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How to undermine a Local Flexibility Market: A Case Study of sthlmflex

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ABSTRACT

This paper explores the challenges of local flexibility markets in Sweden, with a case study of "sthlmflex," a local flexibility market in Stockholm. Local flexibility markets are emerging as important tools for managing local grid congestion, supporting the integration of renewable energy sources, and enhancing the resilience of the electricity grid. The study examines the drivers and barriers faced by market participants, especially aggregators and flexibility service providers. Through qualitative research, the study highlights the operational and challenging dynamics of local flexibility markets. The results show strong interest among actors to learn more about new concepts in the energy sector and to contribute to society. However, the findings also stress the importance of transparent and trustworthy governance, with the distribution system operator not overseeing the market. It is likely that both sellers and buyers would benefit from integrating the ancillary market with the local flexibility market, which should be governed by the transmission system operator.

Keywords: Local flexibility market, energy markets, aggregators, drivers, barriers, flexibility service provider

NOMENCLATURE

ACER	Agency for the Cooperation of Energy Regulators
BRP	Balance Responsible Party
DER	Distributed Energy Resources
DSO	Distribution System Operator
EU	European Union
FCR	Frequency Containment Reserve
FFR	Fast Frequency Reserve
FSP	Flexibility Service Provider
LFM	Local Flexibility Market
mFRR	manual Frequency Restoration Reserve
TSO	Transmission System Operator

1. INTRODUCTION

To achieve the Paris Agreement goal of limiting global warming to a maximum of 2 degrees Celsius, we need to increase the use of renewable energy in our energy system. The "Clean Energy for All Europeans" initiative aims to reach a long-term goal of incorporating at least 80% renewable energy sources, thereby reducing greenhouse gas emissions by 80-100% compared to 1990 levels [1]. This challenges an electricity grid built during a different energy paradigm, characterized by stable energy flows and predictable consumption and production patterns.

With the rapidly increasing consumption due to the energy transition, there is a growing demand for more electricity; however, TSOs and DSOs cannot expand their grids fast enough to meet the rising demand. The traditional method of building new grids (installing new cables, expanding transformer stations) is a time-consuming and lengthy process. Flexibility can be used as a solution to address the peak energy demand caused by the energy transition.

The necessary flexibility can be achieved through various methods. One way to enhance flexibility in the local and regional electrical grid is by implementing an LFM, which establishes a market for buying and selling energy flexibility within a specific geographic area [2,3]. LFMs help lessen the need and urgency for grid reinforcement and other investments, while also encouraging a higher share of DER in the grid [4]. In the “Clean Energy for All Europeans” package, the European Commission explicitly states its preference for solutions based on market mechanisms for congestion management [5], indicating that markets like LFMs are the favored approach by the EU legislature.

There are still significant challenges for LFMs. Much remains unclear about how they should be established, and several “pilots” have not continued beyond the pilot phase. Current research on LFMs has examined and compared various market designs and technical aspects. However, there is still no consensus on the optimal configuration of an LFM or which attributes have the most significant impact [5,6].

In today's world, where old safety doctrines are being questioned and a war is ongoing in Europe, there is a growing demand for resilience in the energy grid. As

shown in several reports related to Ukraine, increasing flexibility can boost the resilience of the entire energy system [7,8]. Similarly, just as DER has helped Ukraine's electricity system withstand the invasion, LFMs in Sweden can enhance the grid's ability to manage disruptions. By allowing DER to respond to local imbalances, these markets reduce reliance on centralized infrastructure and increase redundancy and resilience. This can improve resilience against physical threats like extreme weather or technical faults, as well as against geopolitical risks and potential cyberattacks.

Despite growing interest in LFMs, few studies have examined their long-term viability or evaluated their economic benefits. Some publications, such as Palm et al. [9],have looked into the drivers and barriers for FSPs participating in Swedish LFMs. A more technical article, focused on TSO-DSO coordination within a Swedish LFM, was published by Ruwaida et al. [10]. An indication of limited research on Swedish LFMs is that the EU Joint Research Center's report "Local Electricity Flexibility Markets in Europe" [11] includes only a few sources on Swedish LFMs, primarily a master thesis. Unfortunately, none of the Swedish LFMs within the Coordinet project is currently ongoing [12], so LFMs in Sweden have not been extensively studied.

