D5.1

Report on Demo Planning and Deployment - 1

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API	Application Programming Interface
DSO	Distribution System Operator
FSP	Flexibility Service Provider
REST	Representational State Transfer
TSO	Transmission System Operator
ESG	Environmental, social and governance

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1. Executive Summary

Europe and Sweden stand at a pivotal moment in its journey toward a more sustainable and flexible energy system. With electricity consumption in Sweden projected to double, reaching between 300 and 400 TWh, the transition to a more adaptable energy infrastructure is not just a goal, but a necessity. This report focuses on the preparation and decision-making required to plan and deploy this transition, with a specific emphasis on the Swedish context and the market conditions influencing energy flexibility.

The purpose of this paper is to gather key learnings and strategic insights into the necessary preparation and decision-making processes for a deployment of a more sustainable, flexible energy system in Sweden. This report intends, with its core in the Swedish context, to outline the way forward for the integration of flexibility, propelled by fast growth in demand for energy solutions that will fit the customer, regulatory pressures, and technological advancement. This report outlines tailored value propositions, business models, and deployment of both SWITCH flexibility platform and ectocloud™ for the guidance of stakeholders toward enhanced grid management and the raising of market liquidity.

The report identifies a growing need for flexibility driven by the integration of intermittent and distributed energy sources, the stabilization of electricity prices, and the resolution of grid congestion and imbalances. Svenska Kraftnät, Sweden's Transmission System Operator, has committed to adding 2,500–3,000 MW of capacity in southern Sweden by 2027, with flexibility being a key component in achieving this target. Recent shifts in electricity and ancillary service prices have not only raised public awareness but have also sparked interest in the economic opportunities that flexibility can provide. Drawing on comprehensive qualitative research and interviews with stakeholders, including property owners, developers, industrial companies, and municipalities, this report presents customized value propositions and business models tailored to these segments.

Regulatory initiatives from the European Union, such as RepowerEU and the Clean Energy Package, are advocating for more flexible energy systems, creating opportunities for new market entrants and enhancing grid management. Simultaneously, advancements in AI and smart grids are transforming the flexibility landscape, although the market in Sweden is still in its early stages of development.

The report also emphasizes the importance of careful preparation and strategic planning in the design of value propositions and business models for Flexibility Service Providers (FSPs). It highlights the need for integrated, user-friendly solutions that make the best use of existing resources while addressing the challenges of standardizing communication and aligning business needs with platform functionalities. As a part of this, the report is dedicated to the planning and deployment of the SWITCH flexibility platform, a cloud-based system designed to manage and trade a range of flexibility products. This platform supports local flexibility markets, facilitates FSP engagement, and contributes to improved grid management through visualized congestion forecasting.

The analysis concludes with a strategic roadmap that offers stakeholders a clearer path forward for leveraging flexibility to drive policy and market developments. The goal is to build a more resilient and sustainable energy system by increasing liquidity in Sweden's flexibility markets. While substantial progress has been made, the journey toward a fully operational and efficient flexibility market in Sweden is complex

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and challenging. The insights from this report are crucial for guiding future market developments and accelerating the energy transition.

2. Introduction

2.1. Background

The transition to a more sustainable and flexible energy system is not a goal but a necessity. As Swedish society prepares to double its electricity consumption to 300-400 TWh, the need for better flexibility in the energy infrastructure becomes apparent. This report goes into more detail about the multifaceted drivers and market conditions shaping flexibility from a flexumer (flexible consumer/producer) perspective and that of the energy system, with a closer look at the Swedish context. The report will find out what is underway in the shape of the regulatory landscape, technological innovations, and market dynamics that are defining the future of flexibility in the energy system. Flexibility needs grow in importance as a much larger share of intermittent and distributed generation gets integrated with the grid to stabilize price developments, as well as mitigate congestion and imbalances in the electricity grid. For example, the Swedish TSO, Svenska Kraftnät, points out that southern Sweden should add an extra 2,500–3,000 MW capacity by 2027 to meet the Loss of Load Expectation (LOLE) target and sees flexibility as a critical solution to that [1][1]. In addition to this, the electricity pricing trends and established liquidity in recent ancillary markets has increased public awareness about energy subject-matters and revealed the potential in customers developing new revenue streams and savings from flexibility activities.

The paper also draws from qualitative research with a variety of stakeholders, including property owners, developers, industrial companies, and municipalities. Based on these insights, value propositions and business models were developed for the diverse targeted segments of the marketplace. Finally, a master thesis performed during the project identified barriers and drivers to energy-intensive industries in providing flexibility services as an important input for strategy development and demonstration planning.

The European Union and national bodies are now in the process of rolling out regulatory initiatives, such as RepowerEU, the Clean Energy Package, and upcoming regulation, for example, the Network Code on Demand Response (NC DR), that calls for increased flexibility within energy systems to enable new entrants into the market, optimized grid management, and secure operations. In parallel, new technological advancements, specifically related to AI and smart grids, have gradually altered the landscape of flexibility solutions toward sophistication and efficiency. Such a trend is well evidenced in the rapid growth of home batteries, electric vehicles, and other flexibility assets within Sweden. The market activities point to an increased interest from FSPs and software companies, although the market remains in its earlier stage of maturity. The report draws further on developing the value propositions and business models for FSPs, reiterating on having integrated and user-friendly solutions that bank on the existing resources to generate value through flexibility. This paper also outlines the complexities of establishing these solutions, including standardized communications, alignment between business needs and platform functionality, and associated risks when dealing with flexibility markets. Finally, the paper outlines the development and integration of the SWITCH flexibility platform, which is cloud-based and purposely developed for managing and trading diverse flexibility products. This assists in operating local flexibility markets, supports the engagement and recruitment of FSPs,

[1] Loss of Load Expectation, Swedish target 1h/year (Government decision)

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and improves grid management at the level of congestion forecasting methodologies. Building on a thorough analysis of market conditions, regulatory frameworks, technological progress, and customer insights, this paper develops the strategic roadmap for flexibility takeup in Sweden. The findings will be used to inform stakeholders, further policy and market development on the deployment and preparation-work of different flexibility solutions, and thus contribute to increasing resilience and long-term sustainability of the energy system with greater liquidity on the flexibility markets.

2.2. BeFlexible project - Task 5.1: Flex Market Demo Preparation

Task 5.1 focuses on the planning, preparation, and deployment of flex markets for DEMO 2, a long-track demonstration, following the foundational experience gained from DEMO 1, the fast-track demonstration. This task aims at refining the approach to flex markets, particularly in Sweden, where the pilots will be conducted over three consecutive years during the winter season. A core component of Task 5.1/Pilot 2.1 is the tendering and recruitment process, which will be iterated annually to allow for incremental adjustments and the exploration of different strategies through a trial-and-error approach.

The objectives of WP5 are the following:

"Following the experiences from WP4 (fast-track DEMO1), WP5 as DEMO 2 (long track) aims at 1) implementing and demonstrating and capabilities for flexibility in the DSO sphere such as: internal DSO capabilities, external FSP and aggregator business models and recruitment strategies and flex market platform effectiveness; 2) develop, implement and demonstrate local balancing capabilities in build environment, through the integration of assets in built environment as flex components e.g. battery, charging infrastructure, heat pumps; integration of software solutions and of business and price models that enables prosumers to take part in flexmarket; 3) demonstrate and implement a platform that enables aggregated services from built environment to local flexmarket and TSOs market."

BeFlexible, Grant agreement, 2019.

Key activities within Task 5.1 include the definition of business models, the selection and integration of appropriate technologies, and the engagement of participants. The recruitment strategy emphasizes dialogue with potential actors, recognizing that successful implementation of the flexibility concept hinges on effective customer engagement and consideration of social and cultural factors. This approach will be supported by close alignment with WP1, which focuses on identifying attractive business models based on current and emerging regulatory incentives, and WP2, which is centered on co-creation events and customer engagement.

The flex market demo is naturally linked to the broader framework of Business Use Cases (BUCs) and System Use Cases (SUCs) that guide the project's objectives. Specifically:

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Table 1. BUC and SUC content

Business Use Case (BUC)	System Use Case (SUC)	Pilots
BUC04. Long-term distribution grid congestion management	SUC04.1 – Long-term load forecasts SUC04.2 – Tools for quantifying flexibility needs in a constrained grid point SUC04.3 – Procure availability contracts SUC04.4 – Activate market-based and non-market-based long-term availability contracts SUC04.5 – Integrate flexibility into DSO grid planning processes and tools	Pilot 2.1 Pilot 2.2
BUC06. Short-term congestion constraints forecasting and management for local flexibility service activation	SUC06.1 – Short-term Flexibility procurement based on congestion forecasting SUC06.2 – Short-term Flexibility activation for DSO congestion management	Pilot 2.1
	SUC06.3 – Settlement of flexibility services from DER participating to local market	Pilot 2.1
BUC09. Local and global market coordination for distributed resources system service provision	SUC08.1 – Flexibility Register SUC08.2 – Market data exchange functionalities SUC06.2 – Short term Flexibility activation for DSO congestion management SUC10.2 – Constraints definition SUC10.3 – Bids placements and verification SUC06.3 – Settlement of flexibility services from DER participating to local market	Pilot 2.1

These BUCs and SUCs will be critical in structuring the demonstration activities within Task 5.1, ensuring that the flex markets are not only well-prepared and effectively deployed but also integrated into a larger framework that supports grid stability and efficiency. The experience and insights gained from the iterative process of the north EU DEMO will contribute to the continuous improvement of flex market strategies, enhancing their viability and scalability for future applications.

