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# Generation of Coherent Pan-European Scenario Data for Grid Expansion Studies

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# Agenda

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

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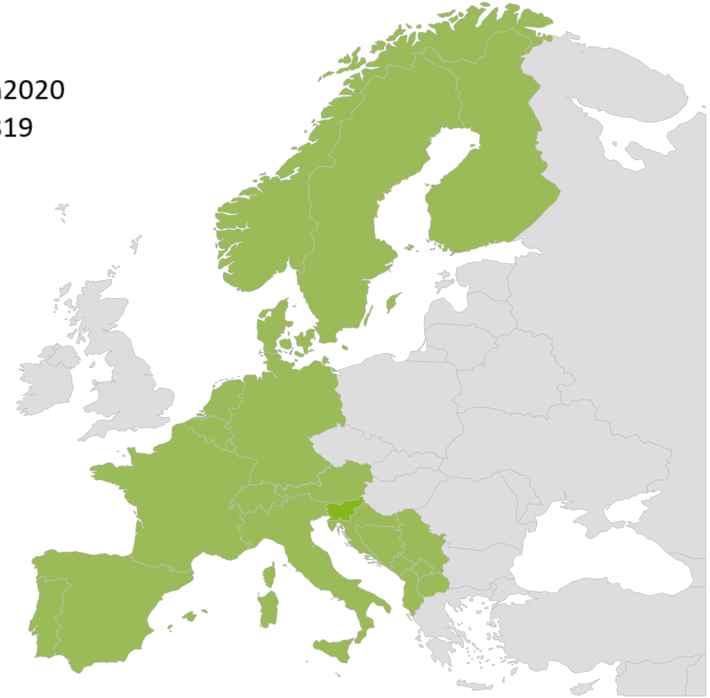
# INTRODUCTION

# Introduction FlexPlan

This project has received funding from the European Union's Horizon2020 research and innovation programme under grant agreement N° 863819

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

- How to determine coherent cross-border conditions between the different regional cases?
- How to provide common input data for the regional cases?

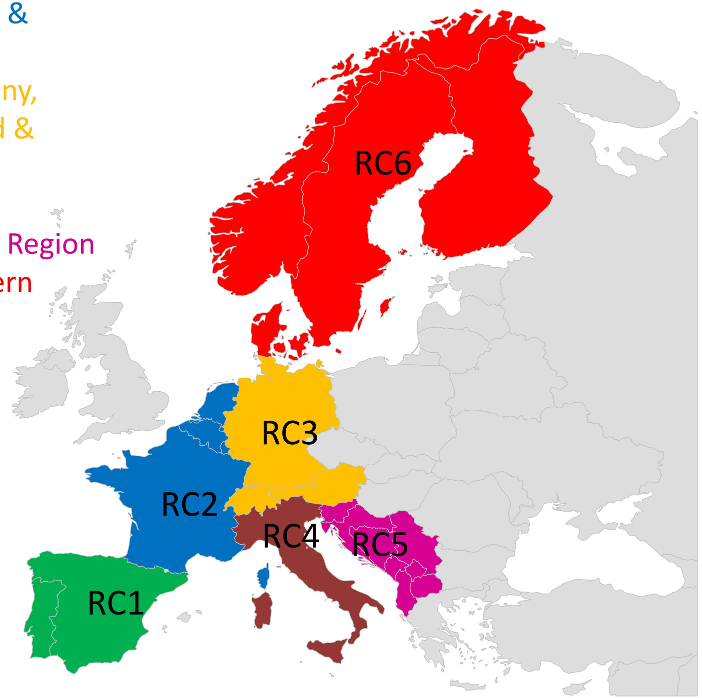


# Introduction

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

- A multi-step modeling approach is applied
  1. Scenario Generation
  2. Pan-European Simulation

RC1 Iberian Peninsula
RC2 France & BeNeLux
RC3 Germany, Switzerland & Austria
RC4 Italy
RC5 Balkan Region
RC6 Northern Countries



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# PAN-EUROPEAN SCENARIOS

# Pan-European Scenarios

- Pan-EU framework, data at national level for three scenarios
  - Installed generation capacities by technology
  - Full hours of use for renewable energy sources
  - Annual electricity consumption and peak load
  - Hourly time series data for consumption
  - Net transfer capacities
  - …

