



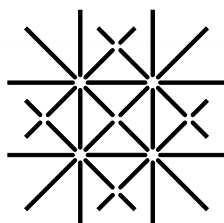
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Electricity market design: Policy coordination and zonal configurations



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Für den Inhalt und die Schlussfolgerungen sind ausschliesslich die Autoren dieses Berichts verantwortlich.

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1. Introduction and project goals

Swiss electricity markets are subject to several large-scale changes. Market power is to be reduced with the second phase of market liberalization, renewables are intended to replace nuclear power, and substantial investments in the grid and short-term storage have to be made and funded. To facilitate these changes, a set of different policy and regulatory measures is already used or planned, such as feed-in tariffs, market deregulation, a potential introduction of capacity markets and possible changes to grid tariffs. These different instruments and regulatory changes are likely to strongly interact with each other.

This project aims at analyzing if and how political interventions in the electricity market could interact and how they may be coordinated with each other, particularly in the context of the intended second phase of liberalization of the Swiss electricity market. Furthermore, possibilities of a zonal configuration with regionally differentiated market designs are investigated in the scope of the project. Finally, the implications of transitions in neighboring electricity markets in France, Germany, Italy, and Austria for the Swiss market are analysed, given the scale of current electricity imports and exports.

The report at hand shall give an overview on both completed work and achievements including model developments and analysis of the first two project phases and an outlook to upcoming tasks.¹

2. Completed tasks and achieved results

The achievements comprise the development of and the analysis with the conceptual electricity market model in the first project phase as well as the collection and preparation of data to be used for the subsequent numerical analysis.

2.1. Development of the conceptual electricity market model

The development of the conceptual electricity market model required numerous intermediate model versions and approaches before arriving at the final model version that is feasible and suitable for the analysis within this project.

The model covers any finite number N of regions with one supplier and one group of consumers of electricity in each region (see Figure 1). In the original state before the (full) liberalization of the market, all consumers can only buy electricity from the local supplier in their own region. As the market gets liberalized, consumers get the option to switch between suppliers. The hesitancy of consumers to switch between suppliers is represented in the model by an *individual switching "cost"* (ISC) that varies over the consumer group in a region. Further, it is assumed that consumers have only limited information about the retail price levels of the different suppliers in the market. This results in a situation where consumers that are willing to switch do not necessarily switch to the supplier with the lowest retail price in the market (as they would if they had (unrealistic) full information about prices) but

¹ A detailed description of the model along with a comprehensive presentation of results of the model analysis is currently in progress and will result in a working paper planned to be completed by the end of 2015.



to any supplier offering a retail price low enough depending on the respective ISC. The limited information about prices is represented in the model by consumers randomly receiving one offer from only one supplier. Depending on the level of ISC, the consumer then decides to switch to the new supplier or to stay with the current one. Repeating this procedure infinite times leads to an equilibrium where all consumers in the entire market end up with a supplier where they will not further switch. In order to satisfy consumers' demands for electricity, suppliers have the option to buy (and sell) electricity on the spot market (orange arrows in Figure 1) and invest into generation facilities for own production. The available technological investment options comprise two stochastic renewable technologies (solar PV and wind), one projectable renewable technology (hydro), and one projectable conventional technology (gas). Investments into these technologies are represented in the model using an investment submodel. Building on a similar theoretical structure as in (Thoma, Krysiak 2012), the model is set up as a two stage model, where suppliers first make investment decisions and then set prices, both under the assumption of profit maximization. While there is full market power on the retail market when suppliers set their prices, only partial market power exists on the spot market. Further, the model includes a set of policy instruments and regulatory measures, namely capacity markets, feed-in tariffs, and transport costs. These measures and instruments can be applied simultaneously in order to analyze possible interactions and coordination options.