2.3. Purpose

Given these Business Use Cases (BUCs) and System Use Cases (SUCs), the purpose of this report is to synthesize the learnings and insights gathered from extensive research and stakeholder engagement to inform the strategic planning, preparation, and deployment of flexibility markets in Sweden as part of the North EU demonstration under the BeFlexible project. Drawing from the evolving regulatory landscape, technological advancements, and market dynamics, the report aims to provide a comprehensive framework for enhancing the liquidity and functionality of local flexibility markets. By addressing the challenges and opportunities associated with integrating flexible energy resources into the grid, the report seeks to offer actionable strategies for recruiting and onboarding Flexibility Service Providers (FSPs), optimizing market operations, and improving grid management. The goal is to contribute to the sustainable and efficient evolution of the energy system through flexibility, ensuring its resilience and alignment with broader climate and energy transition objectives.

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3. Market Environment and Customer Insights

The project team have conducted an analysis of the market environment and drivers for flexibility on a flexumer and energy system perspective with focus on the Swedish market. The market analyses have been conducted by gathering market insights from open sources and public information as well as E.ON internal insights. Below is a presentation of the conclusions and results of that work.

As stated in the introduction, recent year's prices, both for electricity and for ancillary services, have contributed to a public awareness with an increased customer interest in flexibility, also driven by the possibility to create new revenue streams and improve investment cases.

Sustainability is another main driver found across all customer groups as well as the political drivers. Flexibility is increasingly seen as an important aspect to reach climate ambitions, which is necessary for many companies linking to external requirements and internal targets. On a higher level, flexibility is seen as an important contributor to EU and Swedish climate targets, for example through a more efficient use of existing resources as well as reduced use of emission-heavy production facilities.

Flexibility is part of the debate and market activities, however, still it's in general quite immature in terms of FSPs active on the market.

3.1. Regulatory push

The role of flexibility in the energy transition and climate ambitions, is reflected in existing and up-coming regulation and political discussions. EU is pushing for more flexibility across regulations such as Clean Energy Package, RepowerEU and the electricity market design reform. The Clean Energy package released in 2019 opens up for DSOs to use flexibility, and specifically market-based flexibility, to solve issues such as congestion in the grid. Together with this it also opens the markets for new players, both for participating with balancing services and local services such a congestion management and voltage control. This creates new business cases and opportunities for interested stakeholders. In Sweden, this includes the implementation of the role of the independent aggregator and balance service provider (BSP).

The up-coming new network code on demand response (NC DR) is expected to provide a framework for how market-based flexibility should be implemented and partly harmonised across EU. The framework will for example regulate aggregation models, prequalification processes, flexibility market requirements, market design and needed data exchange both between TSO-DSO, DSO-DSO and from service providers and system users. There are already other network codes in force that also touch the topic of flexibility. For example, the system operator guideline (SOGL) regulated how DSO connected resources may participate on balancing markets, giving the DSOs a possibility to block the activation by the TSO for chosen balancing products if this risks the operational security of the DSO grid. The entry of the NC DR is also though to complement and make amendments to the SOGL, where for example the prequalification process is described for balancing products, with the objective of streamline this process with other flexibility services as congestion management and voltage control. This aims to make it easier for service providers to participate with different products and value stack over several markets.

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On a Nordic level, there is an on-going harmonization of balancing services with the aim to open trade over Nordic/European platforms and markets. This includes the transition to 15 min settlement with possibilities for improved planning and adaptation of portfolios before the balance market.

The Swedish Energy Markets Inspectorate (Ei), have made an extensive analysis during 2023 of what should be done to foster flexibility in the energy system. The suggested actions included in the result of the study includes the whole flexibility value chain, from knowledge and information sharing, continue the development of the design of local flexibility market, better TSO-DSO cooperation, data exchange and access to increase transparency for final customers and how to recruit service providers from all sectors. Ei is specifically suggesting actions to incentivise the industry segment to assess their flexibility situation, to increase knowledge among companies and consumers and to facilitate flexibility initiatives through an electricity market hub, retrofit smart steering and assessment of sub metering.

The **fast technology development** is also driving the flexibility market. Improved performance and decreasing prices have seen strong growth of many flexibility assets - the number of home batteries in the Swedish market increased from 15’ to 40’ between 2022-2023. AI is enabling smarter steering, control and automation in both assets and flexibility solutions. Estimates from Ei [2] and PowerCircle[3] combined indicates that V2G technology will be able to provide an expected battery capacity of 50 GWh by 2035. The integration of “smart grids” and renewable energy have paved the way for widespread adoption across all customer segments.

3.2. Market activities

The high prices on the ancillary market have attracted strong attention from potential FSPs and service providers, especially in the battery area where many new players have entered the market. Many of them have pre-qualified to deliver ancillary services to the TSO market and are helping customers to trade on this market. The fast AI development have also seen the rise of many new fast-moving software companies offering flexibility solutions. Among traditional service providers, most players are working with partners to be able to offer flexibility services to customers. However, it is still an immature market, it is many times unclear how viable business models really are or where marketed solutions are in the commercialization process and how the market will develop moving forward. Projection from Swedish TSO SvK shows an increased turnover that will peak 2025/2026.

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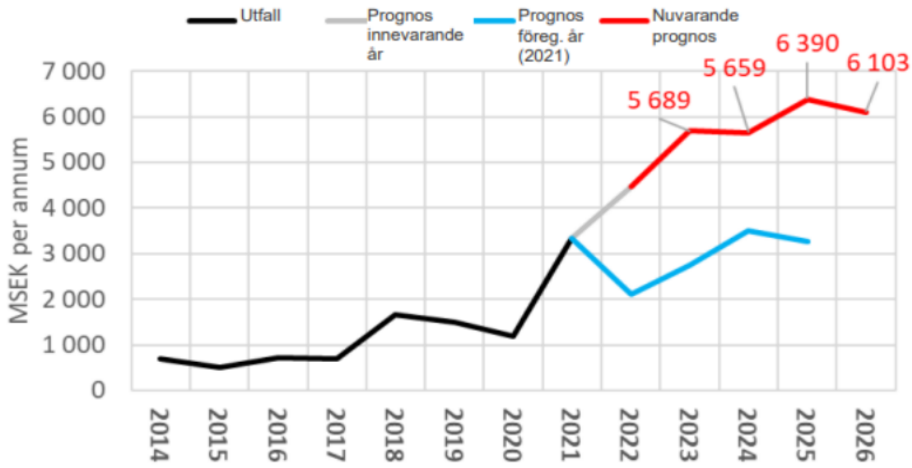

Figure 1: Prognosis of turnover for ancillary services [4]

3.3. Customer drivers

The project team have carried out several qualitative customer interviews to understand their drivers and pain and gains linking to flexibility. The interviews were preceded by internal project work, mapping key customer segment of relevance for the project based on flexibility potential. In the process the project team have used the business model canvas and assessed customer pain gains and jobs and elaborated on the pain relivers and gain creators in design of the value propositions to be deployed in the different pilots and customer segments during the demonstration phase. The conclusions have also been formulated as hypotheses which are to be further verified in the project. The conclusions from the selected customer segments interviews are presented below:

1. Property owners

Property owners care about their sustainable brand, feel local responsibility and are looking for a stable partner for long-term energy solutions. They have existing solutions, e.g. for property management and they are curious about local balancing, ancillary services, energy sharing and -optimization. Strong driver is to decrease the operating cost for their building portfolio and also get control over their running energy costs and usage.

2. Property developers

Developers want to build properties that are attractive on the market, both from a sustainability and cost perspective. Usually there are small margins in their development projects and solutions that supports a lower CAPEX but still enables a future proof end result is appreciated. They want to be at the forefront, for example through environmental certification and a good ESG rating as means for future proofing their project and attracting investors. To be in the forefront by enabling and supporting a flexible energy system could also improve their relations with municipalities, whom in many cases facilitate access to land allocation and building permits.

3. Company with warehouse and logistics

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These companies have low margins, with a strong focus on lowering their costs or increasing revenue. From a flexibility perspective, they want to take advantage of their assets, such as roofs with solar cells and electric vehicles. They usually invest in different energy assets, with a clear interest to harmonize and optimize the operation of these, e.g. heating, cooling, storage, generation charging etc. and offset the flexibility to lower their operating cost.

4. Industrial companies

Their processes are sensitive to interruptions and thus need secure electricity supply. This can be achieved through batteries or fuel cells, that may also be used for flex services. Power usage is high and cutting peaks can be attractive. Flex services may also be interesting for non-sensitive industries that can do without power for shorter periods. For the industrial segment the production line is usually most prioritized and the main concern linking to flexible consumption.

