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AGGREGATE

The value of aggregators in a flexible and decentralized Swiss energy system

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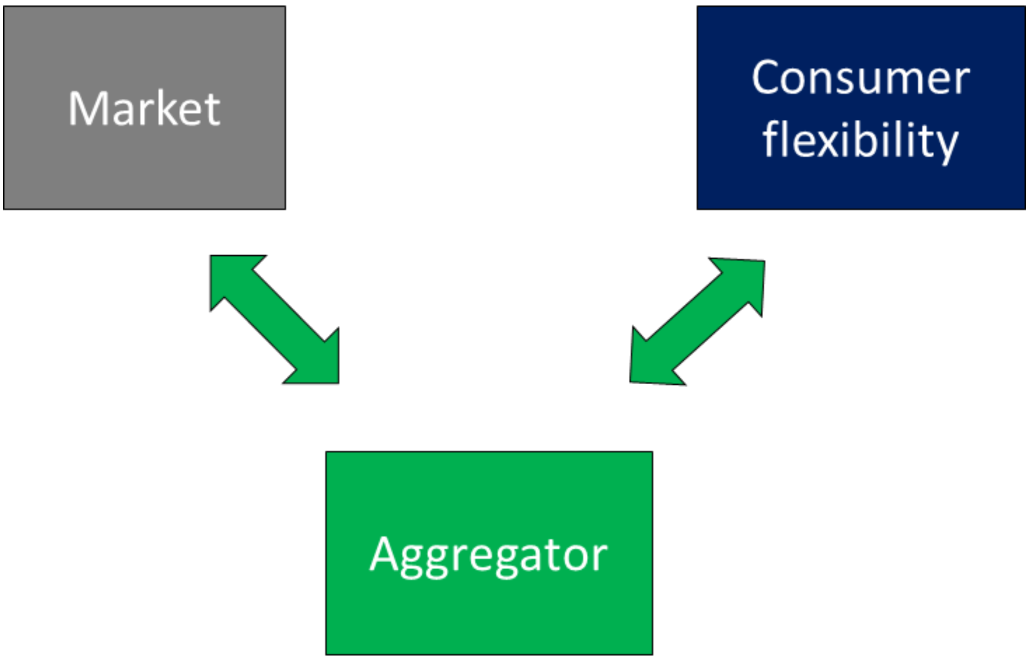

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Zusammenfassung

In einem künftigen Elektrizitätssystem mit hohem Anteil erneuerbarer Energien und neuen Stromnachfrage-Anwendungen wird die Erzeugung allein nicht in der Lage sein, Angebot und Nachfrage auszugleichen. Die aktive Beteiligung dezentraler Energieressourcen ist notwendig. Aufgrund unvollkommener Information, begrenzter Rationalität und regulatorischer Hindernisse reagieren Haushalte jedoch oft nicht auf Preissignale. In diesem Umfeld können Aggregatoren eine wichtige Rolle spielen einzelne Stromverbraucher und Prosumer zu bündeln, um auf den Märkten für Strom und Systemdienstleistungen als Einheit aufzutreten. Eine solche Aggregation kann Effizienzgewinne bringen und den Wohlstand erhöhen, wenn regulatorische Arbitrage vermieden wird. Im Rahmen des Projekts werden wir zunächst den regulatorischen Rahmen bewerten und einen Literaturüberblick geben. Zweitens werden wir die Wohlfahrts- und Systemauswirkungen verschiedener Stufen der Aggregatorbeteiligung in einem dezentralen Schweizer Energiesystem modellieren. Drittens werden wir den Marktrahmen für die Aggregation bewerten (Kosten für das Angebot von und die Nachfrage des Systems nach Flexibilität) und Politikempfehlungen ableiten.

Die Arbeiten in diesem Jahr haben sich auf drei Projekte konzentriert. Erstens haben wir an der Beschreibung des regulatorischen Rahmens für Aggregatoren in der Schweiz gearbeitet, auch mit Blick auf neue Regelungen im Rahmen des Mantelerlass. Eine wichtige Erkenntnis dabei war, dass das Modell, wie Aggregatoren derzeit in der Schweiz Flexibilitäten für Balancing aggregieren können, problematische Anreize in Bezug auf Ausgleichsverbräuche aufweist. Der Mantelerlass enthält Verbesserungen in Bezug auf den Zugriff der Verteilnetzbetreiber auf Flexibilitäten.

