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Electricity market design

Policy coordination and zonal configurations

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List of abbreviations

EWG	Energie - Wirtschaft - Gesellschaft
GWh	Gigawatt hours
MW	Megawatt
MWh	Megawatt hours
NRP	National Research Programme
SCCER CREST	Swiss Competence Centers for Energy Research / Competence Center for Research in Energy, Society and Transition

Summary

In this project, we have developed a conceptual electricity market model in order to analyse possible interactions of policy interventions such as the full market liberalization, the support of renewable energy technologies by feed-in tariffs, and the introduction of capacity markets. The model includes both, the supply and the demand side of an electricity market. On the retail market, the model covers different regions with one supplier of electricity and one consumer group in each region. Before a potential liberalization, all consumers have to buy electricity from the local supplier. After the liberalization, the consumers have the option to switch to another supplier offering lower prices. However, we account for the fact that consumers don't have full information about the different suppliers and retail prices in the market and assume that the consumers are heterogeneous regarding their willingness to switch suppliers after a potential market liberalization. On the supply side, the firms can either invest into controllable or stochastic generation technologies for own production and/or trade electricity on the spot market. Firms have to decide about their investments, the prices they offer to their customers, and the operation of the power plants. Further, the model includes a set of policy interventions as mentioned above.

Out of the analysis with the conceptual model, a number of interesting results could be educed. An important outcome is that the demand and the supply side of an electricity market are decoupled. This implies that policy interventions on one side of the market do not interact with measures on the other side and therefore require no coordination. For example, instruments supporting renewable energies don't have to be adjusted in case of market liberalization as it is intended for the future in the case of the Swiss electricity market. Further, the limited willingness of consumers to switch suppliers allows the supplies to exert market power on the retail market, resulting in prices differences across the different regions with suppliers with larger home markets setting higher prices to the smaller competitors. Given the existence of market power on the retail market, sufficient competition on the spot market is of central importance to support an optimal allocation of investments into production facilities and hereby avoid distortions of investment decisions across the different regions. An optimal allocation of investments between the different regions of the market facilitated by a competitive spot market reduces the need for the coordination of political interventions. However, for the case of a not sufficiently competitive spot market, political interventions will likely need to be coordinated.

As a complement to the conceptual work in our project, we developed and applied a numerical model with the objective to derive a quantification of potential policy and market design adjustments for the Swiss electricity market. Due to the findings from the conceptual work such as the decoupling of the demand and the supply side, the numerical model focuses on the supply side of the electricity market. However, the results from the numerical analysis are planned to feed back into the demand side of the conceptual model. The numerical model represents the largest suppliers of electricity in the Swiss market as separate firms and the smaller suppliers in an aggregated form. Depending on the market share, these firms are assumed to have different abilities for strategic decision taking. Further, the Swiss electricity market is connected to the four neighbouring market in Germany, France, Italy, and Austria allowing for trade between these markets. Similar to the conceptual model, a set of different policy instruments such as capacity markets, feed-in tariffs, and a quota market is applied to the numerical model. The analysis of the numerical model is currently in process and will be presented in the final project report.

Work undertaken and findings obtained

In the past year, project phases I and II comprising the development and the analysis of the conceptual electricity market model have been completed and the setup of a numerical model to be used for quantitative analyses of the Swiss electricity market has been started as part of the final project phase III. The work that has been done on both the conceptual and on the numerical models is presented in the following.

Conceptual model

The work on the conceptual model mainly included further developments to improve the handling of the model. Continuative analyses using the model confirmed previous results and provided additional interesting findings.

An important outcome of our study shows that the retail market and the whole sale market are almost perfectly decoupled even though firms have market power both on the retail and on the spot market. This result has to be seen as an approximation, because it is based on two simplifying assumptions. We assume that aggregate demand is constant and that the international spot market is so much larger than the domestic market that a linear approximation of price reactions suffices. However, it shows that, in a first step, policy should aim for coordinating interventions on the demand side (such as market liberalization and grid tariffs) and, separately, coordinating interventions on the supply side (such as feed-in tariffs and capacity markets).

Our results also show that, in particular on the supply side, a substantial coordination of policies is called for. If renewable energy technologies are to be promoted, as it is the case in most industrialized countries, this promotion requires accompanying measures for non-intermittent technologies, such as capacity payments or a capacity market. These accompanying measures can be required to achieve a cost-minimal outcome and they are almost certainly required, if the government aims at some level of domestic security of supply. Such a goal would then require the availability of some production capacity of non-intermittent technologies for the case where intermittent renewables do not produce, e.g., due to weather conditions.

