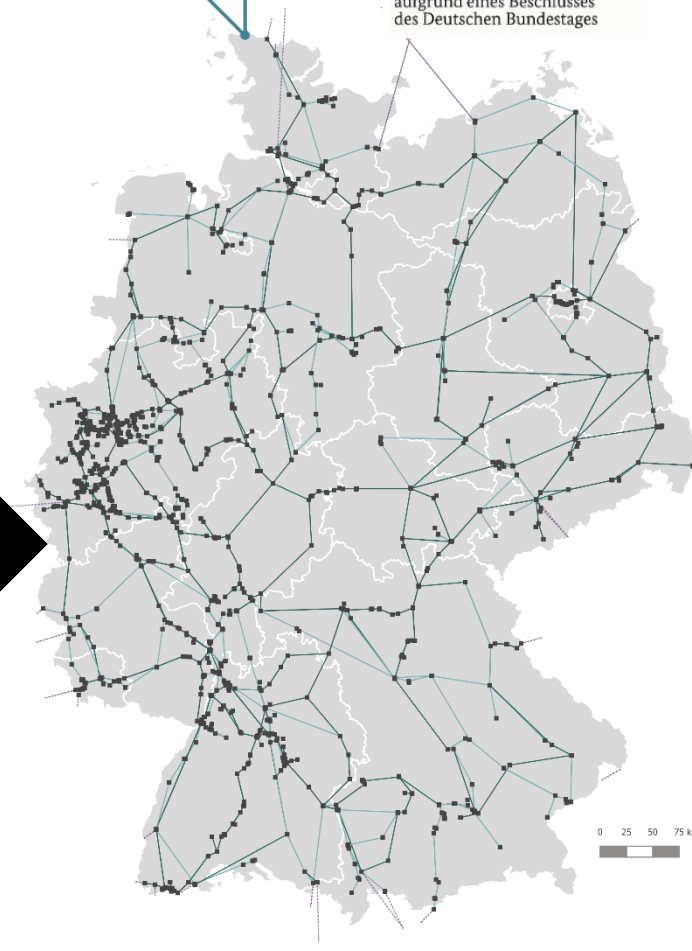
- 0.30 - 1086.86
- 1086.86 - 2173.43
- 2173.43 - 3259.99

installed capacity [MW]

- 32.61 - 1141.14
- 1141.14 - 2249.67
- 2249.67 - 3358.20
- 3358.20 - 4466.72
- 4466.72 - 5575.25
- 5575.25 - 6683.78
- 6683.78 - 7792.31
- 7792.31 - 8900.83
- 8900.83 - 10009.36
- 10009.36 - 11117.89



Disaggregation
workflow

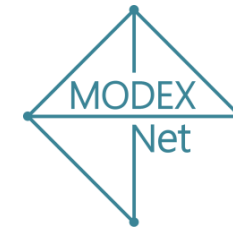


Model of the extra
high voltage grid



- DC
- AC220
- AC380
- BorderCrossing
- Offshore

Introduction



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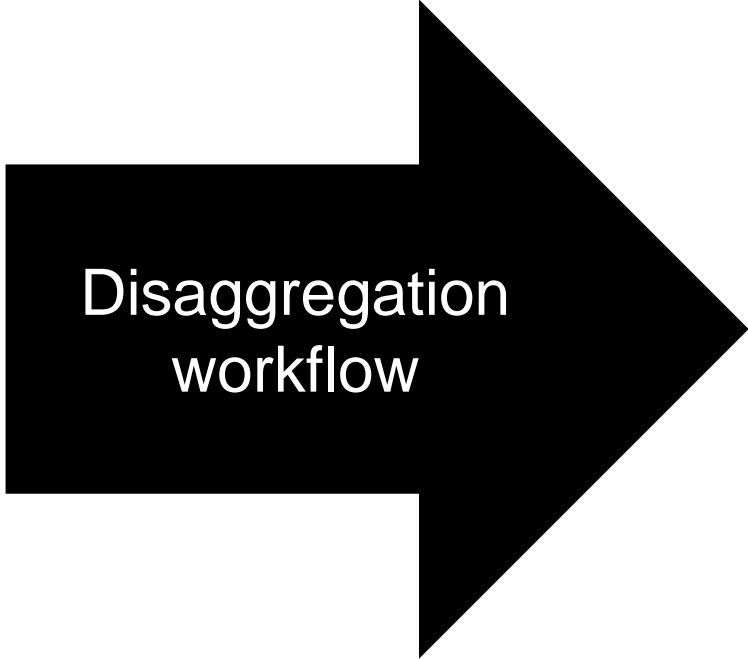
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Input data

