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FlexPlan

Final Project Workshop | 14th February 2023

WP4: Results of the pan-European model

Jawana Gabrielski
TU Dortmund

Agenda

- Introduction
- Pan-European Scenarios
- Pan-European Simulation
- Summary

Introduction

Placement of the work package in the FlexPlan project

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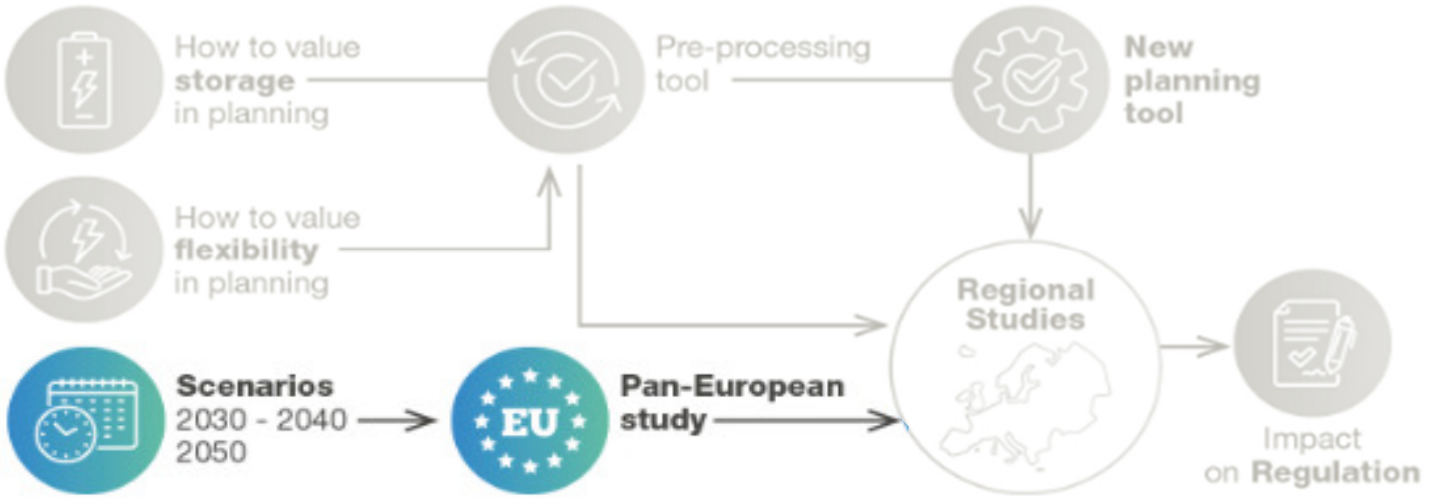
FlexPlan aims to develop a grid planning tool and validate it using six regional cases covering different geographies in Europe

Need for:

- Scenario data
- Time series for non-dispatchable renewable generation and load
- Cross-border conditions



Goals of the work package

FlexPlan

Complete data collection and analysis process, including:

- Three pan-European Scenarios for the considered target years
  - Regionalization (up to grid node detail)
  - Nodal injection and load time series
  - Cross border conditions
- Grid models
  - Transmission and distribution
  - Including geographic information
- Additional data sources for complementary studies
  - Environmental impact
  - Fuel and technology costs

Pan-European Scenarios

Pan-European Scenarios

FlexPlan

- Three Scenarios
  - Pan-EU framework, data at national level
    - Installed generation capacities by technology
    - Annual mean capacity factors for renewable energy sources
    - Annual electricity consumption and peak load
    - Hourly time series data for consumption
    - Net transfer capacities
    - Commodity prices for different types of fuel
    - Total operational reserve power
- Using already validated data sources, to foster work development and achieve a higher acceptance of developed tool and obtained results

➢ Data from TYNDP 2020

Distributed Energy	Global Ambition	National Trends
Top down reflecting the Paris Agreement target		Bottom up reflecting the most recent EU member state National Energy and Climate Plans
Implements decentralized generation by integrating the consumer into the system	Implements centralized generation	

Pan-European Scenarios

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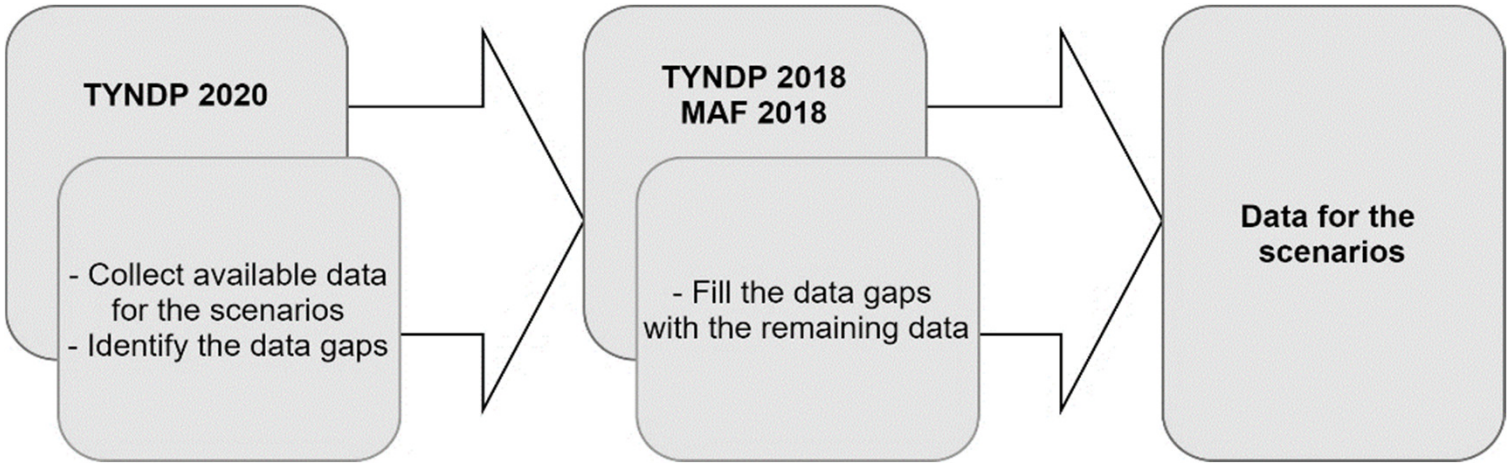
- TYNDP 2020 Scenarios used as main data source
  - Complemented by TYNDP2018 and MAF2018, when needed



- Three target years
  - 2030
  - 2040
  - 2050

Pan-European Scenarios

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- But…
- TYNDP 2020 did not detail data for 2050 when WP4 was in progress

