D2.1 - A database of TradeRES scenarios

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3.0	27.11.2024	PU	The initial version of this deliverable was submitted in M9, and the database was subsequently modified as needed throughout the project. This document presents the final version of the deliverable with the common data on policy scenarios, emission and commodity prices, forecasted technological progress, RES potentials, and other related parameters used in TradeRES project.	
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Disclaimer

Executive Summary

The present deliverable, as part of task 2.1, describes the last edition of the TradeRES' main scenarios and functions as a description of the data and files included in the TradeRES common database. This database is the main outcome of this task and is publicly available on Zenodo.

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1. Scenarios

The TradeRES project created four central scenarios of the future European power system. “Scenario” within TradeRES refers to a structured input data collection that encapsulates certain properties of the underlying future energy system. The four scenarios, abbreviated S1, S2, S3 and S4, are carbon-free by assumption and vary in terms of the flexibility of the demand-side, the variability of the supply-side and the degree of sector-coupling. In addition, TradeRES created a scenario S0 to represent an intermediate energy system on the path to decarbonisation. This scenario S0 with a 60% non-thermal renewables penetration, is considered in some case studies as a departing scenario for reference. It considers exogenous electricity generation capacities based on 2030 national energy and climate plans.

All the five scenarios allow for endogenous investments in additional carbon-free capacities to meet 2030 (S0) or 2050 (S1, S2, S3, S4) projections of electricity (S0, S1, S2, S3, S4) and industrial hydrogen (S1, S2, S3, S4) demands. Electricity demand also covers demand from electric vehicle charging and electric heat pumps, which are modelled endogenously in S1, S2, S3, S4.

Investments in new electricity generation capacities are limited according to natural potentials. Generation technologies cover i) variable, non-thermal renewables - i.e. onshore and offshore wind, utility-scale and rooftop solar photovoltaics (PV), concentrating solar power with storage (CSP), run-of-river (ROR) hydro - ii) storage injections by batteries, reservoir and pumped hydro, and iii) carbon-free thermal power plants, comprising biofuel, waste and nuclear power plants as well as H_2-fired combined cycle and open cycle gas turbines (named CCGTs or OCGTs, respectively).

Cost projections also reflect the year 2050 with all monetary values reflecting 2020€. The data covers all EU27-countries with the exception of Malta, but including Great Britain, Switzerland and Norway. The database is organised to represent one bidding zone per country or aggregated countries, i.e. Luxembourg and Germany, the Baltics (covering Lithuania, Latvia and Estonia) and Balkans (covering Hungary, Romania, Bulgaria, Slovakia, Slovenia, Greece, Cyprus and Croatia) resulting in a total of 19 considered bidding zones. The zones are connected by exogenous power and H_2 transmission capacities according 2030 or 2050 expansion plans in the different scenarios. All load and capacity factor time series reflect the weather year 2019. Complete data assumptions and their sources are presented in the file “*TradeRES_Scenario_data_Ed3.xlsx*”, which is provided as supplementary data in this deliverable and also available on Zenodo [1].

The four 2050 scenarios (S1, S2, S3 and S4) vary three key factors that are particularly interesting from a market design perspective as they are likely to influence market prices. These factors are (i) the level of flexibility of the supply-side, (ii) the level of flexibility of the demand-side and (iii) the degree of coupling between the hydrogen (H_2) and power sectors. First, the variability of the supply-side is varied by enforcing a certain share of non-thermal renewables to cover annual electricity demand by constraint. In S1 and S2, this share is kept at 85%, while it is increased to more than 95% for S3 and S4. Second, demand-side flexibility is increased in scenarios S2 and S4 compared to S1 and S3 by raising the ability of the demand-side to respond to market prices. Third, the degree of sector-coupling is varied via different assumptions for the import price of hydrogen from outside Europe. A higher price makes domestic hydrogen production more attractive and hence, increases the degree of coupling between the power and hydrogen sector. The hydrogen price is assumed to amount to 45€/MWh in S1 and S3 and 117€/MWh in S2 and S4. Figure 1 depicts resulting scenarios. S1 is a "**conservative**" scenario. With low supply-side variability and low demand-side flexibility and sector-coupling, it resembles our current power system the most. With demand-side flexibility increased, S2 is the most "**flexible**" scenario. In contrast, S3 is the most "**variable**" scenario, as a high share of non-thermal, variable renewables meets a moderately flexible demand-side. Finally, S4 represents the most "**radical**" scenario as it represents the greatest changes compared to our current power system.

