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Barriers and goal conflicts for increased energy resilience from flexibility

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ABSTRACT

This study examines the key barriers and goal conflicts that hinder the development of flexibility in the Swedish electricity system. Through 35 interviews with actors from all sectors of the electricity market, 257 unique challenges were identified. A significant concern is the absence of independent flexibility roles, such as the balance service provider, hindering market access for new actors. Regulatory design, unclear responsibilities for emerging carriers like hydrogen, and a lack of unifying leadership further exacerbate uncertainties. Organizational inertia among distribution system operators and opaque market rules are also noted as systemic impediments. Our findings suggest that improved governance and structural reforms are necessary to unlock Sweden's full potential for flexibility.
Keywords: flexibility, drivers, barriers, renewable energy resources, flexibility service provider

NOMENCLATURE

aFRR	automatic Frequency Restoration Reserve
BRP	Balance Responsible Party
BSP	Balance Service Provider
DER	Distributed Energy Sources
DSO	Distribution System Operator
EU	European Union
EV	Electric Vehicle
FCR-D	Frequency Containment Reserve - Distrurbance
FSP	Flexibility Service Provider
LFM	Local Flexibility Market
TSO	Transmission System Operator

1. INTRODUCTION

In today's world, where traditional safety principles are under scrutiny and conflict rages in Europe, there is an increasing need for resilience in the energy grid. Reports regarding Ukraine indicate that greater flexibility can boost the overall resilience of the energy system [1,2]. Just as flexible DER has bolstered Ukraine's electricity system during the invasion, increased flexibility in Sweden can enhance the energy system's capacity to withstand disturbances. By allowing flexible DERs to tackle imbalances, it is possible to lower reliance on centralized infrastructure, thereby enhancing redundancy and resilience in the overall energy system. This increased robustness can protect against physical threats such as extreme weather and technical failures, as well as geopolitical tensions and possible cyberattacks.

While in times of peace, flexibility is also one key to meeting the Paris Agreement's objective of capping global warming at 2 degrees Celsius. To do this, the share of renewable energy production needs to be largely increased within our energy framework. The "Clean Energy for All Europeans" initiative sets a long-term target of integrating at least 80% of renewable energy resources, aiming to reduce greenhouse gas emissions by 80-100% compared to 1990 levels [3]. At the same time, the energy transition is leading to increased consumption, and electricity demand is rising. The EU's ambitions for renewable energy and increased electrification pose a challenge to an electricity grid that was built and designed for a different energy context, characterized by stable energy flows and predictable consumption and production patterns. Both DSOs and TSOs face challenges in expanding their grids to meet the increasing demand and changing usage patterns. Traditional grid construction is a slow and timely process. Therefore, flexibility emerges as a viable solution to address the time varying capacity shortages resulting from the transition. In the Nordic power system, part of this flexibility is procured through short-term balancing products such as FCR-D and aFRR, which both automatically stabilize the grid frequency to 50 Hertz. These ancillary services are only one aspect of flexibility, while there is also flexibility that constitutes shifts in energy use over hours, days, or more extended periods.

This research aims to find the main barriers to increased flexibility in the Swedish electricity system.

2. MATERIALS AND METHODS

In this section of the paper, the methodology is described. The chapter is divided into two sections: the first section presents the research approach for the study, and the second section discusses the interviews conducted and the selection of interviewees.

A qualitative approach, incorporating in-depth interviews, was employed to explore the perceptions of all roles active in the market and to follow up on the insights that emerged from the interviews, as described by Creswell [4] and Kvale and Brinkmann [5]. The purpose of the interviews was explained so that they could share their experience of flexibility in general and the drivers and barriers to flexibility in particular. The interviews were semi-structured and based on the interview agenda for this research. All questions had an open-ended nature, allowing the interviewee to discuss the topic in more detail, as described by Basias and Pollalis [6]. During the interviews, flexibility is key, and as researchers, the questions were adapted to the interviewee's answers. The interviews were conducted during the spring of 2024. To investigate any changes to the prerequisites, we invited twelve of the interviewees to a workshop during the spring of 2025. During the workshop, the initial results were presented, and participants were invited to comment on the findings and explain whether there had been changes for better or worse regarding the possibility of offering flexibility to the energy system.