5. Smaller property owners

A small real estate company, a condominium association or a larger homeowner who has invested in photo voltaics and/or batteries and who wants to improve their investment calculation. It can also be a group of energy users who want to create a solution together.

6. Municipalities

They are planning for habitant growth and want to secure job opportunities in the municipality. They want to minimize the risk that capacity becomes a hinder for growth and electrification and therefore like to contribute to a stable grid situation locally. They have high climate- and environmental ambitions and want to be seen as a frontrunner and partner within smart energy solutions.

3.3.1. Conditions for industries in Sweden to contribute with flexibility to the electricity system

Furthermore, a master thesis has been under the tutorial of the project and conducted by two students at Linköpings University. The master thesis investigates (1) the barriers and drivers for Swedish energy-intensive industries to deliver different types of flexibility services and (2) what types of customer value that can be created from this. The purpose of the thesis is to gather insights of the requirements, barriers and drivers experienced by flex consumers, mainly in energy-intensive industries.

The insights from the Master theses will be utilised in the work moving forward with demonstration, outlining the strategy to recruit FSPs with high potential and interest, design of business models and value propositions.

In the theses a literature study was conducted to identify barriers, drivers, and customer values. The literature study was also used as a basis for the interview guide which was used in the interview study. The interview study was conducted to find out what industrial customers need to deliver flexibility. In addition to the interview guide with the questions, the interviewees were also asked to rank the barriers, drivers and customer values of flexibility identified in the literature. The ranking allowed for more concrete answers on how significant different barriers and drivers were for the business, and which customer values are the most important.

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The results indicate that the primary barriers to delivering flexibility services for Swedish energy-intensive industries, as ranked on average, are hidden costs, sensitive processes, and interconnected processes. Industries have identified various hidden costs, including costs linked to loss of production. When it comes to the industrial processes, many industries have pointed out that they cannot stop their processes at any given moment. This is due to, for example, production planning and the fact that it takes too long to return to normal operation in the event of a production halt.

In addition to the identified barriers in the literature, the organizational maturity of the industries has also been identified as a barrier. Many of the industries have expressed that they are interested in flexibility services, but that they are not familiar with compensation levels and pre-qualification requirements. This suggests that energy companies need to improve the communication of compensation levels and pre-qualification requirements.

The drivers ranked highest on average for delivering flexibility are compensation or other type of reimbursement, controllability of processes and political signals. Compensation for participation and controllability of processes are ranked highly as industries do not want the delivery of flexibility services to negatively affect their core business and revenues. Political signals also ranked high, indicating the importance of developing regulations and policies related to flexibility. Industries argue that there is a lack of clear regulations on what is required. The network code for demand response that is currently being developed can act as a harmonized regulatory framework to ensure consistency with existing regulatory framework.

The customer value ranked highest on average by Swedish energy-intensive industries are internal resilience and increased revenue. The high ranking of internal resilience indicates that it is important for industries to be able to handle the circumstances that the electrification of society and the industrial sector will impose. The high ranking of increased revenue is also consistent with the high ranking of the driver compensation or other type of reimbursement. This shows that the financial aspect is very important for the industries. The reason for the low ranking of organizational growth is mainly because industries do not see flexibility as a way to increase organizational growth. Often there are other measures that contribute more to increased growth and thus these measures are prioritized over flexibility.

In general, most industries are perceived as having a positive view of flexibility and delivering flexibility services is not only seen as a challenge but also as an opportunity. The positive view indicates that industries can be an important key player in solving future electricity needs. For a more comprehensive view on the results, see Appendix.

3.3.2. Flexibility potential Sweden

According to The Swedish Energy Markets Inspectorate (Ei), the need of flexibility for capacity and energy is increasing in all time scales and all Swedish price areas until 2030/2031[5].

The TSO ancillary markets are expected to continue to grow to nearly SEK 4 billion in 2024 and remain at high levels in coming years. Recent years' high prices on the markets for FFR and FCR-D has attracted entry of more flexibility assets, resulting in predictions of a significant drop in market prices since some time back. However, so far price levels have remained stable on high levels, highlighting the difficulties of forecasting developments in the flexibility area.

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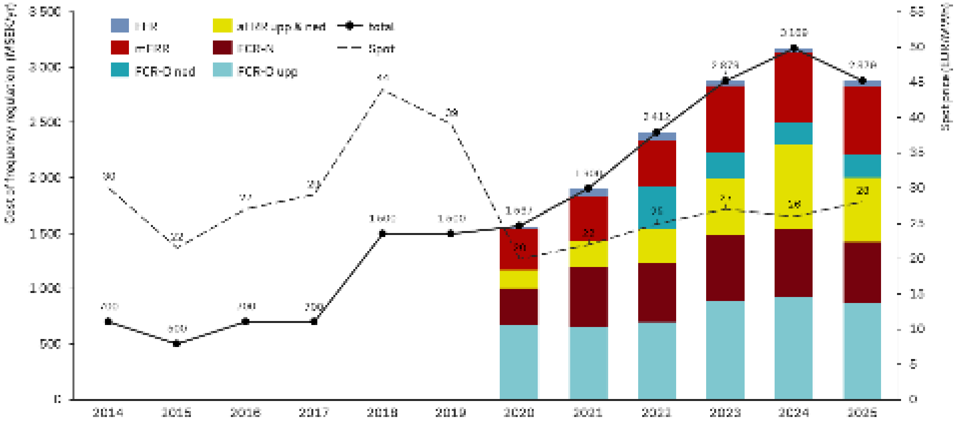

Figure 2: Forecasted total SVK spend on ancillary services (MSEK)

Local flexibility markets are still in an early stage. The overall flexibility demand is expected to increase especially in urban areas, as to invest or reinforce in grid capacity in general takes longer time in comparison to the increased demand for grid connections.

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4. Value Proposition and Business Model

The project team have worked with outlining a direction for value propositions based on various value propositions for FSPs. The methodology used is the business model canvas and assessing customer jobs, pains and gains based on input from the customer dialogues. Further assessments have been done on various value pools, driven from both energy system needs and flexumer optimization potentials.

4.1. Value drivers from flexibility

Flexibility used for congestion in the electricity grids will lead to more efficient use of the grids. Grid congestion usually peaks during a limited time such as rush hour, while the grid has available capacity at other times. Efficient use of the grid also allows more customers to be connected as well as reduce grid investments and thereby lower emissions connected to the construction of new grids.

Effective use of flexibility, both in large scale energy assets and distributed flexibility resources could also contribute to reduced fossil fuel use in heat production in Sweden and in E.ON EIS District heating operations, both in terms of avoiding fossil-fuel peak-load assets and in reduced heat demand through increased system efficiency. On a larger scale, flexibility could reduce imports of fossil-based electricity leading to **lower “carbon intensity”/kWh**.

Within E.ON Nordic there are numerous assets with potential to be leveraged on the flexibility markets. EIS owns and controls assets spanning from CHP, heat pumps, boilers, batteries, and PV installations. Ongoing initiatives include delivering flexibility from the Sjölunda heat pumps to the local flexibility market Södra Skåne. During the last season the pilot tests responded to eight availability orders from the Skåne flex market. We made 2.5 MW of possible downregulation available for one or more hours per occasion. In total, this volume has amounted to 152 MWh. Of these occasions, we delivered flexibility six times, with a total down-regulated volume of 57 MWh.

The pilot tests during the last season shows that there is a potential for district heating coupled assets to play an important role as enabling flexibility to local flexibility markets. The work is initiated to outline a deeper technical assessment in order to scale the number of assets and amount of flexibility that could be offset.

Furthermore, the project is preparing capabilities to enable delivery of flexibility offerings from FSP, in the immediate time through a partnership with 3rd party supplier, to get proof of concept on the market. There is also on-going development in of software solutions to further strengthen the capabilities linking to flexibility for the coming demonstrations including further integration of E.ON EIS assets to SWITCH.

The high prices on the ancillary markets in Sweden (avg. 500 SEK/MW/hour) have led to an increasing customer interest. While the need of flexibility will grow over many years to come and have a strong influence on the energy solutions being offered going forward, uncertainties remain high. The most valuable off-set for flexibility is expected to vary over time, both regarding behind- and in front of the meter, as well as across markets to trade flexibility. The industry segment potential is also pin-pointed by The Swedish Energy Markets Inspectorate (Ei) and is likely to benefit from up-coming incentives to push for the realisation of flexibility. The real estate segment is focused on understanding the flexibility potential in a wider energy perspective with flexibility assets such as heat pumps, batteries, PV and EV-chargers; a need that is likely to increase with the market implementation of effect tariffs in 2027. In the B2C segment, house owners show a growing interest for smart home concepts. Similar concepts in larger scale will be of interest in Energy Communities. Depending on the size and content of the energy community, it can become a valuable flexibility asset in terms of volume. In the electrification of transport, especially the heavy transport segment, the regulatory demand for transformation puts strong pressure on capacity needs, where flexibility can become an enabler.

The **industry segment** which is identified as a high potential segment is yet quite immature in a flexibility perspective. Moreover, the industry segment is likely to benefit from both incentives and stronger requirements to ensure the realisation of flexibility in the near future which was pointed out by Ei.