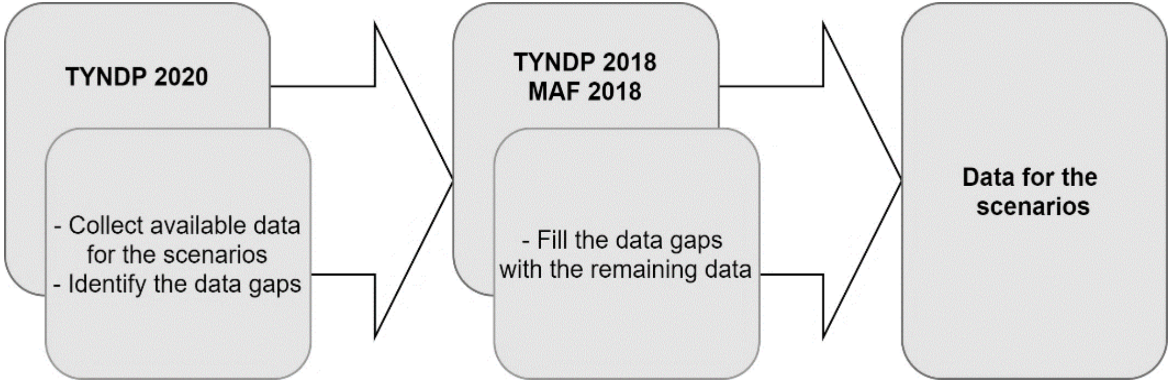
➢ Data from TYNDP 2020 [1]

- Using already validated data sources, to achieve a higher acceptance of developed tool and obtained results

| Distributed Energy | Global Ambition | National Trends |
|---|---|---|
| Top down reflecting the Paris Agreement target | 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

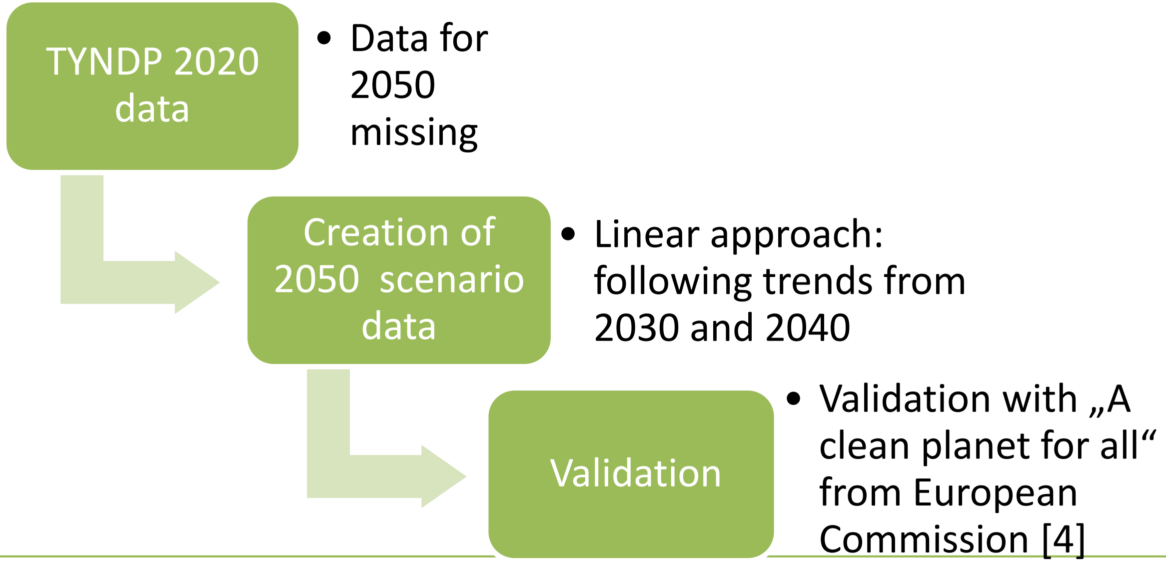
- TYNDP 2020 Scenarios used as main data source
  - Complemented by TYNDP2018 [2] and MAF2018 [3], when needed