In selecting whom to interview, the aim has been to gather a diverse range of actors from the electricity sector, encompassing production, trading, distribution, and consumption. Refer to the table below for a summary of the interviewed actors; the categories in the table correspond to the categories used during the thematic coding. The largest category of interviewees is FSPs, which encompasses both consumption and production. Within the FSP group, there are large energy producers, including those producing nuclear- and hydro energy, as well as operators of megawatt batteries, hydrogen producers, and a range of actors involved in electric vehicles. The category BRP/Aggregator contains actors registered and active as BRP, but they also aggregate and operate flexible resources from other BRPs. All DSOs interviewed had experience from operating a local flexibility market.

Table 1:Data Overview

Actor category	Number of interviews
Market operator	2
TSO	1
DSO	4
FSP	13
Aggregator	7
BRP/Aggregator	4
BRP	4

3. RESULTS

From the 35 interviews, 257 goal conflicts and barriers were identified that hinder the potential flexibility in Sweden. With an inductive approach, the goal conflicts and barriers have been aggregated into twelve different categories, each with three to eleven subcategories. The categories have evolved from grouping similar goal conflicts and barriers repeatedly into larger entities related to specific subjects. At the end of the process, the labeling has been refined to describe each entity accurately.

3.1 Lack of unifying leadership for the energy system

Actors are calling for holistic leadership in the energy transition; however, there are complaints that the TSO is only responsible for electricity, Swedegas is responsible for natural gas, and regarding heating, almost every district heating system is operated separately. With a dispersed responsibility for the diversity of energy carriers, there is no single responsible actor for a new system containing a novel energy carrier. With this in mind, the question of who will carry the system's responsibility for hydrogen remains unanswered.

With the green energy transition underway in northern Sweden, the EU's hydrogen strategy and REPowerEU hydrogen are emerging as key energy carriers. Hydrogen was frequently mentioned during interviews when discussing Sweden's flexibility potential. Some of the current industrial leaders in hydrogen have expressed the view that they should take full responsibility for the development of hydrogen. At the same time, everyone would benefit from the stability that large-scale hydrogen could bring to the electricity market. They asked for an overarching societal responsibility; they described it as if without a clear lead in the transition, a few early adopters would have to bear the cost while many others would benefit from the flexibility that hydrogen can offer the electric system.

3.2 Lack of independent BSP in the Swedish energy system

For the reader unfamiliar with Swedish regulations regarding BSP/BRP today, it is necessary to provide

context to interpret the goal conflicts described in this section.

When EU Commission Regulation 2017/2195 (Electricity Balancing Guideline) came into force on 18 December 2017, member states and TSOs had to align their balancing markets and regulatory frameworks with the regulations within three years [7]. This means that the BSP role should be implemented by December 2020 in all EU member states. During the spring of 2024, when most of the interviews were conducted, the Swedish TSO announced that the BSP role would finally be implemented. A few weeks before the introduction of the BSP role, the TSO announced the requirements for the role, which (in reality) entailed that you needed to be a BRP to be able to be a BSP. During all interviews with companies that aspired to be BSP, they expressed optimism about the future and the upcoming change prior to the announcement of the requirements. During the interviews conducted with potential aggregators after the announcement of the BSP requirements, a notable frustration was apparent among many.