This article aims to examine the situation of a Swedish LFM. Since the actors make up the market, we will adopt the user's perspective and investigate what organizations and individuals involved in the market see as obstacles and their motivations for participation. To learn more about LFMs in Sweden, we will conduct a single case study on sthlmflex. By sharing the results of our research, we aim to provide deeper insights into sthlmflex, enabling comparisons and contrasts with other LFMs. Our findings will help identify similar characteristics and best (or worst) practices that benefit legislators and decision-makers within the energy sector. We aim to map out the barriers and drivers for sellers participating in the LFM called "sthlmflex".

2. MATERIALS AND METHODS

For our research, we have chosen the LFM called "sthlmflex". In this chapter, we will explain the methods used for the research, as well as the background and settings in which this LFM is active. The data collection for our research mainly comes from interviews, complemented by a diverse data-gathering approach that includes various sources, such as official reports from the Swedish TSO and other relevant organizations.

2.1 Sellers' perspective

The "sellers" are the actors who have a resource they can be flexible with, either by owning the resources themselves (FSP) or by controlling the resources on behalf of someone else (aggregator).

2.2 The interviews

A qualitative approach, including in-depth interviews, was used to explore perceptions of the roles active in the market. Stakeholders in sthlmflex and all participating companies were contacted, and interviews were conducted during fall 2023 and spring 2024.

The questions were sent in advance to gather knowledge from the organization rather than from each interviewee. This led to multiple interviewees from the same organization participating in some interviews. To prevent saturation too early, we asked the interviewees for other individuals they would recommend for us to interview. This approach provided valuable information about actors who had left the LFM. These actors were also interviewed, and the reasons for their withdrawal are presented in the results section. In total, 24 companies were interviewed.

The interviews were transcribed, analyzed, and coded to identify patterns, themes, and key aspects related to the research questions [13]. The research relies on interviews with the organizers of sthlmflex, as well as with aggregators, DSOs, and FSPs participating in the market. However, this article focuses on the sellers in the market; we have nonetheless interviewed all types of stakeholders to gain a nuanced understanding of the case. The table below shows the distribution of interviewees and their respective actor categories.

Table 1:Data Overview

Type of actor	# of interviewees	# of companies
TSO	2	1
DSO	6	3
Aggregator	11	8
Market operator	1	1
FSP	8	8
BRP	4	3

Most interviewees were "Sellers," which reflects the actors involved in sthlmflex. The sellers' qualified resources range from less than 0,1 MW to about 34 MW, covering the entire spectrum of sellers in sthlmflex. "Market operator" refers to the company providing the software used to manage bidding and trading. The BRPs interviewed also acted as aggregators, but since their main focus is trading electricity, their perception of the LFM differed in some aspects from that of the aggregator group, as will be shown in the results section.

2.3 Empirical background

In 2011, Sweden was divided into four electric bidding zones to manage national transmission constraints. However, in Stockholm, as in many growing cities, regional grid congestion issues persist. Holmberg et al. highlight this problem within Sweden and suggest creating an electric bidding zone solely for Stockholm to address local bottlenecks that currently hinder the region's new business development [6].

When the LFM in Stockholm was launched, it was likely that the Swedish TSO wanted to avoid pre-empting ACER's comprehensive review of bidding zones, so they chose to initiate an LFM in the congested Stockholm area. The LFM was started by the TSO and the two regional DSOs in greater Stockholm to address regional capacity constraints that occur a few hundred hours each winter. The uniqueness of sthlmflex lies in its coordination between the two regional DSOs, which trade capacity across their different grid areas and pass it through the TSO's grid, increasing the overall grid utilization. This setup is a reason to study the market and assess its viability. Initially, sthlmflex was planned as a pilot for only one season, the winter of 2020/2021. After the first season, the pilot was extended, and it has been extended in stages since, but it remains "a pilot".