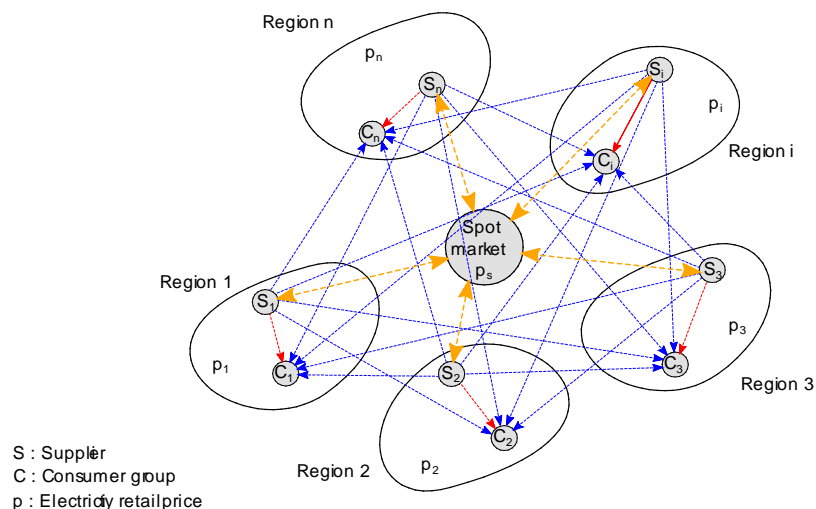


Figure 1: Setup of the conceptual electricity market model representing N regions with one supplier and one consumer group in each region.

2.2. Results from the analysis with the conceptual electricity market model

A number of interesting results could be deduced out of the analysis with the conceptual electricity market model within the first project phase. The most important findings are summarized below:

- The existence of market power on the retail market as a consequence of the limited willingness of consumers to switch supplier results in price differences across the different regions. As Figure 1 (middle subfigure) shows, differences in retail prices increase with the level of hesitation to switch. Further, it can be shown that suppliers having a larger home customer

base set higher prices compared to the competitors with a smaller consumer group in there region (see Figure 1, left subfigure). The reason for this outcome is that the large suppliers' total profit gain from charging higher prices from the home customers that are hesitant to switch exceeds the profit losses from losing some customers that are willing to switch to a competitor offering a lower price. At contrast, for the case of the small suppliers, the profit gains from attracting new customers from other regions with lower prices exceeds the profit losses due to price reductions in the home market.

- An “extreme” case can be observed when very small suppliers with only minor or even no existing customer bases enter the market and set aggressive low prices since the above mentioned effect of profit losses from reduced prices in the home market is negligible or inexistent. Such small suppliers have a strong impact on the retail prices in the entire market since they force the larger suppliers to reduce their prices in order to not losing too many customers to the small competitor.
- Imposing transport costs on the retail prices when buying electricity from suppliers in other regions generally reduces the attractiveness of switching suppliers. As a consequence, in the presence of transport costs, large consumers can set even higher prices without losing customers and small suppliers have to further reduce their prices in order to still attract customers from other regions. Figure 1 (right subfigure) shows the impact of increasing transport costs on retail prices.
- 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.

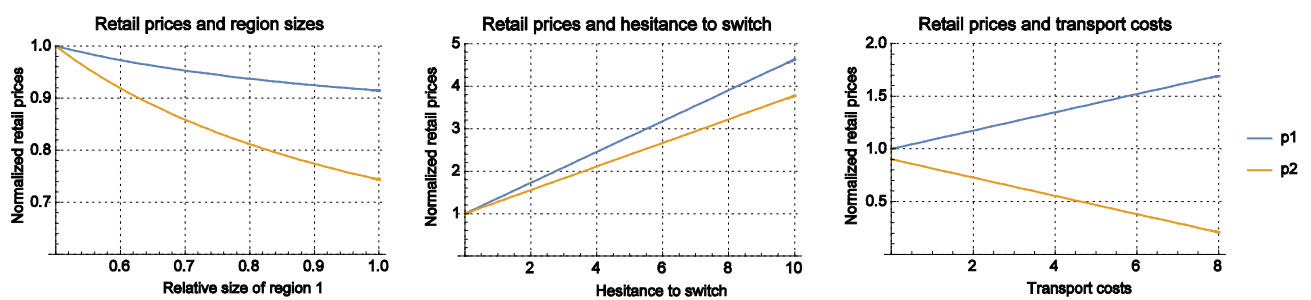


Figure 2: Normalized retail prices (p_1 , p_2) as a function of the relative size of the largest region 1 (left subfigure), the hesitation to switch (middle subfigure), and the transport costs (right subfigure) for an electricity market with $N=2$ regions.