In the **real estate segment**, there is a desire to get help to understand their flexibility potential in a wider energy perspective. This is likely to be further incentivised by the general implementation of effect tariffs in 2027, as the value for realization and use of flexibility is most likely to increase in this segment.

EV-charging is another valuable segment with a need to transform existing fleet due to regulatory demands. The increasing numbers of trucks and high charging effects put strong pressures on capacity needs, where flexibility can become an enabler. Flexibility could also help improving the business case for the switch to the more expensive electrical trucks. There are also requirements for a strong acceleration of the implementation of charging infrastructure.

Energy Communities is likely to become an increasingly important player in the future energy market, not in the least related to flexibility. Depending on the size and content of the energy community, it can become a valuable flexibility asset.

A challenge or barrier to enable these value drivers are the seamless digital infrastructure that allows for the distributed flexibility resources to participate in the market. Today there are many different service providers offering various parts of the value chain. Many of the customers engaged in the project dialogue want to access a solution that can manage all the flexibility potentials based on the most value creation that could be created in the given time, which various over seasons and hours. Therefore, the solutions should be both interoperable with the various distributed resources deployed in the build environment and able to provide to the DSO and TSO market as well as potential optimization behind the meter, which makes it complex.

Furthermore, the challenge in shifting market needs and demand creates uncertainties in the willingness to invest in solutions that enables the market participation. If you can’t say for certain the value potential the investment needs to be lower, or performance based.

4.2. Value proposition for flexibility

E.ON’s value propositions are developed in an iterative way, by testing hypotheses and learning from customer dialogues. Our belief is that the flexibility solution needs to work smoothly and integrated with different assets, systems and products. Another validated hypothesis is that a great deal of customers lacks knowledge and time to fully understand flexibility topics, and that they need a trustworthy service provider to support them to unlock their full flexibility potential.

We work closely together with customers, to understand how value can be created. To have an attractive value proposition, it is of importance to provide customers with increased insight into flexibility potential

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from their existing resources. This includes roadmap and recommendations how to lower costs and generate profits.

The ongoing value proposition work is focusing on customers' current needs and what would be attractive. We then need to consider all potential value pools for the customer, both up and down regulation and both TSO and DSO markets as well as the potential internal flexibility optimization behind the meter. However, building flexibility solutions that work smoothly and integrated sounds simple on paper, but in practice it's a challenge.

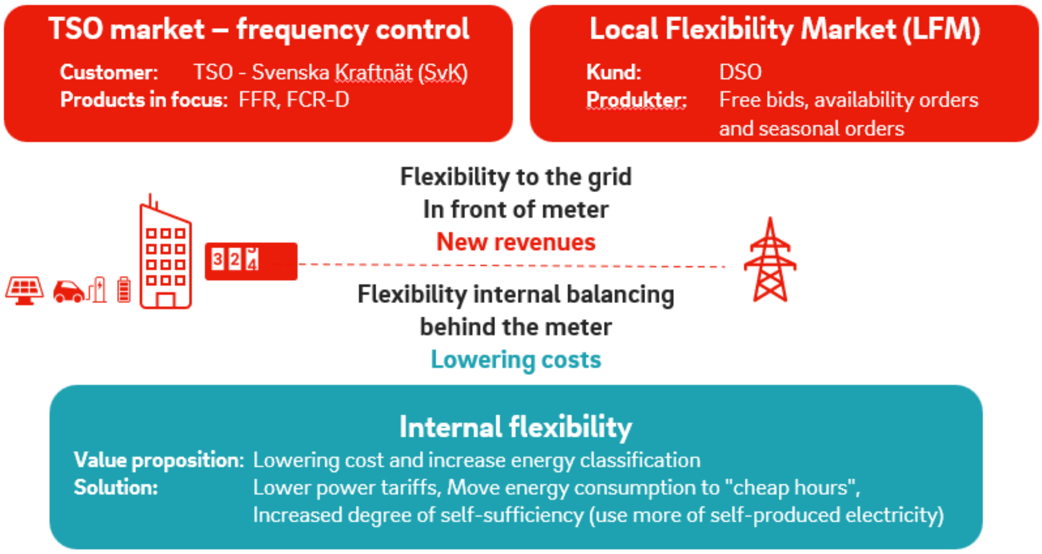

Figure 3: Flexibility value pools for the FSP include both behind and in front of the meter.

The price structure and business model that we are deploying in our pilots is quite simple and performance oriented. Besides any direct investments and installations e.g. in BESS the FSP have a service agreement which is performance based.

4.3. Market risks associated with flexibility offsets

When building business cases based on bidding and value stacking over several flexibility markets, it's of importance to take into account the possible effect the delivery of flexibility may have. While local flexibility markets are highly dependent on the geographical position of the resource, the balancing market by the TSO is national and thereby the opposite. To not create more issues solving one issue in one grid by not considering the connecting grids. For example, solving an issue in the TSO grid may create local congestion for connected DSOs. It is important to take this into account when bidding and value stacking over several markets. The future implementation of article 182 in SOGL by the TSO will also enable the DSO to be able to communicate operational status of the grid and thereby block balancing bids if activated when the local grid is in an unnormal state, thereby affecting the customer and resources blocking potential revenue.

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5. FSP Engagement and Recruitment

5.1. Methodology and Engagement strategy

The engagement of flexibility service providers and potential flexibility service providers will be carried out based on the framework explained in deliverable D2.2: 'Customer Engagement Strategy'. The theoretical basis for the engagement framework is the Actor-Network Theory, a methodological approach which utilizes social theory to understand how people, social dynamics, attitudes and technology form networks to function successfully. This theory will be applied to understand relevant stakeholders (explained in section 2) within the flexibility market and gather insight into their motivations to enhance recruitment and participation in the BeFlexible project.

In addition to the framework which serves as a blueprint for the general engagement approach, research and stakeholder analysis conducted by EON through customer dialogues (section 2), the project will build on this with continued research and the formulation of an engagement plan explained in this section.

The hybrid approach introduced in D2.2 will form part of the methodology responsible for the planning and implementation of the research. The hybrid collaboration approach (Figure 4) is utilised to provide a road map of the engagements expected to occur throughout the BeFlexible project. This approach consists of two major components: (1) examining the top-down perspective from the project and technical coordinators and (2), gathering information from the bottom-up perspective from the pilot site leaders. Combining these perspectives allows for the broad project goals to be aligned with pilot-level needs, which is essential for planning the stakeholder engagement activities.

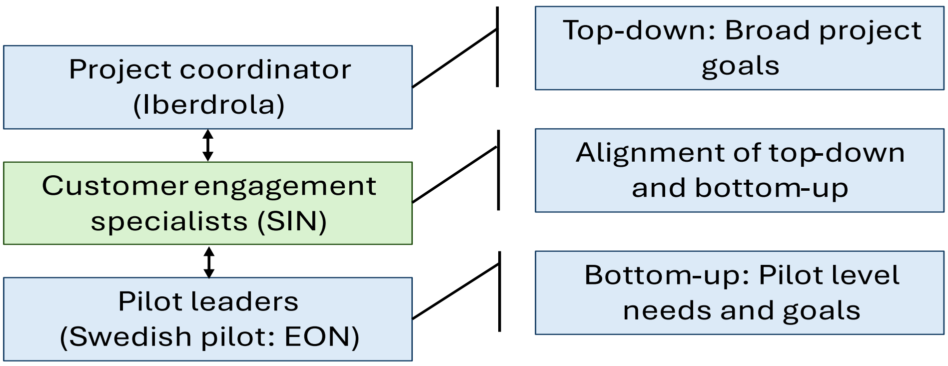

Figure 4: The Hybrid collaboration approach

The relationship at the bottom-up level will be key in this phase of the project as planning and conducting the right research will be dependent on close collaboration between SIN and the Swedish pilot partners. SIN will provide expertise in the design and conducting of the research as well as advising future engagement and communication efforts aimed at recruitment. Additionally, the insights gained from SINs research into the socio-cultural elements of flexibility market participation will inform onboarding efforts. The Swedish

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pilot representatives will provide local knowledge and expertise as well as potential flexibility service providers from within their network who can be utilized as part of the research investigation.

The methodological approach will involve primary research through qualitative and quantitative methods with potential flexibility service providers to gain insight into the business attitudes and motivations at the psychosocial level towards flexibility market participation. The research will gain insight into the barriers and drivers of various industry actors which can be leveraged when attempting to recruit flexibility service providers, enhance the onboarding process and foster continued participation in the flexibility market.

The research will also incorporate feedback loops and transparency with participants. It is important that potential participants and engaged stakeholders feel part of the process and have meaningful input. This is achieved by treating engagement efforts as bi-directional. Although the primary goal from BeFlexible is to gather insight from potential participants, they should not be treated solely as a source from which to extract information. It is important to open communication channels, explain the purpose of the research and share back findings and future plans with stakeholders who become part of the BeFlexible project.