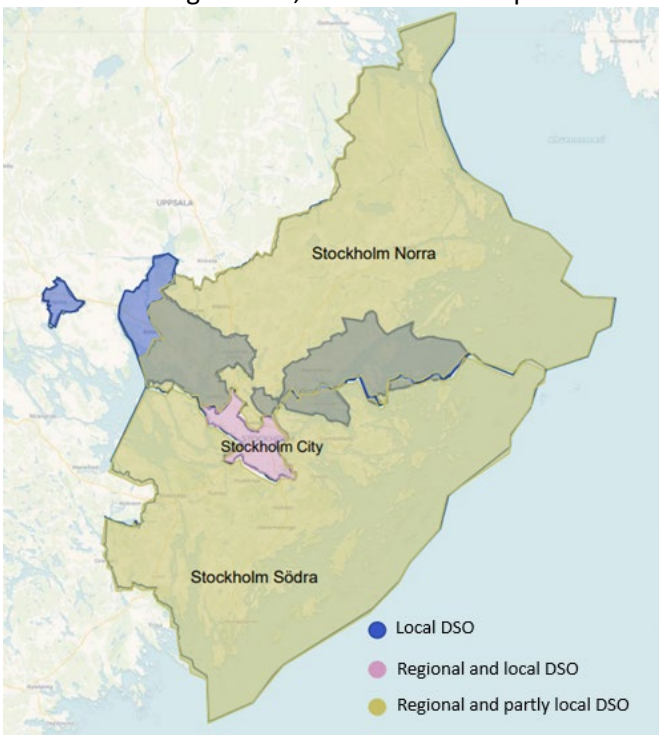

Figure 1: The DSOs of sthlmflex. Based on "sthlmflex säsong 2", p.10 [14].

When mapping the ecosystem of sthlmflex, we first need to explain some local variations that should be considered. In the Swedish electricity system, there is one TSO (220kV-400kV) and two layers of DSOs. These are regional DSO (40kV-130kV) and local DSO (230V-40kV) [10]. Within the sthlmflex area, two DSOs are both local and regional, along with seven local DSOs. Of these seven local DSOs, only one participated as a buyer in the LFM [14]. In the map, the yellow area represents one of the regional DSOs that has multiple underlying local DSOs.

2.3.1 The ancillary market and bidding

In the Nordic power system, the ancillary market is the TSO's tool for stabilizing the grid at 50Hz. This flexibility is acquired through short-term balancing products, ranging from FFR (with sub-second activation and an endurance of 30 seconds) to FCR and the most energy-intensive products of mFRR (with full activation in 15 minutes and an endurance of a full hour). In sthlmflex, the energy (flexibility) traded has higher time granularity, and all bids are measured in MWh per hour, which allows for some leeway during delivery that would not be acceptable in the high-precision ancillary market. During sthlmflex operation, a notable technical detail of the ancillary market was the adjustment of requirements for mFRR. In Sweden, the standard minimum bid for mFRR is 5 MW, but for sthlmflex-linked mFRR bids, the requirement was reduced to 1 MW for energy products to enable participation from smaller actors [14]. The minimum bidding limit within sthlmflex was 0,1MW (with a delivery period of 0,1MWh over an hour).

3. RESULTS

From the interviews, it became clear that opinions on the success of sthlmflex vary widely. In presenting the interview results with sellers, we divided the findings into "Drivers," which explain why they are (or were) participating in sthlmflex, and "Barriers," which highlight the problems they have faced and what they see as the biggest obstacles to their involvement.

3.1 *Drivers for participating in sthlmflex*

The following section outlines the main categories for sellers to participate in the LFM, beginning with the most frequently mentioned driver.

3.1.1 A will to learn from participating

"*Our primary need is to learn. This is something entirely new to us, and while there is extensive academic literature and documentation available on how it is supposed to work, we also need to understand how it actually functions in operational practice.*" -FSP 4

An apparent motivator for all participants in sthlmflex was a desire to learn and curiosity about a new

concept. The willingness to learn among some participants translates into a desire to understand potential future revenue and prepare to monetize it.

A willingness to learn about LFMs by actively participating in one has a clear issue: once participants feel they are no longer gaining knowledge, they need another motivator to stay engaged. This was true for those actors who left the LFM. After learning how sthlmflex worked, they reconsidered their decision to participate. With the motivation to "learn" no longer relevant, the decision ultimately came down to a straightforward financial choice. In the end, actors decided to leave the LFM because the revenue was not enough to sustain their resources in sthlmflex.