Installed capacities
—
Annual demand

Hourly profiles



PV

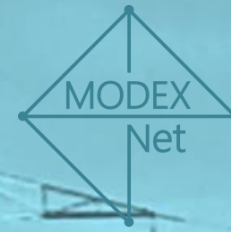
Wind onshore

Wind offshore

Load

Model of the extra
high voltage grid

German grid
for a 2016
scenario



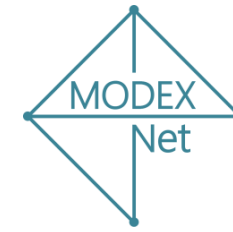
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METHODOLOGY

Methodology

Comparison of disaggregation workflows



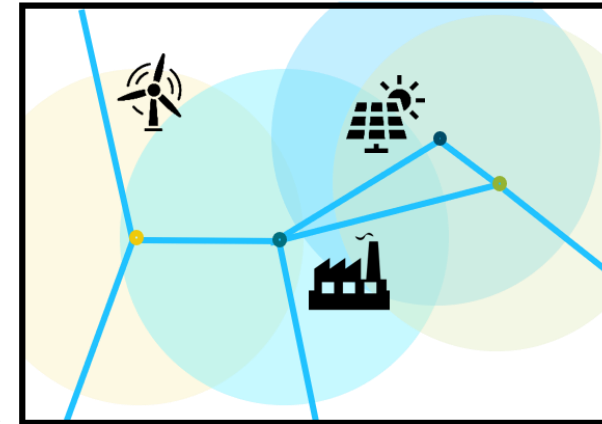
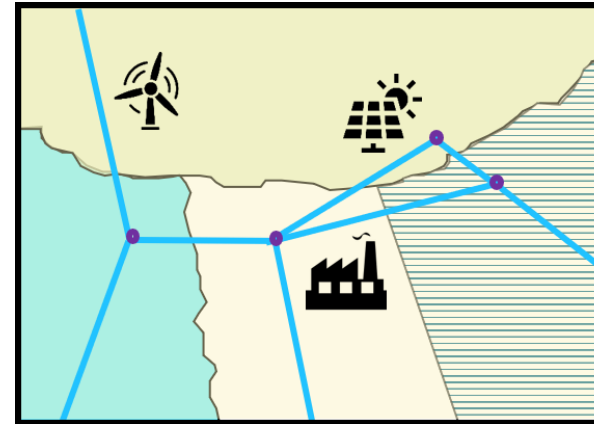
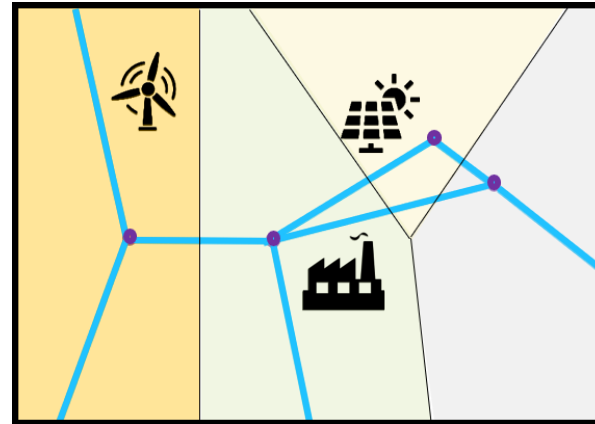
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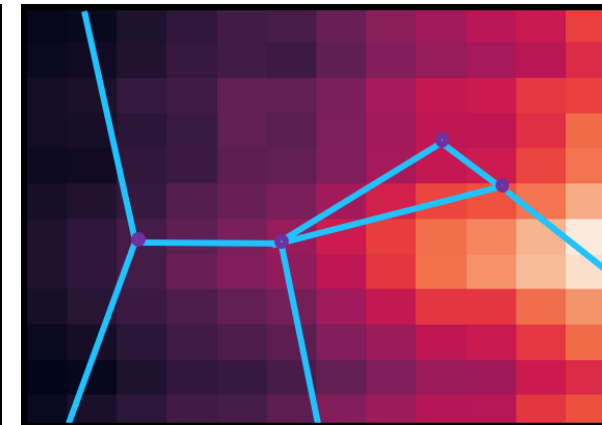
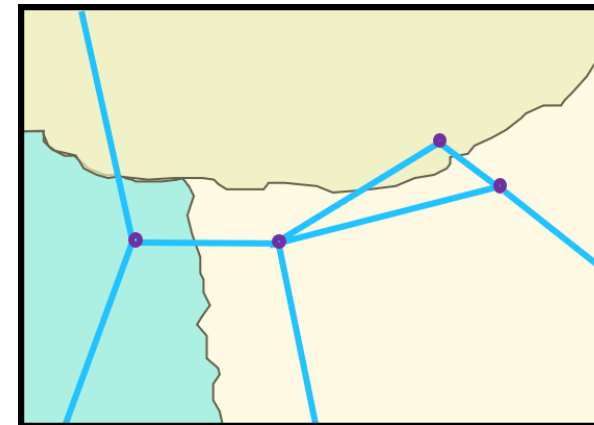
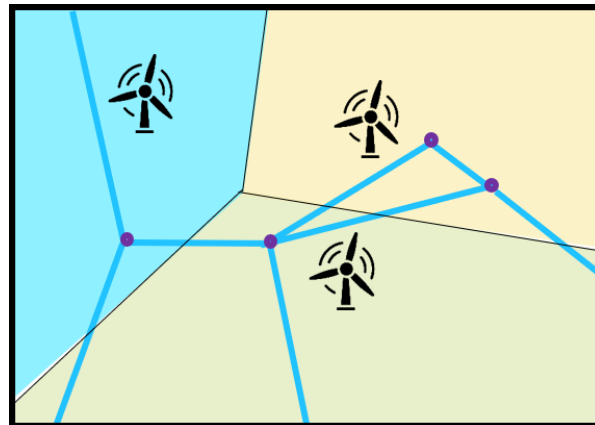
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I. Allocate data inside
a node region into its
node



