INCORPORATING UNCERTAINTY INTO THE USE OF CLIMATE DATA TO INFORM PLANNING STUDIES

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PLANNING STUDIES – OVERVIEW AND ELEMENTS OF UNCERTAINTY

PLANNING STUDIES FOR NETWORK DEVELOPMENT
IDENTIFY THE NEED FOR NETWORK EXPANSION

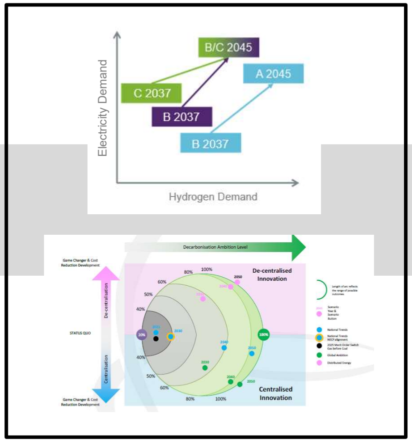
NDP

TYNDP

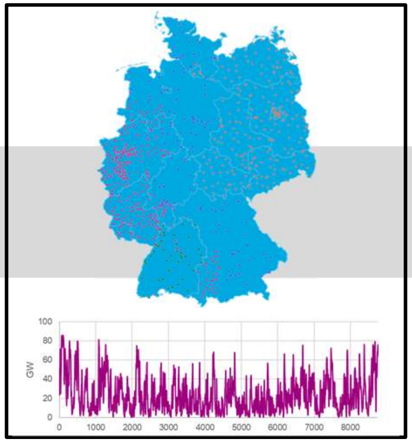
- The national and european network development plan (NDP and TYNDP) are processes with a 2-year-frequency and delivered as a joint product of the national or european TSOs
- Scopes of the studies are target years greater than 10 years from current year with three different scenarios, which cover plausible futures of the energy system, taking into account the energy policy target of carbon neutrality
- Key drivers for carbon neutrality are
  - High renewables (RES) share
  - Sector coupling
  - Flexibilities

GENERAL FRAMEWORK OF PLANNING STUDIES
TOOLCHAIN FROM SCENARIOS TO GRID RESULTS

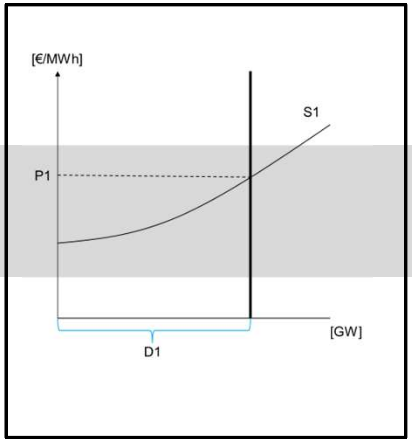
1. Scenario Definition



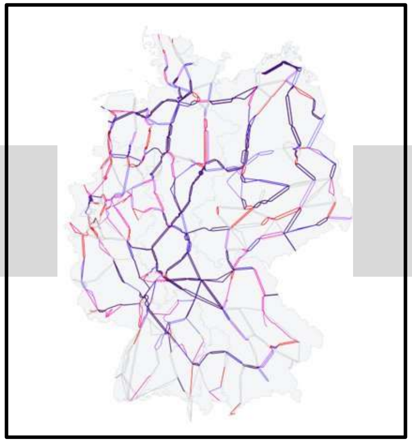
2. Quantification of Storylines



3. Cost Optimised Dispatch



4. Power Flow Calculation

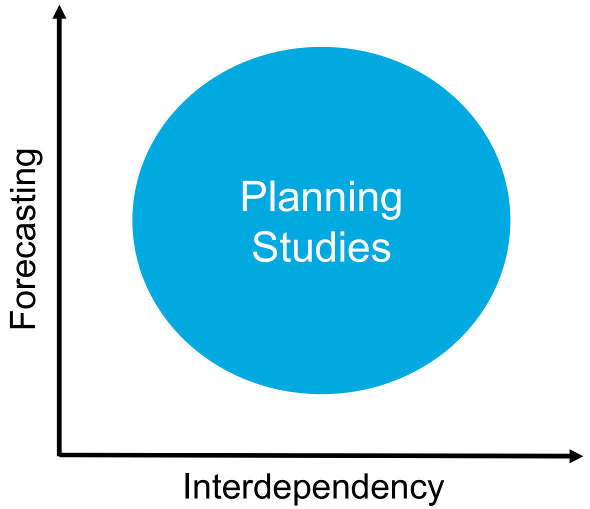


- Identification of Transition Paths to a carbon neutral system defined by usage of specific technologies per sector
- Calculation of RES generation and load profiles in a spatial and temporal resolution
- Hourly-cost-optimisation of power plant dispatch for a target year
- The need for network expansion is identified by the results of power flow calculation

