Conceptualising energy flexibility: a multi-actor perspective in the context of the Swedish energy system

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ABSTRACT

As the Swedish energy system is experiencing capacity shortage challenges brought on by an overburdened grid in an increasingly electrified society, more solutions are needed for its optimization. One proposed solution is the increase of energy flexibility by encouraging public and private actors to enter the so-called local flexibility energy markets. This paper reports on the findings from a qualitative study in which we aimed to articulate how different industry actors conceptualise flexibility. Towards this goal, we employed the theoretical concept of boundary objects to illustrate the different meanings attributed to the same concept. Results show that although a generic definition of flexibility is existent across the different actors, the concept is also understood in accordance with their a) practices and needs, and b) engagement with large actors with significant decision-making power.

Keywords: renewable energy transition, Sweden, energy system, local flexibility market, energy flexibility, boundary object

1. INTRODUCTION

As the renewable energy transition unfolds globally, Sweden is seeing a transformation where new solutions are sought to mediate a more resilient and sustainable national energy system. A consequence of this transition is an increased electrification which is taxing on the infrastructure and leads to congestion at peak load time intervals. In response to these challenges, *flexibility* is proposed as a way of empowering customers to both contribute with and receive resources in order to balance the demands of the energy grid [1].

Flexibility, in the context of the energy system, is presented under slightly different definitions in the current literature, depending on the focus of the respective studies [2]. A generic definition of flexibility sees it as a resource which can be utilized to balance the energy grid's needs; Since this resource is commonly associated with buildings specifically, flexibility has been defined as a way of managing energy demand and generation according to local contexts [3]. Although practically this can be done through several means, the creation of local flexibility markets (henceforth abbreviated as LFMs) implies connecting actors in need of flexibility resources with those who can contribute by lowering their consumption. Since these markets are local, they are coordinated by the Swedish transmission and distribution systems operators; Still in its infancy, Swedish LFMs have been attempted as demonstrations in areas such Skåne, Gotland, or Uppland [4]. LFMs are ultimately envisioned to serve as a platform for coordinating power from distributed energy resources and thus enhancing the overall efficiency and resilience of the electricity grid [5].

LFMs have different aims, functioning as proposed platforms for avoiding costly grid upgrades, management of distribution networks, or balancing resources [5]. In the context of the present paper, LFMs are thought to function as local markets in which the involved actors can buy and sell flexibility resources in times where the grid is congested. Accordingly, an actor with a need for flexibility could purchase from a selling actor who makes it available upon receiving a signal. Practically, this means that a seller would have to, upon responding to a signal, lower or temporarily stop their energy consumption for the respective needed time.

In this paper, we agree with the previously formulated point that the actors engaged in LFMs are required to be in synergy and collaborate in order to successfully manage flexibility in local contexts [5]. However, we take a critical approach to how the respective actors are broadly described as part of encompassing categories such as flexibility service providers (or sellers) and buyers [6]. Although research in this area has previously focused on the benefits and barriers of actors engaging in LFMs, a common belief is

that these actors refer uniformly to the concept and practice of flexibility. However, as actors are different depending on their profiles and local contexts, a fair assumption would be to expect their engagement in LFMs to also differ. Since LFMs are, however, themselves not well-established in Sweden, a study directly observing their practice is difficult but needed for their future establishment.

We ontologically position the study in the view that flexibility is a technical requirement and a social construction shaped by the interactions and perceptions of various actors involved in the energy system. Against this background, this study aims to uncover the embedded nuances in the conceptualisation of flexibility among three main actor groups which are identified in previous literature as highly relevant to the establishment of LFMs, namely flexibility buyers, flexibility service providers, and aggregators. Towards this aim, we asked *how different actors conceptualise flexibility in the context of the energy grid,* discussing also what are the implications of a variation in such a definition. We employed a mix of qualitative methods, which we detail in the following section.

2. MATERIAL AND METHODS

The data was collected from three types of organizations, representative of the main actors for the emerging local flexibility markets:

Flexibility Service Providers are actors who are expected to adjust their production or consumption in order to balance the grid according to its needs and therefore contribute with flexibility. Often described as *sellers* in previous literature, these actors make power available in the grid by lowering their consumption of energy according to the received signal.

Flexibility Buyers are local grid operators and other stakeholders with power requirements which need to be fulfilled in the system, and who would benefit from flexibility resources. These actors place bids on the resources made available by the flexibility service providers described above and are often described as *buyers*.

Aggregators are companies who specialize in managing distributed energy resources, for example by pooling flexibility resources from multiple users. Such actors are private companies which incorporate or dedicate these services in their business model.