From a high-level perspective, the BeFlexible project can be broken down into 3 stages regarding the engagement strategy: recruitment, onboarding and demonstration. The current recruitment stage revolves around awareness raising, communication and building incentives. This is the current stage in which the research proposed in this section aims to uncover insight to build the right incentives and communication strategy to recruit potential flexibility service providers in the Swedish pilot region.

5.1.1. Socio-cultural attitudes and beliefs

It is important to build on the research conducted thus far to further enhance the success of the engagement approach in BeFlexible. Work undertaken thus far has focused on stakeholder analysis and hypothesis generation (see section 4.2). Further insights into energy-intensive industries served to identify the barriers and drivers for delivering flexibility services. In the next phase, research can focus on the socio-cultural attitudes and behaviours of industry stakeholders to supplement the knowledge already gained regarding the motivational barriers and drivers related to economical, technical, organizational and regulatory aspects of a business.

The socio-cultural motivations refer to the attitudes and perspectives which go beyond the economical and organizational needs of a business. This can include how they want their business to be perceived at the societal level and the beliefs and attitudes of individuals which form the socio-cultural makeup of a business. To assess the attitudes and motivations at the business levels beyond the economic and operational level, the next stage in the research process will investigate elements such as attitudes, culture, knowledge and norms. For instance, the level of trust and confidence in the flexibility market can affect willingness to participate. This lack of trust or confidence may come from a lack of knowledge or awareness, but it may also come from the culture or norms of a certain type of industry. For instance, if a company has traditional values that are susceptible to inertia, regardless of the benefits that may come from participating in the flexibility market, attempts at engaging and recruiting such industries will require an approach that respects these values whilst also framing the benefits of participation in relatable terms, such as its ability to minimize disruption and facilitate networking with other local businesses.

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5.1.2. Industry attitudes

To assess the socio-cultural attitudes and beliefs and their impact on flexibility market participation, the CERNA (Climate and Energy Related Norms and Attitudes) survey developed by SIN can be administered. The CERNA was designed to measure an individuals' factual knowledge about climate and energy related matters, assumptions about others' knowledge and attitudes, and the influence of social norms on climate perceptions. The factors the CERNA investigates will be applied in the BeFlexible project to gather insight into the attitudes of various industries towards becoming a flexibility service provider. For example, do representatives from one industry believe their view on the flexibility market and aspects related to flexibility participation are shared by other industry actors and how does that affect their willingness to participate. Many other factors can be investigated through the CERNA, the main purpose is to uncover social-psychological barriers and drivers from industry actors for participating in the flexibility market. Developing a better understanding of the barriers and drivers will facilitate the recruitment and onboarding process with FSP in the BeFlexible project.

5.1.3. Industry attitude to data sharing and digitalization

One area to focus on within the socio-cultural domain relates to a business' attitude towards data sharing and digitalization. For industries to participate in the flexibility market, technical and digital requirements need to be met. Data sharing and security are essential for enhancing flexibility in the energy market, enabling the efficient integration of renewable energy sources, managing network congestion, and promoting market stability. Leveraging data sharing and digitalization technologies like secure computation, blockchain, and Big Data can enhance the resilience and effectiveness of flexibility mechanisms in energy markets. Digitisation in the energy sector enables the automatization of marketing flexibility potentials, facilitating advanced energy management, which is essential for the success of flexibility in the energy market [6] (Schott et al., 2019).

However, equally, if not more important, are the attitudes of a business towards digitalization and data sharing. For example, the transformative nature of digitalization requires the introduction of new working processes and challenges existing ways of working [7] (Hagberg & Jonsson, 2022). The introduction of new processes can threaten the culture of a business and everyday practices at the social level as well as at the operational level. Furthermore, the attitudes towards change can affect motivation towards becoming more digital and even effect elements such as leadership style [8] (Nicolau et al., 2022).

Enershare, another European Commission-funded project, is dedicated to developing data-driven services integrated into a European Energy Data Space platform. By aligning research efforts across projects like Enershare and BeFlexible, there is a significant opportunity to optimise resources and maximise the impact of our collective work. A potential area of collaboration between Enershare and BeFlexible could involve conducting a joint study to explore the attitudes of businesses and organisations within the energy sector toward data sharing and the adoption of data-driven flexibility solutions. Such a study would not only leverage the strengths of both projects but also provide valuable insights that could inform the development of more effective and widely adopted energy services across Europe.

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5.1.4. Communication framing and recruitment

A major focus for the BeFlexible project is the recruitment of flexibility service providers. Therefore, how the benefits of participation are framed in future communication and engagement will be key for recruiting various industry actors into the flexibility market. From developing a better understanding of the attitudes and motivations of various industry actors through research approaches outlined above, communication and engagement strategies can be designed around key factors which are important to the targeted stakeholders. For example, if the findings show that a particular industry has a desire to appear supportive of the local community, communication and recruitment efforts can highlight the local benefits associated with flexibility market participation. Additionally, engagement efforts can be conducted through community-orientated methods such as raising awareness at local events.

Who to target

Research undertaken thus far has identified customer groups and industry profiles which can be leveraged for recruitment purposes in BeFlexible (see section 2.3). The next phase of research can build on these findings to further distinguish industry types and uncover motivations and facilitate a more focused approach for engaging and recruiting flexibility service providers. For example, the attitudes and motivations of energy-intensive industry may differ from other industry types. If the engagement and recruitment strategy only accounts for a particular type of industry, other industry types may not see the benefit which will reduce the scale of recruitment. An investigation into the diverse nature of attitudes and beliefs of various types of industry will allow for the design of a flexible and targeted engagement strategy and maximise recruitment into BeFlexible.

5.2. Engagement and Recruitment during 2023/2024

5.2.1. EIS

The project team have worked in an iterative process to understand how to efficiently create a methodology for recruitment of FSPs. The empiric data that has been evaluated in the task is derived mainly from the customer dialogues and value proposition work carried out in ST 5.1.2. The recruitment process has been designed by outlining the following steps **1,** Formulating a **hypothesis 2,** Understanding the customer **desirability 3,** evaluating the FSP **feasibility** and **4,** Assessing the FSP **viability.**

1, Hypotheses

- We started with defining the Hypotheses, what do we need to understand, and our Hypotheses are based on the definitions of the prioritized customer segments.
- Customer type X finds value in understanding their specific flexibility resources.
- Customer type X wants suggestions on how flexibility resources can be used to generate revenue and reduce costs.

2, Desirability

- What do selected customers think of the concept? What is good? What is missing?
- Does the service lead to other additional values e.g. control, environmental, organizational etc.?

3, Feasibility

- What potential do the flexumer have to act as a FSP e.g. market qualification, digital matureness, sensitive processes etc.?
- Do we need additional capabilities to understand and map the flexibility potential?
- Which degree of stakeholder collaboration is needed to unlock the flexibility potential, e.g. 3rd party service providers, digital integration etc.?
- How do we assess the potential for optimization of the FSP based on the flexumer configuration?

4, Viability

- What are customers willing to pay for the service?
- Which business models are most attractive?
- What does the value proposition look like, e.g. considering internal or external capabilities?
- Are there ways to further minimize costs and increase margins?

5.2.1.1. Recruitment and onboarding of FSPs

In the preparational tasks the project we are engaging our customers and potential FSPs by exploring their flexibility potential. Together with the customer and potential FSP we evaluate what resources can provide the opportunities to apply flex, what flex volume is available and how long endurance is there in these resources. What should be prioritized and is easiest to implement and what value and market potential can flexibility provide. This evaluation provide insights on how the FSP could implement different measures to unlock the flexibility.

5.2.1.2. Other identified values to consider in the recruitment of FSPs

Utilizing flexibility from sustainability perspective is also something to consider, both in terms of providing the proof points for the FSPs in operation as well as means for incentivizing the potential FSP. Increase operational performance could be utilized for CO2 optimization, both directly in E.ON EIS own operations, or indirectly via FSPs, and to reach E.ON and the flexumers Sustainability Targets. From a grip point of view efficient use of flexibility creates the prerequisites for electrification and unlocking the needs for many flexumers to electrify and act as FSPs.

5.2.2. DSO

The communication efforts have primarily focused on educating stakeholders about the reasons behind the establishment of flexibility markets. The rapid electrification of society necessitates significant grid expansion, a process that is both time-consuming and costly. By leveraging flexibility, more customers can transition to renewable energy sources decreasing the need for extensive grid upgrades. Flexibility enables the grid to be used more efficiently, reducing the necessity for additional infrastructure and thereby minimizing environmental impact. The cost of expanding the grid ultimately falls on customers, but utilizing flexibility offers a cost-effective solution for society. As more companies establish themselves, there is a risk that grid capacity will become insufficient. By utilizing flexibility, it is possible to connect more customers to the grid more quickly.

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To communicate these messages effectively, we have hosted webinars to present the flexibility markets, how to participate and explain their benefits. Additionally, we have participated in industry events specific to the markets to convey the message locally, issued press releases to inform and engage a broader audience, updated our website with user-friendly information, and engaged in dialogue with several potential flexibility service providers (FSPs) to discuss opportunities and gather feedback. The conclusion from these efforts is that there is significant interest in flexibility markets, primarily driven by the monetary value and potential revenue streams that flexibility can provide.