ELEMENTS OF UNCERTAINTY IN PLANNING STUDIES

CLIMATE DATA AS A KEY DIMENSION

Uncertainty into the use of climate data



- Climate data is one of several dimensions of uncertainty in creating planning studies
- Uncertainty in planning studies is mainly driven by selected scenario and climate data
- Ensure right interdependency of climate parameters (e.g. wind speed, temperature, solar irradiance, …) by using historical weather years
- Due to the uncertainties in long-term weather forecasting, a selection of representative weather years from the historical data set is necessary for planning studies

Uncertainty is incorporated through various combinations of representative historical weather years and scenario data (e.g. selected technologies)

CLIMATE DATA – HOW IT LOOKS LIKE

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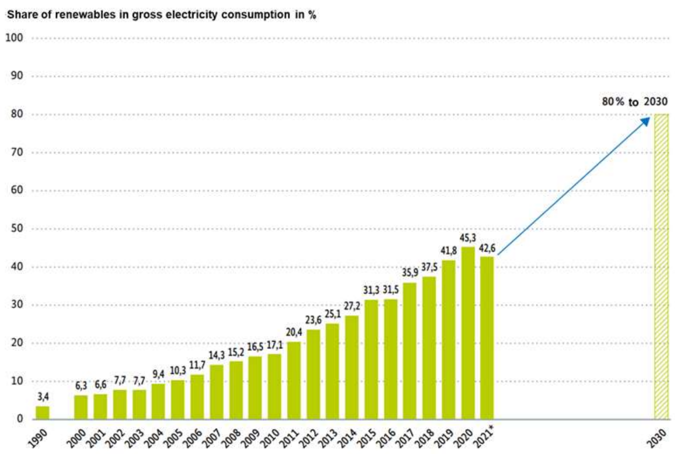
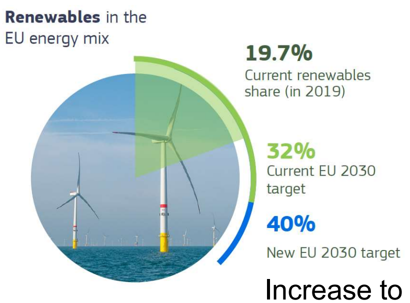
HIGH IMPORTANCE OF RELIABLE CLIMATE DATA