2.3. Data collection and preparation for the numerical analysis

As a basis for the numerical analysis in phase 2, Switzerland-specific data on home customer bases and power plant portfolios of the Swiss electricity suppliers has been collected and prepared. The data



on home market sizes per supplier for now only comprise private households but not small and medium-sized enterprises (SME) with consumptions below 100 MWh (also falling into the category of small consumers that are currently in the regulated market). One of the main reasons for not (yet) including SME's in the database is the fact that the hesitance of enterprises to switch is likely to be significantly different from the hesitance of households and would require a separate treatment. However, for the allocation of households to suppliers the available data on household numbers per community (BFS, 2015) had to be merged with data allocating communities to the respective network operators (and suppliers) (EICoM, 2015). As can be seen in Figure 3, the cumulative share of households of the largest suppliers (left subfigure) and the household numbers of the 20 largest suppliers (right subfigure) illustrate that only a few suppliers apportion a relatively large share of all Swiss household customers for electricity among each other. Data on suppliers' power plant portfolios including facilities in sole and partial possession were not easily available and stem from various sources such as the supplier's or the owning holding company's websites. The collection and processing of these data was extensive mainly due to the high number of power plants and the partially rather complex owner structures including multiple layers of shareholder companies.

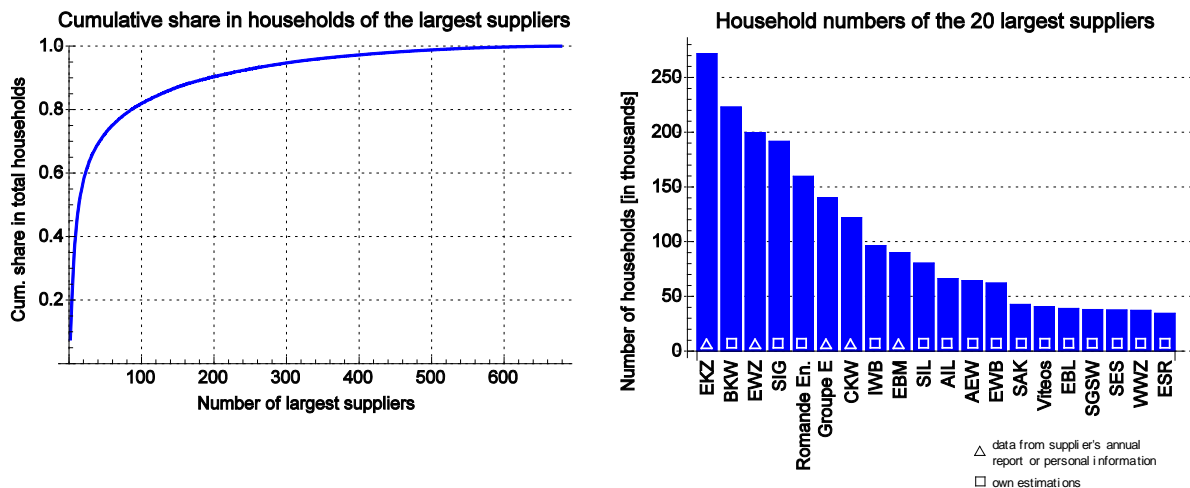


Figure 3: The cumulative share of households of the largest suppliers (left subfigure) and the household numbers of the 20 largest suppliers (right subfigure) illustrate that only a few suppliers apportion a relatively large share of all Swiss household customers for electricity among each other. Sources: BFS (2015); EICoM (2015), Annual reports and personal information of suppliers and own estimations

3. National collaboration

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.²

² <http://www.nfp70.ch/de>
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Furthermore, this project benefits from collaboration with another ongoing EWG project, “*Oligopolistic capacity expansion with subsequent market-bidding under transmission constraints*”, that analyzes the strategic investment decisions of power producers and the resulting impact of market power on profitability and on consumer prices.

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.³

4. Evaluation 2015 and Outlook 2016

4.1. Evaluation 2015

Within the first project phase, important tasks including the development of the conceptual model and the subsequent analysis as well as the collection and preparation of data to be used for the numerical analysis could be successfully completed. However, further tasks such as the analysis of possible interactions and coordination options of policy instruments such as feed-in tariffs and capacity markets still have to be conducted with the application of the abovementioned conceptual electricity market model. While the conceptual electricity market model developed within this project was originally planned to only cover two or three different regions, we succeeded to extend the model to any finite number of regions (consequently resulting in increased computational demands).

