DECARBONISATION OF AUSTRIA'S ELECTRICITY SECTOR UNDER UNCERTAINTIES: CONCEPT AND INPUT DATA

Demet Suna[1], Daniel Schwabeneder[2], Philipp Maier[3], Nicolas Pardo-Garcia[4], Lukas Liebmann[5], Gustav Resch[6], Josef Baumüller[7]

Motivation and Core Objective

In summer 2022, a sequence of extreme hot weather conditions driven by climate change, combined with unpredictable geopolitical disruptions, demonstrated that such events can occur simultaneously, creating substantial challenges for the electricity system. This concern is becoming increasingly important as Austria and the European Union (EU) transition toward decarbonized energy systems that strongly rely on sector coupling and weather-dependent variable renewable energy sources (VRES).

In this context, the Derisk-E[2] project is designed to derive recommendations on how to best derisk future decarbonized electricity systems, with the goal of enhancing the resilience and robustness of Austria's future energy supply against challenges arising from a combination of various uncertainties, including those linked to climate change.

The aim of this work is to present the project's concept and input data, particularly from the climate-change perspective through global warming levels (GWLs) of 2°C, 3°C, and 4°C, and to outline the methodology used to identify extreme meteorological events that may challenge future electricity systems dominated by variable renewable energy sources (VRES).

Methodology of Approach

The methodology combines climate and energy system modelling. For climate data, a systematic assessment of the latest climate change scenarios is conducted. This CMIP6 (Coupled Model Intercomparison Project) [1]climate projection ensemble is analysed to define the climate change signal in Austria and Europe for the reference period 2001–2020, as well as for future scenarios corresponding to GWLs of 2, 3, and 4°C, considering the energy transition scenarios for the target years 2040 and 2050.

On the energy modelling side, we apply a novel form of sensitivity analysis, in which different weather conditions are varied with other uncertainty parameters through parameter ranges regarding

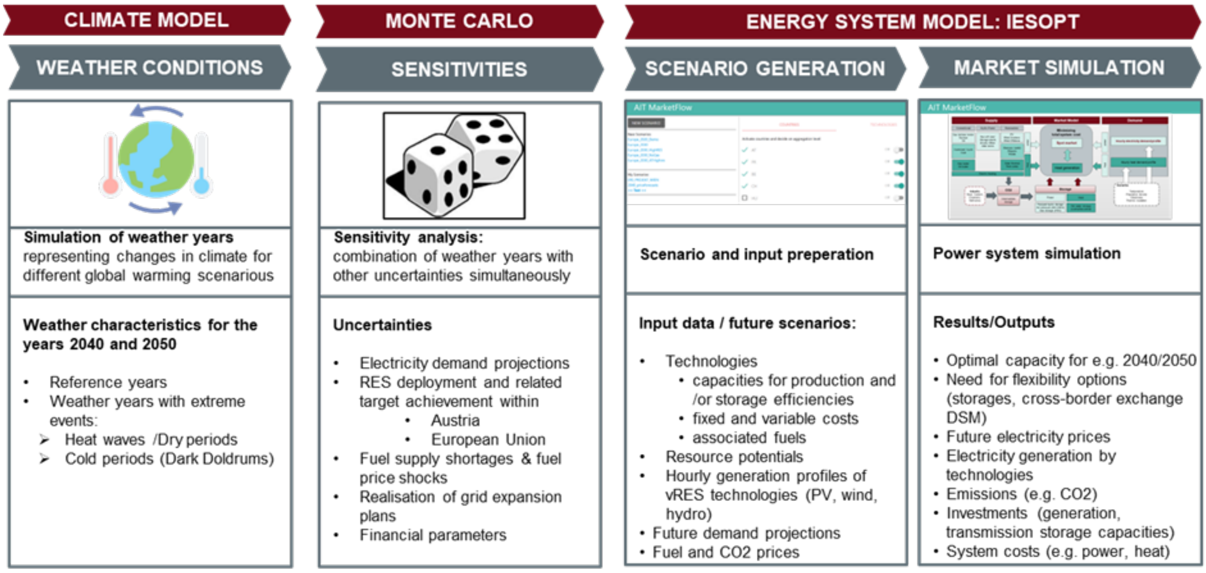
- Electricity demand increase, driven by sector coupling and other aspects.
- VRES deployment and related target achievement within Austria and the EU
- Realization of grid expansion plans
- Fuel supply shortages and fuel price shocks
- Financial parameters with an impact on investments and operation, represented by weighted average cost of capital (WACC)