CLIMATE DATA DETERMINE FUTURE GENERATION PROFILES

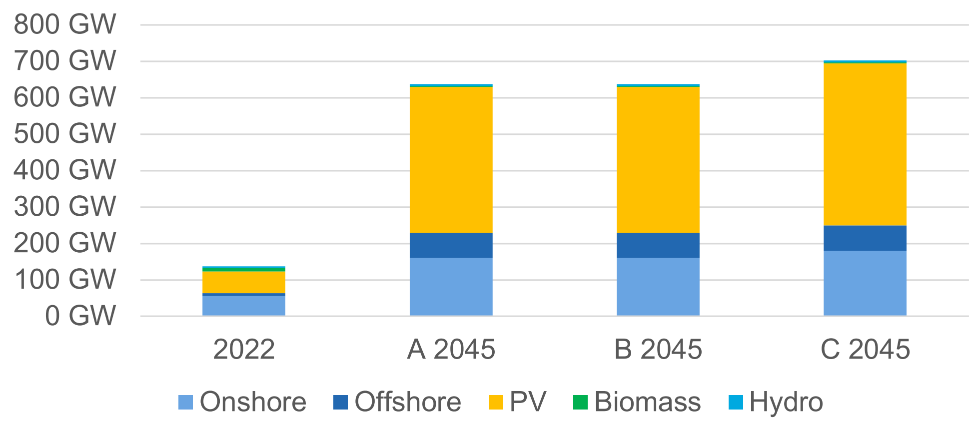
Mid term policy target for RES





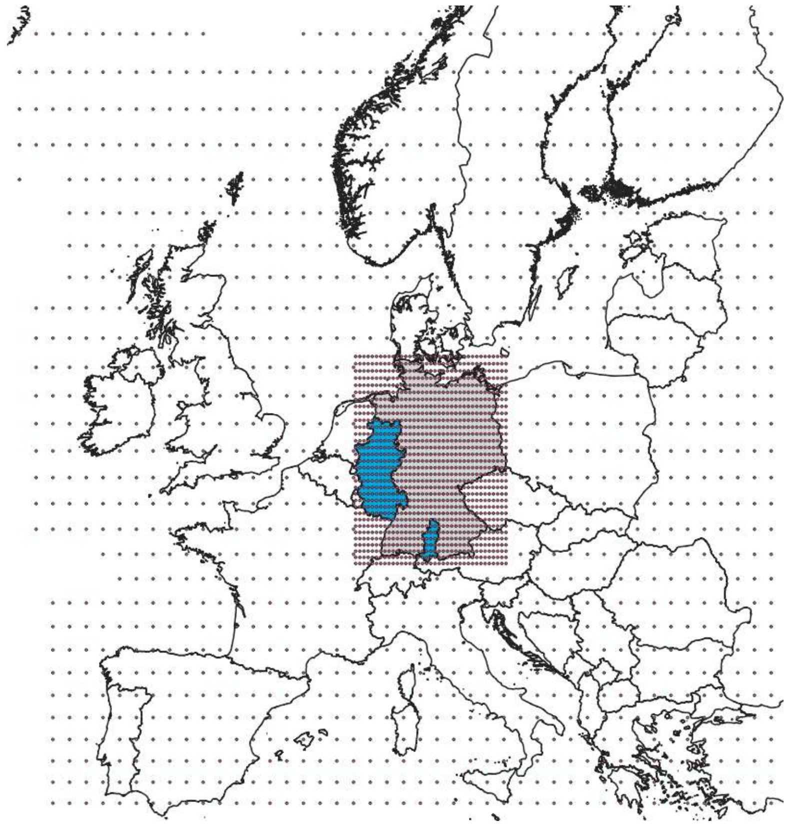
Increase to 45% by RepowerEU package

Installed RES capacities in NDP for Germany



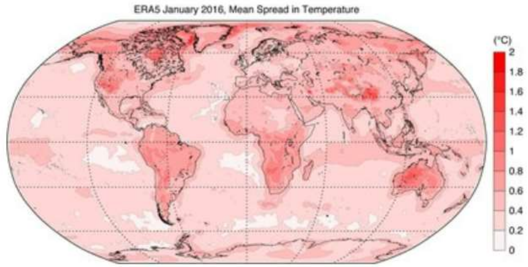
- Policy targets regarding a carbon neutral energy system force extreme expansion of RES capacity
- Generation of RES power plants is directly correlated with the used climate data

ERA5 AS CLIMATE DATASET FOR EUROPE
REANALYSIS DATASET DELIVERS HISTORICAL WEATHER DATA

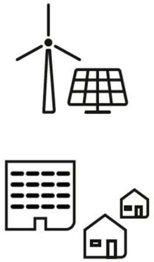


Properties of ERA5 Dataset

- Dataset is build by the principle of data assimilation, a combination of model data with observations from across the world
- Reanalysis data is available from 1940 onwards with atmospheric, ocean wave and land-surface quantities
- Resolution
  - Spatial: 31 km
  - Temporal: 1 h



Usage of ERA5 Dataset



- Focus on atmospheric quantities like wind speed or temperature for different measurement heights
- From scenario quantification perspective usage not only for RES generation but also for load profiles

IDENTIFYING REPRESENTATIVE WEATHER YEARS

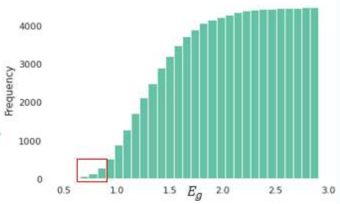
CLUSTERING ALGORITHM BASED ON REANALYSIS ERA5 DATA

Identifying 3 representative weather years

Choose the set of 3-year combinations that best represent the 30-year aggregate distribution

Eucledian Distance of both Indicators for all combis:

$$E_g = \sqrt{\sum_{r \in R} w_r \left[(I_{\mu,r,g})^2 + (I_{\sigma,r,g})^2 \right]}$$