- Three target years
  - 2030
  - 2040
  - 2050

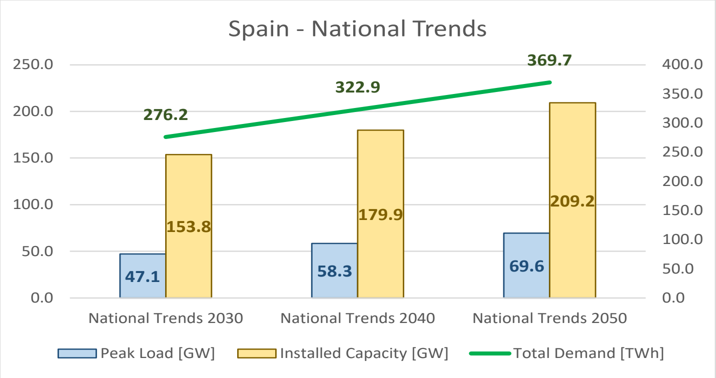
# Pan-European Scenarios

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



# Pan-European Scenarios

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




TYNDP 2020 data

- Data for 2050 missing

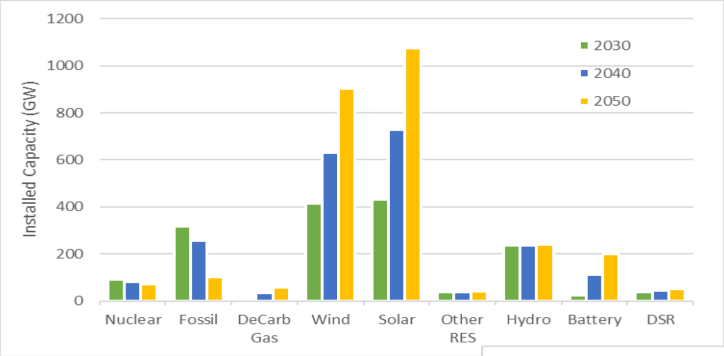
Creation of 2050 scenario data

- Linear approach: following trends from 2030 and 2040

Validation

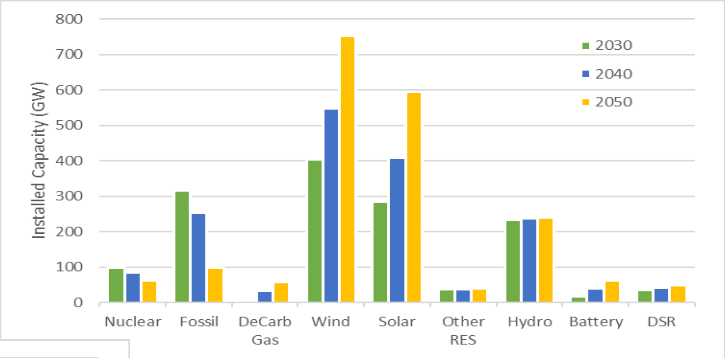
- Validation with „A clean planet for all“ from European Commission