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6. Local Flexibility Market and Product Design

6.1. Background

During different times of the year, electric grids can be more, or less congested. As the electrification of society is increasing grids needs to be reinforced, which can take a long time. A way to speed up the electrification is to utilize the electric grids more efficiently, which also offers the possibility to connect more customers to the grid as well, by leveraging flexibility.

Flexibility means shifting grid usage in time, i.e. moving consumption or production to another time of the day when the grid is less congested. This action is performed by the grid customers, i.e. consumers or producers of electricity, also called FSP (Flexibility Service Provider).

A Local Flexibility Market is a digital marketplace where a DSO can post / notify the market about an upcoming congestion, thereby recruiting customers to take part of the market and support the grid with their flexibility.

In order to do so there are different flexibility products for the FSP's to consume through the marketplace. These products are built to support different needs that the DSO may have and is normally shaped around the need of knowing when FSPs can be available to be flexible, as well the actual shift in time of grid usage.

Over time different Local Flexibility Markets have been established in different geographical areas to manage congestion, through products that have been developed over time to suit the grid needs.

Findings and feedback from the DSO perspective as well as from FSP's has been gathered from continuous dialogues throughout market seasons as well as retrospectives with FSP's, on current existing flexibility products and markets and their respective characteristics - with the purpose of gathering as much feedback and data as possible to continue developing the flexibility products and markets in order to match both the DSO's and FSP's needs in a good manner.

Another finding from previous seasons is that the administrative tasks when recruiting FSP's, for instance drafting and signing agreements, could mean an increasing operative load for the DSO as flexibility interest and market activity increases over time.

6.2. Markets 2023/2024

During the winter season 2023/2024 successful markets in different geographical locations in Sweden has taken place. Customers are waiting to connect to the grid in more locations and the need to shave peak loads is increasing.

During the first winter of the north EU demo establishment of three flexibility markets have taken place; *Hässleholm, Southern Skåne, and Stockholm*. A strategic initiative to address capacity challenges. These markets enable a more efficient use of existing grid infrastructure and support the integration of renewable energy sources.

As stated in section 4.2.2, The communication has mainly focused on the educational part of why the markets have been established. Reasons such as the rapid electrification of society requires significant grid expansion, which is time-consuming. By leveraging flexibility, more customers can transition to renewable energy sources without waiting for extensive grid reinforcements. A substantial portion of a DSO's climate impact arises from grid expansion. Flexibility helps to use the grid more efficiently, reducing the need for additional infrastructure and thereby minimizing environmental impact. By utilizing flexibility, it is possible to connect more customers to the grid in a shorter time frame.

6.2.1. Market prerequisites and compensation principles.

During the initial phase of the project, there have been details presented during the webinars conducted prior to the opening of the flexibility markets. The webinars aimed to educate potential participants about the specific requirements and structures of the flexibility markets in Hässleholm, Southern Skåne, and Stockholm, as well as to explain the compensation principles and operational mechanics.

Hässleholm

- **Flexibility Requirement**: 2 MW
- **Duration**: 90 hours
- **Minimum Resource**: 0.1 MW
- **Minimum Duration**: 1 hour
- **Procurement Method**: Direct procurement
- **Trading Platform**: SWITCH
- **Season**: November 1, 2023 – March 31, 2024

The local flexibility market in Hässleholm required a total of 2 MW of flexible capacity over a 90-hour period. Participants had to be able to provide at least 0.1 MW of flexibility for a minimum duration of one hour. This market operated on a direct procurement basis, utilizing the SWITCH trading platform.

Southern Skåne

- **Flexibility Requirement**: 10 MW
- **Duration**: 100 hours
- **Minimum Resource**: 0.1 MW
- **Minimum Duration**: 1 hour
- **Procurement M**ethod: Direct procurement
- **Trading Platform**: SWITCH
- **Season**: November 1, 2023 – March 31, 2024

In Southern Skåne, the flexibility market sought 10 MW of flexible capacity over 100 hours. Similar to Hässleholm, the minimum resource requirement was 0.1 MW with a minimum duration of one hour. This market also operated on a direct procurement basis through the SWITCH trading platform.

Stockholm

- **Flexibility Requirement**: 0.5-1 MW per market
- **Duration**: 80-160 hours
- **Minimum Resource**: 0.1 MW
- **Minimum Duration**: 1 hour

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- **Procurement Method**: Direct procurement
- **Trading Platform**: NODES Market
- **Season**: December 1, 2023 – March 31, 2024

The Stockholm flexibility market required between 0.5 MW and 1 MW of flexible capacity per market, with a total duration ranging from 80 to 160 hours. The minimum resource requirement was 0.1 MW for a minimum duration of one hour. This market operated on a direct procurement basis using the NODES trading platform.

Compensation Principles for Hässleholm & Southern Skåne For the markets in Hässleholm and Southern Skåne, the compensation principles are straightforward:

- **Activation:** There are currently no penalties for not delivering flexibility. However, participants are compensated based on the percentage of flexibility delivered compared to what was promised. For instance, if 1 MWh was traded and 0.8 MWh was delivered, the participant would receive 80% of the delivery compensation.
- **Availability:** If a participant has committed to being ready to deliver flexibility but cannot do so when called upon, they forfeit their availability compensation. Additionally, if less than 50% of the promised flexibility is delivered, the availability compensation is forfeited.

These details were shared to ensure transparency and to encourage participation by clearly outlining the benefits and requirements associated with these flexibility markets. The webinars served as an essential platform to engage potential FSP's, explain the operational mechanics, and answer any questions to facilitate a smooth and informed market entry.

6.2.2. Product: Availability Orders

Availability Orders is a product that is intended to secure an FSP's possibility to be available to deliver flexibility, i.e. with help from weekly forecasting the DSO can advise FSP's when they are expected to be ready to deliver. If needed the DSO activates the flexibility that the customer has offered.

FSP's participating with Availability Orders receive a fee for being available as well a fee if they also deliver actual flexibility.

For the product Availability Orders specifically, the procedure in previous seasons has been laid out in such a way that FSP's were selected according to the principle "first come, first served". This is not compatible with Swedish public procurement principles. To remedy this, recruitment of FSP's has taken place through direct procurement. This has meant a max price on how much flexibility in total could cost through this product of SEK 1,200,000 per market, i.e. the direct procurement limit.

Recruitment of new FSP's during the course of the season has also been an issue, as well that FSP's haven't been able to vary their activation price for different hours.

The trading times for Availability Orders have worked well from a DSO perspective, but have somewhat collided with other markets, which in turn meant that FSP's have had to choose which market to participate in and actually deliver on.

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The term Guaranteed fee (Swe: Garantiersättning) within this product, with the purpose of giving FSP's an indication of how much flexibility will be needed and what the compensation could be, has created some confusion leaving certain FSP's thinking this was a guaranteed income just by participating in the market.

6.2.3. Product: Seasonal Availability

Also, for the product Seasonal Availability direct procurement has been followed instead of utilizing a public tender. Again, the direct procurement limit of SEK 1,200,000 per market applied.

Seasonal Availability is a product that gives the DSO good conditions from a grid perspective as this product means that FSP's indicate their availability in advance and for an entire season. However, it has proven to be a big step for FSP's to take, especially new ones, based on the aspect of needing to be available so much so often over such a long time. It is, on the other hand, a product that FSP's with energy storage would like to use as their resources are highly planable, but not as many have been able to work with due to an endurance requirement of 4 hours if they are to meet the requirement of at least 0.1 MW at the same time. In addition, it has been found that the endurance requirement of 4 hours has been more difficult to work with in other aspects as well, as FSP's also lock up a block of hours and thus miss out on potential compensation from other markets, e.g. FCR-d from Swedish TSO Svenska kraftnät.

6.2.4. Product: Free Bids

The product Free Bids is a product intended to be easy to participate with. As an FSP there is no need to be available, therefor no requirement to deliver actual flexibility. Instead FSP's can participate with short notice and deliver flexibility as they see fit.

For this product the assessment has been that the procedure is sufficiently compatible with Swedish public procurement principles and that every order on the market can thus be seen as a direct procurement, thereby also adhering to the direct procurement limit of SEK 1,200,000 per market.

However, the product is not compatible with Swedish public procurement principles out of the perspective that the FSP's has been the ones that submit their bids beforehand of the actual need for flexibility from the DSO has been communicated.

Also, for that reason FSP's have been more reluctant to use Free Bids to the same extent as other products, as some experienced it as "bidding blindly".

6.3. Proposed development

The processes of recruiting FSP's and setting up and managing markets needs to be more digitalized and automated, as an increase in interest as well as increase in need of markets means manual processes needs to be replaced in order to remain swift as well keeping down operative costs, an overall more sustainable solution for everyone.

Also, in order to be able to pay more than SEK 1,200,000 per product and market a public tender or a digital procurement system (Swe: Dynamiskt Inköpssystem, abbreviated as DIS) can be utilized.

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Work is ongoing looking into the legal requirements of DIS and public tender and what this means in terms of product-, platform- and market development.