TYNDP 2020 data

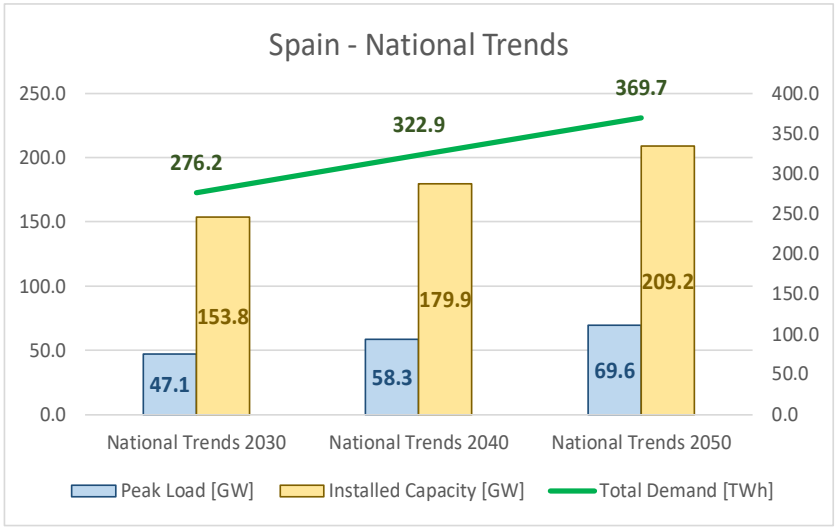
- Data for 2050 missing

Creation of 2050 scenario data

- Linear approach: following trends from 2030 and 2040

Validation

- Validation with „A clean planet for all“ from European Commission



Pan-European Scenarios – Results

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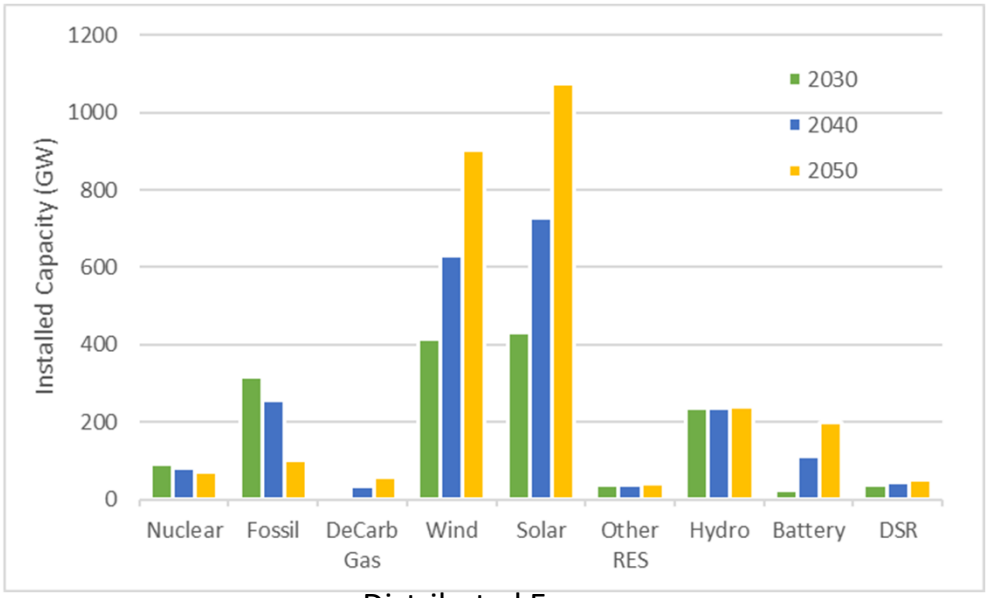
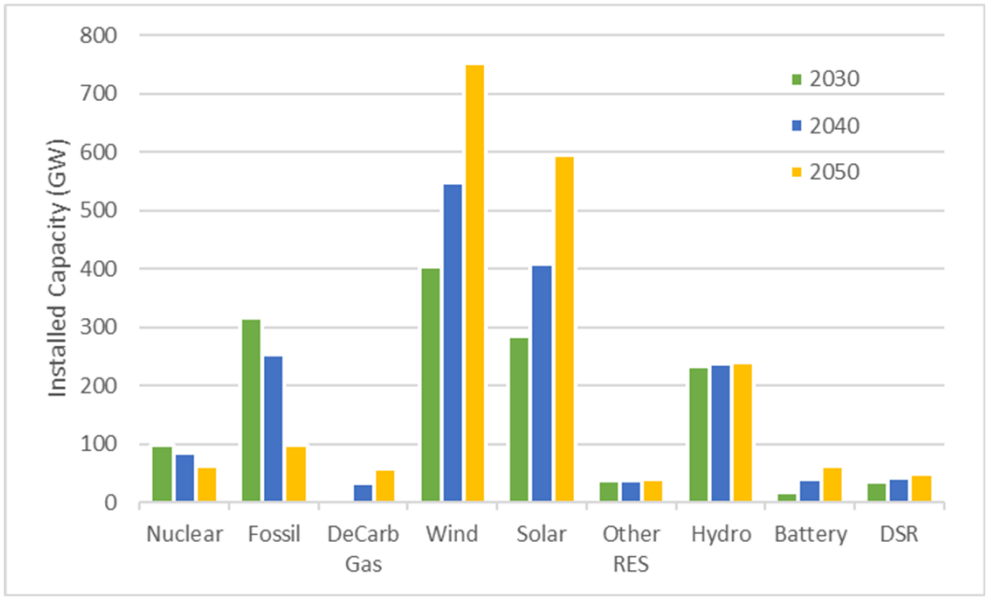
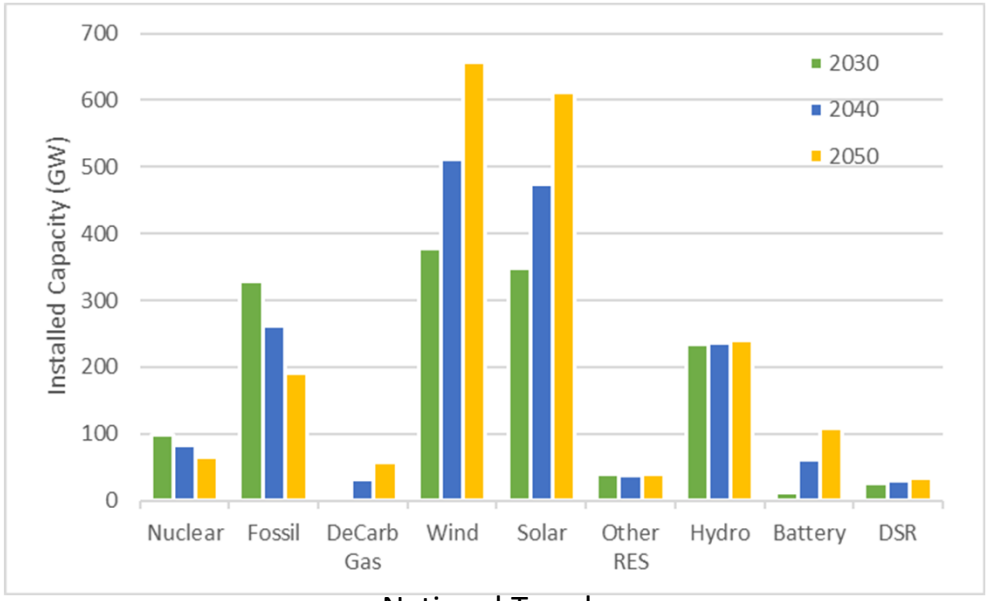


