Bachner, G., Bednar-Friedl, B., Feichtinger, G., Gutschi, C. , Kulmer V., Schinko, T., Schüppel, A.*

IMPACTS OF CLIMATE CHANGE ON THE ELECTRICITY SECTOR: AN INTEGRATED MODELLING APPROACH FOR AUSTRIA

Gabriel Bachner: Wegener Center for Global and Climate Change, University of Graz, Austria
Leechgasse 25, 8010 Graz, Austria
Phone: +43(0)316380-8454, Fax: +43(0)316380-9830, e-mail: gabriel.bachner@uni-graz.at
Birigt Bednar-Friedl: Wegener Center for Global and Climate Change, University of Graz, Austria
Leechgasse 25, 8010 Graz, Austria
Phone: +43(0)316380-7107, Fax: +43(0)316380-9830, e-mail: birgit.friedl@uni-graz.at
Gerald Feichtinger: Institute of Electricity Economics and Energy Innovation, Graz University of Technology, Austria
Inffeldgasse 18, 8010 Graz, Austria
Phone: +43 (0)316873-7909, Fax: +43 (0)316873-7910, e-mail: gerald.feichtinger@tugraz.at
Christoph Gutschi: Institute of Electricity Economics and Energy Innovation, Graz University of Technology, Austria
Inffeldgasse 18, 8010 Graz, Austria
Phone: +43 (0)316873-7900, Fax: +43 (0)316873-7910, e-mail: christoph.gutschi@tugraz.at
Veronika Kulmer: Wegener Center for Global and Climate Change, University of Graz, Austria
Leechgasse 25, 8010 Graz, Austria
Phone: +43(0)316380-8468, Fax: +43(0)316380-9830, e-mail: veronika.kulmer@uni-graz.at
Thomas Schinko: Wegener Center for Global and Climate Change, University of Graz, Austria
Leechgasse 25, 8010 Graz, Austria
Phone: +43(0)316380-8460, Fax: +43(0)316380-9830, e-mail: thomas.schinko@uni-graz.at
Andreas Schüppel: Institute of Electricity Economics and Energy Innovation, Graz University of Technology, Austria
Inffeldgasse 18, 8010 Graz, Austria
Phone: +43 (0)316873-7902, Fax: +43 (0)316873-7910, e-mail: andreas.schueppel@tugraz.at

* Corresponding author

(1) Overview

Power generation in Austria is not only an important source of carbon emissions; it is also highly vulnerable to rising temperatures and changing climatic conditions: Regarding power supply, especially hydropower plants but also upcoming RES will be affected by climate change. Changed evaporation and precipitation patterns (including extreme weather conditions) and shrinking glaciers impact the operation of runoff-river as well as storage hydropower plants. On the other hand, higher ambient temperatures influence cooling processes, outages, efficiencies and effective power of thermal power plants. On the demand side, changing weather conditions result in different consumption for cooling and heating as well as different patterns of electricity use. Therefore this study investigates the climate change impacts on the Austrian electricity industry and its further macroeconomical consequences up to 2050.

Since the electricity sector is characterized by strong international linkages, the impacts for Austria have to be investigated within the Continental European context. The increasing power generation from fluctuating renewable sources, like wind power in Germany and Spain or solar power in the Mediterranean countries (and Germany as well), requires additional capacities for electricity storage and power transmission in Austria.

Furthermore, climate change is associated with rising cooling demand in the south of Europe and declining heating demand in the north. As a consequence of these developments, the power exchange between Austria and its neighbouring countries is expected to increase.

Another specific characteristic of electricity is its key role as an intermediate input in other sectors, particularly for energy intensive sectors, as well as for households. Because of this, not only a detailed analysis of the physical and economic consequences for the sector itself is required, but also an analysis of effects on macroeconomic developments

Therefore this study addresses the following research questions:

- In which way is the electricity sector in Continental Europe affected by climate change on a time scale up to 2050, especially if a varying heating and cooling demand is taken into account?
- What are the associated macroeconomic effects of climate change impacts on the Austrian electricity sector, acknowledging Austria's openness to international trade in the continental European context?

(2) Method

Due to the cross-cutting nature of the problem, we couple a techno-economic electricity sector model (ATLANTIS) with a multi-country multi-sector computable general equilibrium (CGE) model (based on GTAP v7). This methodological approach is based on high-resolution climate change and hydrology scenarios in order to assess climate change effects on river runoff, mean wind speed and mean solar radiation. The results of an econometric analysis of the electricity demand in Continental Europe to assess the impacts of climate change until 2050 are also integrated in both models. ATLANTIS is a comprehensive model including (i) all necessary elements of the physical system (e.g. transmission lines, grid nodes including the final consumption of electricity at each node, power plants and transformers) and (ii) market elements to simulate electricity trade, market coupling mechanisms between market areas and the economic behaviour of major European power companies. While ATLANTIS assesses the climate change impacts (e.g. the effects of climate change on power plant infrastructure and power generation from renewable energy sources, RES) over time on a monthly basis for Europe, the CGE model accounts of feedback effects of other sectors, macroeconomic structures and international trade (both within the EU and abroad). Therefore the model comprises 19 sectors (electricity sector, six electricity intensive sectors and nine non-electricity intensive sectors) and 18 regions with special consideration of Europe (Austria, Italy and 7 European aggregates). At the centrepiece of this study there is an iterative interface of data and model results between the CGE model (data on electricity demand) and ATLANTIS (data on electricity production and investment) in order to evaluate the sectoral and economy-wide climate change impacts for the Austrian electricity sector.

While climate change is one key factor for the development of the electricity sector, political decisions e.g. with regard to the role played by RES are as important. We define therefore two baseline scenarios for 2050, one in which Europe sticks to its energy policies as envisioned by the European Commission (2010), and one in which mitigation is taken worldwide to achieve the 450 ppm target as specified by the WEO (OECD/IEA, 2010). Against these two baseline scenarios we compare the impacts of four different regional climate scenarios (selected from the ENSEMBLES project, van der Linden and Mitchell, 2009). These scenarios differ with respect to future developments in the key climate parameters temperature, precipitation, wind speed, and global radiation, which are major drivers of electricity demand and production in Europe.

With this integrated model setup we expect to quantify the economic consequences of climate change impacts on the electricity sector in Austria for a time scale up to 2050, taking account of macroeconomic feedback effects. Furthermore we will derive changes in the composition of the Austrian power plant complex, driven by the impacts of climate change. Another focal point of the analysis is the estimation of costs associated with climate change impacts on the electricity sector.

(3) Results

Preliminary results indicate that:

- Minor changes in the seasonal distribution of heating and cooling demand might occur
- For hydropower a seasonal shift can be observed in all climate scenarios. While the energy yield of hydro power plants is declining between August and October, the maximum of hydro power generation is shifted from May towards March. In the worst case, hydro power plants located at Austria's main river Danube may face a decrease of production in the summer period up to 20 % of monthly generation.
- Political decisions e.g. on the share of RES or regarding mitigation might lead to higher variation in impacts for the energy sector than different climatic conditions

- Regarding macroeconomic effects, effects are strongest for electricity intensive sectors (e.g. chemical industry, manufacture of other non-metallic mineral products), but there are also differences across European countries due to their exposure to climate change as well as to their generation mix.

(4) References

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