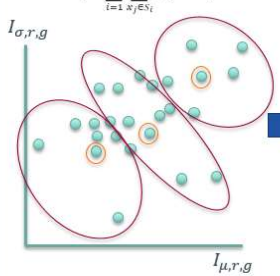
How well the 3-year combination represents the 30 years aggregate distribution

Filter set of candidates (highest 1%) that best represent the aggregate distribution

K-Medoids for ranking chosen set

Score function of k-medoids method (Eucledian Distance of both indicators)

$$J_g = \sum_{i=1}^{k} \sum_{x_j \in S_i} \|x_j - \mu_i\|^2$$



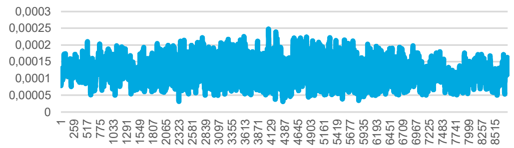
Rank	Combination	E_g
1.	(1992, 1998, 2016)	0.4885
2.	(1987, 1995, 1999)	0.5287
3.	(1990, 2009, 2016)	0.5365
4.	(1987, 1995, 2008)	0.6173
5.	(1989, 2001, 2004)	0.6185
6.	(2007, 2009, 2013)	0.6202
7.	(1989, 2002, 2004)	0.6250
8.	(1986, 2007, 2016)	0.6255
...		
18.	(1986, 1995, 2009)	0.6538
...		
4495.	(1987, 1996, 2010)	2.9100

Compute K-Medoids score of all candidates as "Inverse Clustering" to ensure representativeness

Choose from the set the candidate that best fulfills the clustering criterion

Overview Resolution

Spatial resolution based on country code



Temporal resolution for 8760 hours (one model year)

- Goal of the assessment is to find the combination of 3 years from 1987 to 2016 that best represents the entire 30 years
- Algorithm is based on 3 steps
  - Definition of hourly time series of residual load on a regional level for all considered years

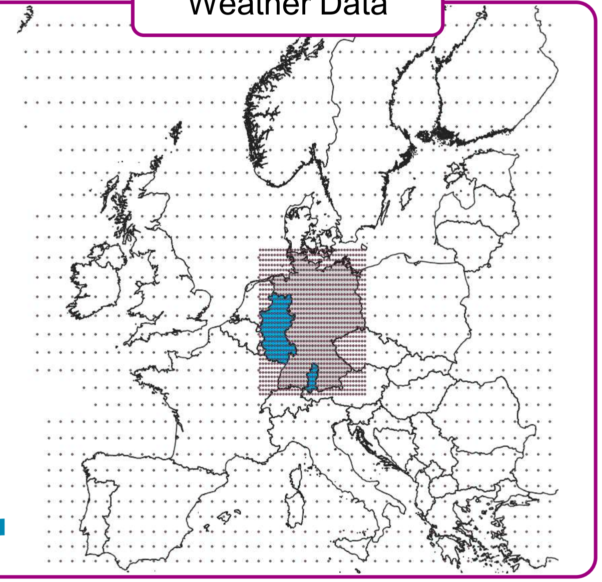
$$V_{residual\ load,z,h} = V_{load,z,h} - \left(V_{solar,z,h} + V_{wind,z,h} + V_{hydro,z,h}\right)$$

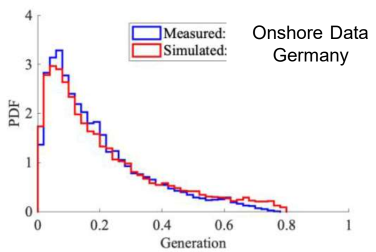
  - Compute delta indicators to assess how years compare to the 30-year average
  - Selection of most representative combination of 3 years
    - Good fit to aggregated distribution
    - Capturing largest space of possiblities

