SECURES

SECURING AUSTRIA'S ELECTRICITY SUPPLY IN TIMES OF CLIMATE CHANGE


Policy brief

Energy systems are increasingly impacted by climate change

The planning and operation of electricity systems are increasingly impacted by climate change, and meteorological conditions have become more relevant due to increasing weather-dependent renewable electricity generation shares. The project SECURES (Securing Austria's Electricity Supply in times of Climate Change) analysed challenges and opportunities for Austria's future electricity system to ensure a reliable, sustainable and cost-efficient power supply under climate change. Combining detailed climate and energy system modelling with an intense stakeholder dialogue served as a basis for this process.

Combining climate modelling and energy system modelling

The overall methodological approach included an in-depth analysis of structural changes in weather and electricity demand and generation due to climate change and decarbonisation. A comprehensive meteorological dataset (SECURES-Met) for Austria and Europe specifically designed for that purpose was created by an iterative creative process between meteorologists and energy modellers to fit energy modelling requirements (NUTS0-NUTS3 level, hourly resolution). SECURES-Met covers the years 1981-2020 for the historical period and up to 1981-2100 for two GHG emission scenarios, i.e. one with moderate (RCP 4.5) and one with stronger climate impacts (RCP 8.5). Variables include temperature, radiation, wind power and hydropower potential (separated into run-of-river (RoR) and reservoir). We developed and applied interdisciplinary methods to identify extreme events and weather years from a meteorological and an energy system perspective.

Three open-access datasets: SECURES-Met, SECURES-Energy, and SECURES-EMod

Based on the meteorological dataset, hourly profiles of all relevant, weather-dependent supply and demand components were generated: solar, wind onshore/offshore, hydro reservoir and hydro RoR generation profiles and e-heating, e-cooling, and e-mobility demand profiles for the years 2011-2100. The dataset SECURES-Energy provided the basis for the energy system modelling within the project and can be adapted and applied to many different contexts. Regarding full-load hours, no strong trend (neither strongly increasing nor decreasing) could be observed for solar, wind, and hydro RoR in the considered emission scenarios in Austria. The strongest interannual variability of full-load hours now and in the future was observed for hydro RoR with higher interannual variability with increasing climate change impact in Austria, which poses a challenge for highly hydro-dependent electricity systems. Additionally, seasonal patterns are affected: Hydro RoR generation is expected to decrease during summer and increase during winter, implying a flattening of the seasonal profile compared to today (cf. Figure 1).

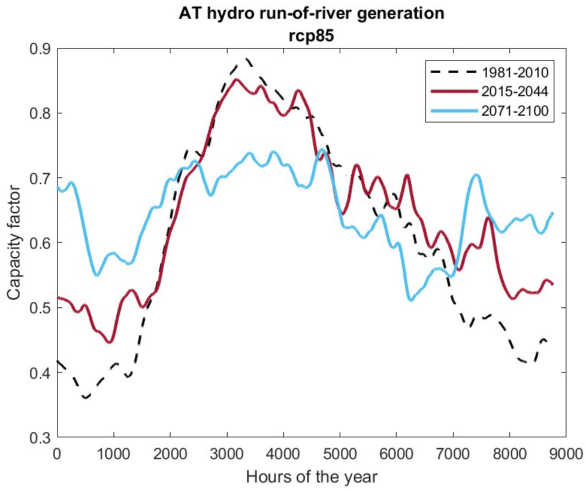

Figure 1: Shift of the seasonal generation pattern of run-of-river hydropower in the strong emission scenario (RCP8.5); a flattening over the whole year is observable, increasing generation during winter and decreasing generation during summer.

For heating demand, a strong decrease (-35%), and for cooling demand, a distinct increase (+144%) in the strong emission scenario (RCP 8.5) at the end of the century (2071-2100) compared to the reference period (1981-2010) was observed (pure temperature signal). There is a relative shift of critical residual load situations to the summer, showing the increasing relevance of heat waves, while most critical situations are still expected to occur during winter in the Central European electricity system.