# Pan-European Scenarios – Results



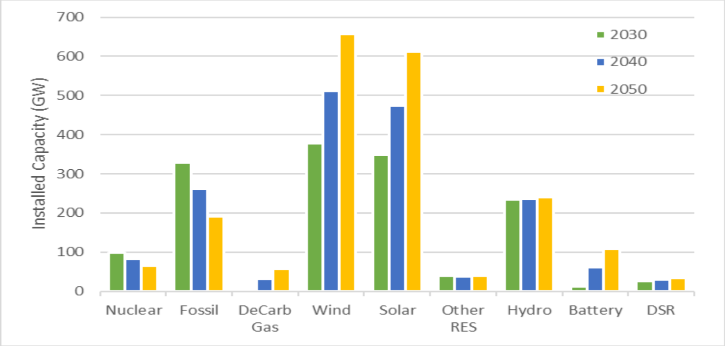

Distributed Energy

- decentralized




Global Ambition

- centralized

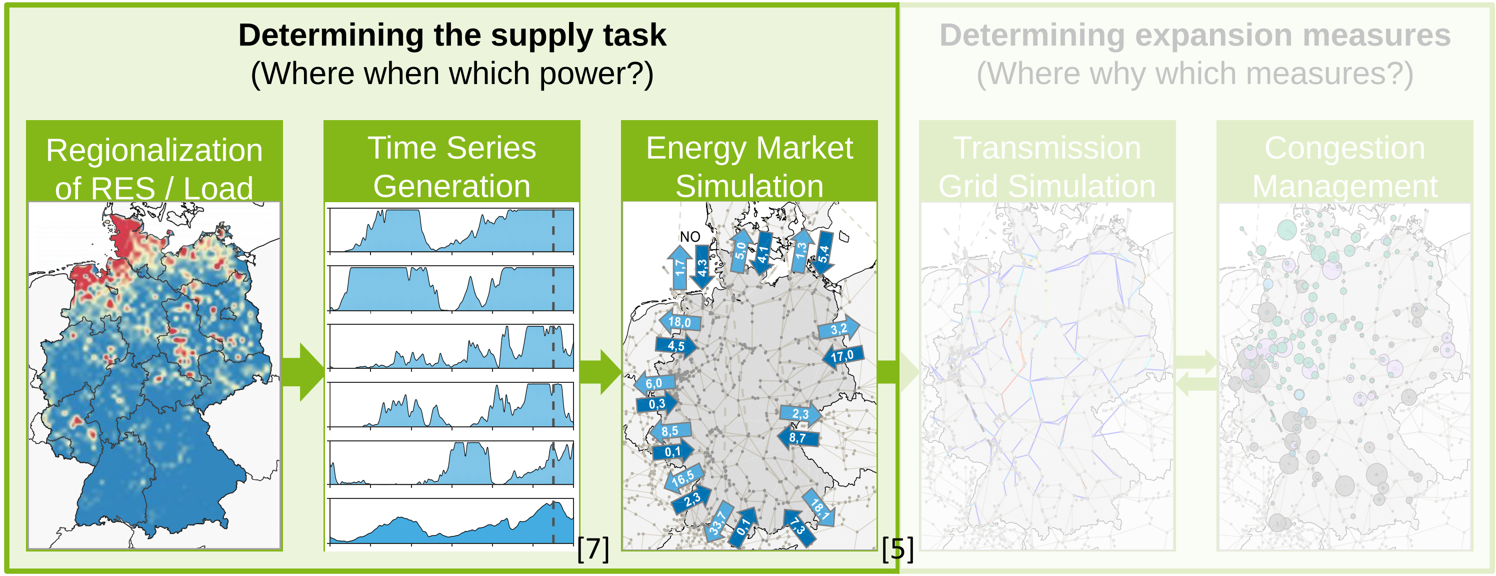



National Trends

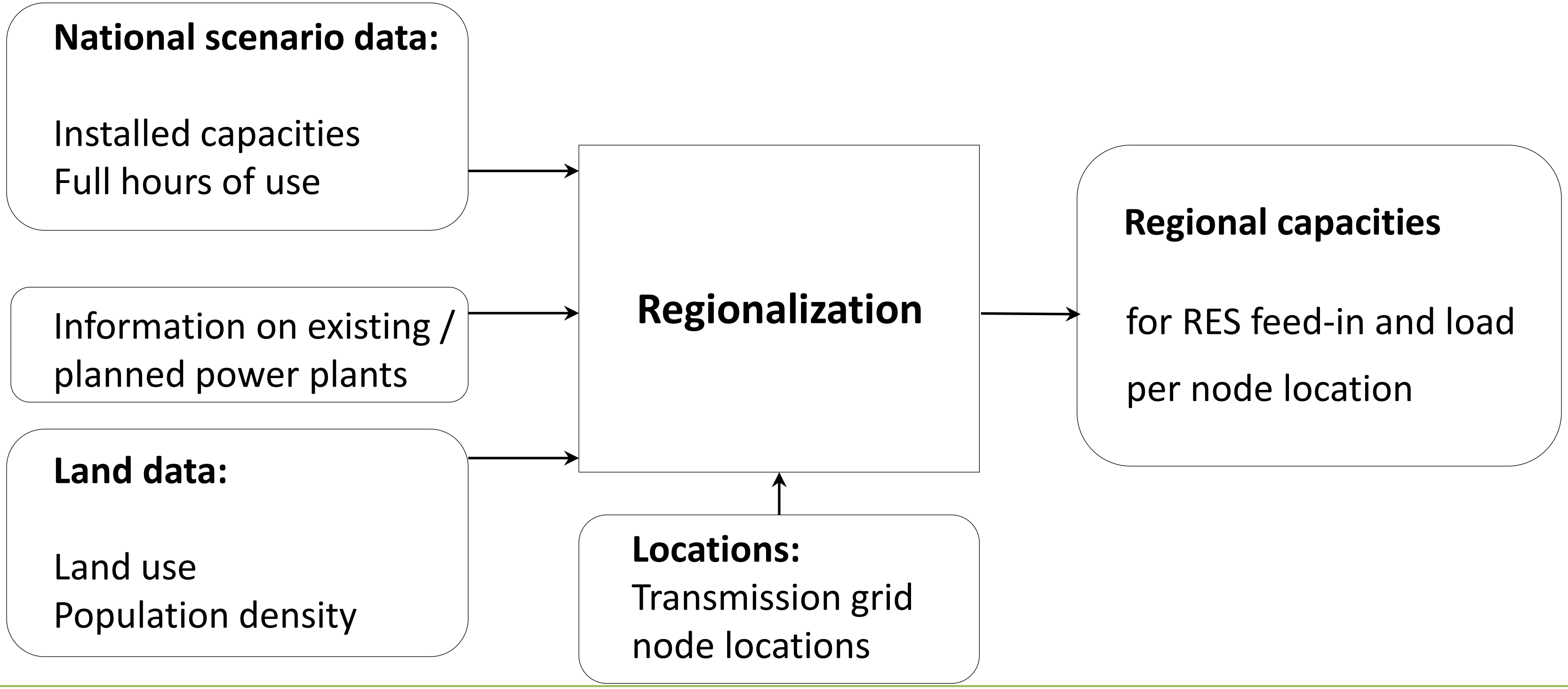
# PAN-EUROPEAN SIMULATION

# Pan-European Simulation – Framework

Existing simulation framework MILES (Model for Internaltional Energy Systems) [5] was used

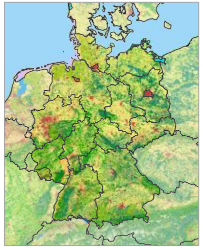


# Pan-European Simulation – Regionalization



# Pan-European Simulation – Regionalization

Corine Land Cover Dataset [6]