Zweitens haben wir an der Konzeption eines möglichen Marktmodells gearbeitet, das Endkunden ermöglichen würde, für spezifische Geräte wie Wärmepumpen oder Elektroautos zu einem anderen Stromanbieter zu wechseln, ohne jedoch die Absicherung des mittleren Preisniveaus durch den lokalen EVU zu verlieren. An diesem Strang arbeiten wir unter dem Titel «Device Specific Suppliers in a Monopolistic Retail Market».

Drittens haben wir dynamische Tarife untersucht, die dabei helfen können, Verbraucher anzureizen, flexible Verbrauchseinheiten nach den Knappheiten am Markt auszurichten. In Bezug auf solche dynamischen Tarife haben wir insbesondere untersucht, wie sich eine Absicherung des Preisniveaus (Hedging) für Endverbraucher mit dynamischen Preisen kombinieren lässt. Die Analyse hat gezeigt, dass Tarife für Endverbraucher möglich sind, die eine ähnlich hohe Stabilität der Stromrechnung ermöglichen wie fixe Tarife, jedoch gänzlich unverzerrte Anreize aus dynamischen Strompreisen geben können. Wir haben unsere Analyse bei einem wissenschaftlichen Journal unter dem Titel «Profile contracts for retail customers» eingereicht.

Bei unserem Stakeholder-Workshop im Mai konnten wir erste Arbeiten bereits vorstellen und viel hilfreiches Feedback für die weiteren Arbeiten sammeln.

Summary

In a future electricity system with high shares of renewables and new demand entities, conventional generation alone will not be able to balance supply and demand. Therefore, active participation of distributed energy resources is necessary. Yet, due to imperfect information, bounded rationality, and regulatory barriers, households often do not react to price signals. In this environment, aggregators can play an important role in pooling prosumers to act jointly on power and ancillary services markets. Such aggregation can yield efficiency gains and increase welfare, while regulatory arbitrage must be avoided. In the project, we will first evaluate the regulatory framework and provide a literature overview. Second, we will model the welfare and system impacts of different levels of aggregator participation in a decentralized Swiss energy system. Third, we will assess the market framework for aggregation (costs of supply of and system demand for flexibility) and derive policy conclusions.

This year's work has focussed on three work streams. Firstly, we worked on the description of the regulatory framework for aggregators in Switzerland, also with a view to new regulations under the Mantelerlass. An important finding was that the model of how aggregators can currently aggregate flexibility for balancing in Switzerland has problematic incentives and can cause what we call catch-up consumption, which reduces the overall value of such balancing provision. The Mantelerlass contains improvements in relation to the access of distribution system operators to flexibilities.

Secondly, we have been working on the design of a possible market model that would allow customers to switch to another electricity supplier for specific devices such as heat pumps or electric cars, without losing the protection of the average price level by the local energy supplier. We are working on this strand under the title "Device Specific Suppliers in a Monopolistic Retail Market".

Thirdly, we have investigated dynamic retail tariffs that can help incentivise consumers to align flexible consumption units with market shortages. With regard to such dynamic tariffs, we have analysed in particular how price level hedging for end consumers can be combined with dynamic prices. The analysis has shown that tariffs for end consumers are possible that enable a similarly high stability of the electricity bill as fixed tariffs but can provide completely undistorted incentives from dynamic electricity prices. We call these types of tariffs profile contracts and have submitted our analysis to a scientific journal under the title "Profile contracts for retail customers".

At our stakeholder workshop in May, we were able to present our initial work and gathered a lot of helpful feedback for further work.

1 Introduction

1.1 Background

The power sector has experienced tremendous change over the last decades, shifting from a centralized market based on large production units to a market with a multitude of actors of different sizes, a higher market share of distributed energy resources (DERs), and an increasing role of demand-side response (DSR). This trend is expected to accelerate in the coming years. At the same time, electricity consumers in households are often neither able nor incentivized to fully harness the flexibility potential embedded in their demand assets, such as heat pumps and electric vehicles, as they do not have access to market signals and informational requirements of flexibility usage are too high to be viable for individual entities.

