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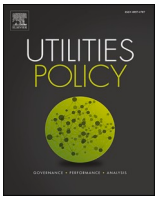

Full-length article

Drivers and barriers to participation in Sweden's local flexibility markets for electricity

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ABSTRACT

Local flexibility markets (LFM) for electricity are in their early stages, and most research has focused on their design aspects and aggregators, while little attention has been paid to providers and potential providers of flexibility resources. The present research aims to fill this gap by analysing data from 25 in-depth interviews with enrolled and potential flexibility service providers of two LFMs in Sweden. The primary goal of the analysis is to identify the drivers and barriers to participating in and providing flexibility to LFMs that are influencing these actors. Our findings show that monetary incentives were not as important as expected. The main drivers were as follows: an aggregator acting as a mediator between the buyer and the provider; a champion with personal engagement in the organisation; a wish to be a part of resolving congestion in the electricity grid; and gaining knowledge about flexibility as a resource. The main barriers identified were that LFM design was challenging to understand and that extensive knowledge about how the market functions was needed to participate. Other barriers were related to existing regulations, manual and time-consuming processes, participation not being profitable enough, perceived interference with the companies' core businesses, and the risk of compromising customer relationships. For the future, it is essential to simplify participation, develop automation, and contribute to establishing aggregators who can support potential flexibility service providers.

1. Introduction

The European electricity market has historically been designed around the capabilities of traditional centralised large-scale generating units. With the legislative acts included in the Clean Energy for All Europeans package, the European Commission introduced new definitions for the demand side regarding response, active customers, and aggregators (Lowitzsch et al., 2020; Palm, 2021). The idea is to increase procurement of energy use flexibility and distributed energy resources to make better use of these unexploited resources in the management of European electricity grids. The recent emergence of local flexibility markets (LFMs) can be seen as a response to this, as the aim is to procure flexibility using market mechanisms (Minniti et al., 2018). This approach lets producers and consumers offer a certain level of flexibility at a particular time and price, after which the market determines which bids will be accepted, given the grid's current need for flexibility (Minniti et al., 2018). In other words, LFMs enable owners of flexibility resources to offer them as a service to the distribution system operator (DSO), which helps manage peak demand and production.

The concept of LMFs is still relatively new, and most LFMs are run as pilot demonstrations (Madina et al., 2020; Heinrich et al., 2020). A large body of research on LFMs has focused on the role of aggregators (Barbero et al., 2020; Eid et al., 2016; Kubli and Canzi, 2021; Poplavskaya and De Vries, 2018; Rozentale et al., 2020). Some research exists on LFM business models, where aggregators are often—but not always—key actors (Hamwi et al., 2021; Okur et al., 2020, 2021; Specht and Madlener, 2019). Several studies on LFM design (Minniti et al., 2018; Ramos et al., 2016; Robinson and Sioshansi, 2020; Pressmair et al., 2021; Villar et al., 2018) and LFMs' ability to deal with grid congestion (Heinrich et al., 2020; Khomami et al., 2020; Liu et al., 2021; Paredes and Aguado, 2021; Stawska et al., 2021).

Less attention has been paid to the individual owners of flexibility resources, flexibility itself, or potential flexibility service providers. This study addresses this gap by examining LFMs from the perspective of a broader range of flexibility service providers than aggregators alone. The analysis includes individual owners of flexibility resources that are part of an LFM and individual owners of flexibility resources that have been invited to participate in LFMs but have chosen not to participate. The aim is to analyse the drivers of and barriers to participating in an

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List of abbreviation

DSO	distribution system operator
ICT	information and communication technology
LFM	local flexibility market
FSP	flexibility service provider
PFSP	potential flexibility service provider
TSO	transmission system operator

LFM from the perspective of these actors. To this end, in-depth interviews were conducted with enrolled and potential participants in two geographically-separated LFMs in Sweden that were part of the Horizon 2020 project "CoordiNet" (Ruwaida et al., 2022) (see also: coordinet-project.eu/for more information about the project).

2. Barriers and drivers: relevant factors identified in earlier studies on LFMs

In the following section, we will present the barriers and drivers to providing flexibility found in earlier research on LFMs. First, we will introduce the sociotechnical framing of the barriers and drivers applied in the analysis and some earlier frameworks used when analysing barriers and drivers in energy research.

2.1. A sociotechnical system approach to barriers and drivers

It has been well noted in earlier research that diffusion of energy technologies tends to be slow because it needs investments, existing solutions are interlocked with other technology networks, and there is a need for additional knowledge among key actors (Hughes, 1983; Kaijser, 1986; Bell et al., 2014; Geels, 2005). There is a need to accelerate the uptake of smart and energy-efficient solutions, but there are also many challenges connected to this uptake, as has been demonstrated in earlier studies. (Schot and Geels, 2007; Thollander and Ottosson, 2008; Palm and Thollander, 2010; Kojonsaari and Palm, 2021). Among the theoretical models used to analyse barriers and drivers of energy decision-making is the sociotechnical system approach, which will also be applied here (Rotmans et al., 2001; Geels, 2004; Smith et al., 2005). Sociotechnical systems perspectives emphasise how society and technology are intertwined and use system-based methodologies. From the perspective of sociotechnical systems, non-linear interactions between technical elements, specific individuals and organisations, legal frameworks, and institutional and political structures are observed. Changes to one part of the system must consider the other parts to keep the system functioning. Applying the framework to the energy decisions of flexibility providers and potential flexibility providers in an LFM means emphasising that actors have agency but are also embedded in structures that shape their preferences, goals, and strategies (Geels, 2004; Thollander et al., 2010). Actors act upon but also restructure these systems (Geels, 2004; Giddens, 1984).