Modelling the future energy system: decarbonisation and climate change

On the energy side, modelling was conducted by use of the open-source energy system model Balmorel. Geographically, modelling covered Austria but also other European countries to represent the interconnected character of Europe's electricity system. Time-wise, we modelled specific focal years in the near (2030) to mid-future (2050). The central aspect of scenario design comprised the combination of two distinct energy sector pathways for Austria/Europe up to 2050 with the climate scenarios described above. In the *Reference (REF)* pathway and corresponding scenarios, Austria aims to achieve a RES-based electricity supply by 2030 and beyond. However, it represents less decarbonisation ambition in other sectors and EU countries and is accordingly matched with a strong climate change scenario (RCP 8.5). The *Decarbonisation Needs (DN)* pathway represents a strong decarbonisation ambition across the whole EU, implying net zero by 2050. Consequently, a strong growth of electricity demand is expected, driven by strong sector coupling for decarbonising other sectors like industry and mobility. *DN* was coupled with a medium climate change scenario (RCP 4.5). Since in our energy system analysis, we focus on security of supply, for both pathways described above, we additionally analysed weather years reflecting extreme weather conditions (i.e. dark doldrums and heat waves) for the mid-future (2050).

A comparison of the results of both energy sector pathways (REF vs. DN) shows the challenges that come along with the energy transition that is indispensable from a climate and societal perspective (cf. Figure 2). Gross final electricity demand is expected to grow by 55% by 2050 compared to today (2021) in REF, whereas the DN pathway implies a growth of 140%. Consequently, a significantly stronger uptake of supply-side assets is also applicable, specifically in wind and photovoltaics (PV). With higher amounts of weather-dependent generation, short-term fluctuations in corresponding electricity generation grow strongly, requiring large amounts of system flexibility to ensure the match between electricity demand and supply in every hour. Thus, a comparison between DN and REF indicates the significantly larger amount of flexible storage, generation, and demand assets required by 2050. According to modelling, the total stock of storage and selected demand-side flexibility components in capacity terms by 2050 is ca. 170% higher in DN than in REF (cf. Figure 2).