"*The BSP role is merely a paper construct with no practical significance in its current form. One must be honest and acknowledge that a failure is a failure. They have had since 2017 to implement something relatively simple that most of Europe's TSOs have managed, and they have completely failed to do so. As a result, we currently have no independent BSP in Sweden, and we are uncertain about when we might obtain one. Our relationship with the BRP is essential and a prerequisite—we cannot do anything without them. Everything we do depends on their permission. That relationship is important and currently good; however, for the foreseeable future, we will continue to operate through the BRP. If flexibility is to be established, there must be a diversity of actors and sufficient liquidity in the market. With this failed BSP implementation, there is a significant risk we will not achieve that."* – Aggregator 1

"*It has not turned out well at all, and there will not really be a BSP role now […] it is being introduced in May [*2024*], but since you must have been a BRP and already delivered ancillary services, nothing will actually change.*" – Aggregator 2

During the autumn of 2024, the Swedish TSO announced that the full implementation of the independent BSP role is planned for 2028 [8], eleven years after the regulation took effect and eight years after the implementation was stipulated to be in place. According to the Swedish TSO, the reason for delaying the independent BSP is that their current IT system cannot handle the settlement and compensation mechanisms that will result from splitting the BSP and BRP. During the workshop, the concept of the "uncompensated BSP" was mentioned by aggregators as a way forward.

3.2.1 BRPs impose obstacles for aggregators

The absence of an independent BSP constitutes the barrier to flexibility that sparked the most frustration during the conducted interviews. Several interviewees mentioned the barrier, but considerable frustration was evident among companies that saw enormous potential in an independent BSP, such as aggregators and companies with many distributed resources. Aggregators described it as: having much flexibility that could not be facilitated, as potential customers with flexible resources were locked into other BRPs.

Aggregators described in some cases that half of their working time was spent administering the BRPs to which their customers belonged, the work with the existing BRPs was also mentioned by some aggregators as the most significant cost in their operations. An estimate was made that with the independent BSP, some aggregators would quickly be able to increase their flexibility portfolio by ~60%.

"*What we felt at the time was that the so-called 'old, established BRP actors' — if you'll excuse the expression — appeared primarily focused on optimizing their own flexibility, while largely disregarding the flexibility potential of their customers.*" - BRP/Aggregator 2

Some aggregators described it as if they had customers with potential flexibility, the customers' BRPs would not say no. However, some of them would require a substantial share of the revenue, making the business case obsolete. However, this seems to vary substantially across different BRPs.

3.2.2 Resources across various BRPs hinder aggregation

For aggregators that work with large numbers of small resources, such as heat pumps in private homes or EV chargers for residential use, it constitutes a significant problem that they need a contract with each BRP to utilize the inherent flexibility. The problem is represented well by this quotation from a producer and operator of EV chargers.

"W*e had been waiting for the BSP role because the main obstacle for us today is that we have around 800 property owners as customers in Sweden, and it is nearly impossible for us to, first, find out who their BRP is, and second, potentially switch. We have been waiting for the BSP role, and the ambition is to offer all our customers*

the opportunity to participate [in the Swedish ancillary market]." FSP 4

Aggregators focusing on heat pumps state that the flexibility provided by the thermal inertia in each house can be utilized for implicit flexibility based on the day-ahead price. They had examples of when they offered flexibility to the local DSO, but with an independent BSP, the TSO ancillary market would constitute a significant opportunity to utilize all the flexibility they have at their disposal. Additionally, EV manufacturers face the same issue; they have thousands of cars that can be controlled remotely, but they need to have a contract with each BRP where the EVs are charged.

3.3 The cost of being flexible

That a possible revenue stream will not be free of costs might seem obvious, and the wear and tear of different resources was frequently mentioned; however, there were costs associated with being flexible that were not immediately apparent.

For some flexible resources, the wear and tear from flexible use is significant, and this aspect of being flexible was frequently mentioned. It is not always a significant consideration or barrier, as it is sometimes not mentioned at all and is mentioned by others as a matter of awareness rather than a barrier. The actors who generally saw this as a more significant barrier were the industries or aggregators focused on specific industries. The lifetime of some switches or appliances is measured in on/off cycles rather than operating time; this can, in some cases, result in the appliance being unable to operate flexibly, or it might increase the service cost for the appliance. One industry that used iron casting as a part of its process said that it strived to maintain as stable production as possible. However, it still implemented appliances to operate some of its resources flexibly. They admitted that their flexibility adaptations would likely have an impact on their long-term maintenance costs but that the expected cost had not been calculated; they invested in the expectation that the benefits would outweigh the increased maintenance costs. This goal conflict became more apparent when the TSO implemented new demands for FCR-D on September 1, 2023. Suddenly, the industry had to take into account a much greater ware than previously.