II. Distribute data
region values into its
nodes

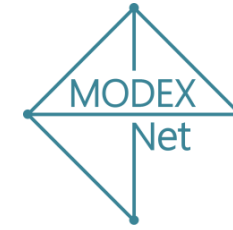


III. Overlap of data and
node regions

It could be a **post-processing**, e.g. harmonize national values

Methodology

Comparison of disaggregation workflows



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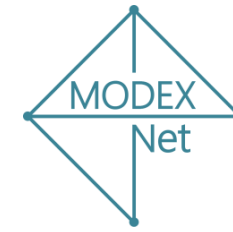


- PV installed capacity

Bottom-up / Top-Down	As LAU or NUTS level	
BU/ TD	Input resolution & source	Node allocation
ELMOD eTraGo Europower		Generator belonging to a node region Generator belonging to a node region Overlap of generation regions and node regions
ISAAr MarS/ZKNOT MILES		Generator belonging to a node region Generator belonging to a node region Generator belonging to a LAU region (& distributed to nodes in the allocation region)
PERSEUS PowerFlex		Generator belonging to a node region Overlap of LAU generation region and node regions

Methodology

Comparison of disaggregation outputs



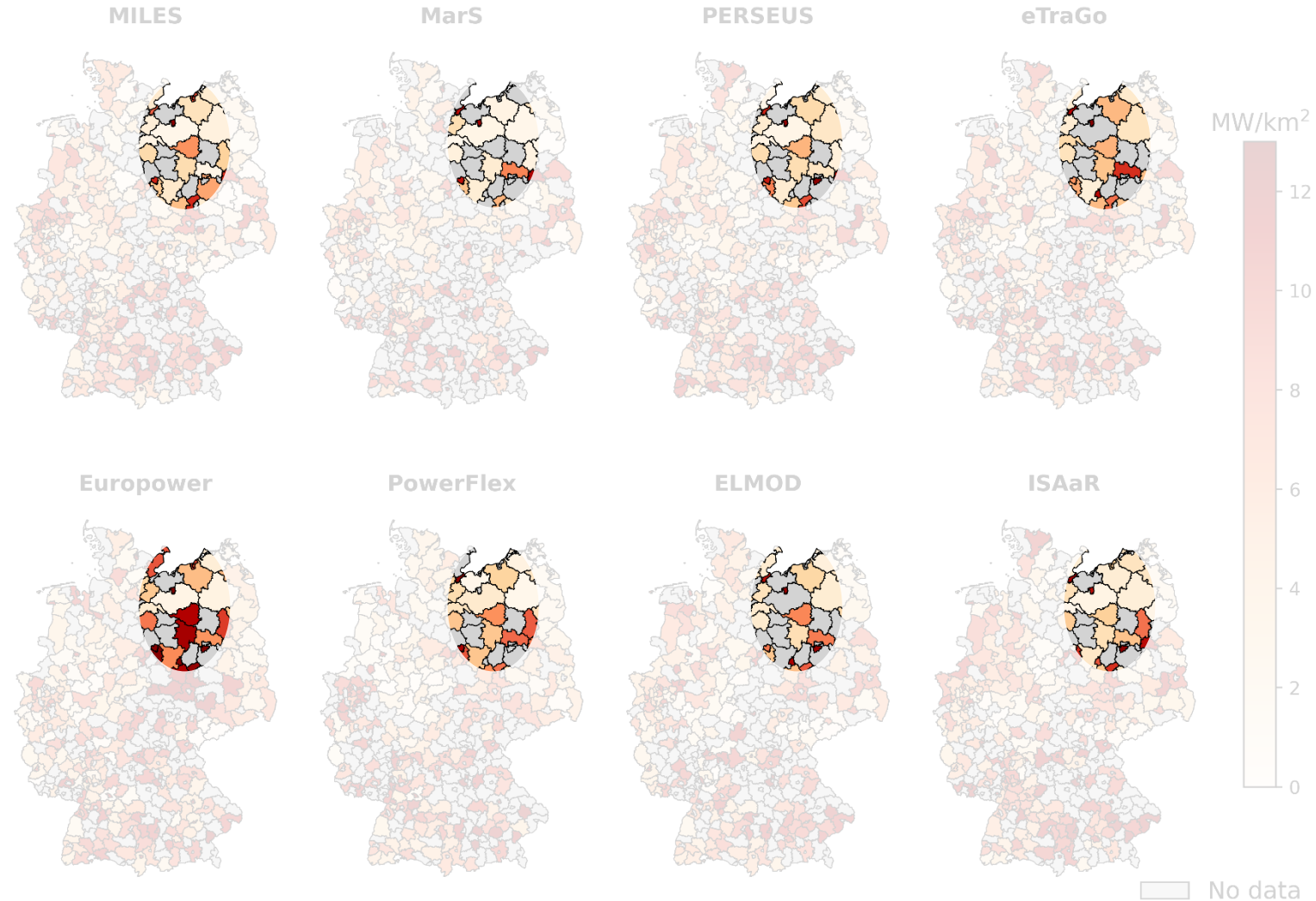
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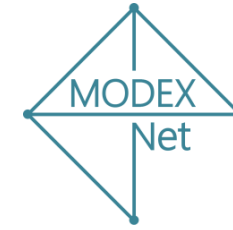


Warning: Just data in ehv-nodes
aggregated to NUTS 3 regions



Methodology

Comparison of disaggregation outputs



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- **Installed capacity and annual demand comparison:** RMSE across all NUTS 3 regions (using 0 if no installed capacity)

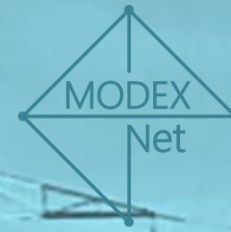
$$RMSE(x, y) = \sqrt{\frac{\sum_{n=1}^N (x_n - y_n)^2}{N}}$$

where $\{x_n\}_{1 \leq n \leq N}$ and $\{y_n\}_{1 \leq n \leq N}$ are installed capacities

