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Impact of different market designs in the CWE market area on electricity prices and on the competitiveness of Swiss hydropower (Power Design)

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1. Project goals

This project aims to assess the impact of market design choices in the neighbouring electricity markets on the competitiveness of hydropower and on the costs of support schemes for renewable energies (RES) in Switzerland.

2. Summary

The main objective of the research project is to assess how changes in the framework conditions of European and Swiss energy markets (e.g. market design and support schemes for renewable energy) affect the competitiveness of hydropower and funding volumes for RES in Switzerland. For this, we investigate the price effect of changes in the market design in Switzerland and its neighbouring countries. Different market scenarios are developed taking into account the EU energy roadmap and the Energy Strategy 2050 scenarios (Prognos AG 2012). The scenarios are input to an agent-based spot market model of the market coupling area of Central-Western Europe[1] (CWE), Switzerland and Italy. The model evaluates medium and long-term price developments and forms the core of this research project.

To carry out the analysis a sequential approach is applied. Firstly an econometric analysis identifies the main drivers of the Swiss electricity prices and the ones of the neighbouring countries. Then, the agent-based model PowerACE simulates the future capacity development of power plants and the resulting wholesale electricity prices for different market design assumptions. The resulting prices will be used to analyse the required RES subsidies due to alternative support schemes and RES scenarios. Subsequently, stochastic scenario trees will be generated and used for the stochastic optimization of the dispatch of Swiss hydropower storage plants.

In 2016, an econometric analysis of Swiss electricity prices has been carried out (Dehler et al. 2016). The analysis focuses on main drivers from neighbouring countries of the Swiss wholesale electricity prices. The results indicate that in summer, Swiss prices correlate with the day-ahead wholesale prices of neighbouring countries. E.g. high wind power production in Germany decreases wholesale prices in Switzerland and Germany. In winter, high demand in Switzerland, France, and Italy raises wholesale prices in Switzerland.

The results were presented on several occasions:

- 14th Symposium Energieinnovationen in Graz, Austria (Dehler et al. 2016)
- IAEE International Conference in Bergen, Norway (Keles und Dehler 2016)
- Energy Research Conference Disentis, Switzerland
- Workshop organized by the Swiss Federal Office of Energy (SFOE) in Zürich, Switzerland

[1] CWE: Belgium, France, Germany, (Austria,) Luxemburg, the Netherlands

3. Work undertaken and findings obtained

Publication: Econometric analysis of Swiss electricity prices
Electricity prices are determined by a variety of factors. In the short-term (e.g. on a day-ahead basis), such factors include weather conditions, electricity generation from RES, fuel and carbon emission allowance prices, demand levels and availabilities of power plants. The combination of these drivers causes the strong temporal cycles (e.g. daily, weekly) of electricity prices. Furthermore, European electricity markets are integrated through physical interconnections and various trading arrangements which make national electricity prices dependent on developments in interconnected regions.
Given the geographical situation, the Swiss electricity market - although not directly part of the European day-ahead market coupling - is affected by developments in neighbouring countries (e.g. German wind power production). An econometric analysis was carried out to determine the main fundamental drivers of Swiss electricity prices (and that of neighbouring countries). Suitable econometric methods (e.g. multiple regression) were applied and allowed to assess the quantitative impact of relevant factors on Swiss electricity prices.
This analysis was discussed at several occasions (Energy Research Conference Disentis, IAEE International Conference, SFOE-Workshop) and published in Dehler et al. (2016)[2]. The paper focuses on fundamental drivers from neighbouring countries of the Swiss wholesale electricity prices. The investigation shows that in summer, Swiss prices significantly correlate with the day-ahead wholesale prices of neighbouring countries (Germany and France). Especially German renewable power production significantly influences the Swiss prices. In winter, high electricity demand in Switzerland, France and Italy raises the Swiss prices, while the German load plays a larger role in summer. At the same time, gas prices impact the price for electricity in summer and winter, notwithstanding the fact that Switzerland has no major plants running on fossil fuels.

Work in progress: Agent based electricity market modelling with the PowerACE model
In order to analyse the effect of heterogeneous designs of European electricity markets on wholesale spot prices, the existing agent-based simulation model *PowerACE* is appropriately extended. The *PowerACE* model is an agent-based, bottom-up simulation model for wholesale electricity markets (see Genoese 2010). The model allows the integration of dedicated capacity remuneration mechanisms (e.g. Keles et al. 2016) which can be selected for different market areas. Besides the short-term operation of power plants, the investment in new generation units or the decommission of existing plants are individual agent decisions. The decisions are based on a net present value approach. In general, the advantage of the decentralized agent decision modelling is that imperfect market conditions like oligopolistic bidding behaviour can be taken into account.