3.4 The lack of standardization hinders participation

The need for standards is highlighted several times. What part of standardization they are interested in depends very much on what markets they have experience from. A European aggregator states that, based on their experience, the differences between Finngrid and SvK (the Finnish and Swedish TSOs) in the ancillary markets are substantial. Regarding LFMs, it is undeniable that almost every actor requests standardization of qualification procedures, market procedures, and bidding times for different markets, as well as for traded products. All actors express the need for standardization. The aggregators and other SPs express a frustrated need for standards between markets. The DSOs and market operators are aware of the need for standardization. However, they do not express the same frustration or sense of urgency – for them, all the deviations between markets have, at some point, been justified in the process of creating the markets. One DSO requests that the LFMs in Sweden agree on at least some products that are the same across different markets, with the same prequalification. Then, there could be other products with local adaptations.

3.5 Climate and environment

There is an overarching conflict of goals between the environment and climate. Investments made for the climate will have an impact on the local environment, and that is something an interviewee working with small-scale pumped hydro had experience with; there were constant considerations that had to be made in his business. However, it constitutes a constant consideration for climate investments that have any impact on the local environment.

Recently, several smaller hydropower plants in Sweden have been shut down. On a national scale, none of them contribute significant power; however, they may contribute more than expected due to local capacity constraints. Biological diversity is a key consideration when discussing hydropower, leading to reassessments of hydropower permits in recent years. However, these reassessments are not only viewed as a threat to hydropower but also as a possibility, arguing that the energy system today is in greater need of inertia and production than it was 80 years ago when the permits were issued. One interviewee saw considerable potential in small-scale hydro; he argued that an increased permit for just a few centimeters of increased regulation would constitute a large amount of increased flexibility.

3.6 Regulations and requirements holding flexibility back

To contribute with aFRR to the Swedish ancillary service, there is a requirement for a specific communication line to the TSO. The Swedish TSO announced in January 2025 that new actors could bid

aFRR via “ombud”, but it remains to be seen if this is something that interests other actors. During the workshop, none of the actors had experience with the new solution, but there was a doubt that it would make a difference.

3.7 The investment cost to become flexible in combination with the uncertain revenue potential

An FSP stated that the value of flexibility would need to be approximately ten times higher in the LFMs for it to be economically interesting at all. Several FSPs have ignored offerings from LFM-participation due to the burdensome onboarding process and low compensation in the LFMs in Sweden.

There is also uncertainty about the long-term liquidity in the ancillary services and the result of the pan-EU review of the electric bidding zones. They hesitated to make investments since they sensed that there was no certainty about where the electricity market was developing.

3.8 Lack of knowledge

Actors who do not have energy as their primary field of operation are unaware of the concept of flexibility and the possibilities that come from it. For many actors, the power supply is often taken for granted, and there is concern that if they start operating their machinery flexibly, it might negatively impact their operation. The lack of knowledge also results in aggregators and DSOs encountering a substantial workload in educating the FSPs who own flexible resources. In cases where resource owners do not grasp the concept of flexibility and its potential contribution, it is challenging to motivate them to make the necessary investments to operate the machinery flexibly.

3.9 Market rules and configurations as an obstacle to participation

A problem frequently mentioned is the varying closing times for different markets and the way they are traded. The most mentioned markets were the LFMs and the ancillary service, but the intra-day market could be better coordinated with these. An integrated market for all types of flex would significantly reduce the administrative work for flexibility providers. The different markets are competing for the same resources, and these resources will be allocated to the market that offers the highest payment.

3.10 Revenue regulation and ways of working of the DSO

During the process of conducting interviews, many viewpoints were represented; early on, it was clear that some actors diverged more clearly than others. In some aspects, it was clear that the DSOs had quite a different perspective on how well the energy transition was working and where the problems lay.