The results presented above aim at showing how interventions on electricity markets such as a market liberalization or the introduction of transport costs could affect the decision behavior of market participants including private household consumers (switching between suppliers) and suppliers of electricity (setting profit-maximizing retail prices) under the existence of market power on the retail market. The outcomes of our investigations also illustrate the importance of a sufficiently competitive spot market in order to avoid distortions of investment decisions and reduce the need for coordination of political interventions. Given the fact that we used for our analysis a conceptual electricity market model without inclusion of real-world data, our results are more suitable to support the understanding of liberalized electricity markets in a qualitative rather than in a quantitative way. Quantitative results will be deduced from the upcoming analysis using a numerical model.

4.2. Outlook 2016

The work on model development and data preparation completed so far allows for tackling the next tasks comprising amongst others:

- The further application of the conceptual model to analyze interactions and possible coordination options of policy instruments and interventions including feed-in tariffs, market liberalization, transport costs, and capacity markets. This task will yield insights into the pathways in

³ <http://www.sccer-crest.ch/>



which these instruments are interrelated and could be coordinated and rounds off phase 1 of the project.

- As part of phase 2, the results of the analysis with the conceptual model of phase 1 and the prepared data regarding the suppliers' customer bases and power plant facilities will feed in an adjusted version of the conceptual model to be used for a numerical analysis depicting the most important interactions and possible gains of coordinating the instrument on a national scale.
- In phase 3, we will extend the numerical analysis by investigating the benefits of a zonal approach including different levels of zonal configurations (zonal pricing, differentiated policies). For this analysis, we extend the existing model with a regional structure based on elements of the Swissmod electricity market model (see Schlecht, Weigt (2014)).
- Furthermore, the analysis will be repeated for different assumptions regarding developments in neighboring markets in order to verify to what extent different policy and market designs are robust to different international developments and whether a zonal design is advantageous in this regard.



Publication bibliography

BFS (2015): Regionalporträts: Kennzahlen aller Gemeinden. Bundesamt für Statistik. Available online at <http://www.bfs.admin.ch/bfs/portal/de/index/regionen/22/lexi.Document.157693.xls>, checked on 10/22/2015.

EICom (2015): Schweizerische Gemeinden und zuständige Stromnetzbetreiber. Eidgenössische Elektrizitätskommission. Available online at <http://www.elcom.admin.ch/themen/00002/00097/index.html?lang=de>, updated on 9/25/2015, checked on 10/22/2015.

Schlecht, Ingmar; Weigt, Hannes (2014): Swissmod - a model of the Swiss electricity market. Basel: WWZ (WWZ-Discussion Paper, 14/04).

Thoma, Mirjam I.; Krysiak, Frank C. (2012): Ökonomische Analyse zur Kombination von verschiedenen Regulierungsinstrumenten im Schweizer Energiemarkt nach 2012. Schlussbericht.



List of abbreviations

AEW	AEW Energie AG
AIL	Aziende Industriali di Lugano SA
BFE	Bundesamt für Energie
BFS	Bundesamt für Statistik
BKW	BKW Energie AG
CKW	Centralschweizerische Kraftwerke AG
EBL	Genossenschaft Elektra Baselland
EBM	Genossenschaft Elektra Birseck, Münchenstein
EICOM	Eidgenössischen Elektrizitätskommission
EKZ	Elektrizitätswerke des Kanton Zürich
ESR	Energie de Sion-Région SA
ETHZ	ETH Zurich
EWB	Energie Wasser Bern
EWG	Energie - Wirtschaft - Gesellschaft
EWZ	Elektrizitätswerk der Stadt Zürich
ISC	Individual Switching Cost
IWB	Industrielle Werke Basel
PV	(solar) Photovoltaics
MWh	Megawattstunde
NRP	National Research Program
Romande En.	Romande Energie SA
SAK	St.Gallisch-Appenzellische Kraftwerke AG
SCCER CREST	(Swiss) Competence Center for Research in Energy, Society and Transition
SGSW	Sankt Galler Stadtwerke
SES	Società Elettrica Sopracenerina
SIG	Services Industriels de Genève
SIL	Services Industriels Lausanne
SME	Small and Medium-sized Enterprises
WWZ	Wasserwerke Zug AG