Hughes developed the idea of technological 'style' to denote the historically and geographically constrained nature of electricity systems (Hughes, 1983, 1986). Technical systems interact with their surroundings and are subject to various outside forces that impact their design, including geographic, political, economic, social, legal, cultural, and historical circumstances (Palm and Wihlborg, 2006). Because a system's technical style is limited by space and time, energy systems develop differently across places. Barriers and drivers are thus embedded in time and place and, as such, are unique to that context (Palm, 2018). Even so, it is possible to detect patterns and trends, and most earlier studies apply some form of categorisation or taxonomy when systemising and analysing barriers and enablers.

In earlier energy research, a common approach has been categorising barriers—and to a lesser extent, drivers. Dahlgren et al. (2022) categorised barriers according to the (a) system and (b) actor levels. Weber (1997) identifies (a) Institutional barriers; (b) market barriers; (c) organisational barriers; and (d) behavioural barriers. Reddy (2013) categorises barriers in the following way: (a) financial–economic, (b) technical, (c) awareness and information, (d) institutional–organisational, (e) regulatory, and (f) personnel and behavioural barriers. Thollander et al. (2010) categorised them as a) technological systems, b) technological regimes, and c) sociotechnical regimes. In our sociotechnical analysis, a combination of a theoretical and empirical approach has been used where relevant categories from earlier research were applied (behavioural, organisational, economic, technological, policy, and regulation, informational) and later developed and extended by empirical findings from the explorative questions asked to the interviewees about the barriers and drivers they experienced.

2.2. Barriers and drivers in earlier studies of LFMs

LFMs are still in their early stages, and previous research has mainly focused on barriers to LFMs' development. Several studies have identified market design barriers that negatively impact the performance and participation in LFMs. Examples of such barriers include a lack of standardisation (meaning a lack of prevalent procedures for joining and participating in an LFM); minimum bid size requirements; the maximum allowed reaction time of the flexibility source (notification time); the required duration of delivery; the minimum period during which a participant must guarantee flexibility (product resolution); and when and how often the market opens (tender period). If there is no daily auction, predicting flexibility potential could be difficult for the prior-day market. [e.g. (Minniti et al., 2018; Heinrich et al., 2020; Barbero et al., 2020; Pressmair et al., 2021; Ruwaida et al., 2022),]

Technological barriers, such as smart metres, include a lack of information and communication infrastructure (Minniti et al., 2018). Vice versa, good information and communication infrastructure (such as when a country has a broad rollout of smart metres) has been identified as an enabler of LFMs. Furthermore, digitalisation and automation technologies allow for more control over one's energy assets, thus driving LFM participation (Alavijeh et al., 2021).

Several economic barriers have also been identified, such as low prices on the LFM market, high technical costs for smart metre installation, communication and control technologies, and automation (Barbero et al., 2020). Economic barriers may also surface when flexibility is traded in multiple markets, such as when the benefits of participating in balancing markets exceed those of local flexibility trading (Villar et al., 2018; Rious et al., 2015). Existing regulations and policies are continuously mentioned as barriers, [e.g. (Pressmair et al., 2021; Bouloumpasis et al., 2021; Abdelmotteleb et al., 2022),] but can also be a driver of LFM adoption, such as when DSOs are given new incentives or carbon emission costs increase (Alavijeh et al., 2021).

One study's main focus was on the drivers behind developing LFMs. Alavijeh et al. (2021) investigated drivers behind LFM emergence. Their explorative study aims to understand key factors and trends impacting future LFMs, and the authors also want to contribute to the better design and implementation of future LFMs. Alavijeh et al. (2021) identified the key drivers related to end-users' willingness to participate, to invest in automation and digitalisation, and the influence of regulatory and financial incentives.

In the literature on aggregators, actors are often described as drivers or enablers of the demand-side response. An aggregator acts as a third party between the buyer and the provider. In the case of LFMs, an aggregator is mainly needed for smaller flexibility service providers, while larger entities can provide flexibility services directly to the market (Minniti et al., 2018; Eid et al., 2015). An aggregator can enable and simplify participation in an LFM simply by being knowledgeable about the prices for different types of flexibility in the market. Another way an aggregator can act as an enabler for the flexibility market and

facilitate the effective functioning of the market is by aggregating multiple individual flexibility services into tradable values (Eid et al., 2015).

Thus far, much previous research on LFMs has focused on the role of aggregators. Some exceptions exist, where some studies, such as Pressmair et al. (2021), have taken a broader view and included more actors. Pressmair et al. (2021) applied a Delphi panel approach to explore barriers to establishing LFMs and included one business innovation consultant, one project manager in the energy sector, one facility manager, and one Energy Service Company. Based on barriers identified in earlier research and in the Delphi study, Pressmair et al. (2021) identified standardisation issues as the main barrier to participation. To circumvent this barrier, they developed a market model introducing spatiotemporally varying price signals reflecting the capacity constraints of the distribution grid. This approach avoided barriers related to standardisation and what they call 'lifestyle' barriers, such as lack of expertise. However, this fails to address other barriers, e.g., those connected to regulations or lack of interest.