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

n=1: one dimensional
n>1: multi dimensional

National scenario data
Installed capacities

Land use
Population density

Regionalization factors

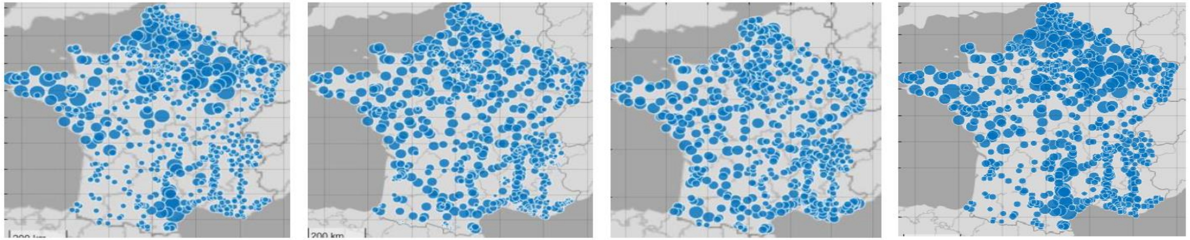
**Spatial distribution**

Existing planned power plants

Regional capacities per node location

# Pan-European Simulation – Regionalization for Wind Power Plants

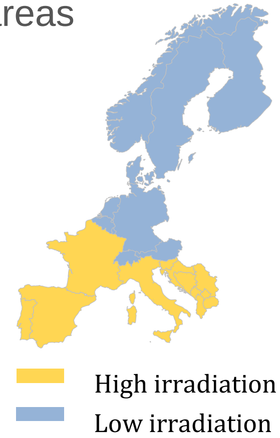
- Limited number of commonly excepted locations with good wind conditions → Repowering is very common for wind power plants
- ➢ Extrapolation of existing plants
- Analyzing the spatial distribution of existing plants, reveals the correlation between the distribution of wind power plants and two factors: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

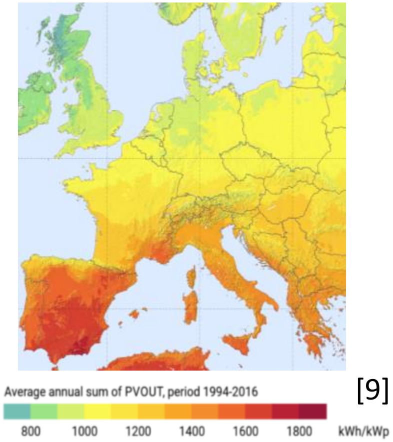


a) Existing plants b) Agricultural areas c) Population density d) WTG distribution

# Pan-European Simulation – Regionalization for Photovoltaic Plants

- 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
  - Countries with low solar irradiation: correlation with urban areas
  - Countires with higher solar irradiation correlation with non-irrigated arable land