Distributed Energy



Global Ambition



National Trends

Pan-European Scenarios – Additional Data

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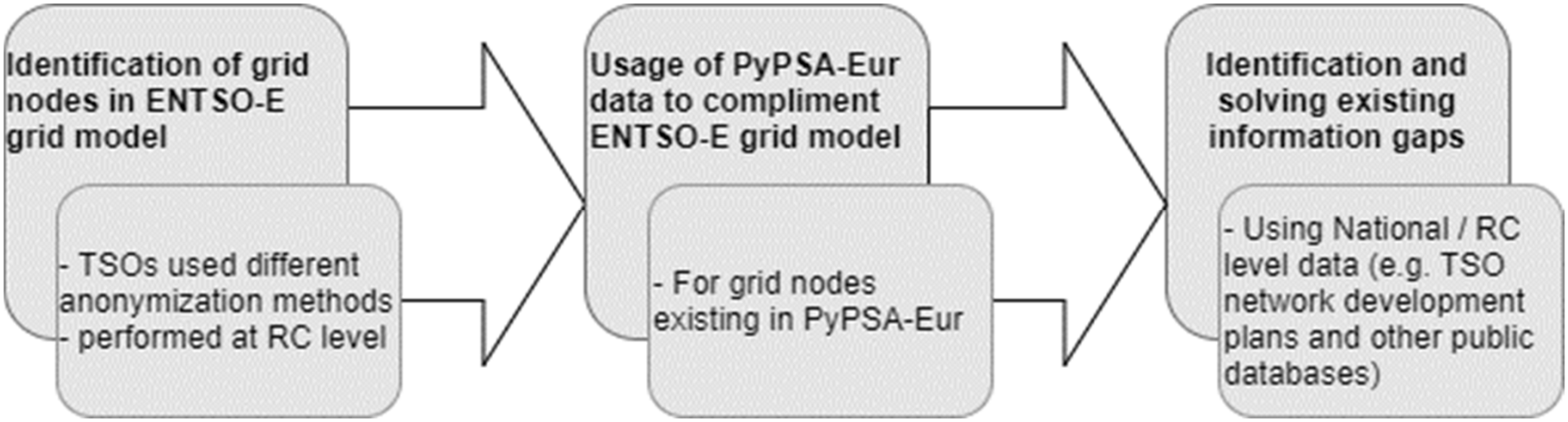
Transmission grid data models

- Pan-European grid model from ENTSO-E
  - Missing data for Nordic countries
  - Missing geographic information
- Additional transmission grid data model:
  - PyPSA (open data)
- Identification of geographic information

Power plant data

- Power plant matching database
- Information from regional cases



Pan-European Simulation

Pan-European Simulation

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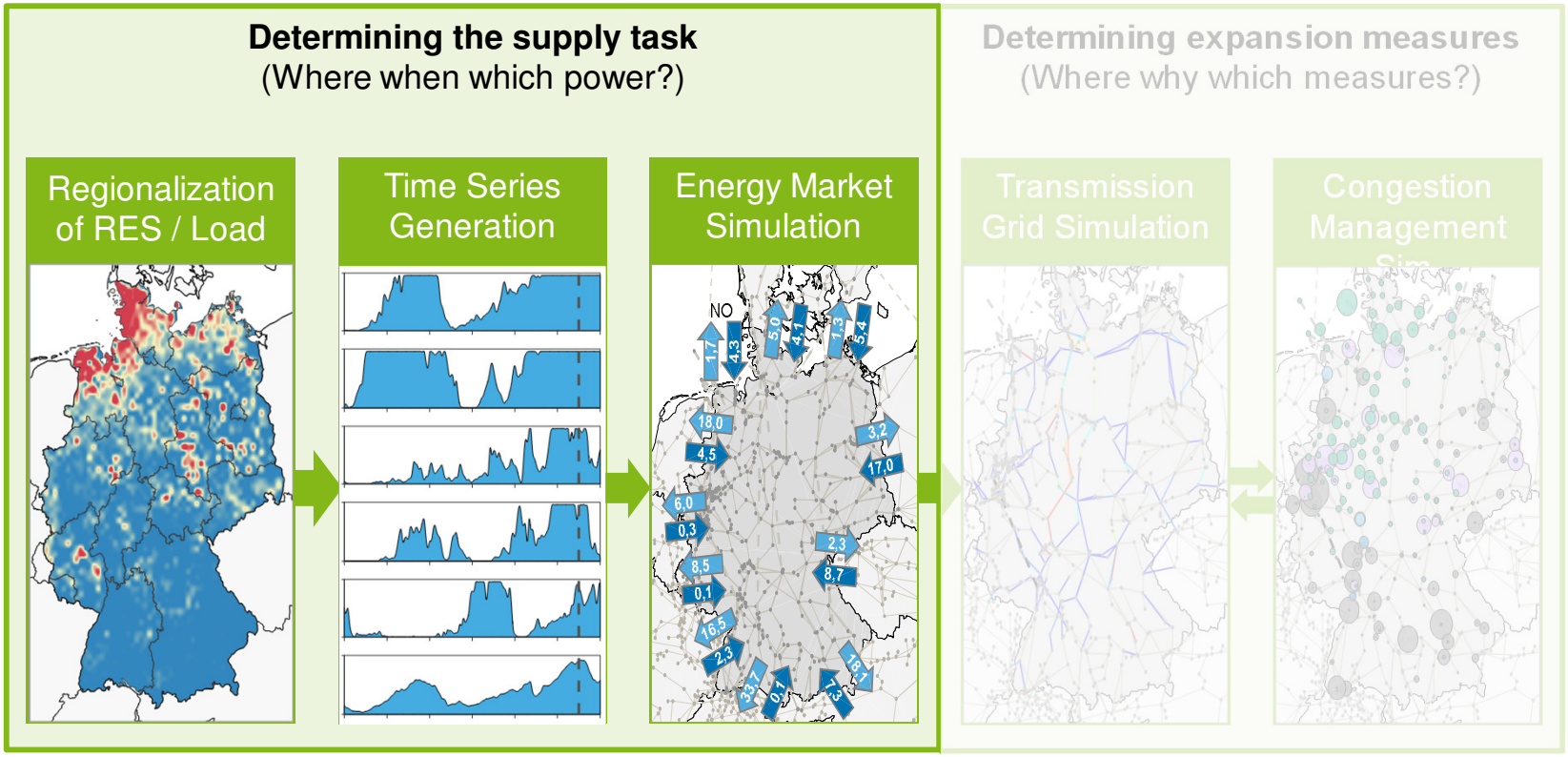
- Existing simulation framework MILES (Model for Internaltional Energy Systems) was used



Pan-European Simulation Regionalization

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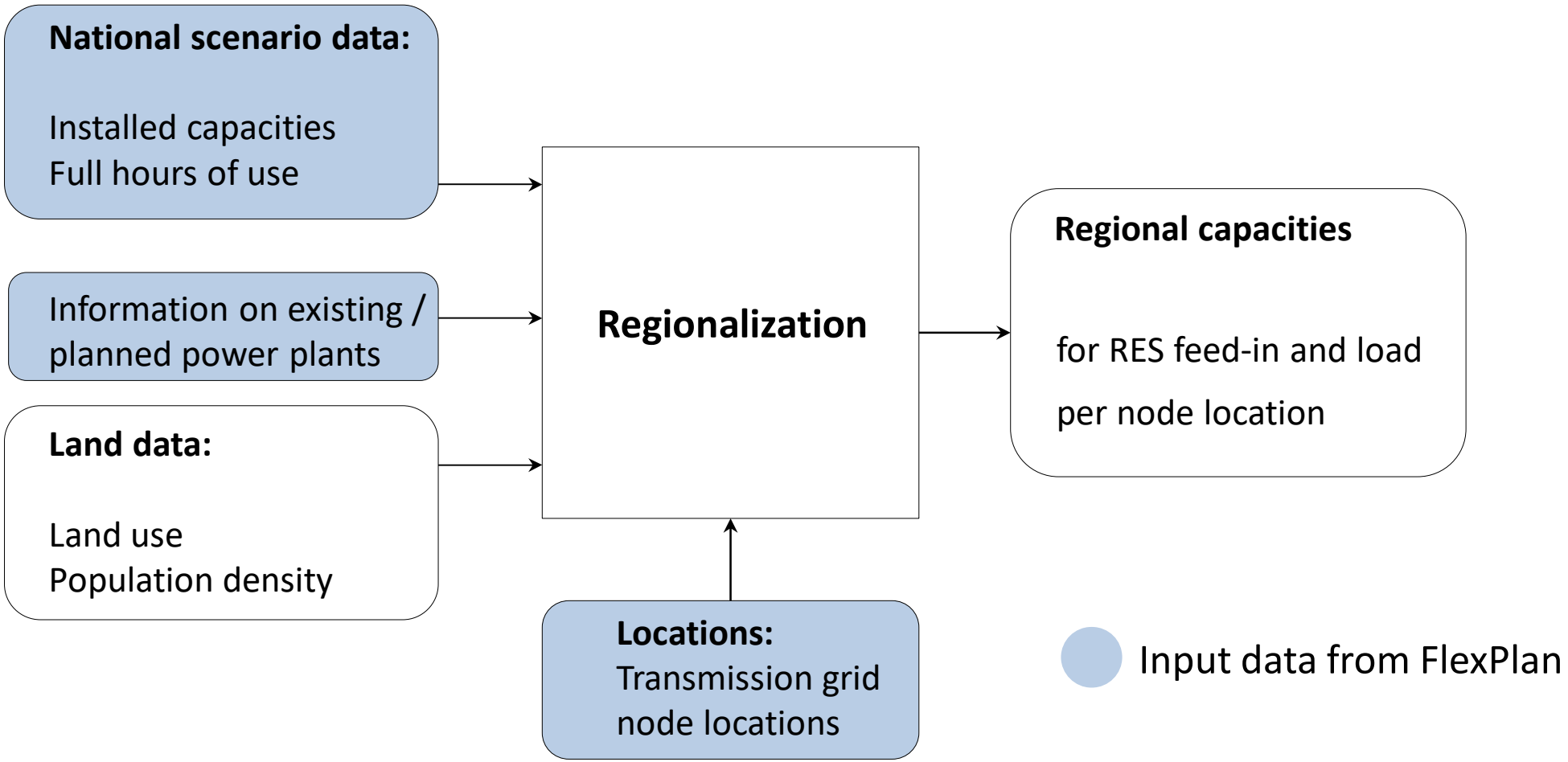