- **Profile comparison:** Mean value of the Pearson correlation of the profiles across all NUTS 3 with installed capacity.

$$Pearson(X, Y) = \frac{cov(X, Y)}{\sigma_X \sigma_Y}$$

where $\{X_n^t\}_{1 \leq n' \leq N}^{1 \leq t \leq 8760}$ and $\{Y_n^t\}_{1 \leq n' \leq N}^{1 \leq t \leq 8760}$ are the absolute profiles



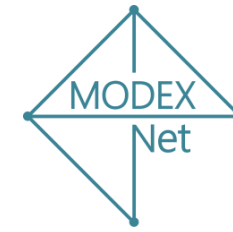
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RESULTS

Results

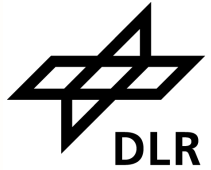
Comparison of disaggregation workflows



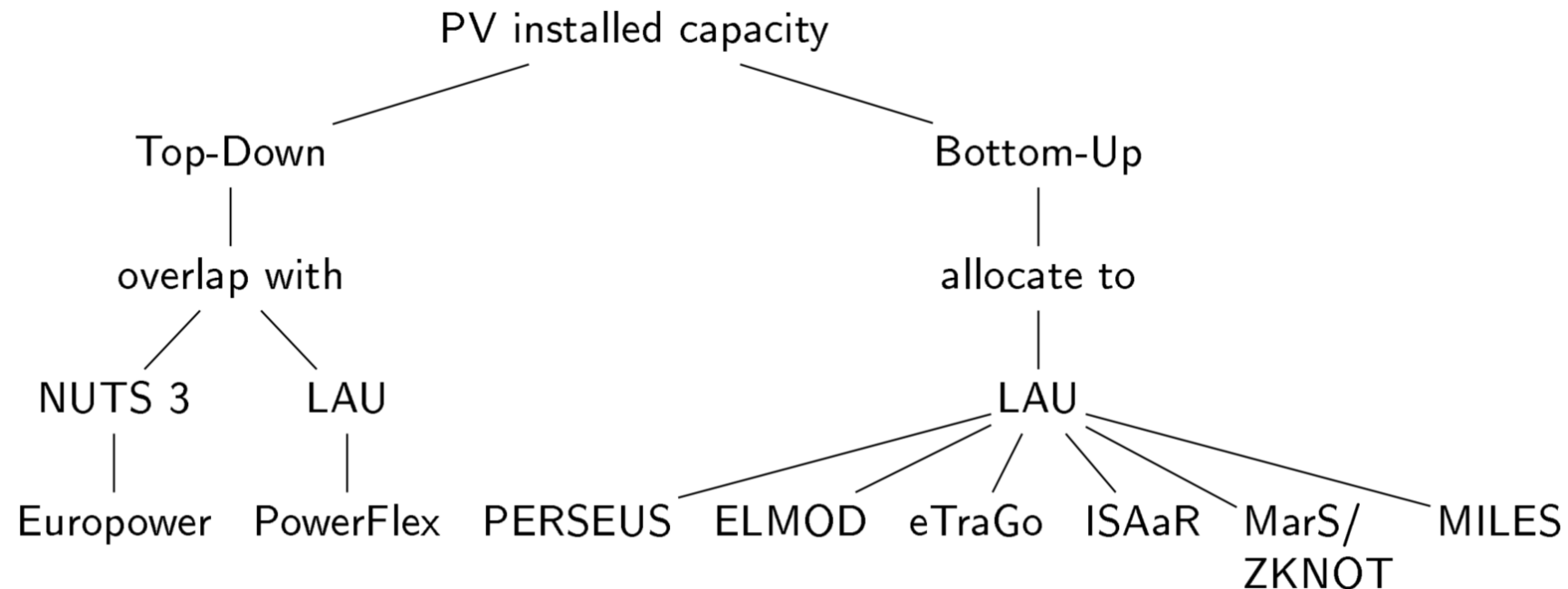
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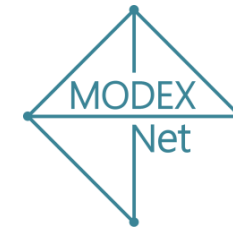