From the interviews, it became apparent that the mindset and way of working need to change within many DSOs. Both DSOs and other sector actors expressed this. One interviewee from a DSO described it as if DSOs have an inherent risk-averse mindset, where they do not trust anything that involves risk, such as flexibility. With flexibility, there is a need to work with a mindset that accepts degrees of certainty. The usual way to operate and dimension electric grids in Sweden is by rule of thumb rather than calculating or assessing risk in expansions. One regional DSO stated that there had been occasions when they had denied customers connections based on their conventional rule of thumb. However, in a later scenario, they reevaluated the situation after conducting a thorough analysis of the premises and realized that it was possible to accept more customers in that location.

With flexibility, one DSO mentioned a need to employ new people who are not accustomed to the existing way of working; with the current staff, it would not be possible to make changes. The same explanation for the risk-averse culture that is dominating the DSOs of today was given by two interviewees. The explanation can be traced back to the deregulation of the energy system in 1996, when electric companies were split into energy trading and DSOs, and the electricity market ceased being a monopoly. In the organizations that split into two, the risk-averse steward personalities took employment with the new DSO organizations. At the same time, employees who were keen on development and risk took jobs at electricity trading organizations. According to this recurring anecdote, the risk-averse cultures of DSOs have become deeply entrenched and resistant to change.

4. DISCUSSION

An overarching, holistic ambition and leadership could create confidence in the direction of the transition, which would overcome more minor hurdles of uncertainty. With the bankruptcy of Northvolt, the paused green steel projects, there is uncertainty if hydrogen is still the future and if Sweden needs the energy previously taken for granted. Hence, a clear direction for the energy sector is needed.

Regulatory uncertainty and the structure of agreements, such as conditional connection contracts, are seen as obstacles and can often counteract market-

based flexibility mechanisms. The absence of clear governmental goals or specific regulatory guidelines for the uptake of flexibility creates uncertainty and reduces the willingness to invest. Overcoming established organizational cultures within companies and DSOs, often focused on building physical assets rather than managing flexible demand, is also necessary.

Unlocking the broader potential requires focused effort. Simplifying technical and administrative processes for market participation while also enhancing collaboration among industries, aggregators, and DSOs is key to success. Significant untapped potential lies in aggregated distributed resources, such as EV charging, which can free up substantial network capacity if regulatory hurdles are addressed and technical aggregation challenges are managed effectively. A first step in doing this would be to implement the independent BSP role, but uncompensated – an action that would require bold leadership to go against the current oligopoly of BRPs. A bid limit to the uncompensated BSP would milden the potential effect for the BRPs maintaining the oligopoly.

Tailoring flexibility solutions to address specific local grid bottlenecks appears more effective than generic approaches. Policy signals, clear market structures, and revised business models are crucial for incentivizing the necessary investments. At the same time, cultural shifts are required to transition beyond traditional grid reinforcement as the sole solution.

From the large group of interviewees, there were many of whom had experience from abroad, and there were many good examples of how problems had been solved in other European countries. Outside the scope of this article but for the interested researcher, some comparisons were: for compensation mechanisms for BSP – look at the solution in Spain; for integrated market models, look at Canada or the project in Finland; promoting/forcing DSOs to use flexibility investigate the solution in the Netherlands; Finland's solution for aFRR.

5. CONCLUSIONS

The barriers to flexibility are versatile, some easy to delaminate, and some inevitable. The barriers are imposed at all levels, and with strong and clear leadership in the energy sector, significant changes could be successful. Our leading suggestions to legislators and TSO would be to:

- Implement the uncompensated BSP.

The uncompensated model would, in theory, be easy to implement (probably also in practice, but that is outside our field of knowledge), and the independent BSP has the potential to make a very large difference in the flexibility available to the market.

Secondly, our recommendations are:

- Integrate the intra-day market, LFMs, and the ancillary market.
- Update the revenue frame to not only promote flexibility but to force the use of flexibility.
- Make a unified, comprehensive, and holistic plan for the field of energy, including all energy carriers.
- Investigate the possibility of evaluating and prequalifying products for the ancillary market on a Nordic level.

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