Pan-European Simulation Regionalization

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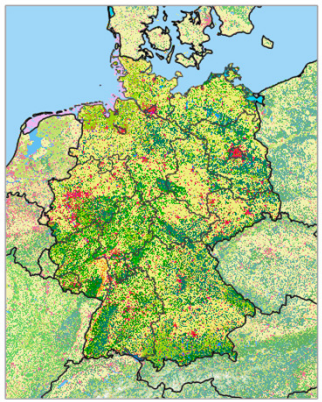
- Use of Regionalization module of MILES

Corine Land Cover Dataset



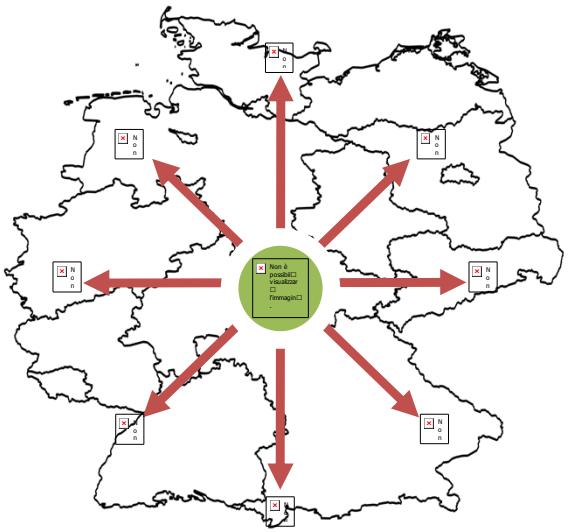
$$F_{Regionalization} = \frac{\prod F^n_{Region}}{\sum_{Region} \prod F^n_{Region}}$$

Land use
Population density

Regionalization factors

Spatial distribution

Existing power plants



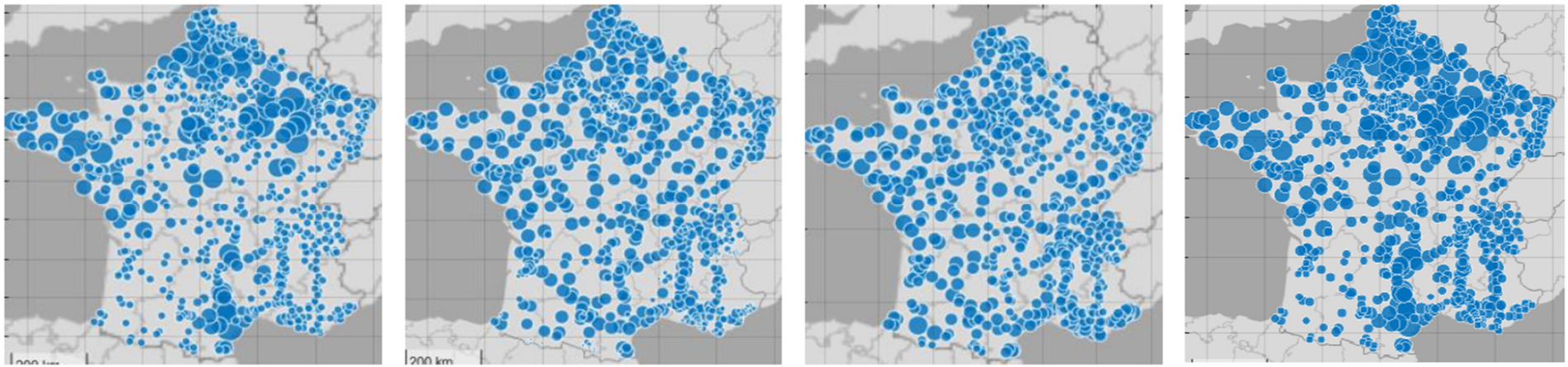
National scenario data
Installed capacities

Regional capacities per node location

Pan-European Simulation Regionalization Wind

FlexPlan

- Limited number of commonly excepted locations with good wind conditions → Repowering is very common for wind power plants
- ➢ Extrapolation of existing plants
- Analyzing the spatial distribution of existing plants, reveals the correlation between the distribution of wind power plants and two factors: the population density and the agricultural use of the area (agricultural areas with low population density)
- ➢ Agricultural areas weighted reciprocal to population density