In earlier research, the integration of LFMs into existing markets has been identified as both a barrier and a driver. An LFM can be integrated as a separate platform or part of other platforms, such as a transmission system operator (TSO). A separate platform is useful for a DSO, as the market can be adapted to local needs. An integrated market can reduce costs and complexity for market participants, who do not, for example, have to be active in several markets (Pressmair et al., 2021; Schittekatte and Meeus, 2020).

The barriers and drivers covered in earlier research have mainly been identified by actors other than enrolled flexibility service providers. In this study, the idea is to give flexibility and potential flexibility service providers a voice and understand their perspectives on the drivers and barriers to their participation. Earlier research was considered during coding and in drafting the interview questions. The basic idea was, however, to have the interviewees frame their answers without being influenced by how others had defined them in earlier research. When possible, the nomenclature used in previous research on barriers and drivers was maintained in the analysis to afford comparisons between drivers and barriers in our study and those in previous research.

3. Material and methods

This article represents an exploratory and qualitative study. The aim is to explore the barriers and drivers flex providers and potential flex providers experience when entering an LFM. The research is based on in-depth interviews with enrolled and potential flexibility service providers of two LFMs that were part of the Horizon 2020 project CoordiNet, which ran from January 2019 to June 2022. In short, the CoordiNet project aimed to demonstrate how TSOs, DSOs, and consumers could collaborate and coordinate to provide flexibility services to different levels of the electricity grid.

3.1. Empirical context

CoordiNet had eight demonstration sites in total—two in Greece, two in Spain, and four in Sweden—all with slightly different practical circumstances and purposes. This study was conducted in the context of CoordiNet Uppland and CoordiNet Skåne, both located in Sweden. The authors of this article were not part of the CoordiNet project but had obtained permission from the project owners to follow the project and interview members of the organisations that had been invited to participate.

Different DSOs initiated the two LFMs to resolve local distribution capacity constraints during winter that occurred a few hundred hours per year in their regions. The LFMs in question were developed and tested for the first time during the winter of 2019–2020 and were run in the two subsequent winters.

3.2. Interviews

The organisations invited prior to the winter season of 2020/2021 to participate in the CoordiNet Uppland and CoordiNet Skåne LFMs were contacted by the authors of this article via e-mail in late fall of 2020 and asked to participate in an interview. A qualitative approach was chosen to explore and capture the different factors the actors could have experienced and to be able to follow up on these statements. In-depth interviews allow researchers to ask follow-up questions and allow interviewees to choose how to express themselves (Creswell and Creswell, 2017; Kvale and Brinkmann, 2009). In-depth interviews also allow the interviewees to contextualise their experience within their local setting, and, accordingly, their answers can be related to their sociotechnical situatedness (Nardi and Nardi, 1996; Suchman, 2007). The stated purpose of the interview was for them to speak to their experiences and opinions about the CoordiNet project and the associated LFM they had been invited to participate in, with a particular focus on their perceived drivers of and barriers to providing electricity use flexibility.

In total, 25 in-depth interviews (Kvale and Brinkmann, 2009) were conducted with representatives of the organisations. In some cases, more than one representative was interviewed, resulting in 30 total informants in total. The interviewed organisations represented industry, energy storage, building owners, aggregators, heat producers, renewable power producers, and transportation providers.

Twelve of the organisations officially participated as flexibility service providers (FSP) in one of the LFMs, while the other 13 organisations decided not to participate at the time the interviews were conducted. We refer to these 13 organisations as "potential flexibility service providers" (PFSP). The flexibility service providers in the LFMs were generally positive about participating in the study, while potential flexibility service providers were much more challenging to enrol as informants. Many (around 15) declined participation due to a perceived lack of understanding and knowledge about the issue. The PFSPs who agreed to be interviewed knew how the LMF was designed and works.

The interview structure and interview guide were the same across all interviews, except for minor changes to the questions depending on whether the particular organisation had chosen to participate in the LFM. One or two researchers conducted the interviews through online video meetings lasting about an hour each. Interviews were recorded with the permission of informants and transcribed verbatim. Transcripts were coded by the authors of this article using the qualitative data analysis software Nvivo, and a standard coding scheme was developed and refined for the study. We have coded the interviews with FSPs and PFSPs with individual letters not to reveal the identities of the organisations in question.

As this is a qualitative study, conducting a quantitative analysis of the results is impossible. This analysis cannot achieve significant results, but the results can indicate which barriers and drivers can be identified from the actors' experiences. In-depth interviews also provide a more elaborative view of the barriers and drivers, where interviewees can explain why and how a factor is seen as a driver or barrier (Kvale and Brinkmann, 2009; Roulston, 2010). The analysis indicates what drivers and barriers merit further investigations in future research with a larger sample.