In order to quantitatively illustrate our conceptual model and rounding off our model analysis, we conducted a numerical example that is based on data representing an electricity market comprising the four largest Swiss suppliers and their corresponding household customers (BFS (2015), ElCom (2015), Schlecht and Weigt (2014)). The data include amongst others the technical and economical characteristics of hydro, wind, and solar photovoltaic technologies and annual quantities of electricity sold by the suppliers to their household customers. Using these data, we show on the demand side the possible impact of a potential full liberalization of the Swiss electricity market on the switching behaviour of household customers and how the hesitancy of consumers to switching suppliers could affect retail prices. On the supply side, we give an insight into how subsidies of new renewables might influence a social cost-optimal subsidy of the controllable technology.

As described in the last years' annual report, we assume that before a potential (full) liberalization of the electricity market all (household) customers can only buy electricity from their local supplier. After the liberalization, the customers are free to switch between suppliers. As our example illustrates, this leads to a reallocation of consumer shares to the different suppliers. Figure 1 shows the quantities of electricity the suppliers sell to the consumers in each region before and after the liberalization (left axis) as well as the retail prices the firms set after the liberalization (right axis). Due to the consumers' hesitancy to switch suppliers, the firms exert market power on the retail market resulting in larger suppliers (i.e. suppliers with larger original home markets) setting higher prices than smaller suppliers (i.e. suppliers with smaller original home markets). As consumers (obviously) are only willing to switch to suppliers offering a lower price than the current one, consequently, smaller suppliers serve consumers from more different regions than larger suppliers (see Figure 1). Partly due to the fact that consumers switch only in one direction (towards lower prices), we can observe that the aggregate demands of larger suppliers becomes smaller after the liberalization, the opposite is the case for smaller suppliers.

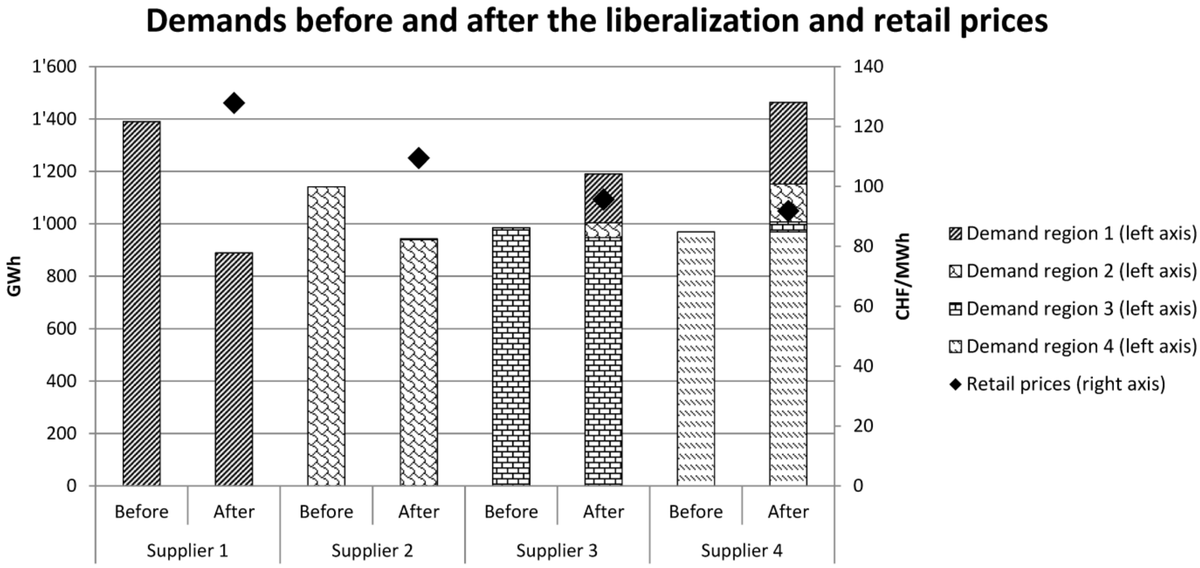

Figure 1: Retail prices and demanded quantities of electricity by supplier and region before and after a market liberalization

Next, we analyze retail prices as a function of the hesitancy of consumers to switch suppliers. As Figure 2 shows, retail prices in the entire market (linearly) increase with the hesitancy to switch that is represented by the fixed cost parameter f_c. Additionally, larger suppliers set higher prices compared to their smaller competitors. This result illustrates that the existence of consumers' hesitancy to switch suppliers gives the suppliers the opportunity to exert market power and demand higher retail prices from their customers. A potential introduction of quantity-specific transport costs (represented by the parameter t_c) as a fee that consumers have to pay when buying electricity from another region basically reduces the attractiveness for consumers to switching from the local supplier to a supplier in another region and has different implications for the suppliers in the market. Whereas the larger suppliers can increase their prices due to the higher barrier for consumers to switch away from the local supplier, the smaller supplier have to decrease their prices in order to still attract customers from other regions (see Figure 3).