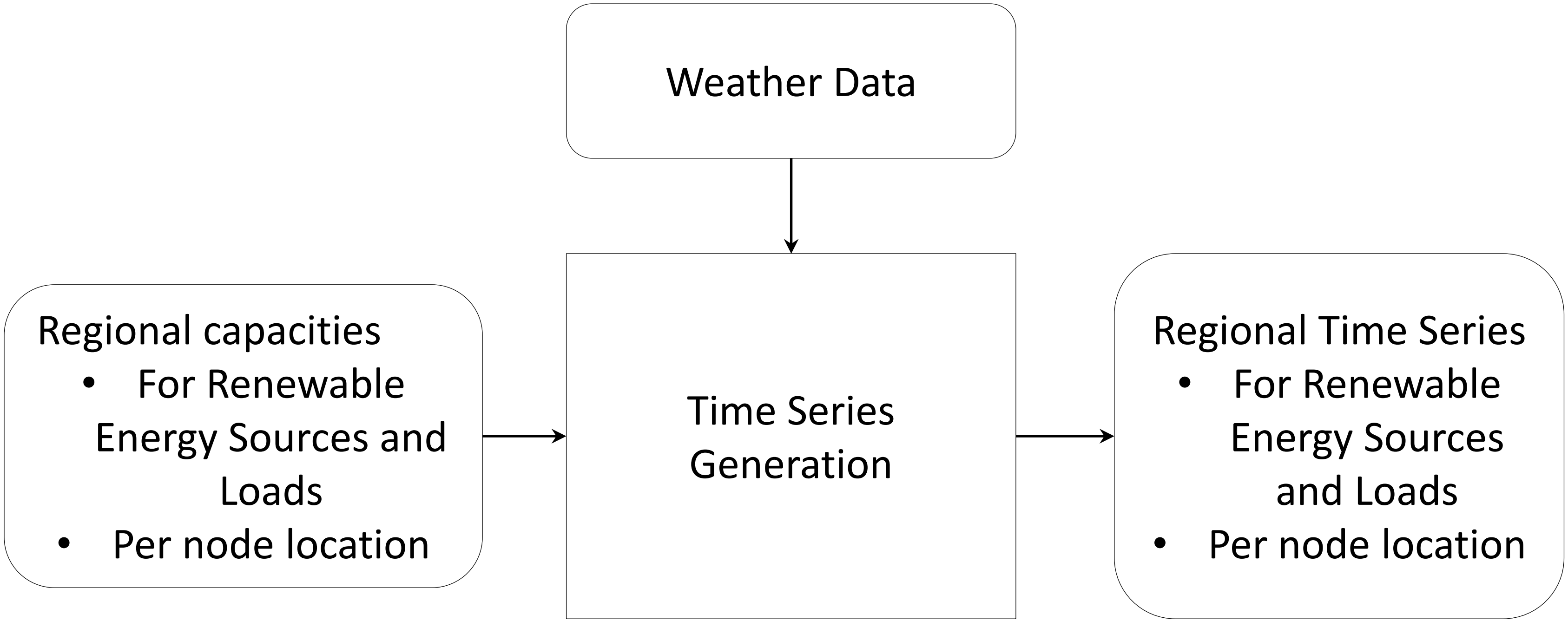




[9]

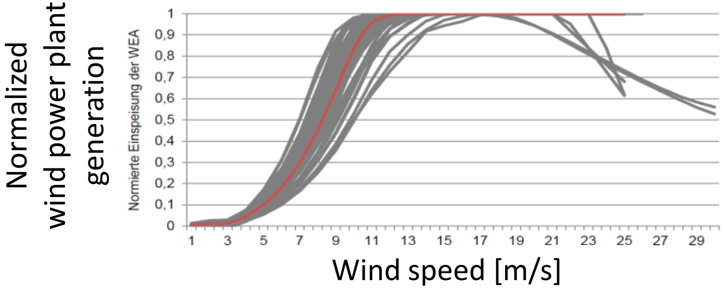
# Pan-European Simulation – Regionalization factors

| 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



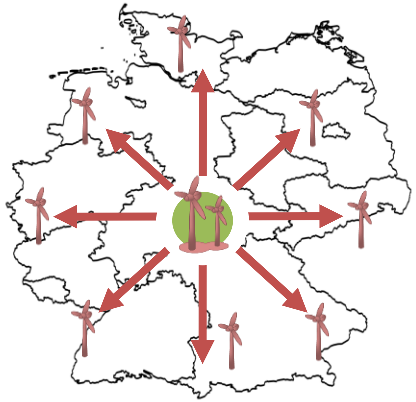
# Pan-European Simulation – Time Series Generation




Characteristic curve [8]