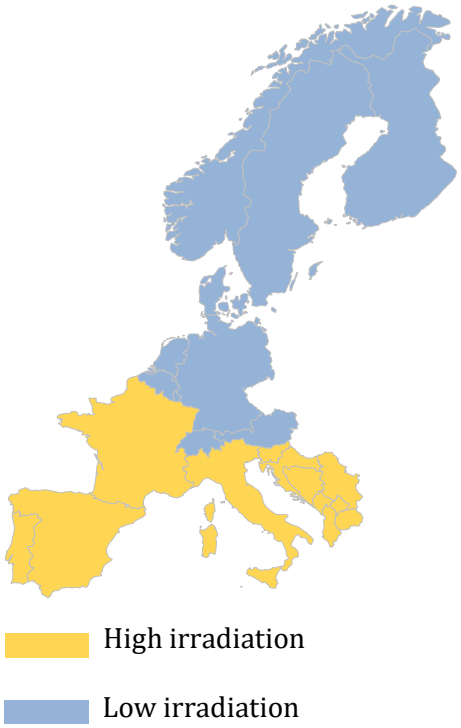


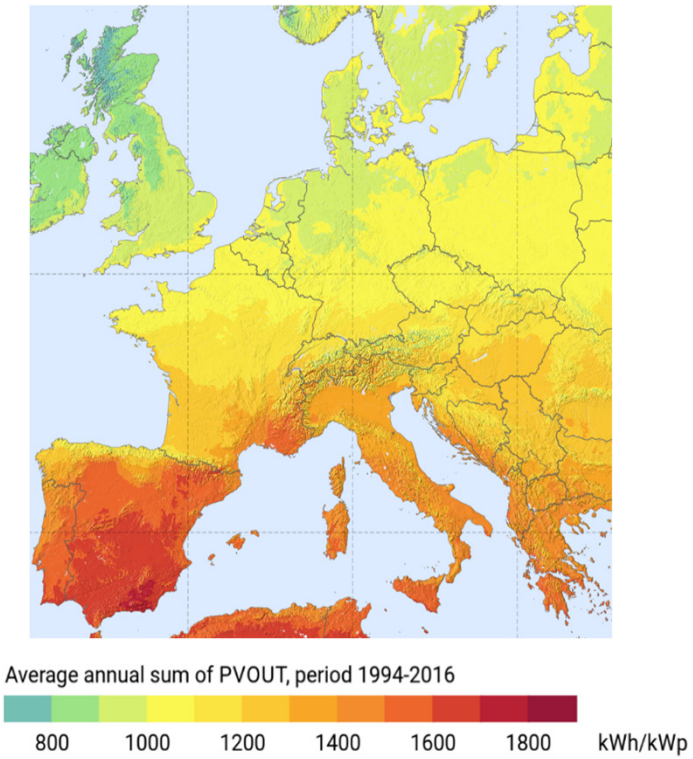
a) Existing plants b) Agricultural areas c) Population density d) WTG distribution

Pan-European Simulation Regionalization Photovoltaic

FlexPlan

- Countries with poor solar irradiation most of the PV power plants are private and mostly placed close to the consumer, i.e., on rooftops,
- Countries with high solar irradiation, where PV systems are mainly ground mounted
- Distinguishing between countries based on average irradiance comparison
  - Low solar irradiation correlation with urban areas
  - Higher solar irradiation correlation with non-irrigated arable land





Pan-European Simulation Regionalization

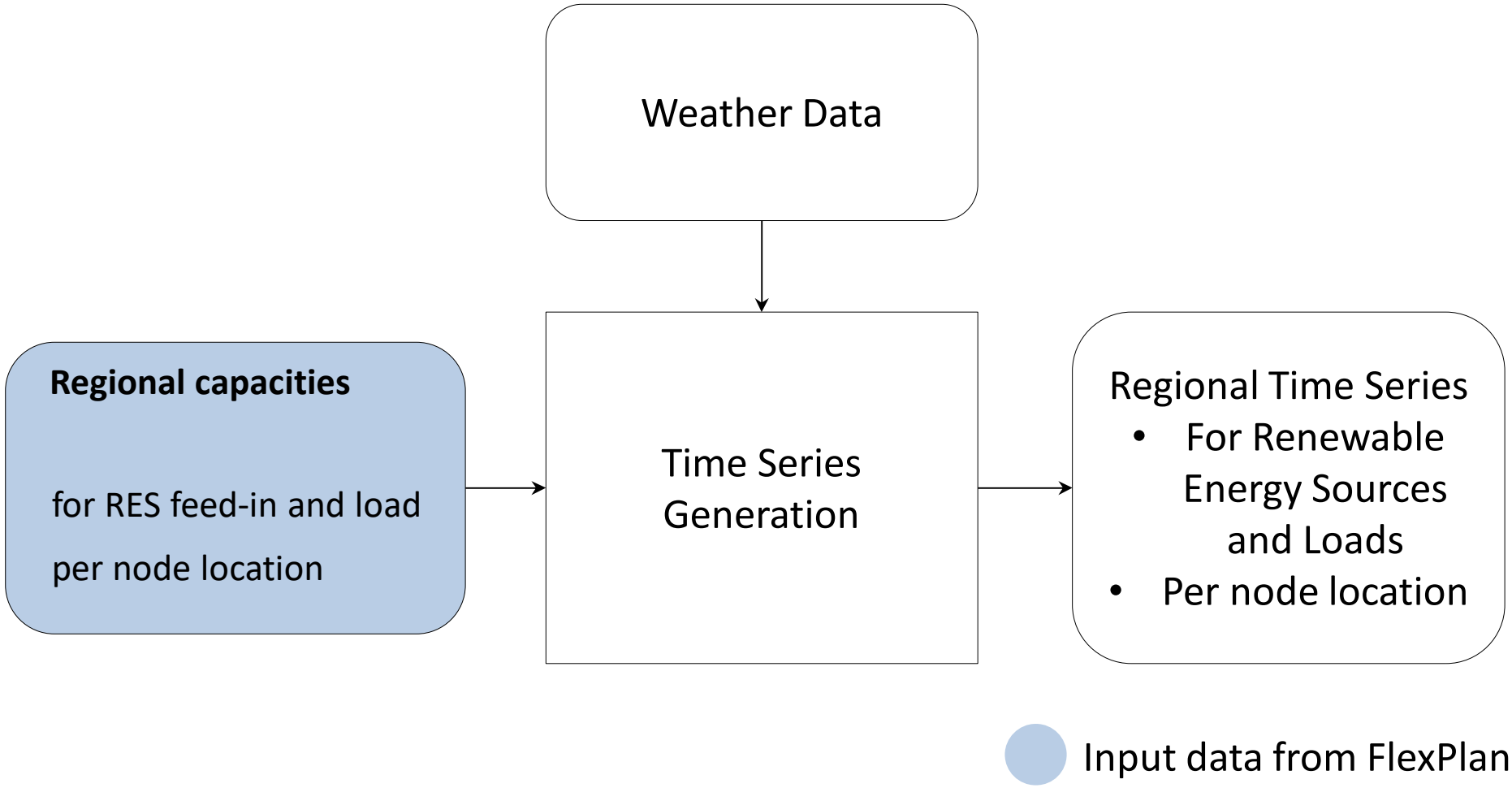
FlexPlan

$$F_{Regionalization} = \frac{\prod F_{Region}^{n}}{\sum_{Region} \prod F_{Region}^{n}}$$

Type	Used information
Load	Population density
Solar	Land use (urban areas, non-irrigated arable land)
Wind	Land use (agricultural areas) weighted reciprocal to population desity
Hydro	Upscaling

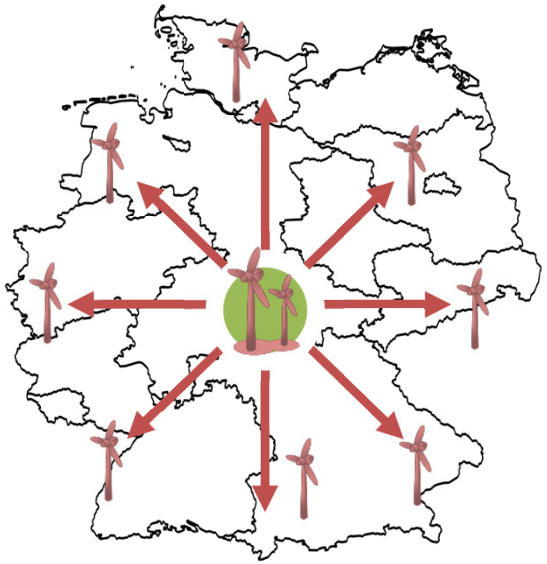
Pan-European Simulation Time Series Generation