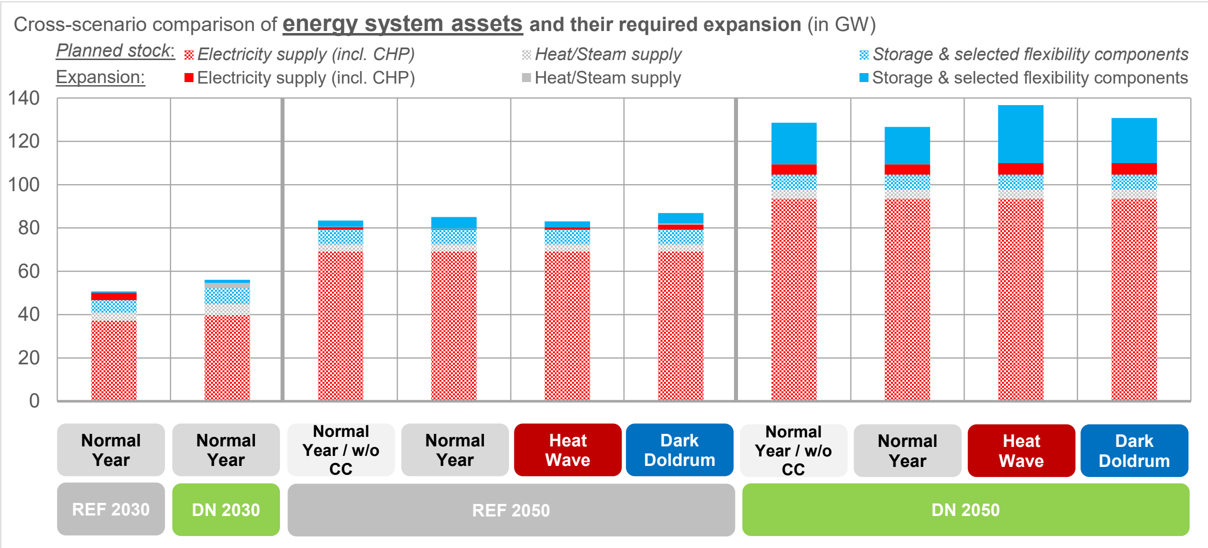

Figure 2: Scenario comparison of energy system assets and their expansion

How does climate change impact the above? On the demand side, for normal weather conditions, aggregated impacts appear marginal, partly due to the compensating effects of heating and cooling and partly due to the low share of weather-dependent load in overall electricity demand in decarbonised energy systems. On the supply side, high interannual variations are visible and impacts highly depend on the chosen weather year. For normal weather conditions, wind and RoR hydropower show a slightly higher annual generation, whereas, for solar PV, negligible differences are observable in the modelled normal weather years in line with the long-term climate projections. Of key importance is the consideration of extreme weather conditions since, with ongoing climate change, the frequency and duration of such events increase according to climate projections. In our analysis, a heat wave and a dark doldrum served as a stress test for security of supply. Results from 2050 DN scenarios show that for safeguarding electricity supply under these extreme conditions, in comparison to a normal weather year, a stronger uptake of wind energy appears useful from a least-cost system perspective. For storage and demand-side flexibility assets, there are both similarities and differences between a heat wave and a dark doldrum: For both events, modelling suggested increasing the H_2 electrolyser stock as well as accompanying H_2 storage, allowing a system-friendly operation of the electrolyser fleet. In a dark doldrum, thermal storage is useful for load shifting, both at the heat and the electricity side, as a consequence of increased sector coupling. In the case of a heat wave, when hydro and wind generation is generally low, batteries are the key system asset since they help to shift the high PV infeed during the day to the evening when the sun is not shining.

The sketched outcomes of SECURES can support Austrian policymakers and stakeholders to overcome and solve possible conflicts in policy targets for security of energy supply, the need for decarbonisation, and the consequences for the Austrian economy, all affected by increasing impacts arising from climate change.

Policy implications

Summing up, the results show that for adequate modelling of future decarbonised energy systems, it is highly relevant to consider the effects of climate change. Key outcomes of the project SECURES are: Firstly, we produced three European-wide open-access datasets (SECURES-Met, SECURES-Energy, and SECURES-EMod) for historical climate and climate change projections. Secondly, we reviewed and further developed methodological approaches to identify and evaluate extreme weather years for energy system modelling from a meteorological and an energy system perspective using hourly time series. Thirdly, we provide insights into different decarbonisation scenarios under climate change impact in Austria.

Key policy recommendations

- For enhancing the energy transition towards decarbonisation, there are strong investments in energy system assets indispensable, be it at the generation, demand or storage side. This has been demonstrated by the modelling undertaken in the course of SECURES. Specifically, storage and the inclusion of the demand side appear of key relevance to safeguard the match between demand and supply in the electricity sector during all time steps.
- To best cope with future climate impacts, it is necessary to make Austria's electricity sector future-proof and climate-ready. In future years, the majority of electricity supply within Austria as well as in other parts of Europe will rely on weather-dependent renewable energy sources like wind, solar, or hydro. Thus, in practical terms, this implies considering for planning purposes not only default weather conditions. Instead, coping with extreme weather situations, specifically heat waves and dark doldrums, shall become the new standard in energy system planning.
- Apart from investments in various system assets, it is a key necessity to establish markets and include an increasingly broad set of actors. Today, there is a gap in markets for flexibility services. Once established, rules for the participation of various market actors need to be simple and transparent in order to enlarge the outreach.

Further information, reports, publications, and datasets are available at https://www.secures.at/publications.

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