**Correction factor**

ensure that the installed capacity is not exceeded



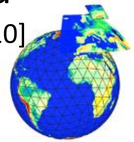
Regional installed capacities

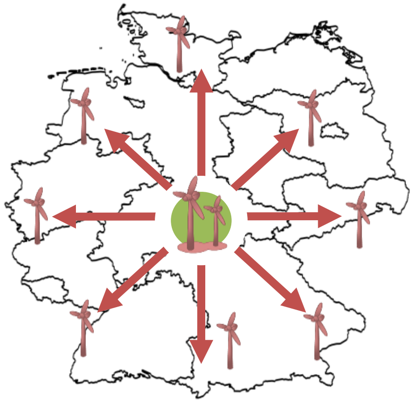
**Time Series Generation**

Generated energy defined by the scenario

**Weather data**

Cosmo EU Model [10]
weather year 2012



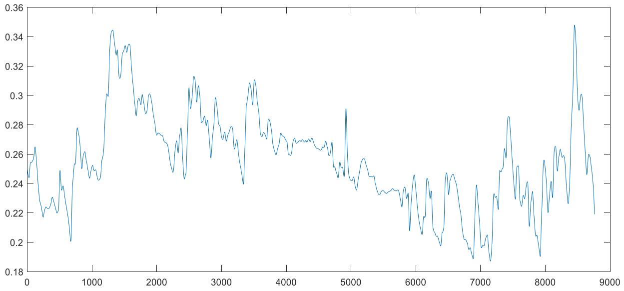


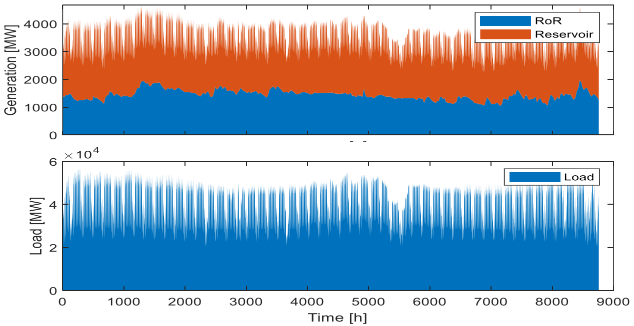
Regional time series

# Pan-European Simulation – Time Series Generation for Hydro

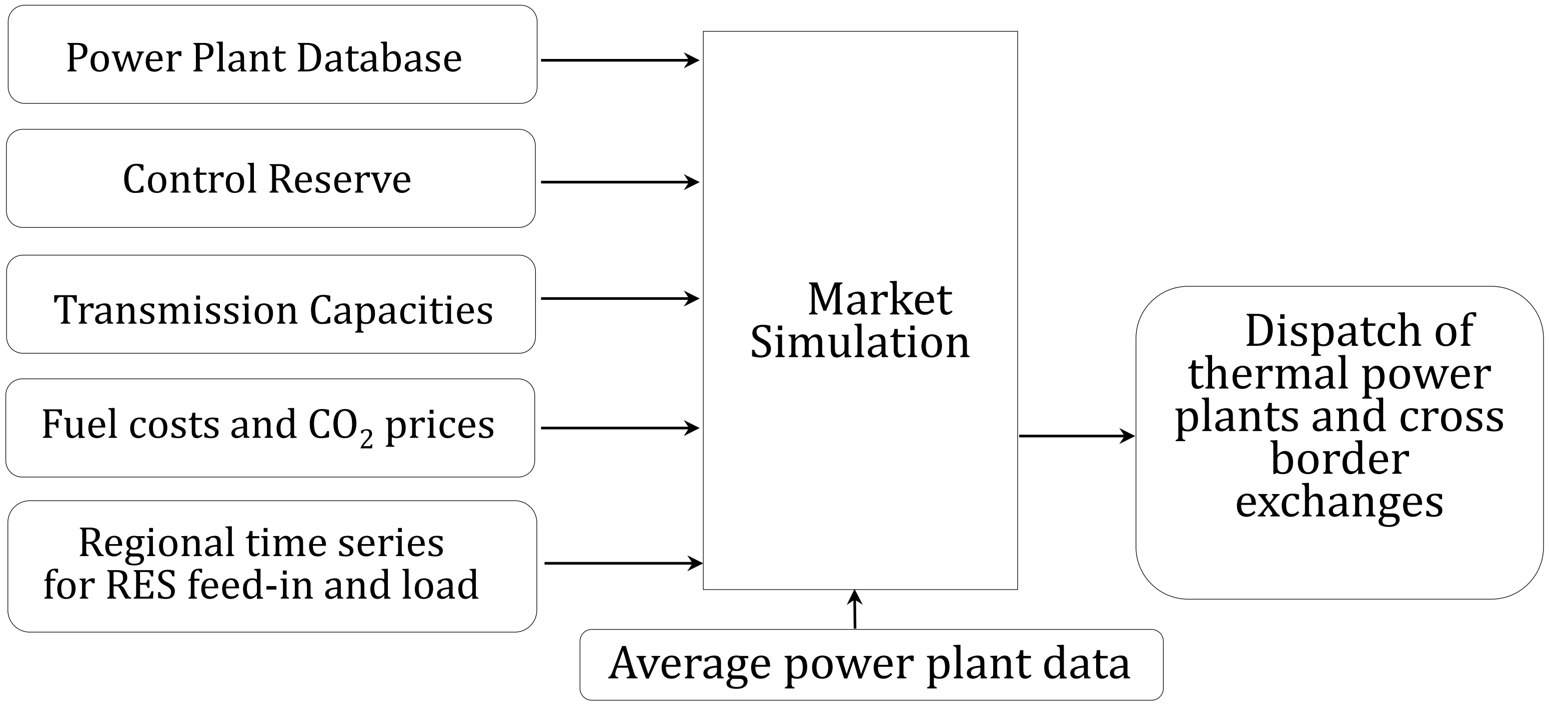
- Run of river power plants depend on the amount of water being available in rivers and due to a seasonal variability of rivers they follow a seasonal trend
➢ Average historical capacity factors [11] are used