In 2016 and 2017 the *PowerACE* model extension is work in progress. As up to now the geographical focus of application of the model has been on Germany, the model is adjusted to cover Switzerland and its neighbouring countries. For this task, collection of corresponding model input data is necessary. Examples for relevant data are the existing conventional power plants and their operators, electricity demand, electricity generation from RES and interconnector capacities.
The future feed-in of renewable sources in neighbouring countries will be provided exogenously according to the EU Reference Scenario 2016. Swiss policy and economic development is assumed to follow the scenarios developed by PROGNOS (Prognos AG 2012). After setting up the market areas for the *PowerACE* model, the simulation will be executed. In addition to a mere regional extension, capacity mechanisms will be considered in *PowerACE* (e.g. a decentralized capacity market in France or the capacity reserve in Germany) in order to assess the different market design options and their influence to the Swiss electricity market.

[2] Further publications are in preparation

4. International cooperation

The project team:

Chair of Energy Economics at Karlsruhe Institute of Technology

The ***Chair of Energy Economics*** belongs to the Institute for Industrial Production (IIP) at the ***Karlsruhe Institute of Technology (KIT).*** The Chair of Energy Economics (established in 2008, ~30 employees) is headed by Prof. Dr. Wolf Fichtner and consists of four research groups: "Renewable Energy and Energy Efficiency", "Energy Markets and Energy System Analysis", "Distributed energy systems and networks" and "Transport and Energy".
Activities at the Chair of Energy Economics include the interdisciplinary research and teaching, especially the conjunction of engineering-economic approaches and quantitative methods of operations research and informatics. A major focus is the analysis of security of supply aspects and market design options for electricity markets.

Team members:
Joris Dehler is member of the group energy markets and energy system analysis (EMESA) since 2014. He holds a Diplom in mathematics from Albert-Ludwigs-University Freiburg, Germany.
Florian Zimmermann is member of the group EMESA since 2014 and focuses on agent-based energy market modelling. He holds a master's degree in Industrial Engineering and Management from the KIT.
Dr. Dogan Keles leads the EMESA group at KIT since 2013 and has more than 8 years of experience in modelling of prices, markets and energy systems.
Prof. Dr. Wolf Fichtner leads the Chair of Energy Economics at KIT and has a long experience in energy markets and system analysis.

Energy Economics Group of Paul Scherrer Institute

The ***Energy Economics Group (EEG) of the Laboratory for Energy Systems Analysis (LEA) of Paul Scherrer Institute (PSI)*** has extensive experience in analysing energy technology development and identifying policy strategies towards the realisation of sustainable energy systems at the Swiss, European and global levels. The group has participated in a series of projects funded by the BFE, Swisselectric Research, European Commission and third party organisations such as the World Energy Council.

Team members:
Dr. Martin Densing has over 10 years of experience in energy system modelling (mostly global models) and stochastic hydropower dispatch planning.
Dr. Evangelos Panos has long experience in energy system modelling at global, European and national levels and in econometric modelling.
Dr. Stefan Hirschberg leads the Laboratory for Energy Systems Analysis (LEA) of PSI and has a long experience in energy system analysis and technology risk management.

5. Evaluation 2016 and outlook for 2017

As a preparatory work package, an econometric analysis of the Swiss electricity price was conducted, discussed at several occasions and published in 2016. The results were presented

- at the 14th "Symposium Energieinnovationen" in Graz, Austria (Dehler et al. 2016),
- at the IAEE International Conference in Bergen, Norway (Keles und Dehler 2016),
- at the Energy Research Conference Disentis, Switzerland and
- in Zürich, Switzerland, at a workshop organized by the Swiss Federal Office of Energy (SFOE).

As a major finding, influencing factors could be differentiated by season and country of origin. Apart from providing insights into different drivers of Swiss electricity prices, the international research team could gain an understanding for the Swiss market in its international context. Based on the experiences made, the following work packages will allow deeper insights into the interdependencies of European energy markets and particularly Switzerland.

In the PowerACE model new market design options have been implemented. A capacity reserve/strategic reserve has been implemented, a central capacity market was improved, and a decentral market will be adjusted for the new French capacity market implementation. Data research for Switzerland, Austria and Italy is still in progress to run the models.

Further, in November 2016, Florian Zimmermann stayed at the Paul Scherrer Institute in Villigen. The aim of this stay was to intensify the collaboration between the Energy Economics group at PSI and the Chair of Energy Economics at KIT. Further data research for Switzerland and the transfer of methodologies for the models were discussed and a joint publication was elaborated and structured.

In 2017, the modelling in PowerACE as well as the simulations of the scenarios will be finalized. Furthermore, some publications or participations on conferences to present the first results are planned (e.g. IAEE International Conference or at the 10th "Internationale Energiewirtschaftstagung", Vienna, Austria). Also WP 3 (the impact on renewable funding) and WP 4a (scenario tree generation) will be started.

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