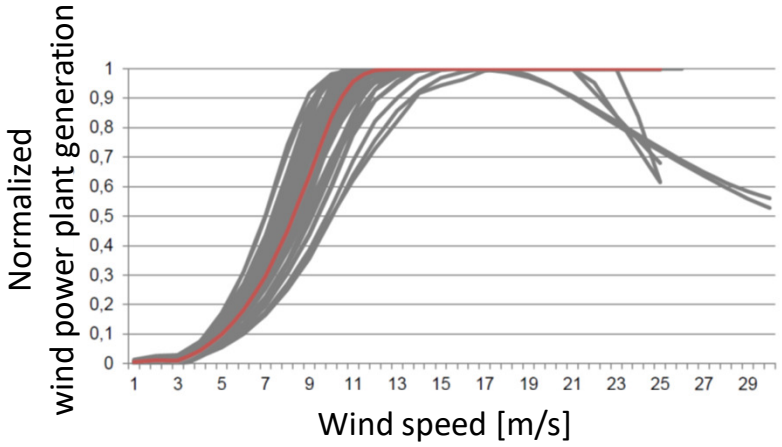
FlexPlan



Pan-European Simulation Time Series Generation

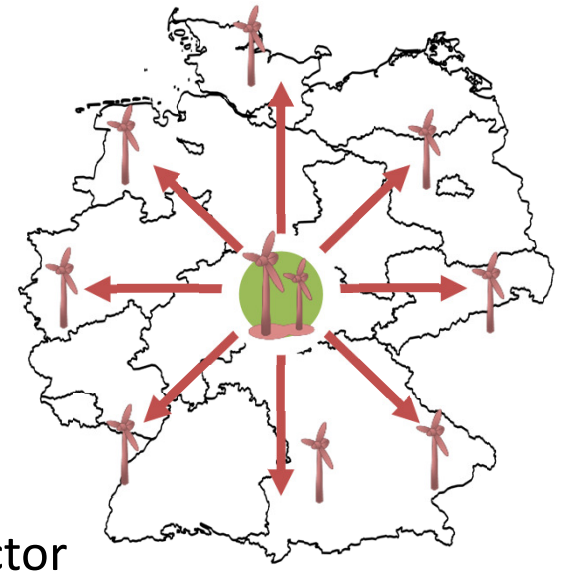
FlexPlan





Characteristic curve

Time Series Generation



Regional installed capacities

Correction factor

ensure that the installed capacity is not exceeded

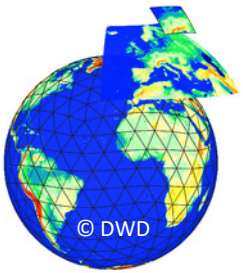
Regional time series

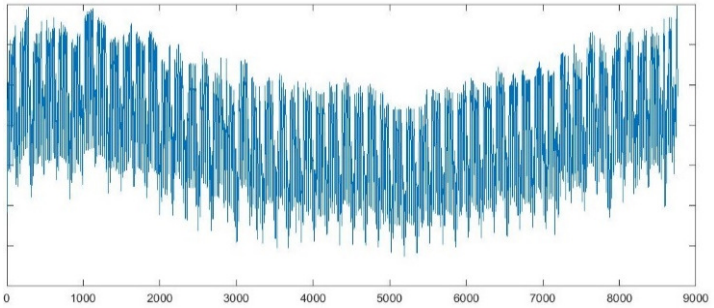
Generated energy defined by the scenario

Weather data

Cosmo EU Model

weather year 2012





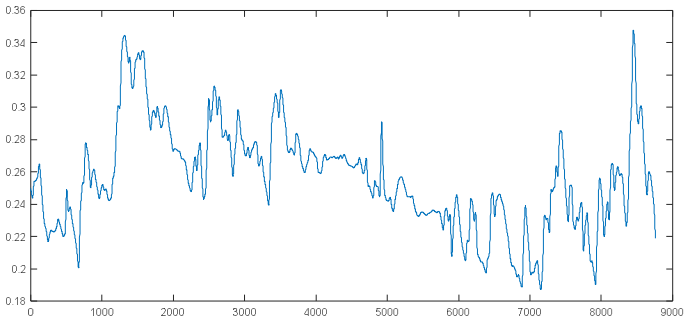
Pan-European Simulation Time Series Generation

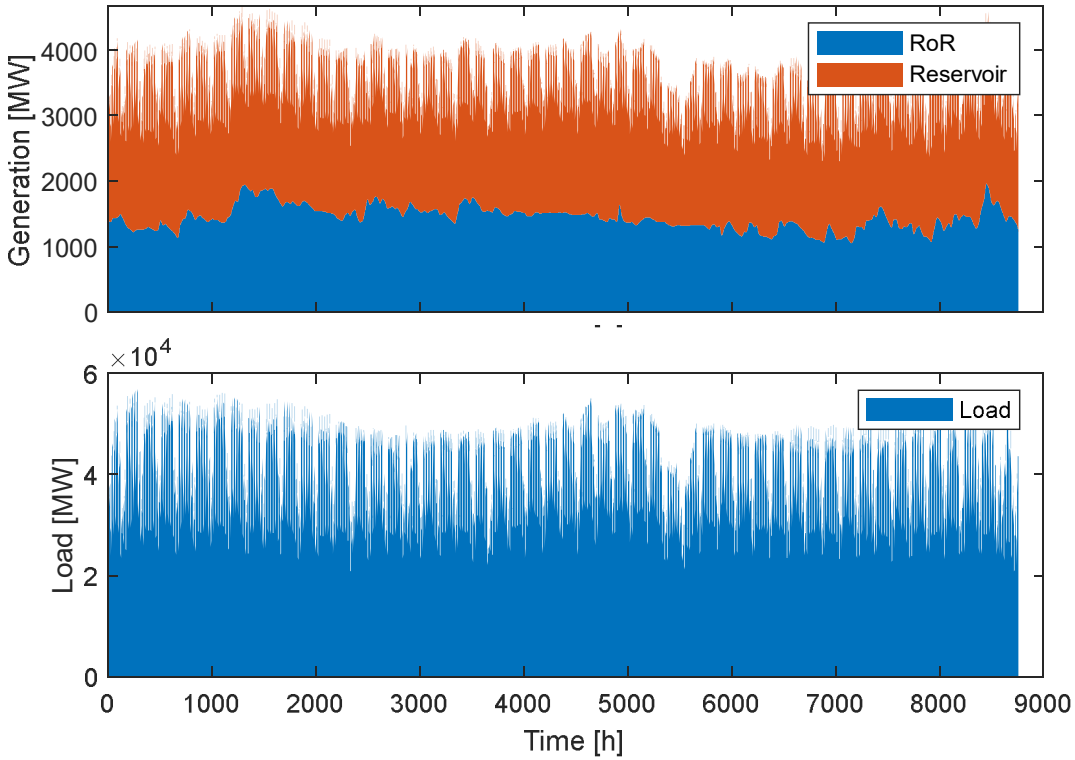
FlexPlan

- Run of river power plants depend on the amount of water being available in rivers and due to a seasonal variability of rivers they follow a seasonal trend