In this market environment, aggregators may play a central role in pooling consumers, producers, and prosumers, leading to expected efficiency and welfare gains. Real-world electricity markets often lack the conditions of an ideal market, such as complete information, perfect coordination, rational behavior, and perfect regulation. As a result, they fail to realize direct price signals (e.g., due to fixed retail tariffs, Borenstein and Bushnell 2019, monopolistic retail settings and minimum size requirements for participation in wholesale markets). To address these issues, aggregators group multiple agents (consumers, producers, prosumers) and bundle them into one entity, which can participate in day-ahead, intraday, and ancillary service markets. In this way, aggregators act as intermediaries to leverage untapped flexibility and address the market failures outlined above, increasing overall economic efficiency by reducing peak residual demand and balancing the system through temporal and spatial harmonization of generation and demand profiles. However, regulatory and incentive structures must be well designed to lift the full flexibility potential of aggregation and avoid regulatory arbitrage.

1.2 Project Goals.

The objective of the project is to identify the economic value of aggregators in a flexible and decentralized Swiss energy system and to provide guidance on a regulatory framework that reduces barriers to system-beneficial aggregation and avoids incentives for regulatory arbitrage.

In this context, this project aims to:

- review the regulatory framework aggregators are operating in,
- analyze the value of aggregators in providing a solution to the imperfect information of consumers to manage flexibility,
- derive recommendations for improving the regulatory framework to avoid opportunistic aggregation and enable beneficial aggregation

2 Results

Since the official kick-off of AGGREGATE on 01.12.2022, we have focused on the tasks listed on WP1 and WP2. In the following subsections we discuss in more detail the outcome of each one.

2.1 Regulatory framework

In this work stream we studied the current regulatory framework for the operation of aggregators in both Switzerland and the EU, with a stronger focus on the Swiss market.

We found that while in the EU most barriers for the operation of aggregators have been lifted, in Switzerland there are still regional monopolies in place, which is the single biggest hurdle for aggregating flexible assets in Switzerland and constraints aggregators to small niche markets. Below we summarize our key findings.

Currently, the Swiss retail electricity market operates under a hybrid model. Large consumers (above 100 MWh per year) can freely choose their electricity supplier and actively participate in the European electricity market. On the other hand, smaller consumers are still bound to regional retail monopolies, are the only entities that can provide electricity to the customers in their supply region. Most customers in Switzerland are on fixed price tariffs or time-of-use tariffs which offer no or little incentive to make demand assets flexible.

In this context, aggregators are limited to operate in Switzerland under three different schemes:

- **Balancing pools:** Regulated since 2013. Enables supply of balancing reserves through distributed assets, making ancillary markets available for small consumers and/or producers.
- **Own consumption communities:** Regulated since 2018. A group of end consumers and or prosumers can join to be considered a single final consumer. This enables them to avoid grid tariffs by maximizing their own consumption. Furthermore, if the final aggregated consumption is higher than 100 MWh/year, the community can choose their own electricity supplier in the market.
- **Emergency reserve generation:** Regulated since 2022. Scheme aimed to improve the system's security by adding emergency generators to the country's reserve capacity on a voluntary and remunerated basis.

We found that the current regulatory environment in Switzerland strongly limits the participation of aggregators in the market, not only because of the non-liberalized retail market, but also because the only market in which aggregators can operate for retail customers is the balancing market, which is a relatively small market. To give an idea on the size of the balancing market, in 2021 its monetary volume was only 2,5% of the total energy market transactions in Switzerland.