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



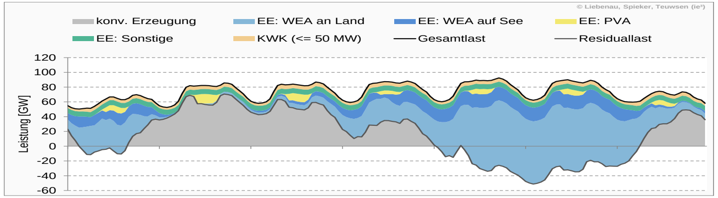
# Market Simulation



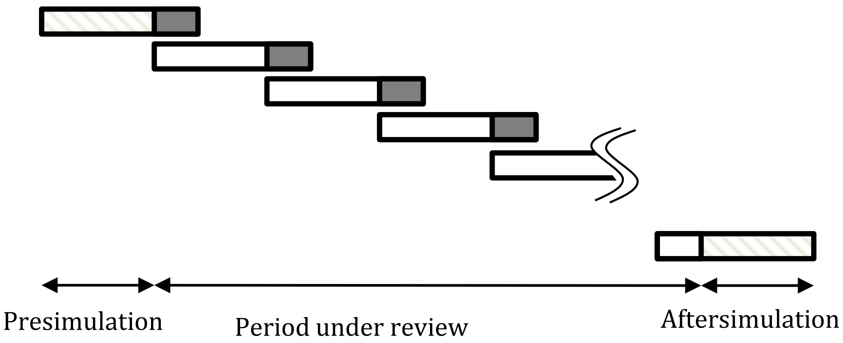
# Market Simulation

Minimization of system-wide generation costs

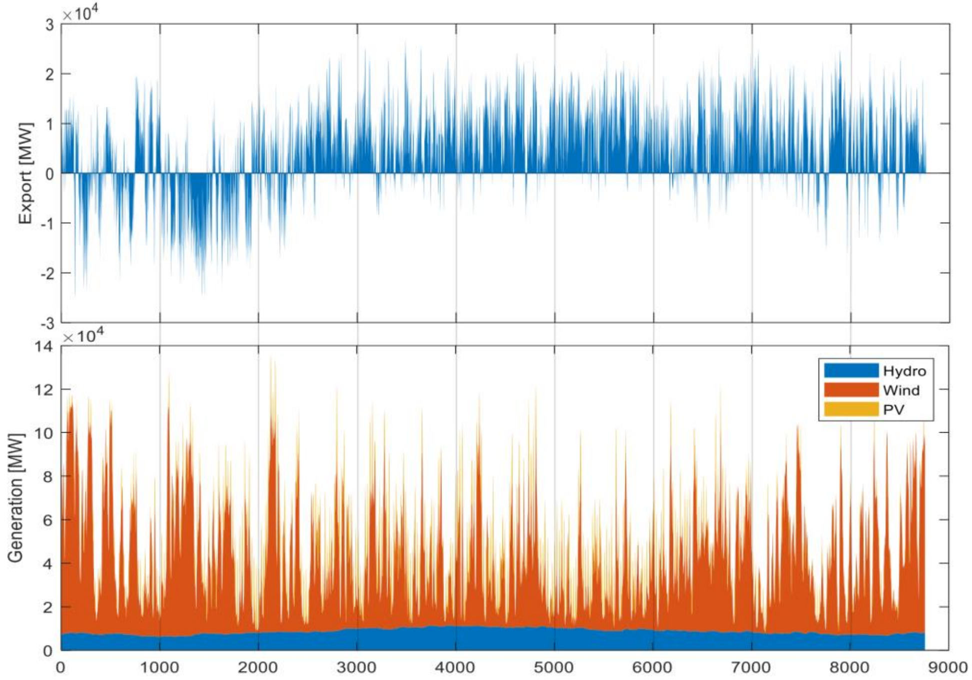
- Constraints:
  - Load and control reserve coverage
  - Min and max power outputs of generation units
  - Minimum up- and downtimes
  - Ramping limits of generation units
  - Turbine and pump power limits
  - Storage capacities
  - Maximum transfer capacities




- 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 – Exemplary Results

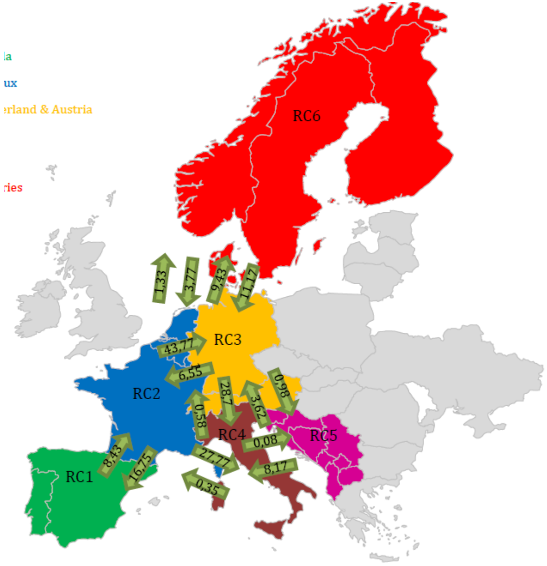


# SUMMARY

# Summary

Obtained results:

- Scenario data for three variants and three target years
- 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




  - Nodal time series of RES and loads can be used as input data and coherent border conditions enable to split the pan-European grid into regional case studies
  - Provide a common ground for the regional cases

# Sources


[1] ENTSO-E and ENTSO-G, „TYNDP 2020 - Scenarios Data,“ 2020.

[2] ENTSO-E, „Input grid datasets for the preparation of the TYNDP 2018,“ [Online].

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[5] C. Spieker, Europäische Strommarkt- und Übertragungsnetzsimulation zur techno-ökonomischen Bewertung der Netzentwicklung, Dortmund, 2019.

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[9] Solargis, „Solar resource map,“ 2019.

[10] Deutscher Wetterdienst, „Regionalmodell COSMO-EU,“ [Online]. Available: http://www.dwd.de.

[11] M. De Felice, „ENTSO-E Hydropower modelling data (PECD) in CSV format (Version 4)“.

# FlexPlan

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FlexPlan-Project.eu

Thank you