➢ Average historical capacity factors are used

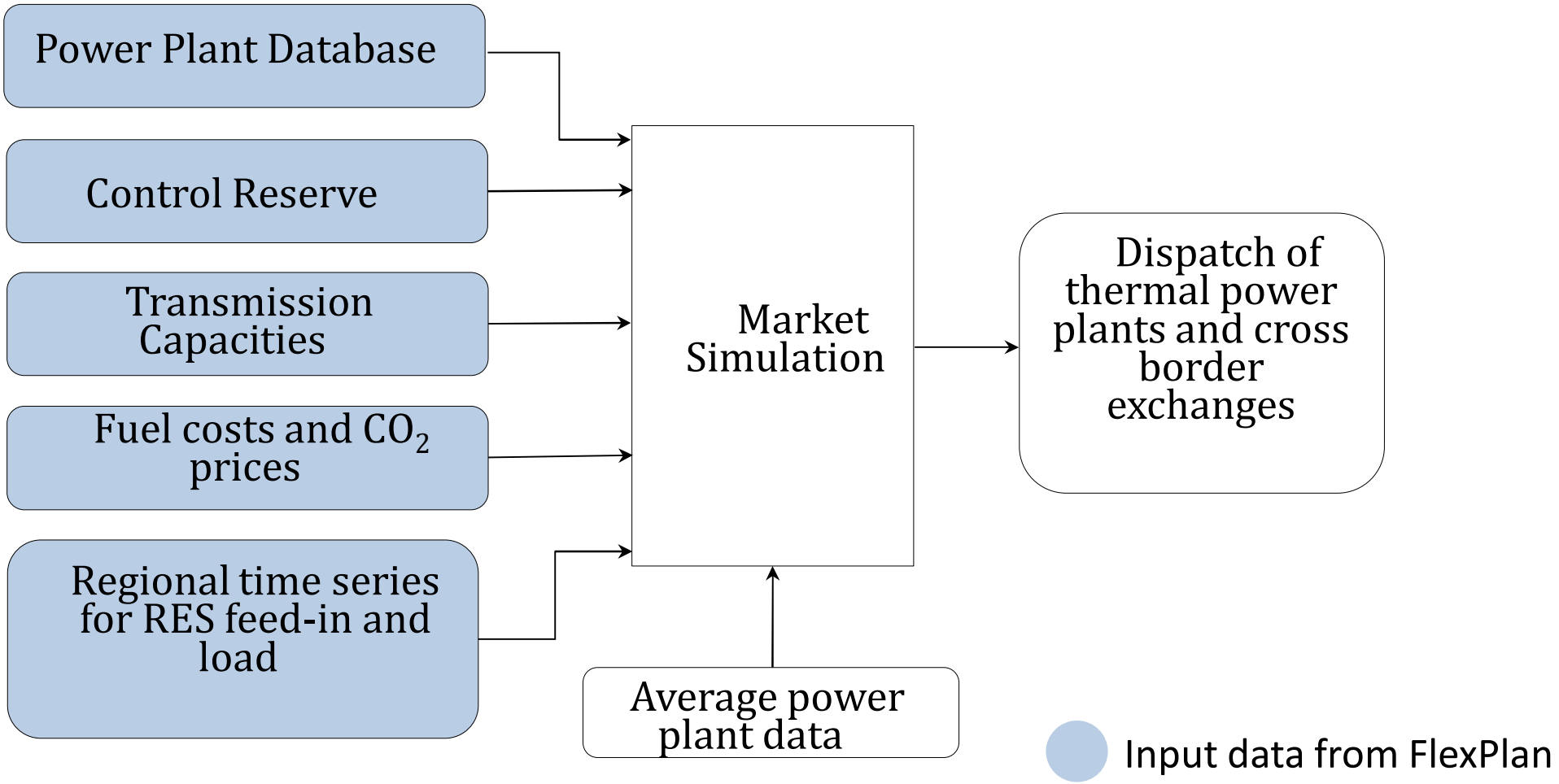
- Reservoir power plants are less weather depended and controllable
- Assumption reservoir power plants used to cover the load → proportional to load





Pan-European Simulation Market Simulation

FlexPlan



Pan-European Simulation Market Simulation

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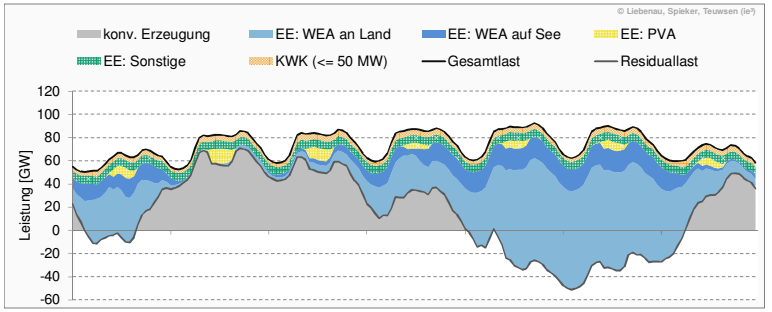


Objective function:

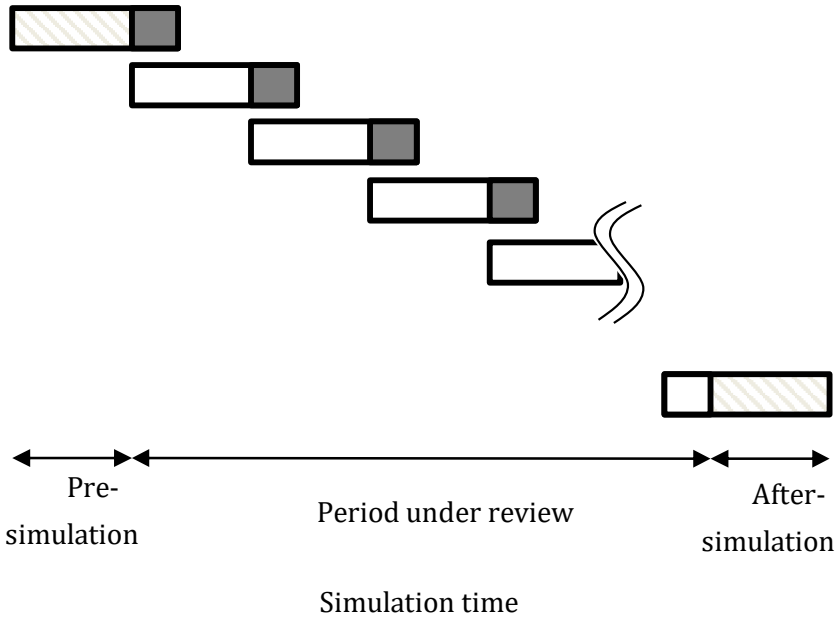
- Minimization of system-wide generation costs

Constraints:

- Load and control reserve coverage
- Minimum and maximum power outputs of generation units
- Minimum up- and downtimes
- Ramping limits of generation units
- Turbine and pump power limits
- Storage capacities
- Maximum transfer capacities

Rolling horizon

- The year is divided into overlapping intervals of equal duration of ten days
- Representing the planning horizon of the market participants
- These intervals are solved successively