A key finding in our analysis of the current aggregators operation framework in Switzerland concerns a problem we call "catch-up consumption". Catch-up consumption occurs when the demand reduction triggered by aggregators of flexible demand assets (such as heat pumps or electric vehicles) causes additional consumption in subsequent market time units, outside of the balancing call-up period. The problem with such catch-up consumption is that it leads to new imbalances in the subsequent market time units, which are not compensated for in the current operational framework for balancing provision. Additionally, since there is no information exchange between the independent aggregator and the Balance Group Operator, the latter would not be able to anticipate this catch-up consumption, which would mean that in the worst case, the current aggregator model could be causing a similar amount of imbalance than what it solves before. While this effect is clearly existing from a theoretical point of view, it would be worthwhile to analyse it also empirically, especially if we consider that the growing capacity of flexible demand assets in the system could make this problem more significant. To that end, we are in contact with one of our cooperation partners to potentially exchange data for an empirical analysis.

2.2 Device Specific Suppliers in a Monopolistic Retail Market

Here, we have been working on the design of a possible market model that would allow customers to switch to another electricity supplier for specific devices such as heat pumps or electric cars, without losing the average price level hedge by the local energy supplier. Enabling such device specific suppliers would be a step to opening up the Swiss retail electricity market, but limited to the type of assets where consumer choice is most impactful as they can be operated in a flexible manner.

The reason why we analyse such a market model is the key finding of the previous workstream on the regulatory framework, namely the fact that current regulations constrain aggregation to small niche markets and prevent them from the much more relevant – and societally beneficial – use of flexible assets with respect to market-oriented dynamic energy procurement on day-ahead and intraday markets in addition to the balancing provision that is possible already now.

The main challenge when allowing for device specific suppliers would be strategic incentives for customers to always switch to the device suppliers when market prices are low and switch back to the monopolist when prices are high. We therefore worked on mechanisms that would involve compensation payments between the local monopoly and the device specific supplier, to eliminate such systematic cherry-picking incentives.

2.3 Profile contracts for retail customers

In this work stream, we have teamed-up with Christian Winzer (ZHAW, SWEET PATHFNDR) and Lion Hirth (Hertie School) to investigate dynamic tariffs that can help incentivise consumers to align flexible devices with market signals. Granular price signals that convey abundance or scarcity of electricity are a precondition for consumers or aggregators acting on their behalf to exploit this flexibility. However, unmitigated real time prices expose consumers to electricity cost risks. To tackle the dual need of providing flexibility incentives while protecting consumers from cost shocks, real time tariffs with a hedging component can be a solution. In such contracts customers pre-agree an amount of energy and a consumption profile, while hourly deviations are charged at spot prices. We have analysed design options of such tariffs by using a dataset of anonymized smart meter data. The dataset used in this analysis is openly available as a part of the "Open Data" initiative of CKW AG (2023), a Swiss regional electric utility, and pre-processed by Sawicki (2023).

Profile contracts are real time tariffs with a hedging component. They have a long duration of typically one or multiple years. In such contracts, customers pre-agree an amount of energy and a consumption profile, while hourly deviations (both positive and negative) are priced at spot prices. In essence, they are simply commodity hedging contracts. As electricity cannot easily be stored, electricity is a heterogenous commodity across time, so electricity delivered in any specific time period can be regarded as a separate product for which a specific hedging quantity must be defined. This is the purpose of the profile. In that sense, profile contracts are an adoption of the generic commodity hedging contract (McKinnon, 1967) applied for the case of electricity (Borenstein, 2007).

In other words, profile contracts mean that customers purchase a load profile which is defined in advance at a fixed reference price (e.g., the forward price). For their hour-by-hour excess consumption compared to the pre-purchased profile, they pay the spot price and for their underconsumption compared to the purchased profile, they receive a refund equal to the spot price. This means profile contracts combine incentives for demand response with a high degree of certainty of the electricity bill.

The most striking result from our analysis is that all analysed hedging scenarios effectively protect consumers from large bill deviations compared to the spot pricing scenario and come very close to the fixed tariff scenario. The standard deviations of the relative bill deviation of all the hedging tariffs is significantly lower than the spot pricing benchmark and the same magnitude as that of the fixed tariff. The stability of the bills is also depicted in the box plots in Figure 1. The fact that consumers, if they actually faced such tariffs, could react to them by using relatively cheaper hours to use flexible assets, provides an upside for consumers which not represented in our tariff simulations.