DEEP DIVE – INCORPORATING UNCERTAINTY THROUGH COUPLING OF SCENARIO AND CLIMATE DATA

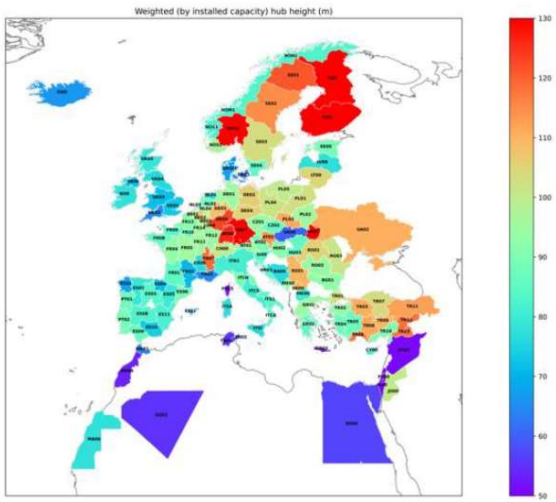
RES GENERATION WITHIN SCENARIO QUANTIFICATION
COMBINATION OF POWER CURVES AND CLIMATE DATA

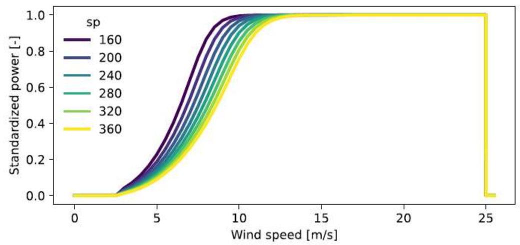
Weather Data





Technology Data





- The combination of weather and technology data has always a regional component of both of these parameters
- The chosen subparameter of technology defines the usage of weather data
  - Subparameters of wind technology can be summarized in specific power curve
  - $P(t) = ws_{HubHeight}(t) \cdot sp(ws_{HubHeight}(t)) \cdot Installed\ Capacity$
- All permissible combinations of weather years and technologies are collected in a database (Pan-European-Climate-Database PECD)
  - Relative hourly values enable simple calculation with RES capacities

OUTLOOK – CONSIDERATION OF CLIMATE CHANGE

NEXTGEN PECD WITH CLIMATE PROJECTIONS
SWITCHING FROM REANALYSIS TO PROJECTION DATA

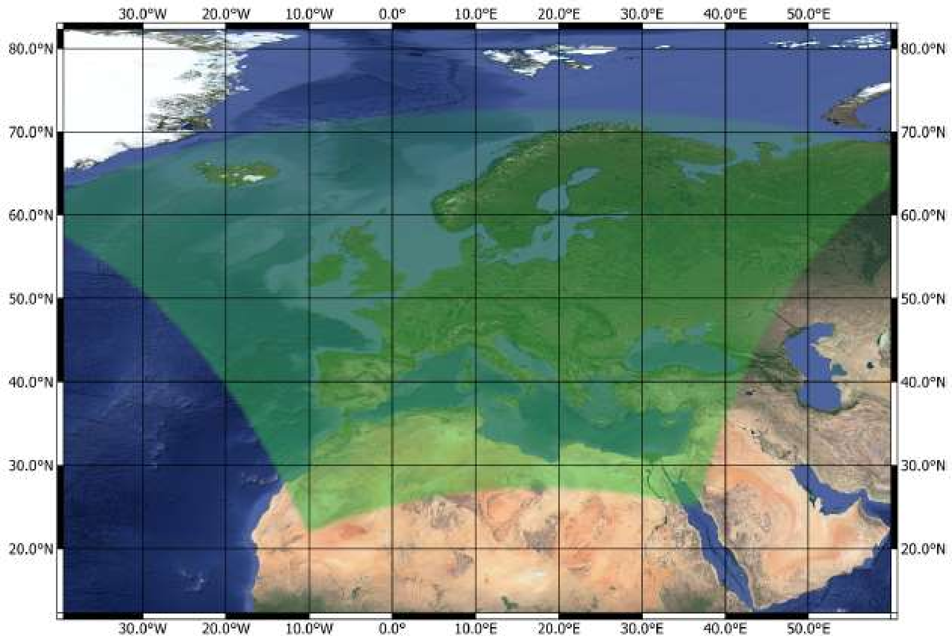


Figure 2.9: EURO-CORDEX 0.11° domain coverage, represented by the shadow area.

- Work in progress – benchmarking and validation is needed
- Switching from wordwide ERA5 reanalysis dataset to european EURO-CORDEX climate projection dataset
- Uncertainties in the climate model continue to be adress with a variance in projected weather years
  - Projected data consider the long-term, average CO_2 impact better than historical data
  - Replacement in the dimension of climate data from historical to projected data

- Final goal of NextGen PECD is the storage of all relevant climate data in combination with different technologies (historical and projected)

THANK YOU FOR YOUR ATTENTION!

Any questions?