Pan-European Simulation

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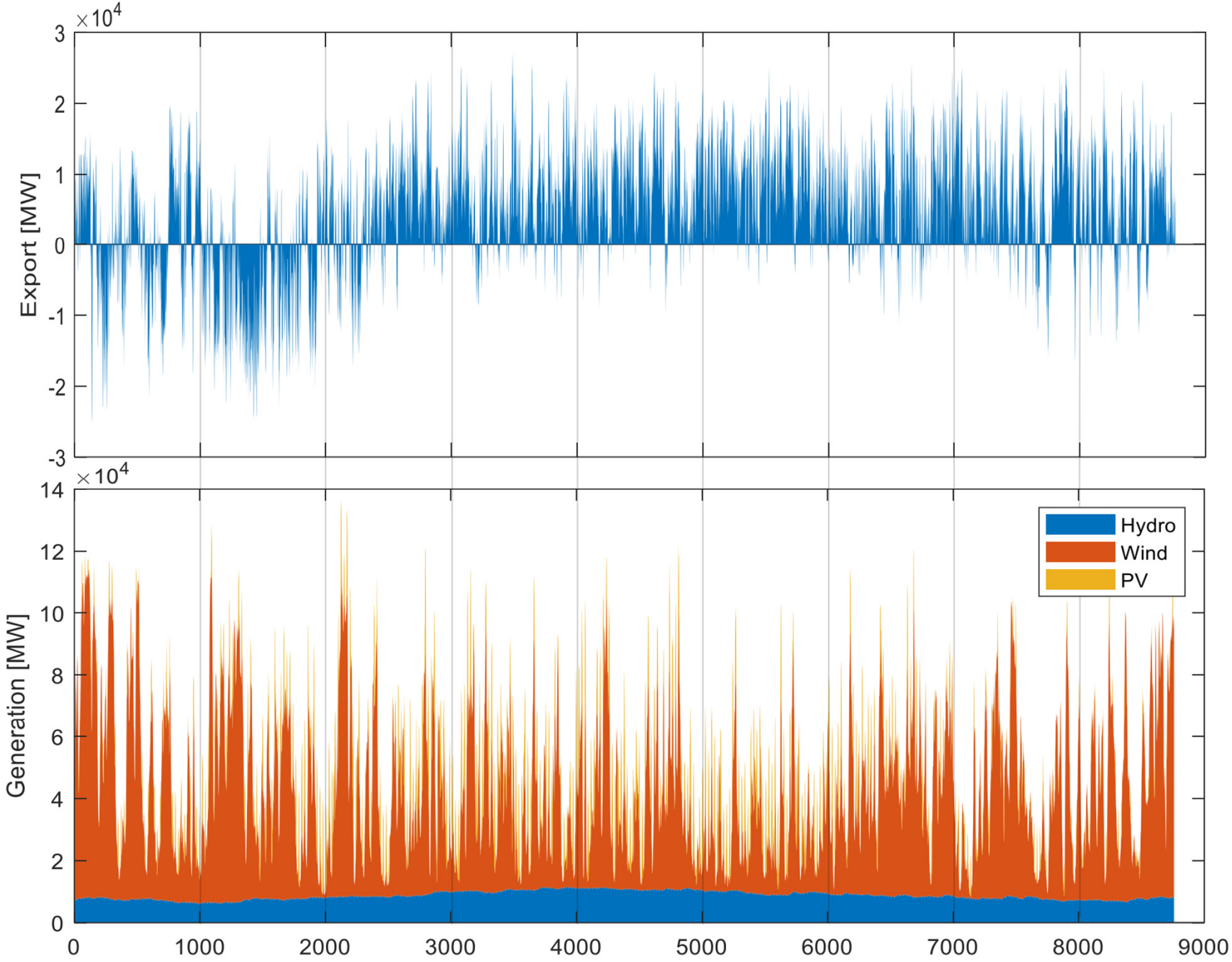

Pan-European Simulation Market Simulation

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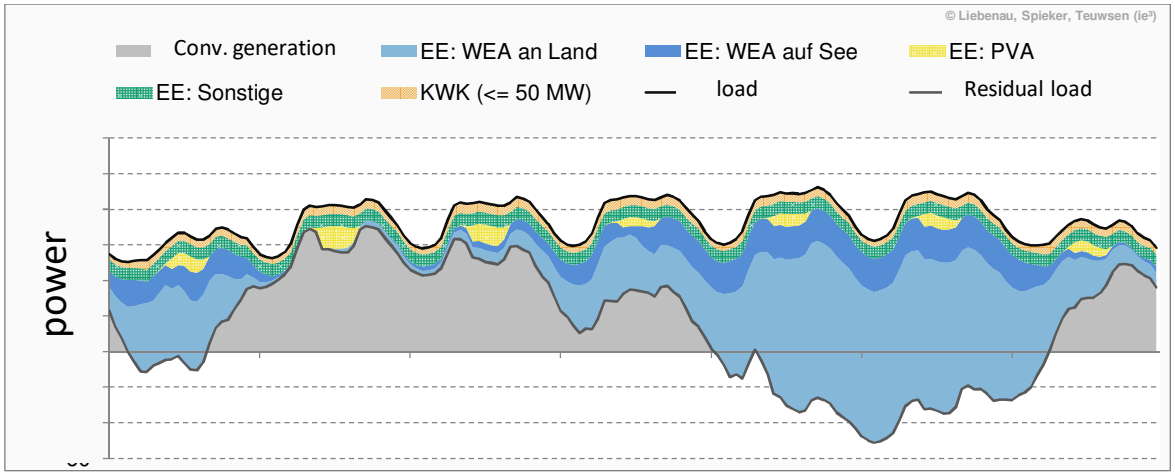


Input data

- Power plant database
- Fuel prices and prices for CO_2 certificates
- **RES feed-in time series**
- **Load time series**
- Control reserve
- Maximum transmission capacities

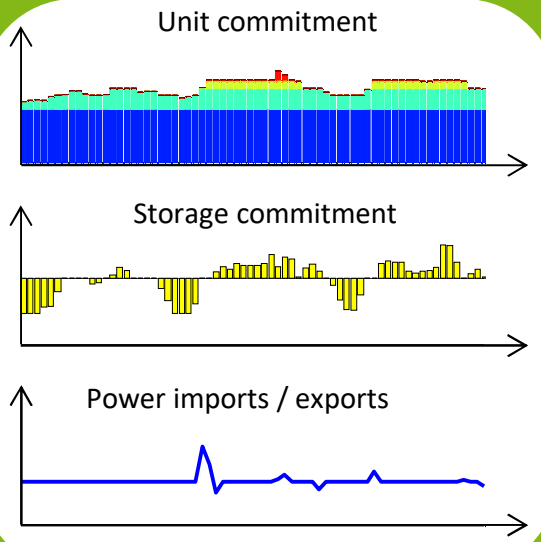
Market simulation

Objective function:
Minimization of system-wide generation costs

Constraints:

- Load and control reserve coverage
- Minimum and maximum power outputs of generating units
- Minimum up- and downtimes of generating units
- Ramping limits of generating units
- Turbine and pump power limits, storage capacities
- Maximum trading/transfer capacities

Simulation results



Summary

Summary

FlexPlan

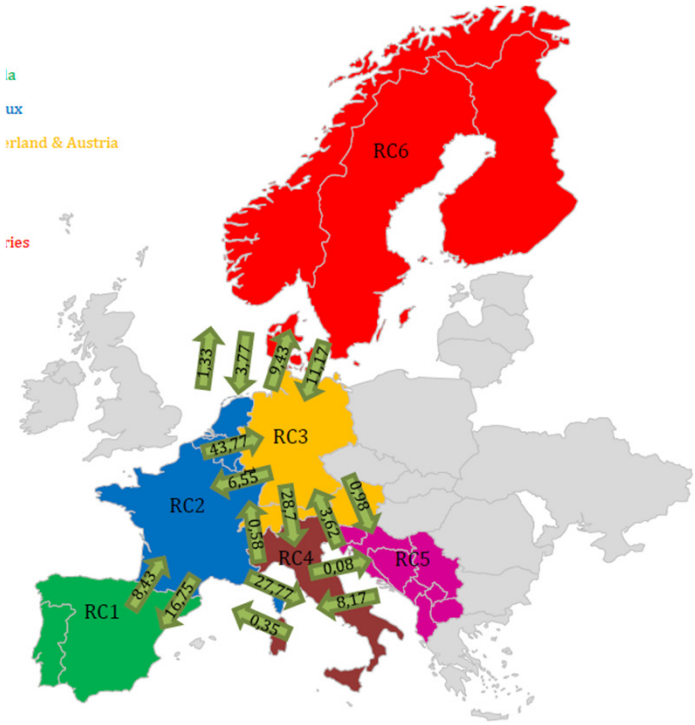
Obtained results:

- Scenario data for three variants and three target years resulting in nine scenarios
- Additional data (grid models including geographic information, Power plant data)

- Spatial distribution of renewable energy sources and loads
- Renewable injection and consumption time series per node
- Cross border conditions

- The results provide a common ground for the regional cases within the FlexPlan project

- Nodal time series of RES and loads can be used as input data and coherent border conditions enable to split the pan-EU grid into regional case studies



Thank you…

Jawana Gabrielski

Contact Information

Affiliation: TU Dortmund
Phone: +49 231 9700 980
Email: jawana.gabrielski@tu-dortmund.de

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