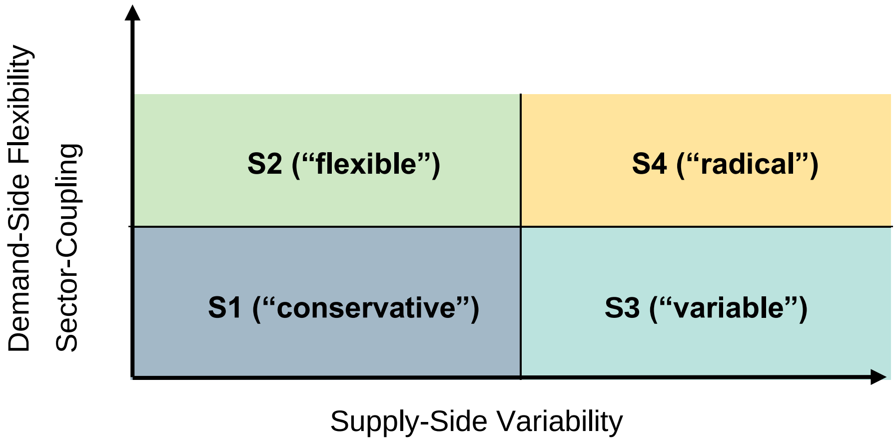

Figure 1 The four central scenarios with varying levels of supply-side variability, demand-side flexibility and sector coupling.

2. Common data on scenarios

The common data on the scenarios are given in the supplementary data file. Table 1 describes the data items that are included in the data file. Compared to the previous version of the file

- commodity prices, wind and solar potentials, and initial technology capacities have been adjusted;
- new technology data has been updated; and
- hydrogen transmission capacities, aggregated demand, demand time series, renewable time series, building data, and EV data have been added.

Table 1. Description of data items in the scenario data file

	Description
Emission factors	Kg of CO_2 equivalents emitted from burning 1 MWh of fuel
Commodity prices	Price assumptions for commodities
New technology data	Projected cost and technical parameters of new energy conversion (production, consumption, storage) technologies
Wind potential	Wind (offshore and onshore) potential in European countries
Solar potential	Solar (different PV categories and CSP) potential in European countries
Transmission capacities	Electricity and hydrogen transmission capacities in the scenarios
Initial technology capacities	"Initial" electricity generation capacities in the scenarios
Aggregated demand	Assumptions on aggregated electricity demand by sector and bidding zone
Demand time series	Load consumption time series
Renewable time series	Capacity factor time series, hydro inflow time series
Building data	Main assumptions used in the model for heating and cooling of buildings
EV data	Main assumptions for the private passenger vehicles and their electrification

3. Supplementary data

TradeRES_D2_1_Scenario_data_Ed3.xlsx includes all data assumptions and their sources for the scenarios. The file is provided as supplementary data in this deliverable.

The data assumptions were translated to the input data format required by the open-source optimisation tool Backbone:

- TradeRES_base_data_powersystem.xlsx (base system without new flexibilities)
- TradeRES_H2_data.xlsx (industrial hydrogen demand that can be covered by imports or electrolysers as a flexibility)
- TradeRES_EV_data.xlsx (electric vehicles as additional demand and flexibility)
- TradeRES_building_data.sqlite (replacing electricity demand from space heating with partially flexible options based on building envelope, heat storages and parallel heaters)

These files are provided on Zenodo [1] and can be read into a Spine database serving the Backbone tool using the Spine Toolbox project available at https://github.com/TradeRES/TradeRES-Backbone-demo. All of the files follow the data definitions used by Backbone and the data format is introduced in TradeRES D2.3 “How to use TradeRES optimization models database” [2].

References

[1] N. Helistö, S. Johanndeiter, J. Kiviluoma, L. Similä, T. Rasku, E. Harrison, N. Wang, N. Martin Gregorio, O. Usmani, R. Hernandez Serna, J. Kochems, E. Sperber, N. Chrysanthopoulos, A. Couto, H. Algarvio & A. Estanqueiro, "TradeRES scenario database" [Data set], 2024. https://doi.org/10.5281/zenodo.10692697

[2] J. Kiviluoma, N. Wang, S. Johanndeiter & M. Cvetkovic, "TradeRES D2.3 How to use TradeRES optimization models database", 2022 [Online]. Available: https://traderes.eu/