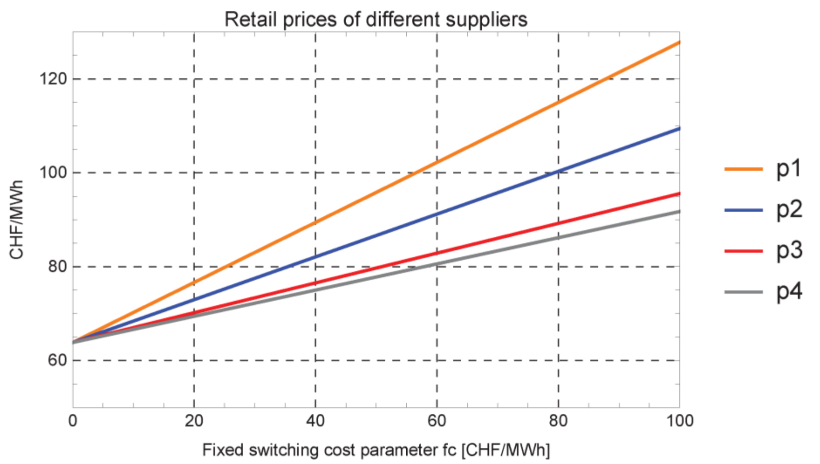

Figure 2: Retail prices (p1, p2, p3, p4) set by suppliers after market liberalization as a function of the hesitancy of consumers to switch suppliers.

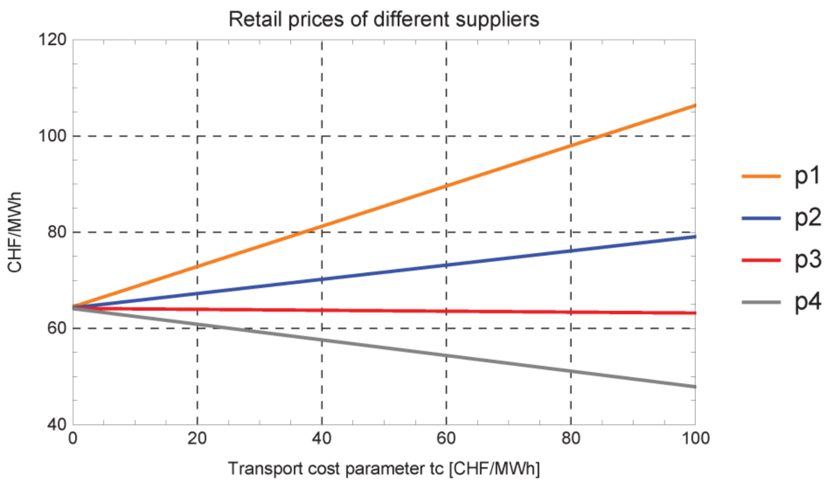

Figure 3: Retail prices (p1, p2, p3, p4) set by suppliers after market liberalization as a function of transport cost.

The results from the numerical example also have shown that without subsidization, no investments, neither in renewable technologies nor in the controllable technologies, are attractive given the dataset used for our analysis. Instead, electricity that is needed to meet domestic demands is imported from the international markets. This result is less surprising since it reflects well the current market situation in Switzerland where electricity prices are too low to make investments into new capacities profitable.

Numerical model

In order to complement the analysis with the conceptual model, we developed and apply a numerical model with the objective to derive a quantification of potential policy adjustments for the Swiss electricity market. Due to the finding from the conceptual work (i.e. the decoupling of the demand and the supply side), the numerical model focuses on the supply side of the electricity market. However, the results from the numerical analysis are planned to feed in back into the demand side of the conceptual model.

The numerical model represents the supply side of the Swiss electricity market. In doing so, the three largest suppliers (i.e. Axpo, Alpiq and BKW) are modelled as separate firms that can strategically decide about investments into generation technologies and the operation of the plants. The remaining suppliers in the market are modelled in aggregate as a competitive fringe without strategic behaviour. All suppliers in the market have to meet the domestic residual demand either by electricity from own production or from imports from the four neighbouring countries Germany, France, Italy, and Austria. The interlinkage between the Swiss suppliers and the abroad are represented by linear import-export functions based on merit order curves in the respective countries (see Figure 4). Further, the model includes a network operator that manages all imports and exports and ensures correct power flows in the system.