4. Results

This section presents the results from the interviews, organised by the stated drivers of (Section 4.1) and barriers to (Section 4.2) participating in and providing flexibility to LFMs. The barriers and drivers have been categorised according to the categorisation performed in earlier research, but also by how the interviewees framed them. When possible, the nomenclature used in previous research on barriers and drivers was maintained to compare the drivers and barriers in our study and those in previous research.

4.1. Drivers of participating in a local flexibility market

Table 1 summarises the driver informants mentioned that encouraged participation in the LFM.

Each driver is discussed below in order of their appearance in Table 1.

4.1.1. Organisation and attitudes

Many informants had some responsibility within their organisation for energy or environmental activities, which was also reflected when discussing drivers behind LFM engagement. Early in the interviews, it became apparent that personal interest had been a primary driver for them to become a flexibility service provider. This interest was often the background behind why the organisation began to take an interest in flexibility issues. Because of this, we decided to add a question about personal interest to the interview guide. This 'personal engagement' driver was the only driver specifically mentioned during the interviews, explaining its high frequency (see Table 1). A typical response to why an organisation initially became interested in participating in an LFM is reflected in this quote:

> If I hadn't found this and engaged in it, we would most likely not been involved at this point. It is I who have driven it internally, and it suited my role so well. (FSP H)

Several informants expressed that they were more interested in the topic than their organisation. Another typical response regarding personal engagement was that their interest was related to curiosity about the issue and a wish to learn more about flexibility as a service:

> I was interested to learn more and understand what it was all about … to avoid ending up saying no to something you haven't really grasped the idea of. (PFSP L)

Another frequent answer was that being active in an LFM fit nicely within the organisation's goals and strategies:

> We adopted an energy strategy last year where this was included, that we should work with these issues. So, that's why I basically thought I've been given a mandate for this. (PFSP B)

Public relations—or the idea of public relations—seemed to partially motivate participation in the events leading up to the formation of the LFM, even if the organisations interviewed eventually declined to participate in the LFM. These relationships ranged from relationships with existing and future customers to relationships with potential partners in the flexibility market.

> So, of course, PR that we work with this and sustainability. (PFSP E)

> Because we want to rebrand ourselves more towards working even with energy issues and show that we are an energy actor. (PFSP A)

Whether an organisation perceived that they had flexibility to offer could be relevant to how active they were in developing an LFM. Some organisations were convinced they had plenty of flexibility to offer, and this conviction became a driver.

> So simply, we can get new revenue from the facilities we already have without downsizing … we do not have to deteriorate at any other stage, so to say. (FSP H)

As discussed below, under 'barriers', similar organisations could be equally convinced of the opposite, i.e., that they did not have any flexibility to offer, which led to this perception forming a barrier.

Engagement in forums dealing with topics related to CoordiNet was a reason many of the informants took an initial interest in CoordiNet. Related forums arranged, for example, seminars and workshops discussing CoordiNet, which initiated interest in participating in an LFM.

> Then there were some seminars about CoordiNet, and I signed up for these seminars. (PFSP G)

4.1.2. Economy

Economic interests seem like a relevant driving factor for a market, but since there was no scope for significant economic reward, economic incentives had less to do with immediate payback. There were other monetary values: how much will LFM involvement cost the organisation in terms of pre-studies, project costs, investment in required technologies, and organisational time and other resources, and what is the eventual payback, i.e., quantifiable (compensation, financial assistance) or non-quantifiable (such as attracting high-quality employees and the value of facilities) Energy was a substantial cost for several of the interviewed organisations, so finding a way to cut energy costs was a primary driver:

> In companies of our size, the media and energy budget make up about fifty percent of the budget. So, it is clear that it is a big item for us to work with. (PFSP G)

The FSP more often mentioned future profit potential as a driver than the PFSO. Potential areas for future economic incentives were also identified. One example was energy storage, which was seen as possibly offering good business in the future:

> We notice that the interest in electrical vehicles, it is rising exponentially now, there is a huge development and a huge demand for charging posts. / … / We have a great opportunity, but also limitations to how much each car can charge. We have good opportunities to flatten the curve, to postpone the charging to later that day and so on … It is quite easy to work with; it is a simple problem to define; it is a lot of power capacity requiring a small effort, so I think it is probably one of the most profitable issues. (PFSP H)

Although there were no reports during the interviews that organisations had faced such a dramatic consequence of grid capacity shortages as a power outage, several actors who had recent experiences applying for increased power capacity (required for the expansion of their facilities) had either been informed that the full amount they had requested would not be possible or were aware that this might be an issue for future applications. One organisation that wanted to expand its activities had been denied their request due to a lack of grid capacity. This organisation completed their expansion plans, but the denied request made the company aware that future expansions may be impossible if the electricity grid reaches maximum capacity.

Table 1
Identified drivers of participating in an LFM.