3.1.2 A feeling of societal responsibility

A sense of social responsibility also emerged as a motivating factor during several interviews. Some FSPs felt that by participating in sthlmflex, they were helping society. Many interviewees associated the concept of "flexibility" with a belief that being flexible benefits the society they are part of. It was also evident that some viewed societal good as a stronger motivator than others. Some FSPs expressed frustration that they had invested a lot of time and money in participating in sthlmflex. For example, one FSP's first season involved significant investments and work hours, yet the revenue was 0 SEK, leaving them feeling demotivated. The disappointment came from the fact that, since they had not sold a single kWh, their efforts had not benefitted society.

3.1.3 The revenue from participating

Many FSPs aimed to generate revenue by participating in sthlmflex. For FSPs with "slower" flexibility resources that do not meet the requirements for the ancillary market, sthlmflex was very appealing because it opened a revenue stream that had previously been inaccessible. In the ancillary market, activation times range from sub-seconds to minutes, while on sthlmflex, the delivery window is over an entire hour. Common resource types include, for example, heat pumps and property automation.

3.1.4 An engaged and encouraging electricity provider

One external factor that came up during several interviews with FSPs was that many of them shared the same electricity provider, which was also interviewed. This provider had been helpful in educating their customers about the concept of LFMs and in highlighting what resources from the FSP that was well suited for participation in sthlmflex. Several interviewees mentioned that without their electricity provider's help in explaining the idea of flexibility and how the FSP could contribute, they would not have participated in sthlmflex.

3.1.5 The possibility of forwarding bids to the ancillary market

The ability to forward bids not accepted in sthlmflex to the TSO's ancillary market was a valued feature among participants with large resources. While it was not described as a game changer, the outcome was that major actors qualified for mFRR did not face any additional loss compared to participating in the ancillary market.

3.2 *Barriers to participating in sthlmflex*

The following section highlights the main barriers that sellers face when participating in the LFM, beginning with the most frequently mentioned barrier.

3.2.1 Small resources struggle for market relevance

Several FSPs expressed that they feel too small to compete in the market. Some mentioned that it seems like the LFMs in Sweden are only aimed at significant grid users and that smaller resources are not wanted. When asking the project board for sthlmflex, the minimum size to join sthlmflex is clear: 0,1 MW. There are no other restrictions, still several interviewees felt "small." One FSP tried using several different resources, but they still felt that even though they had multiple resources above the minimum bidding size (0,1 MW), they were too small for buyers to be interested. They also had several smaller units that could have been aggregated to reach the limit, but the costs involved made it commercially unviable.

3.2.2 Lack of economy and potential for revenue

Nearly every seller we interviewed said that the revenue from sthlmflex was too low. The revenue did not surpass the investments made to develop the resource and qualify it for sthlmflex. Additionally, the cost of manual labor needed for managing bidding and activations exceeded the profit from sthlmflex.

"*If we look at a market like the one operated by Svenska kraftnät* (TSO)*, participation is handled through bidding via BRPs. Everyone is used to this process—they have done it for many years with hydropower. There are APIs available, you just set them up and the system runs smoothly. It is very cost-efficient to participate. In contrast, participating in a local flexibility market—*

where you might earn just 10% of that income—is economically unviable. It is completely unreasonable, since we have to spend significantly more time per megawatt to take part in such a market, and the compensation simply does not reflect that effort." Aggregator 1

Revenue in the ancillary market was seen as better, and the traded volumes are higher, which increased the certainty of selling flexibility to the ancillary market.

3.2.3 Lack of knowledge and understanding of energy

Actors without a background in energy, such as property owners, were less familiar with energy concepts than energy actors. They also found it harder to price their resources because they lacked experience in pricing electricity usage. This group would prefer if buyers offered a price per MW that they could respond to rather than setting a bid level themselves.

3.2.4 Complex and counterproductive power tariffs

Often, an LFM is an initiative from a single DSO, and the power tariffs that apply to the customer within the LFM tend to be consistent. A challenge with sthlmflex, which includes nine different local DSOs, is that multiple power tariffs apply within sthlmflex. One customer noted the difficulty of having two identical flexible resources with different DSOs. Making the same business decision for these flexible resources led to two different monetary outcomes, since these resources had different power tariffs. This made it difficult for actors to calculate their actions in the market.