The comprehensive model-based power system analysis should include the calculation of multiple sensitivity scenarios using Monte Carlo method, implemented with the AIT´s energy system optimization

[1] AIT Austrian Institute of Technology, Center for Energy, Giefinggasse 6, 1210 Wien Österreich, +43 664 2351944, demet.suna@ait.ac.at, https://www.ait.ac.at/ueber-das-ait/center/center-for-energy
[2] AIT Austrian Institute of Technology, Daniel.schwabeneder@ait.ac.at
[3] BOKU University, Institute of Meteorology and Climatology, Gregor-Mendel-Straße 33 1180 Vienna, Austria, +43 1 47654-81414, philipp.maier@boku.ac.at, https://boku.ac.at/en/oekb/imet
[4] AIT Austrian Institute of Technology, nicolas.pardo-garcia@ait.ac.at
[5] AIT Austrian Institute of Technology, lukas.liebmann@ait,ac.at
[6] AIT Austrian Institute of Technology, gustav.resch@ait.ac.at.
[7] TU Wien, Institut für Managementwissenschaften, josef.baumueller@tuwien.ac.at

[2] The Derisk-E project is funded by the Climate and Energy Fund (KLIEN) within the framework of the 16th Austrian Climate Research Programme (ACRP) under project number FO999913169.

model IESopt [2]. The probability distribution of outcomes (e.g., capacity of flexibility options, investment needs, electricity prices) from manifold simulations allow to identify most likely values and worst cases representing extreme conditions. Figure 1 shows the methodological concepts of the project.



Expected results

The expected project results can be categorized into four key areas:

- **Climatological Dataset**: A climatological dataset of synthetic-time-series that fulfil the climatical criteria for the GWLs in the CMIP6 models, combined with energy transition scenarios.
- **Electricity Demand & Supply Analysis**: Clear insights into how climate change can affect electricity demand (e-cooling, e-heating, and e-transport) and supply (impacted by temperature, wind speed, solar radiation, and hydro inflow), with a focus on extreme events.
- **Uncertainty Quantification**: Defined uncertainty ranges for key factors like electricity demand increases, renewable energy deployment, fuel supply risks, and financial uncertainties, offering a clearer view of the risks facing the energy sector.
- **Power System Resilience**: Model-based analysis and recommendations for Austrian policymakers on derisking the electricity system, including simulations of manifold sensitivity scenarios and the identification of optimal asset mixes for future needs.

The project is currently in the inception phase, focusing on preparing climate data, establishing reference system parameters, including European-wide model inputs based on TYNDP2024 [3] and detailed Austrian demand and supply projections in line with Transition scenarios for 2040 and 2050 [4]. The power system analysis of the dark doldrums year 2017 and the heatwave year 2022 serve as reference points to guide the characterization of extreme events and identify similar conditions in future climate projections.

Referenzen

[1] WCRP, 'CMIP6 -Coupled Model Intercomparison Project Phase 6', Program for Climate Model Diagnosis & Intercomparison. Accessed: Jan. 22, 2023. [Online]. Available: https://pcmdi.llnl.gov/CMIP6/Guide/dataManagers.html

[2] www.ait.ac.at, 'IESopt - AIT Austrian Institute Of Technology', ait.ac.at. Accessed: Dec. 04, 2025. [Online]. Available: https://www.ait.ac.at/themen/flexibilitaet-geschaeftsmodelle/projekte/iesopt

[3] ENTSO-E and ENTSOG, 'TYNDP 2024- Scenarios-Downloads-Distributed Energy 2050 Scearios for Climate Years 1995,2008 and 2009'. Accessed: Sept. 30, 2025. [Online]. Available: https://2024.entsos-tyndp-scenarios.eu/download/

[4] UBA, 'Energie- und Treibhausgasszenario Transition 2040 - Bericht für das Szenario Transition 2040 mit einer Zeitreihe von 2020 bis 2050', 2023. [Online]. Available: https://www.umweltbundesamt.at/fileadmin/site/publikationen/rep0880.pdf