The simulations also show that the main advantage for the cost stability in the analysed tariffs comes from hedging at all and does not improve much with the choice of more sophisticated profiles. The standard deviation for the baseload hedge is only marginally higher than that of the tariffs that use hedge profiles that are intended to be better tailored to customer's own consumption profile. This shows that for the hedge to work it is not necessary that customers are fully hedged in each individual hour, and that the sum of positive and negative individual hourly deviations from hedge profiles cancel out to reach an overall stable bill even without sophisticated profile designs. Interestingly, this result shows that it is not important for the hedged profile to closely match individual customers' consumption profiles – but even a completely flat baseload profile hedge is a good hedge to smoothen customers' energy bills.

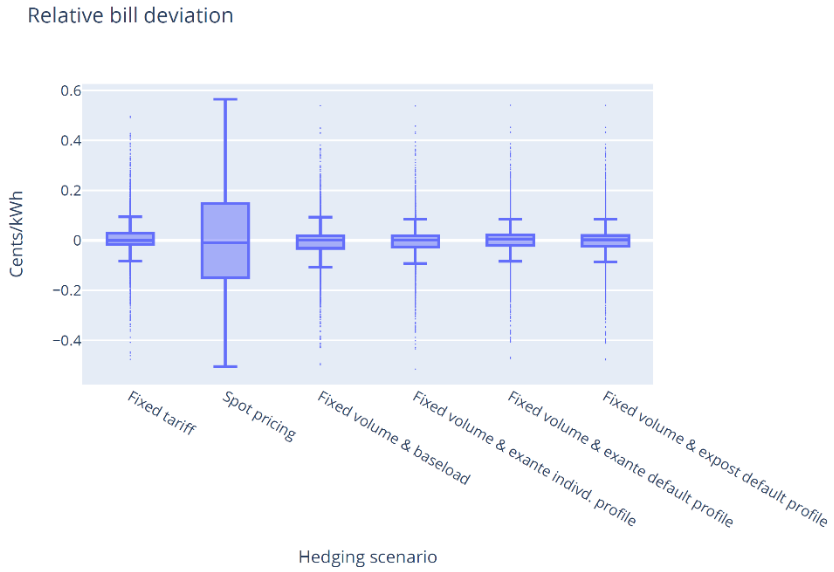

Figure 1: Relative bill deviation per hedging scenario compared to a fixed tariff and a spot pricing tariff

3 Next steps

Our work in the next year on the one hand consists of continuing the work streams started this year. This involves both academic journal publications and potential work in revising submitted manuscripts, but also developing the concepts further.

On the other hand, we will start numerical modelling to analyze the value of flexibility aggregation in the Swiss electricity market.

4 National and International Cooperation

Our advisory group forms an integral part of our project and is our main cooperation vehicle for exchange with companies, industrial associations and the academics on our advisory board.

For our work on profile contracts for retail customers, we collaborated with Prof. Dr. Lion Hirth (Hertie School) and Dr. Christian Winzer (ZHAW Winterthur, SWEET PATHFNDR).

Furthermore, we exchanged with the Competence Center for Thermal Energy Storage from the Lucerne University of Applied Sciences (HSLU) on quantification of heating demand to better estimate the flexibility potentials in the heating sector.

5 Communication

On May 4th, 2023, we conducted the first project workshop in Zurich. All the project's industry and academic advisors were invited to participate. The workshop featured three main presentations on results by the AGGREGATE team, summarising the progress done so far. Further external speakers enriched the workshop and enabled exchange with tangent research.

On July 25th, 2023, we presented our concept of "Device Specific Suppliers in a Monopolistic Retail Market" at the 18th European Conference of the International Association for Energy Economics (IAEE), which took place in MIlan, Italy.

Finally, on October 5th, 2023, we presented our paper "Profile contracts for retail customers" at the 32nd Young Energy Economists and Engineers Seminar (YEEES 32) in Nuremberg, Germany.

6 Publications

Winzer, Christian, Hector Ramirez, Lion Hirth, Ingmar Schlecht (2023). Profile contracts for retail customers: Analysis of a tariff that incentivizes demand response while hedging customer bills. Working paper (submitted to journal). https://www.zhaw.ch/storage/sml/institute-zentren/cee/upload/Winzer_et_al_2023_Retail_profile_contracts.pdf

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