Following a pre-study last year, a project of scaling up and implementing Non-firm Connection Agreements (Swe: Villkorade Avtal) has also taken place which further built on the need of investigating more flexibility potential and markets in order to shorten connection requests queue and further enable the electrification of society.

6.3.1. Markets development

Ongoing initiatives support the analysis of flexibility potential within the grid, assessing whether flexibility can meet the grid needs. Evaluating the value of flexibility compared to other possible grid solutions is essential. These initiatives involve designing, changing, and implementing processes to support ongoing operations. The goal is to continuously investigate existing and new markets at an improved rate to be as proactive as possible.

Additionally, FSP’s have asked to understand market longevity better, i.e. the total running time for a specific market from when its set up and implemented to when it may not be needed anymore. This can be cumbersome to indicate due to lack of data from incoming projects, population growth etc. however we aim to be more transparent about this and communicate it clearly when setting up markets. This transparency allows FSP’s to understand the return on investment (ROI) of flexibility better. For the recently announced markets, this has been communicated effectively.

Bålsta A flexibility market is ongoing in Bålsta to help meet future energy needs until at least 2029.

Enköping (New!) A new flexibility market is being established in Enköping to secure the area's energy needs and growth until at least 2029.

Hässleholm In Hässleholm, a major grid reinforcement is underway, expected to be completed by 2028 at the earliest. To ensure the connection rate of new customers, we are building a flexibility market to act as a buffer. This market is open at least until 2028.

Kallhäll (New!) A flexibility market is being established in Kallhäll to support growth and electrification. This market is active until at least 2027.

Kungsängen (New!) The flexibility market in Kungsängen aims to secure continued growth and electrification until the physical capacity is expanded. This market is active until at least 2027.

North-East Skåne (New!) To support growth and electrification, a flexibility market is being launched in North-East Skåne around Kristianstad. Active until at least 2028, this market covers Torsebro, Vinnö, Önnestad, Kristianstad C, Knislinge, and Broby.

North Örebro (New!) The flexibility market in North Örebro aims to support continued growth and electrification by optimizing and streamlining the electricity grid in Örebro. The market will be active until at least 2030.

Southern Skåne The flexibility market in Södra Skåne aims to build up the amount of available flexibility proactively. The need is expected to increase rapidly with the region's expansion. This market is open at least until 2029.

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Vaxholm E.ON operates a flexibility market in Vaxholm to support the area's energy needs and growth until at least 2027.

These initiatives and the establishment of flexibility markets across these regions aims at enhancing grid efficiency and ensuring that the energy infrastructure can meet future demands. By communicating market longevity and potential ROI, we aim to engage more participants and increase market liquidity.

6.3.2. Availability Orders

For the product Availability Orders, the proposal is to align trading times with other markets, such as FCR-d at Swedish TSO Svenska Kraftnät (clearing at D-1 00.30), with a clearing at D-2 18.00.

Another proposal is to remove the term “Guaranteed compensation” (Swe: Garantiersättning) to avoid further misunderstandings, still indicating market needs as FSP’s value this kind of transparency.

Since the existing principle ”first come, first served” isn’t compatible with Swedish public procurement principles the proposal is the replace with the principle ”lowest bid wins”, which is a model that is also fairer since it gives better competitive opportunities in between FSP’s. This principle means that every bid received by the DSO is compared to one another from a price perspective, and the lowest bid is the one that is appointed actual delivery of flexibility.

6.3.3. Seasonal Availability

For the product Seasonal Availability, the proposal is to have a shorter requirement for endurance that can be set individually per market period as well as conditions on when recovery of the FSP’s asset can be performed, depending for instance on if there are still peak loads in the grid during the block of hours that has been requested to be available.

At the same time the proposal is to have a mechanism that premiers FSP’s with longer endurance, meaning their bid weighs heavier than the same bid from an FSP with shorter endurance – and informing about this method of selection in the market terms and conditions.

Another proposal is to remove the barrier / demand that FSP’s cannot participate in other markets during the block of hours that has been agreed upon. This may in its turn mean that if an FSP with a shorter endurance than asked for provides a bid (for instance for just one hour when the need is for four consecutive hours) that they cannot participate in and be compensated from other markets as they agree to a longer block of hours.

6.3.4. Free Bids

For the product Free Bids, the proposal is to change the method so that the DSO publishes the needs onto the market before bids can come in, thus making the product compatible with Swedish public procurement principles. This in its turn means implementing trading times where FSP’s, like the product Availability Orders, has a time window where they can leave bids onto the market.

The proposal is that this time window is D-2 18.30 until D-1 08.30 for DayAhead trading and D-1 15.00 to H-4 for IntraDay trading, and clearing done DayAhead at D-1 09.00 and IntraDay at H-3.

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6.3.5. Product name changes

From a product naming point of view feedback has been received that products Availability Orders and Seasonal Availability can be mixed up, due to similarities in their respective names and characteristics.

Another finding from interactions with FSP's is that not many actually remember the names of the different products. Different DSO's can use different platforms which for that reason means products could have different names, which could further complicate for FSP's to remember it all.

Some FSP's participating on local flexibility markets have started using the abbreviation LFM (short for Local Flexibility Markets) in different contexts to explain what market they participate in.

Parallel to this there are ongoing discussions on standardizing products on a national level so that FSP's that participate on different geographical markets more easily can participate in new and more markets, and that standardizing names of the products would make sense both from a DSO as well an FSP perspective.

Looking at Swedish TSO Svenska kraftnät they have a ”naming convention” for their products where the abbreviations explain on a high level what the respective product is intended for (eg. FFR, FCR-d etc.).

The proposal is to rename products with a similar "naming convention" as Swedish TSO Svenska kraftnät.

This would both mean we align markets and create a more understandable bigger picture but also achieve same naming nationally which is beneficial for all DSO's and their respective FSP's. For that reason, a nomination of names started during 2024 and is ongoing with a goal to decide new names during the year.

6.4. Risks with proposal

What are the greatest risks of implementing these changes?

- Risk that conditions on recovery is hard to follow up, requires real time measurement to work 24/7.
- That FSP's feel that terms and conditions for participating on markets are constantly changing and requires new efforts from their operations.
- That the complexity increases for the DSO as well for participating FSP's.
- That development of the products-, markets- and platform isn't possible from a time perspective before the coming season.

6.4.1. Alternative solutions

Reviewing products used in other platforms and other DSO markets is worthwhile. Doing this could mean the need of developing whole new products. After having done market reviews of this kind the decision is not to implement brand new types of products, but continue looking into what is offered on the wider market in order to catch those perspective as well.

This type of collaboration in between DSO's and market operators is very much needed, not just by looking at the need of having standardized products on a national level, according to the regulation 2019/943 (EU).

Alternatives to developing products would be to keep using the existing products as they are, thus needing to stay below SEK 1,200,000 and continue with direct procurement as a public tender has other demands and requirements.

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Alternatives to flexibility markets could be non-market-based solutions such as Non-firm Connection Agreements (Swe: Villkorade Avtal). This means customers can be connected, or get an expanded connection, to the grid even though the area may be congested by leveraging conditions in the agreement that stipulate how much capacity can be guaranteed and how much could be steered, either up or down, as well how the steering is done and an estimate of how often this may happen for the customer.

Customers that have a Non-firm Connection Agreement can if they want to also choose to participate in Local Flexibility Markets, which enables the market-based option for them, as well provides a possibility of being reimbursed for being flexible as well getting a proactive notification on when a congestion time period may come.

If a customer with a Non-firm Connection Agreement chooses not to participate in a Local Flexibility Market they will be steered as a last resort if there isn't enough market-based flexibility to utilize. In an event like this the customer isn't reimbursed.

If a customer with a Non-firm Connection Agreement instead chooses to participate in a Local Flexibility Market they can "jump the queue", i.e. instead of being steered as a last resort as Non-firm Connection Agreements are non-market-based solutions (mentioned above), they can participate in a flexibility market, and therefor with a market-based solution, and could match DSO capacity needs with a potential to have the winning bid and therefor be reimbursed for their market-based flexibility. The bid needs to partly or fully match the DSO capacity needs just like any other bid in the flexibility market, which means it does not need to be matching the conditional capacity the customer have in their Non-firm Connection Agreement.

This means the customer can choose to support the market-based needs and could lower the cost for flexibility as we have more FSP's than otherwise, meaning more competition in the markets.

Regardless this is a potential overall win-win for everyone involved, i.e. the DSO, the customer with a Non-firm Connection Agreement, other FSP's as well the overall customer base of the DSO.

A Non-firm Connection Agreement is intended to be a temporary solution up until the grid conditions have changed and in accordance with Energimarknadsinspektionen DSO’s in Sweden needs to investigate the possibility of resolving the congestion with market-based solutions (for instance Flexibility Markets) before activating non-market-based ones, i.e. before actually steering a customer with Non-firm Connection Agreement.