Data was collected through 16 interviews in which we individually discussed with representatives from all three categories on their opinions and experiences of LFMs. The interviews were conducted face to face as well as digitally, and followed a semi-structured localist approach in which we aimed not to assess whether the participants could correctly identify a definition of flexibility, but understand *how* they constructed one in their situated accounts [7].

Based on the insights collected from the individual interviews, we then further contextualized them by organizing three focus groups, one for each type of actor.

Lastly, we organized an open space workshop [8] with participants from all types of actors. This was intended as an opportunity for the participants to discuss their energy needs and requirements together in a shared discussion. The workshop was organized in three sections, one during which we presented preliminary results from the study, divided the participants in discussions groups, and then invited them to present their main discussion points in plenum. Following the main aim of open space workshops, respectively that of not providing an established agenda or task other than that of discussion, allowed the generation of insights which the preliminary results at that point did not account for yet.

All participants were informed about the purpose of the project and consented to the recording of interviews and focus groups/workshops. No sensitive information as defined by the Swedish Ethical Review Authority [9] was collected.

Method	**Type of actor**	**Participants**
Interviews	Flexibility buyers	6
Interviews	Flexibility Service Providers	5
Interviews	Aggregators	5
Focus Group	Flexibility buyers	4
Focus Group	Flexibility Service providers	7
Focus Group	Aggregators	6
Workshop	All three types of actors	15

Table 1:Data Overview

The resulting material from the data collection (overview in Table 1) was in the form of audio recordings and visuals. The audio material was transcribed verbatim and later analyzed following a two-cycle coding process [10] through which we first categorized the material descriptively, and later inductively thematized according to emerging themes. In this paper, we report on findings specific to the emerging theme of how flexibility was

conceptualized by the participants. To develop an analytical discussion, we operationalized the concept of *boundary object,* which we explain in the following section

3. THEORY

We apply the concept of *boundary objects* [11,12] to analytically articulate the meaning-making behind the different conceptualizations of flexibility across different actors.

Boundary objects refer to either concrete or more conceptual items which can be operationalized by different groups in slightly different manners, while still maintaining a common understanding. In their original work, Star and Griesemer [11,12] developed this theory in the context of the scientific community and the creation of scientific knowledge. However, boundary objects have been employed in many other disciplines due to their broad applicability [13]. Although boundary objects have been previously applied in the context of energy studies [14,15], in this paper we are especially interested in their interdisciplinary application at the intersection of organizational and energy studies, as LFMs organize their practices around energy issues.

The original definition of a boundary object, namely that of "objects that are both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites" [11:46] is indicative to a useful application in local contexts where broad concepts are introduced, such as the case of flexibility in LFMs.

The appeal towards expressing flexibility as a boundary object is twofold: firstly, it provides analytical ground to develop an understanding on how different views of flexibility from different actors *matter* in a system as complex as the energy one; and secondly, it offers the possibility to further understand how such differences can be acted upon, rather than ignored or kept at bay. Accordingly, we present the main results in the following section.

4. RESULTS

The study participants shared a common understanding of what flexibility is in a broad manner, as illustrated by a participant who defined it as *"being able to shift consumption to a time where it would have not happened otherwise. This can happen manually or automatically by responding to existing signals"*.

Although this is a recognisable and correct definition of flexibility, this was expressed differently between the different types of actors, but also internally within these categories themselves. For example, for aggregators flexibility was seen as a resource that is to be shifted, this in itself being the focus of their business models. For flexibility service providers, the concept referred to a resource which they could hypothetically provide; while for flexibility buyers this was a solution to balance the overburdened grid. However, especially in the case of the last two types of actors, there also existed a view of what flexibility means depending on their specific practices and needs, as well as their engagement with large actors.

4.1 Practices and needs

Flexibility in the context of our study was discussed as a solution to an infrastructural problem to the grid congestion issue, but also as part of a more profound societal change towards sustainable energy production and consumption. Thus, while some actors saw flexibility and LFMs as sustainable solutions, others conceptualised them more as business opportunities:

"One can work with flexibility in different ways, and I know that normally when we refer to it people tend to think about it from a tariff perspective, meaning that they set a price for the hours when the grid is overburdened"

Thus, the actors who conceptualised flexibility as mainly a sustainable solution defined it as something which everyone who could engage with should, as it was seen as a societal responsibility towards building a more sustainable and resilient energy grid. In contrast, the actors who were connecting it more to financial gain, were experiencing adoption barriers as they saw the existing lack of incentives/rewards for entering LFMs and contributing with flexibility as very difficult to overcome. Thus, the actors whose needs were more aligned to profit saw flexibility as potentially interesting but not mature enough, while actors who were not strongly profit-oriented saw it as a moral duty.