Category	Types of drivers	Number of respondents expressing these drivers
Organisation and attitudes	Personal engagement	8 FSP, 6 PFSP
	Goals and strategy	5 FSP, 7 PFSP
	Public relations	3 FSP, 8 PFSP
	Networks and engagement in related forums	1 FSP, 2 PFSP
	Flexibility resources	4 FSP; 1 PFSP
Economy	Potential revenue, avoidance of future costs	8 FSP, 2 PFSP
Information	Opportunity to learn and influence	2 FSP, 7 PFSP
Technology	Access to aggregation services	3 FSP, 1 PFSP
	Automation	2 PFSP
	Opportunity to develop and innovate	5 PFSP
Social responsibility	Contribution to social responsibility	5 FSP, 4 PFSP
	Urban planning	1 FSP
Policies and regulations	Regulations	1 FSP, 1 PFSP
	Political signalling	1 FSP

> Now it was early so we could redesign and find more energy-efficient solutions. / … / So, it affects us, not in the daily work, but we see that in new establishments and beyond. It used to be like you sent in a service report, and then you got what you wanted. This is not possible anymore. (PFSP I)

4.1.3. Information

One factor raised by informants as a driver for participating in LFMs was that participation increased knowledge and information about flexibility and how to earn money via flexibility:

> It is not really so much for the money that we have been involved in the first stage, but rather our curiosity and that we can, hopefully, learn something. (FSP F)

The knowledge gained from participating in an LFM was perceived as valuable for organisations in the future because they saw how they could adapt this knowledge internally to develop more efficient electricity-use processes. The PFSP especially mentioned the importance of gaining more information. The FSP saw an opportunity to both gain more knowledge and to be able to influence future LFM design:

> If you come to the conclusion that a flexibility market is a good solution, then you want to participate, and then you want to be involved and get all the insights and lessons from it so you are prepared for it. And it is also an opportunity to be part of the discussion and come up with ideas and highlight the problems that you experience. (FSP C)

4.1.4. Technology

One potential flexibility provider discussed turnkey solutions as a driver to participating in a market, i.e., the idea that someone offers a service (as an aggregator) or that technology for energy optimisation where flexibility was included is installed. CoordiNet Uppland worked actively with one aggregator to support the flexibility service providers, and the inclusion of the aggregator was suggested as a driver:

> This [thing] with aggregators is good. It makes it easier so that property owners themselves don't need to think about each property. (PFSP K)

Automation, where some form of automated system solution is turning flexibility assets on and off, was mentioned by several informants as an enabling technology that motivated them to participate:

> It is not possible for us to manually every morning think about this and then place a bid for the next day. And if we get the bid, then someone has to go and turn off a switch in a cupboard. That is not possible or interesting; this has to be automated. (PFSP J)

Technological development, or the opportunity to learn and develop new technical solutions, was one driver mentioned by the PFSP. The idea of combining photovoltaics with batteries made their role as flexibility service providers even more intriguing. Others discussed the possibilities of using their existing technologies, such as reserve charging stations, power plants, and the heating system, to increase the level of flexibility they could offer to the market. These aspects are reflected in the quote below:

> Thanks to the affinity laws, by reducing airflow by twenty percent, we would halve the power requirement to drive the fans, so it will be quite a lot, and I think twenty percent air, maybe you can spare a couple or three hours without anyone noticing, I'm pretty sure of it. And it is also such an efficiency resource that is quite easy to work with anyway. (PFSP J)

4.1.5. Social responsibility

For some, the driver was to be able to contribute to regional development and a realisation that they had an asset that could be useful to the public good and facilitate the continuation of a secure electricity supply for the common good.

> If we can contribute and take on social responsibility, we have no problems doing that. We are happy to contribute, so we can combine having social and financial benefits. If they coincide, it's great. (PFSP J)

One flexibility service provider suggested a relevant driver was when the municipal planning office included energy and flexibility in the planning phase of a city district, as seen in the quotes below:

> Then I think it's also a lot about, namely, what strategic choices the municipality makes in expanding its operations. / … / If you can include requirements for energy recovery in the planning, you can start working with it in a more efficient way. (FSP K)

4.1.6. Policies and regulations

The possibility of upcoming policies and regulations was a driver for some informants. They believed that 'hard policy' (meaning binding legal instruments) should be introduced on the market. This policy would motivate companies to engage in flexibility and, for example, to conduct energy audits focusing on flexibility potential within the organisation. However, participants stated that in order for this to happen, "*there [must] be very strong legal requirements*" (FSP K). It would not happen voluntarily.

4.2. Barriers to participating in a local flexibility market

Table 2 summarises the different barriers to LFM participation expressed by informants.

4.2.1. Economy

The difficulty of making a profit by providing flexibility to the LFM was a recurrent topic in all interviews. One example of a relevant answer is:

> Yes, an obstacle or limitation or how to call it, is that, if you look at the local flexibility markets, they are not so continuous … or the need is very limited. It is a few hours or days a year and some years not at all. It makes it difficult to get a well-functioning market, and it's difficult to be profitable if you are called out just three times biannually. (FSP H)

One informant explained that they had looked into the opportunity of becoming a flexibility service provider, but it had become too expensive for them:

> It falls on … well, costs quite simply. / … / Technology – it can be solved, but it will require money, and depending on the installation

Table 2
Identified barriers to participating in an LFM.