- PV installed capacity



Results

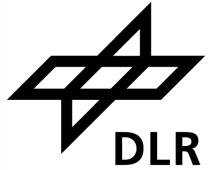
Comparison of disaggregation workflows



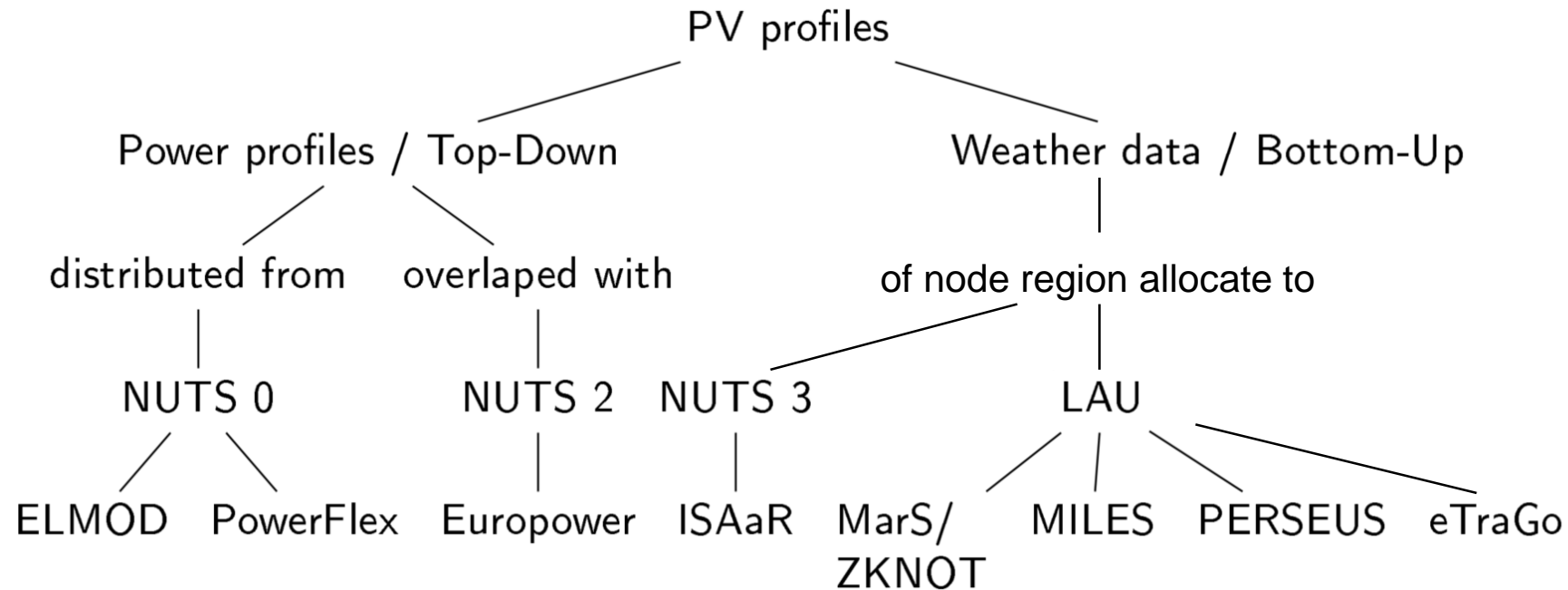
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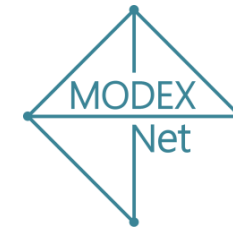