Furthermore, within specific actor groups, the view of flexibility differed according to what type of organisations were at hand. In this view, flexibility was defined depending on the type of activities conducted, often tied to specific kinds of buildings. Given examples where flexibility was seen as an unrealistic aim were steel production where activities were difficult to stop once initiated, or a hospital which relied on electricity for critical services and thus would have been unable to easily shift consumption when asked to. However, such

types of actors were categorised under the same label (of flexibility service providers) as, for example, office buildings which could shift their consumption with ease as this meant decreasing ventilation or heating in most cases. Furthermore, most participants saw flexibility as a resource which could be deployed in times of a national crisis, therefore devaluating it in times of stability.

The different views of flexibility appear, thus, in accordance with the respective actors' contexts and practices. In turn, this affects the willingness and ease to which specific actors can enter LFMs. Despite having a common understanding of flexibility, the different nuances in this conceptualisation change how flexibility can then be operationalised in local contexts.

4.2 Engagement with large actors with significant decision-making power.

Most of the actors in the study connected the concept of flexibility to the national energy grid, often ascribing meaning to this as "helping the grid". Thus, this lead to further linking flexibility to large actors who hold significant decision-making, such as the governmental power system operator, or the national power company, the latter being especially often mentioned by study participants since they are managing the LFM in question and hence are in a high-power position.

More specifically, actors explained their engagement and/or prospective entry in LFMs as contingent on how such large actors take decisions to form the respective markets and how they act within them.

"The dialogue has stalled with the national power company. We have had discussions on at least two occasions, but they feel that we are too small. I have a hard time understanding why they can't see us as a whole. They're just looking at each individual berry, and not the entire basket of berries."

In this case, the participant often referred to flexibility and LFMs in particular, in conjunction to large actors who hold the decision to either allow their entry into these platforms or not. Although large actors dominate in how often they are referred to when discussing flexibility, actors such as aggregators who, in the example above, could pool flexibility resources from small actors are not mentioned or even known to some potential flexibility service providers. From this perspective, the participant cited above understood flexibility as a resource which only medium and large size actors could be involved in, therefore excluding their own organisation. Such misconceptions are, of course, in direct contrast to how aggregators view flexibility as a resource which they can pool from multiple small actors. Thus, flexibility and LFMs can be directly understood as attached to large actors who become synonymous with the balancing of the energy grid due to their large decision-making power in this arena. Accordingly, flexibility in such cases stops being an abstract concept and becomes dependent on the large actors and their own views of what LFMs are and how they should be developed in the future, dictating thus a normative view of flexibility which can be then further adopted by the other actors involved.

5. FLEXIBILITY AS BOUNDARY OBJECTS

Understanding the concept of flexibility (in the context of LFMs, as well as generally) as a boundary object means the attribution of two of its characteristics, namely *robustness* and *plasticity* [16]. From this perspective, flexibility is a boundary object because it allows for a shared understanding of it across different types of actors, while at the same time differing significantly within this community of practice. As illustrated above, not only can different actors understand flexibility differently according to their own contexts, but even organisations which are categorised to be as the same type can, indeed, have divergent views. Thus, flexibility can be considered a boundary object as it allows for different actors with diverse understandings of it to still operationalise it within a larger context of a community of practice, in this case that of LFMs.

Seen as a boundary object, flexibility becomes thus a more dynamic resource in the energy system than first thought, its complexities emerging as possible strengths. While an initial criticism of LFMs is that they are not mature enough and/or well-regulated in order to be understood and engaged with as intended, their complexity comes from the diverse manners through which they are viewed from within. However, another quality of flexibility as a boundary object is also their adaptability, meaning that the concept is complex but flexible enough in order to be easily adapted to local contexts and therefore be more relatable to specific actors.

An important point here is that the dominant conceptualisation of flexibility from large actors with high decision power can act as an institutionalised boundary object [16]. This has the implication that a

dominant view of flexibility can then be unreflexively adapted by other (smaller) actors without the previously-mentioned adaptability element. To this point, the metaphor of individual berries versus their basket used by a participant previously cited, reflects the potential negative output when broader perspectives are not taken in consideration and actors are not seen as elements of a larger system. Such misalignment in views between aggregators (who pool flexibility resources) and other actors indicate the potential difficulty in creating a unified, functional boundary object when power dynamics are uneven.