Category	Type of barriers	Number of respondents expressing these barriers
Economy	Costs exceeding benefits	4 FSP, 6 PFSP
	Lack of incentives	1 FSP
Information	Difficult to understand and explain	4 FSP, 7 PFSP
Technology	Lack of technical prerequisites and solutions, such as ICT and automation systems	2, FSP, 6 PFSP
Regulations	Regulations and permissions	2 FSP, 4 PFSP
Organisation	Lack of flexibility in organisations	5 PFSP
	Risk	3 FSP, 1 PFSP
	Collaboration between divisions	1 FSP
LFM design	Functional requirements	5 FSP, 1 PSFP
	Separate flexibility markets	3 FSP, 2 PSFP

and what technology already exists, it can be more or less expensive. / … / It becomes too expensive for us (PFSP G)

Furthermore, one informant discussed the lack of incentives to become a flexibility service provider, suggesting that the price for flexibility on the market must increase significantly to make it possible for them to participate:

Yes, there were a lot of different administrative aspects that led to it [the decision to not join the LFM]. In terms of compensation, it was not close to profitable with our type of reserve power. (PFSP M)

4.2.2. Information

A major reported barrier relates to information, and this included both problems for the interviewees in understanding the LFM and problems experienced when trying to inform others in their organisation of the ideas behind the flexibility market and why their organisation should spend time and resources to become involved.

It is difficult to gain the knowledge to know how much effect we can have. (PFSP C)

Yes, I find it difficult to explain to others. And I think I would have a hard time having anyone else to do this. I can do it myself and then explain what we have done. (PFSP A)

In large organisations such as a municipality, it could also be a challenge to have different parts of the administration both understand and be prepared to commit themselves to coordinate how they use electricity:

It is the coordination, i.e., the cross-administrative coordination. Several different administrations must have the same understanding on how to participate and approach this [the LFM]. I think it would require someone who only works with this basically full-time. (PFSP D)

One informational problem was related to the requirement to bid the day before flexibility should be provided. Further confusion was related to when flexibility was sold as reduction, i.e., periods during which the organisation agreed not to use electricity for a period of time.

And that question … batteries are pretty clear. If you have a battery, then you can measure how much electricity you are storing and [supplying]; it is quite easy to talk about what you have contributed to the grid. But reducing consumption is more unclear because no one knows what you were going to consume. Or you could say that you had intended to consume something, but it may be untrue what you come up with. You might claim that you reduced the consumption a lot, but it might have happened anyway. (PFSP K)

There were also some stories circulating; for example, a sports arena that had turned on all their lighting used that as their base load and then earned money on the resulting falsified reduction in consumption. As the business model was designed, it was the flexibility service provider who decided the price of the flexibility resource; this was not an easy task and became a barrier to participation:

Because now, it is the case that you have to bid on your flexibility, and then you have to price yourself. I would have preferred it to be the other way around, that I bid on my flexibility, and then I get an offer that we can buy it for this price, and then I can say yes or no. Instead of me setting the price and they should say yes or no. (PFSP A)

I have no idea what price to set on flexibility. It can differ [by] several hundred percentages when we internally have discussed reasonable prices. We have no idea. (FSP L)

CoordiNet was a testbed, and clear standards were not developed. For flexibility service providers, this contributed to confusion about how the market operated and what to expect from the bidding process and price levels.

4.2.3. Technology

The lack of ICT and monitoring systems that could support companies in providing flexibility was an oft-discussed barrier. The need for ICT support was related to a time perspective, i.e., the perspective that it would not be too time-consuming to deliver flexibility:

If there needs to be a property manager who should go down to a boiler room and turn it off, then it will not happen; it must work via some control system. (PFSP K)

No, but in the current situation, it is far too manual. (FSP H)

It would be much easier if it could go automatically; as it is now, you still have to do it manually. (PFSP A)

As discussed above, automation was seen as a necessary next step for all respondents if the LFM was to survive in the long run and be scaled up.

4.2.4. Regulations

One barrier mentioned included existing regulations related to the organisation's core activities, which could make it difficult to become a flexibility service provider:

We are governed by regulatory authorities. / … / Therefore, it is not just a decision from one day to another to change the way we do things, but it can be many, many years before you make a change. It is a huge inertia in our way of working. (PFSP L)

Another example was related to whether the organisation had a reserve aggregate which could potentially be used to provide flexibility. However, then environmental regulations could stop it from being used for purposes other than as a reserve capacity for that particular company:

If you have a data centre and have a diesel tank, then it is not just about starting to sell diesel to the electricity market. / … / There are probably many who are not aware that they are changing their business by participating in a flexibility market. They may not have a license to be a power plant, but they have a license to be a data centre. (FSP J)

4.2.5. Organisation

As mentioned above, a particular technology could be seen as a flexibility resource by some, while for others owning the same technology meant they had no resource for flexibility. One example was how heat pumps were perceived. This informant thought their heat pump was not a flexibility resource due to their older system:

It would be the heat pumps. We have two, but they are old. No, I would not be able to turn them off tomorrow or today. (PFSP B)

Some respondents meant they had no access to flexibility. For example, property owners connected to district heating could not influence when and how they used electricity due to district heating. Other property owners related a lack of flexibility to the risk of interfering with or disturbing their tenants' everyday lives. Other respondents were afraid that they would interrupt their core business by turning electricity on and off:

And another big obstacle is that you are afraid that this will disrupt the core business, with this new one, that you will be in trouble, that you will have to redo your processes and that you will disrupt the revenue streams. (FSP K)

One parking company reflected that it could be a risk that their customers could become upset if they started to use battery charging as a flexibility resource:

It may be that the electric car customer notices that we benefit from the fact that they are flexible, and there is an outcry and that we cannot do this … so I think it is an obstacle for us. (PFSP A)

4.2.6. LFM design

CoordiNet has been used as a testbed to trial the idea of an LFM. There were, however, many uncertainties connected to the LFM, and many felt it was difficult to understand the legal aspects of the contract between the flexibility service provider and the market operator.