■ PV profiles



Results

Comparison of disaggregation output



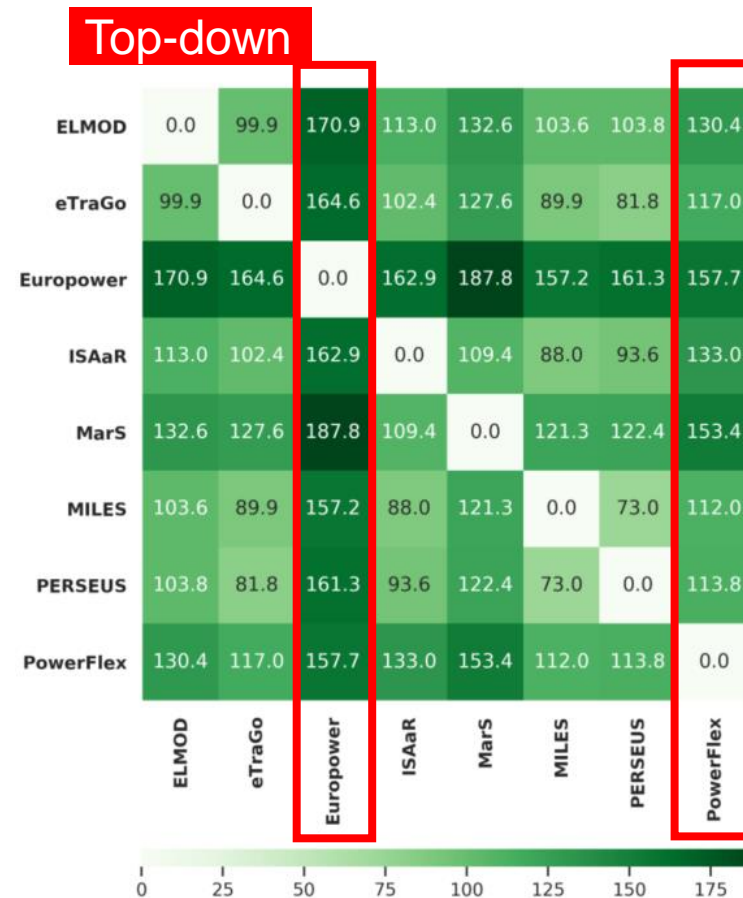
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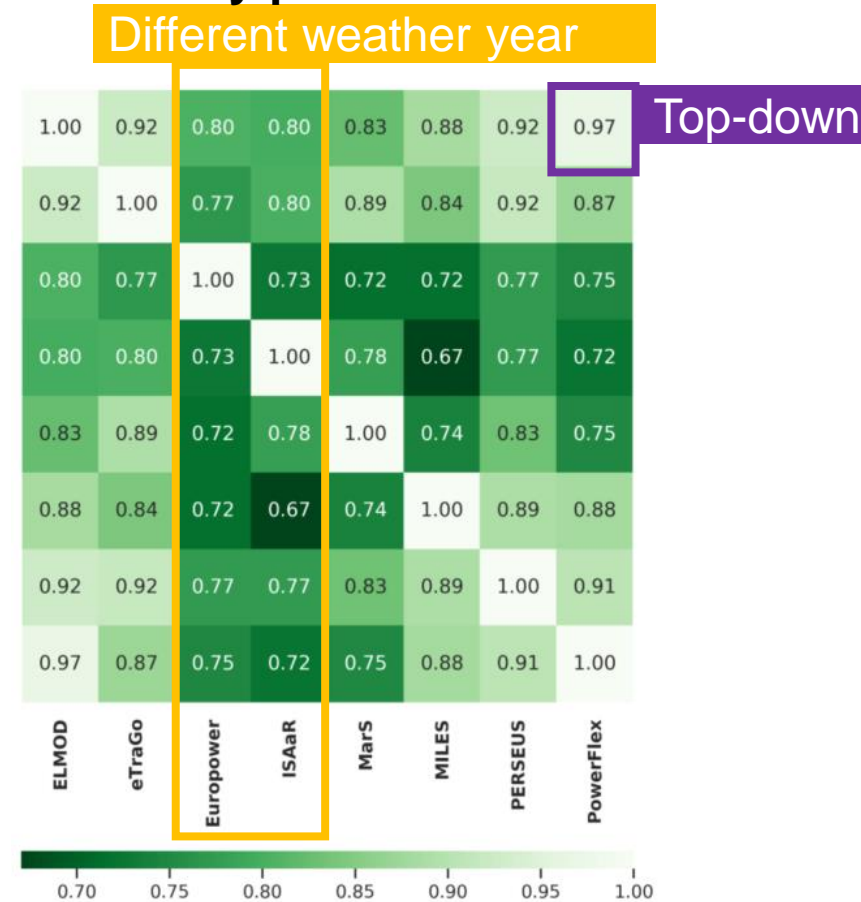
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RMSE of PV installed capacities:

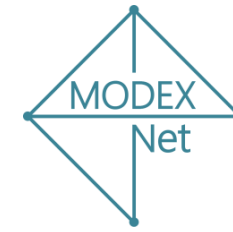


Mean value of Pearson correlations of
PV availability profiles:



Results

Comparison of disaggregation workflows



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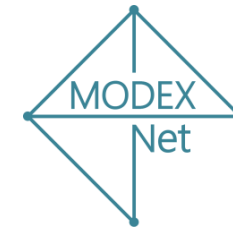
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- **Wind onshore and PV:**
 - Installed capacity using a bottom-up allocation from LAU regions
 - Profiles from weather data using high spatial resolution
- **Wind offshore:**
 - Installed capacities mostly allocated to the grid connection points
 - Profiles either use offshore region potentials or one location
- **Demand:**
 - Mostly done by a top-down distribution from national sectoral load profiles (e.g. agricultural, residential, retail, industry) and
 - Annual demand factor using bottom-up allocation based on administrative regional parameters (e.g. GDP, population, temperature, land use...)

Results

Comparison of disaggregation output



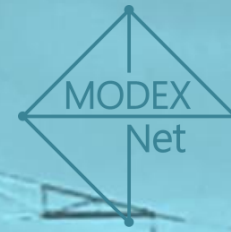
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- In all cases the Top-down/Bottom-up approach is the main factor that influences the output
- **Wind onshore** disaggregation differences are of a higher magnitude than **PV**.
- **Wind offshore** disaggregation is strongly influenced by onshore connection (either Baltic Sea or North Sea)
- **Demand** disaggregation depends highly on the source, sectors and date of the data. Nevertheless, the profiles look very similar, since they are mostly based on national profiles.

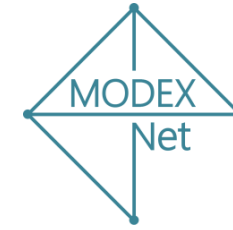


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CONCLUSIONS

Conclusions



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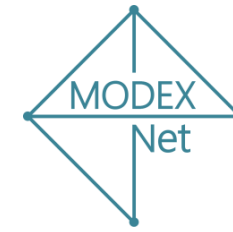
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- A high resolution is necessary to be able to compare disaggregation workflows (NUTS 3 is adequate for transmission grid models)
- The resolution of the input data and the use of Top-down/Bottom-up workflows are the two main influence factors in the disaggregation process.
- PV produces a closer disaggregation output regardless of the workflow.
- The disaggregation outputs of demand profiles are significantly close, regardless of the workflows (probably because most models use standard load profiles).

Sources



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- Project website (harmonization data and final report):

<https://www.energiesystem-forschung.de/forschen/projekte/modex-net>

- Publications in a RSER Special Issue:

- Comparison of different methods of spatial disaggregation of electricity generation and consumption time series

<https://www.sciencedirect.com/science/article/pii/S1364032122001101>

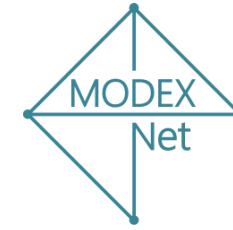
- Development of an open framework for a qualitative and quantitative comparison of power system and electricity grid models for Europe

<https://www.sciencedirect.com/science/article/pii/S1364032121013174>

- Impact of model parametrization and formulation on the explorative power of electricity network congestion management models - Insights from a grid model comparison experiment

<https://www.sciencedirect.com/science/article/pii/S1364032122000910>

Impressum



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Thema: **Comparison of different methods of spatial disaggregation of electricity generation and consumption time series**

MODEX-Net

Datum: 8.9.2022

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Institut: DLR-VE

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