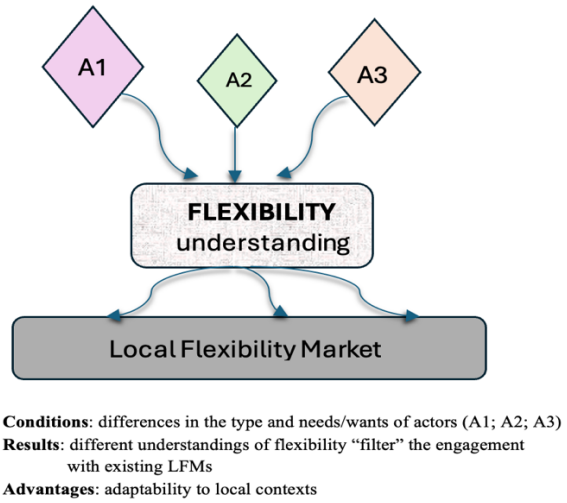

Figure 1: Flexibility as a boundary object. Based on visualisation proposed by Star (1989, p.49).

Thus, seen as a boundary object, flexibility can function as a collaborative framework, rather than as a mere resource, providing the common platform upon which more specific application can be built for the needs and profiles of specific actors. Through this view, such actors must be described with more finesse than as mere buyers/sellers. As illustrated in Figure 1, actors relevant to LFMs are various in size, type, as well as needs/wants; this primary condition leads to several conceptualisations of flexibility (rather than an assumed unified one), through which the engagement with LFMs are, in a sense, filtered. Without being sensitised to such a situation, this can appear as a failure of LFMs to function successfully; however, when seen as a strength the emerging advantage of adaptability to local contexts can be capitalised upon, but only if this is a situation which is further investigated in the given context.

Understanding how actors themselves conceptualise flexibility makes visible what can be argued to be normative views from the perspective of the envisioned purpose of LFMs, and therefore what and who is excluded/included. Thus, parameters such as the size of the actors, their relationship with larger actors, their practices, or their motivations should be considered in the future. Ultimately, the existing frameworks presenting flexibility as a resource employed by actors seen to be as largely homogenous entities is insufficient and requires more fine-tuning in relation to the context in which it is situated. This study illustrates how such details can be reached through an articulation of how different actors conceptualise flexibility and their role in the LFMs. Furthermore, seen as a boundary object, the complex characteristic of flexibility is made visible as a strength rather than a hindrance.

6. CONCLUSIONS

In this study we aimed to understand *how different actors conceptualise flexibility in the context of the energy grid.* We provided an illustration of how actors have a common general understanding of flexibility as a resource which can be shifted in accordance with the needs of the energy grid in order to (re)balance it. However, we also indicated that more nuanced conceptualisations of flexibility differ in significant manners between types of actors, and notably even within the same categories. This emergent quality of flexibility as being able to be operationalised within a community of practice like that of LFMs while its actors have different views of what this means for their own contexts, is indicative of a boundary object. Articulated as a boundary object, flexibility is understood as a way of bridging diverse perspectives on engagement in platforms such as LFMs. Furthermore, this shifts the focus from attempting to solve the inherent complexity of flexibility towards seeing it as a strength and therefore capitalising on its potential. If actors are better understood as more diverse than binary and broad categories such as sellers and buyers, more relevant applications can be further sustained in the development of flexibility-related platforms which are specific to their local contexts.

The work contributes to a growing body of research focusing on flexibility in the energy system as a solution for the need of increasing national resilience and optimization. Besides its theoretical contribution of understanding flexibility as a boundary object, the study is also more pragmatically relevant to practitioners and policymakers who engage with definitions of flexibility for regulatory purposes. We argue that if this area is to

be further regulated and developed, policy needs to be inclusive of the various way flexibility is understood by different actors in order to ultimately pave the way to fruitful collaborations between private and public actors.

A limitation of the present study is its focus on industrial actors only. Towards continuing the effort of mapping different conceptualizations of flexibility, variations of this understanding across other types of actors should be conducted. For example, as flexibility remains a viable option for households through their use of aggregators or partaking in initiatives such as energy communities, future studies should also approach the topic of how flexibility is conceptualised by homeowners. This is especially relevant as homeowners have a high autonomy in deciding whether they can engage in flexibility practices and if so, how. A common denominator for future research opportunities is the aggregator, which by virtue of functioning as a bridge between buyers and sellers of flexibility, emerges as a highly relevant, albeit underexplored actor.

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