It's something we have not solved yet, what to get paid for this. You have to get paid for what you have actually delivered, and [calculating] what we actually have delivered for flexibility proved to be super cumbersome. (PFSP A)

The compensation, it must be much clearer what you get when delivering flexibility. And the connected risks need also to be clarified. (FSP F)

The short-term nature of the contract was another barrier connected to LFM design:

One thing we want to be clear about, if you have short contracts, it will never be possible to make any investments. No. So it is almost impossible to make any investments on such short contracts. (FSP J)

The challenges with the bidding procedure were mentioned above, where the bidder needed knowledge and information about the value of flexibility, which few providers had. Another related barrier was the day-ahead market mentioned above, in which flexibility service providers needed to communicate how much flexibility they could provide a day in advance. As one of the flexibility service providers elaborated:

In CoordiNet, you lose all information that is added between the day before and the control occasion. Because you need to place the bid the day before, your hands are tied. You can have a very good forecast, but it is a dynamic system that will not come … it will never be as good a forecast as when measuring in real time. (FSP C)

Another barrier for flexibility service providers was that it was not clear whether the regional or local grid should be optimised. It was unclear whether the regional or the local network's needs should be prioritised, which was regarded as a relevant but unresolved issue. Lack of integration between different LFMs and the TSO's flexibility market was also seen as a barrier to LFM participation:

The revenue is higher at the TSO markets compared to the CoordiNet Skåne market. At least five times higher. (FSP J)

5. Discussion

The results of this study show that the drivers of and barriers to participating in the CoordiNet Uppland and Coordinet Skåne LFMs are diverse. The barriers and drivers are summarised in Fig. 1.

An immediate reflection on the results is that PFSP and FSP often answered similarly but also deviated regarding some factors, which will be discussed in more detail below. We also searched for patterns between different groups within the two, i.e., if property owners had similar responses, but no clear patterns were found. One reason is that LFM is a new phenomenon, and the actors have not created explicit opinions. Another reason is that no dominant discourse is established around the LFM that the interviewees can relate to, contributing to more scattered reflections than if the actors were asked to reflect on a more mature phenomenon.

Concerning why organisations chose to participate in the LFM, many FSPs stressed that participating resonated with their organisation's goals and strategy, and as such, the idea and purpose of the LFM were easy to embed in the existing organisation (Thollander and Palm, 2015). The LFM was embedded in the ongoing debate about the lack of capacity in the grid. Those whose operations were highly dependent on a reliable supply of energy (and power) also saw their participation in the LFM as a way of mitigating the risk of not being granted access to the power needed for current or future operations. These drivers are discussed in earlier research—but more as preconditions rather than as explicit drivers.

CATEGORY	BARRIERS	DRIVERS
Organization and attitudes	Lack flexibility in organizations; risk, collaboration between divisions	Personal engagement; Goals and strategy; Public relations; Public relations; Networks and engagement in related forums; Flexibility resources
Economy	Costs exceeding benefits, lack of incentives	Potential revenue, avoidance of future costs
Information	Difficult to understand and explain	Opportunity to learn and influence
Technology	Lack of technical prerequisites and solutions, such as ICT and automation systems	Access to aggregation services; automation ;and technologies
Social responsibility	----	Contribution to social responsibility; urban planning
Policy and regulations	Regulations and permissions	Regulations, political signaling
LFM design	Functional requirements; Separate flexibility markets	----

Fig. 1. Summary of identified barriers and drivers.

Another finding less often discussed in earlier research was that several of our informants, both FSP and PFSP, saw the existing socio-technical system or their customer relationships as major barriers to becoming a flexibility service provider. The former represented organisations that had production processes which could be negatively affected by the provision of flexibility (e.g., processes that ran continuously), and the latter organisations observed that the provision of flexibility could negatively affect their customers' comfort or energy bills (e.g., by using a heat pump in a multi-family house as flexibility resource) or could disturb activities that required carefully-controlled indoor environments. How best to approach these concerns needs more study.

Less often discussed in earlier research on LFMs is the importance of a champion inside an organisation (Geels, 2007). One's own interest was a key driver in our study, which indicates that the dependence on individual champions within the organisations who mobilise support internally might be an overseen but vital driver. A champion seems to be needed to overcome the barrier to obtaining and understanding the information needed to offer flexibility to the LFM. The positive effects of participating in other networks and discussing issues of importance for an LFM are also overlooked in earlier research and are worth considering in future LFM development.

One of the surprising results was that financial incentives had not been the main driver for organisations to participate in LFMs. Informants stressed that their organisation did not earn any money from participating. Both the market price of flexibility and the number of times the bids were activated was too low to motivate participation purely on economic terms. A few PFSPs saw this as a reason not to participate in the LFM; for most, this was not an issue in the short term, as they saw plenty of other reasons to participate. Most informants, however, stressed that the business case would be a key issue to resolve to motivate long-term LFM engagement, but in the short run, the economy was not a problem. The *potential* to profit from being part of an LFM was a more important driver for the FSP than the PFSP.