3.2.5 Lack of independence and trust for the LFM

"*We are somewhat concerned about the so-called independent market platforms being launched as part of proprietary flexibility services, particularly when they are owned by corporate groups that, for example, also own a balance responsible party. We place great importance on the independent role of such platforms. In our view, none of the current flexibility market platforms are truly independent, considering their ownership structures—all of them include an aggregator and an electricity supplier within the same corporate group.*" Aggregator 1

Some sellers in sthlmflex raised concerns about the governance of sthlmflex. They believe that since the DSO operates the LFM, they prioritize their own interests rather than acting in the best interest of all. Although few specific examples were provided, the sellers expressed a general feeling about this issue. One example mentioned was that a local DSO, which is also a buyer, largely promotes other businesses within their own corporate group. This group also owns the flex tool used in sthlmflex and a cogeneration plant for district heating that functions as an independent FSP in sthlmflex [15].

3.2.6 Qualifying and getting started in the LFM

Several sellers complained about the effort needed to get started in sthlmflex, saying it was not worth it. Some mentioned that, based on their experience with sthlmflex, they decided not to join other LFMs. Additionally, we interviewed potential FSPs with experience from other LFMs who did not think it was worth the trouble to go through the qualification process for sthlmflex. Several FSPs with these experiences asked for standardization of the qualification process across different LFMs to reduce the workload of getting started. The lack of standardized products, product requirements, and market processes leads to a learning curve that must be started each time an actor enters a new market.

3.2.7 Short-sighted planning and only a pilot

The fact that stlmflex is only a pilot means actors do not truly "believe" in the market. Some do not consider it worth the effort to get started or the effort needed to become more involved in the project, given the time and flexibility resources. The initial trial period was only one season, and subsequent extensions were usually announced without sufficient notice, lasting one to two seasons. The project board's long-term goals were unclear, creating uncertainty for participants.

4. DISCUSSION

It is encouraging that many of the interviewees showed enthusiasm to learn about a new concept in the energy sector. However, as in any market, the primary reason for participation is long-term revenue, and most other incentives are unlikely to motivate participation on their own without a sustainable financial foundation. It is also worth noting that better coordination and integration of sthlmflex and the ancillary market would benefit both FSPs/aggregators and DSOs. With coordinated markets, DSOs would have an LFM where FSPs remain engaged and continue providing services for the benefit of the local, regional, and national grid. This could resemble a "Integrated Market Model," as mentioned by Ruwaida et al. [10]. An integrated market model could increase trust in the market by reducing the dominance of DSOs. The scenario would align more with the ideas of Rebenaque et al. and Holmberg et al., who

suggest that one key success factor for an LFM is that it must be independent and not controlled by the DSO [6,16].

A limitation to this research is that it was conducted in an ongoing market. It would be very interesting to conduct a comparative study analyzing the early stages of an LFM's setup, focusing on the configuration when all actors are still positive. The study would then track the actors over time, summarize each season, and evaluate their decision whether to continue participating in the next season.

For future work, it would be interesting to investigate which governance models of LFMs that both increase trust in the market and also the sellers' willingness to participate. sthlmlfex was unique in Sweden in that the TSO initiated it, but could the TSO have acted more actively to increase the trust in the market? To enhance the results from LFMs, it would be interesting to investigate how LFMs can be more integrated with the TSO's ancillary market. It would be interesting to research the viability of LFMs where the TSO actively bis with the DSO, such as the newly initiated "FinFlex" in Helsinki [17].

5. CONCLUSIONS

First, it can be concluded that a temporary solution or "pilot" is not appreciated by the actors who are expected to take a calculated investment risk. It is reasonable to evaluate a new phenomenon as a pilot in the first phase, but the long-term intentions should be clearer.

Actors are interested in participating in new solutions. However, once the desire to learn has been exhausted, the only remaining motivator for a seller is the economic incentive. If it is not enough, they will exit the market.

In summary, clear leadership and guidance are crucial for developing the LFM. There should be a monetary incentive for market participation, which is probably best achieved by avoiding direct competition with the ancillary market and instead adopting an integrated market model.

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