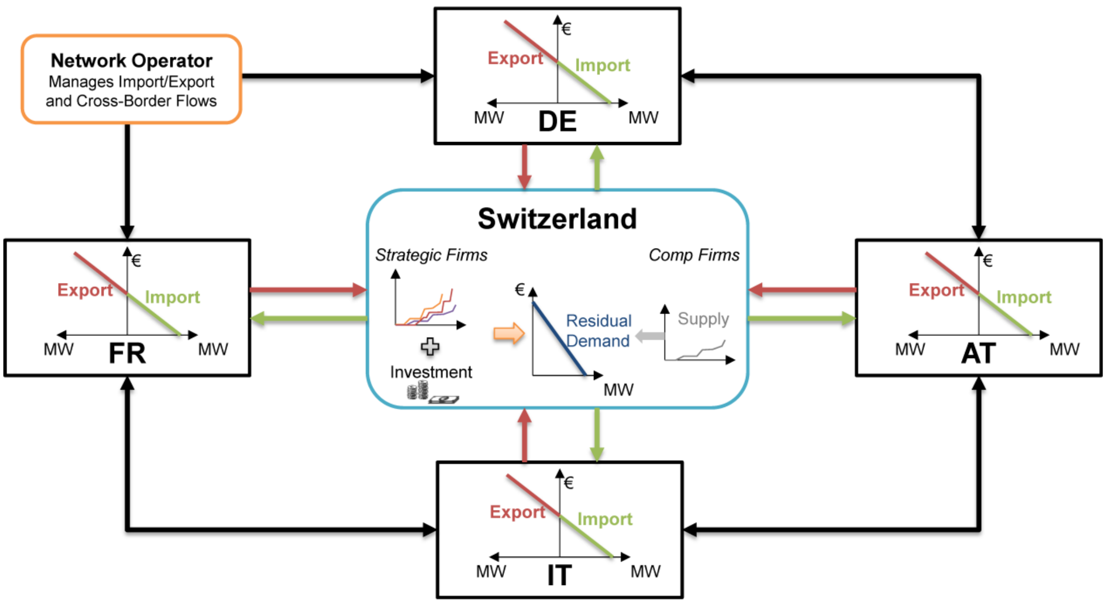

Figure 4: Basic setup of the numerical model including the Swiss electricity market and the four neighbouring countries.

Concerning the data structure we use a 5-year steps resolution with representative hours and seasons to account for the temporal characteristics of the year. Further, we apply investment costs that are based on average values. For renewables (i.e. solar and wind), we assume a decline in capital costs over time and account for the significant differences in the quality of the respective sites and their limited potentials. The Swiss demand elasticity is calibrated to historic data.

At the time when this report was written, the numerical model was still in a testing phase and the actual analysis of the different policy instruments including capacity market, feed-in tariffs, and quota markets will be completed in the remaining time of the project.

National cooperation

Our project benefits from collaboration with another ongoing project, *“Oligopolistic capacity expansion with subsequent market-bidding under transmission constraints”*, of the Research Program Energy - economy - society (EWG). This project analyzes the strategic investment decisions of power producers and the resulting impact of market power on profitability and on consumer prices. As part of this collaboration, two joined workshops were held in the past year with the purpose of exchanging information on the two projects and harmonizing important assumptions underlying the two modeling approaches.

Further, our project is carried out in close cooperation with the NRP 70 project *Assessing Future Electricity Markets (AFEM)* and complements this national research project by focusing on market structural elements (i.e. impact of liberalization), network and energy tariff structures, different renewable energy sources support schemes, the impact of the demand side, and its translation into regional/zonal set-ups.[1]

Finally, our project is embedded within the *Swiss Competence Center for Research in Energy, Society and Transition (SCCER CREST)* that aims at contributing to the energy transition in Switzerland. This competence center brings together research groups from different disciplines and almost all major Swiss research institutions.[2]

Evaluation 2016 and outlook for 2017

Within the past year, the work on the development of and the analysis using the conceptual model has been completed. This part of our project comprised tasks such as the analysis of possible interactions and coordination options of policy instruments such as feed-in tariffs and capacity markets. Additionally, we complemented the conceptual analysis with a numerical example based on data representing the Swiss electricity market. This investigation allowed for a quantification of the results obtained from the theoretical analysis. In parallel to the conceptual work of the project, a numerical model has been developed. The subsequent numerical analyses of policy instruments and potential regional designs for the Swiss electricity market has recently started and will be completed beginning of 2017 when the project ends.

[1] http://www.nfp70.ch/de
[2] http://www.sccer-crest.ch/

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