A lack of standardisation and business models are discussed in earlier research [by, e.g. (Pressmair et al., 2021),], but not how they contributed to problems in communicating relevant information within the flexibility service provider organisation in getting people on board and, in turn, in obtaining a favourable decision regarding LFM participation. This issue was raised as a barrier in this study. How to best design and distribute information to PFPS and FPS is an area that needs further research. Earlier research most often addressed the view of the aggregators or the market operator, which results in advice on the need to provide much more technical and detailed information than our informants sought. An interesting result was that PFSP mentioned the possibility of receiving information about efficient energy use as a driver of LFM participation; FSP less often mentioned this.

The lack of ICT infrastructure and automation were also mentioned as barriers in earlier studies. [e.g. (Minniti et al., 2018),] Having to bid and activate flexibility resources manually regularly was considered to be too cumbersome to motivate participation over the long term. This situation was especially the case for PFSP. Therefore, the informants confirmed earlier findings stressing the importance of automating these processes. [e.g. (Alavijeh et al., 2021)] Some FSPs had partnered up with an aggregator who took care of most of the work since the FSPs did not have the technology or competencies needed to do it themselves. The aggregator installed the technical components needed to control their flexibility resources remotely and managed the bidding and activation process for the FSPs. These organisations would not have participated in the LFM had that solution not been available. Our findings both confirm and strengthen the conclusions of earlier research that claim that aggregators play an essential facilitating role in an LFM (Eid et al., 2015). One of the main conclusions of this study is that there is a need to support flexibility service providers in everything from identifying a flexibility resource to how to offer it to the market. Access to flexibility resources was a driver for FSP, while the lack of access to flexibility was a barrier for PFSP. However, it might be that PFSP just needed support in identifying their flexibility resources. This situation did not apply to all PFSPs, as some seemed to understand their flexibility potential well. Lack of information and lack of ICT infrastructure and automation seemed to be the most formidable barriers to PFSP joining the LFM.

An important driver for several organisations was a wish to contribute positively to society. Some also emphasised that they wanted to contribute to solving local capacity constraints. These are drivers that are less often discussed in earlier research. The PFSP also mentions public relations, i.e., that participation in an LFM would show that they work more often with energy and sustainability as a driver than the FSP. This finding indicates they want to contribute to society, but this contribution must be evident.

Policy and regulations were not often discussed, and this category was neither an important nor a central driver. Much more often discussed was the design of the LFM. In line with earlier studies (Minniti et al., 2018; Heinrich et al., 2020; Barbero et al., 2020), LFM design was a barrier, especially for FSP. The lack of standardisation and the difficulties in predicting flexibility potential were confirmed as barriers in this study. Less often discussed in earlier studies, but stressed by our respondents, was the importance of making it as easy as possible to participate in the LFM. The present setup was considered too time-consuming and required too much knowledge and new technology.

Related to the LFM itself, several informants noted they were required to estimate their baselines (i.e., the load profile they would have had if they had not activated their flexibility resource at a given time), which was not easy. Similarly, some found it difficult to estimate the costs associated with their flexibility provision. Combined with the fact that the long-term market conditions for the provision of flexibility were unknown (as the concept of LFMs and the commodification of flexibility, in general, was still in its infancy), this made it difficult to estimate the return on investments and the long-term potential from a business perspective, which in turn could be associated with difficulties in securing resources and support for participation in the LFM within the organisation. These are findings also seen in earlier research (Minniti et al., 2018; Heinrich et al., 2020; Barbero et al., 2020; Pressmair et al., 2021). One contribution from this study is the finding that PFSP wanted to contribute to the development of the LFM by participating in the innovation process and developing user-oriented solutions. It seems advisable to include both PFPS and FPS in the innovation process to foster the technical simplicity many of the informants highlighted as a prerequisite for long-term engagement in LFMs.

6. Conclusion

The identified drivers and barriers indicate potential improvement, considering the attractiveness, functionality, and long-term sustainability of LFMs. To conclude, lack of flexibility was a relevant barrier to PFSP participation, while access to flexibility was a driver for FSP. The perceived lack of flexibility can, however, be a barrier connected to information, and a way to overcome this can be to offer (for example) flexibility audits to PFSP. An additional main barrier for PFSP was the lack of developed automated processes. A driver identified by FSP had an aggregator as a partner. The critical role of the aggregator is confirmed in this study, and their role in supporting automated processes, for example, could be further emphasised for PFSP. The aggregator should be supported with information on all aspects of the market and lower the threshold for small flexibility providers by pooling flexibility and offering it to the market. Their role could, however, be further developed, at least concerning the Swedish LFMs. Another conclusion is the importance of champions within both FPSP and FSP. Having a person with a personal interest in energy and flexibility, together with an established network, were important drivers for both FSP and PFSP. One conclusion is the importance of emphasising values other than purely economic factors in LFM participation. Many of the interviewed PFSPs emphasised values such as contributing to the greater social good when

mitigating grid congestion by contributing to a more reliable or sustainable grid for the public.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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