6.5. Plan for execution

The changes needed for the products means needing to develop the platform E.ON Switch in many ways, for instance one being that FSP’s should be able to qualify their organization and resources in a new and digital way when implementing a system like DIS. Another big change is how the platform supports more parameters such as endurance and recovery, both from a resource qualifying perspective but also seen to how the platform handles bidding, and comparation of bids. Swedish public tender requirements say all bids must remain fully anonymous and non-disclosed for everyone up until the moment of clearing when the platform selects the lowest bid (or bids) that matches the need that the DSO has. At the moment of clearing the platform needs to go through all bids that have come in and sort out the ones that fit the needs of the grid in the most cost conscious way, whilst at the same time handling multiple products that can coincide

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within the same congested period, where some bids should be compared to one another looking at parameters such as endurance and also looking at recovery period if the congested period lasts for the consecutive hours.

There are also other changes needed from a platform and market perspective looking at information we present, where/what/when/how? not only new trading times for the products. The information needs to be digitalized even more, and be presented partly in the platform, partly on the web as well in documents. Guides and other material how to participate in local flexibility markets needs to be created as well, in order to support scalability best possible and not create a bottleneck within support functions.

Looking at the benefits of doing this the decision is to move forward and focus on the development from all perspectives, with a goal to have it all ready until market start 2024/2025. This could mean tough prioritizations in functionality is needed in order to ensure critical deliveries.

One important change is that 'Guarantee hours' (part of 'Guaranteed compensation, in product Availability Orders) will now longer be a parameter in the product but instead be set by the market responsible when setting up the market itself, i.e. indication and communication of the market needs.

Changing the product Free Bids to a type of Availability Order (but as an energy product and not a capacity product, i.e. no compensation for availability, just for flexibility) that can be used closer to the actual hour of need is slightly easier as we have much of the parts already in place by looking at the current Availability Order product.

As for investigating new potential markets the way of working that has been implemented is both to reactively respond to requests from a DSO perspective, i.e from the organization and its customer requests, as well proactively looking at different locations in the grids and forecast what may happen in the coming years, including known projects, urbanization and other parameters. Getting these types of forecasts accurate means quite a lot of work with data, both short-term as well long-term (up to 10 years ahead) looking at high-, mid- and low load scenarios.

Current focus is on power transformers from 130kV and below where congestion management is needed, and will expand on that scope with time. The methodology is to look at the risk classification of the object at hand (i.e. currently power transformers) and from that look at both N-0 and N-1 scenarios. If scenarios exceed 100% load on the object at hand, it's recommended to proceed with looking at the potential for a flexibility market in that location. This is done both as a qualitative run-through of what kind of known customer base there is in that given location, that could be suited to be FSP's (e.g. larger real estate/housing complexes, municipalities etc.), but also a data-driven process of assessing potential of aggregated resources.

It's also recommended to look at what a flexibility market could mean in terms of postponing a re-investment in the grid, i.e. postponing a replacement or upgrade of a power transformer for instance.

All this input can be reviewed and provides the material needed to decide whether or not a flexibility market should be set up, as well how long it would be active, ultimately providing both the potential and value of flexibility.

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6.6. Summary and recommendations

The investigatory work with DIS has shown the implementation to be bigger than originally thought. There are not any apparent showstoppers but implementation may not be done until market start 2024/2025.

Regardless DIS is implemented or not, the new products provide the opportunity to be compatible Swedish public procurement principles as well the possibility of also keep working with direct procurement if needed. Development of the products and their respective characteristics is ongoing with the goal of having development completed before markets start.

Therefor the recommendation is to utilize these new products and work on also implementing DIS so that the way of working with new markets and recruitment of FSP's is as digitalized as possible.

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7. Platform Development and Integration

7.1. SWITCH

Originally developed as a demonstration test bed within the CoordiNET project [9] during 2019-2022, the E.ON-developed SWITCH platform has been repurposed for deployment in BeFlexible. SWITCH is a cloud-based platform running on Azure, with multiple REST APIs and a web user interface. It is designed to be scalable, highly customizable and user friendly. For additional details on user experience, functionalities, and setup of the platform, see the final CoordiNET report referenced above.

Platform data model and high-level architecture has remained the same since 2022 when the Coordinet project was finalized. Learnings from pervious market seasons revealed some limitations in the implemented market design and flexibility products. Consequently, a redesign of the platform was initiated early 2024 to be launched before the winter market season of 2024/2025. The following sections outline usage and development of the currently deployed version of SWITCH, while the reworked platform will be described in future reports.

7.1.1. SWITCH fundamentals

To enable trading and management of various flexibility products, there are some key components needed:

1. **Infrastructure and configuration of organizations, users, markets etc.**
   Website hosting, IT operations and databases are built to work with the Microsoft Azure cloud service and .NET software framework, with a backend written in C# (a common programming language for Azure-based applications). Users are authenticated through Azure active directory integration and can login from a publicly available portal. Access rights to various operations can be configured for individual users or API clients. Users can belong to one or multiple organizations, typically either as an FSP or DSO representative. Most configuration of markets, substations and resources can be done by designated organization administrators, while setup of meters (for data handling) and organizations (to manage what features and functionality that are activated) must be done by a platform administrator.
2. **Storing and usage of time-series data**
   To automate monitoring and validation of flexibility as well as the prediction of grid needs, fast and accurate handling of real-time and forecast data values is essential. For most use cases this data is pushed to SWITCH using API endpoints to save different types of time-series data, e.g. momentaneous power meter values or calculated averages for grid substation load. The platform uses meters with one or multiple registers to manage the data flow. Readings (i.e. data values) are stored for prediction, validation, automation and notification purposes, and can be visualized and exported from the UI. Having this data stored and readily available enables systematic operations of flexibility markets, from forecasting substation overloads to verifying flexibility delivery for each participating resource.
3. **Managing substations and resources**
   For any DSO organization, an administrator will need to set up at least one substation, belonging to the DSO, to use flexibility services in SWITCH. Ideally the substation will have both real-time monitoring of power levels and forecast data of future load levels 1 to 7 days ahead. Any resource connected to the

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substation that can provide flexibility services needs to first go through a qualification phase where the DSO approves or rejects the application. Once approved, the DSO and FSP can trade on the market. As mentioned above, the validation of flexibility delivery relies on the availability of accurate and timely data readings for the FSP resources, both real-time and baseline values.

4. **Scheduling and trading flexibility**
   The most direct way an FSP can participate in a market is by selling flexibility according to its availability from qualified resources. This can be done by configuring a weekly recurring order schedule or creating sell orders via API endpoints. Scheduling allows for inputting a minimum and maximum quantity range (in MW for each hour) and a price for activating and delivering flexibility. The sell orders are created by SWITCH before the market opens, and the DSO can purchase whatever quantities are needed based on their forecasting and other inputs.
5. **Requesting availability**
   To incentivize proactivity from the FSPs, DSOs can create hourly buy orders for availability, e.g. remunerate the sellers for being ready to deliver flexibility (see also section 5.3.3 for product details). The grid needs can be managed for each substation, and load forecasting can simplify the process of quantifying the congestion issues. FSPs are notified about the created availability orders and can match the requested quantity for each hour according to the availability of their resources. The DSO can then choose which availability to purchase for activation and delivery of flexibility.
6. **Follow-up and settlement**
   After each flexibility delivery, the market order data is compared with real-time metering and baseline values for the FSP resource. SWITCH will calculate a delivery percentage which can be used for specifying the remuneration, depending on market and product rules. Each order and transaction (i.e., the match between sell and buy orders) can be viewed and exported from the UI through pages showing tables of historic data.

7.1.2. Challenges and learnings in development

Lacking a clear standard or best practice for the design of a flexibility platform, an agile methodology has been chosen to continuously adapt the main feature set of SWITCH, while adhering to national and international law and regulation. In addition, there's been much effort spend to improve functionality and usability in order to accelerate the adoption of flexibility tools in Sweden.

During 2022 to early 2024, multiple challenges were identified and associated learnings were incorporated either into iterations of the platform or in requirements for the next major revision. These include:

Standardization of communication

Feedback from FSPs and aggregators has shown a clear need to standardize communication protocols nationally and provide documentation on integration details. Starting with a national recommendation for the industry to use the communication protocol OpenADR 3.0 for Non-firm Connection Agreements [OpenADR 3.0; 10], implementing standardized systems and tools has been a substantial part of the development effort. This makes the onboarding process for an integrator more straight-forward and predictable, while reducing the risk of too many national variants of communication protocols.

Discrepancies between business needs and platform functionality

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In an inconstant context of platform development, structured feedback loops between business stakeholders and software developers are critical to maintain alignment between overall goals and actual functionality in the platform. Requirements should originate from stakeholder needs and must be understood by developers. Issues of misalignment can be mitigated by increasing the usage of common interfaces between teams or employees involved in the development process, such as shared documentation, requirements, design drafts etc. Another helpful action is to foster engagement and usage of the platform by stakeholders and customers. With rapid feedback, the short- and longterm goals can be clarified and implemented, which in turn increases alignment.

Gaming, data tampering and baseline management

During the market season of 2022/2023, a risk was identified of FSPs tampering with their resource data by e.g. changing their register configuration. To mitigate this, control over created resources was moved to DSOs and functionality for FSP qualification was added. This meant that FSPs could input information about a new resource and send it for DSO approval. Once created, the resource would be managed by the DSO organization (i.e., the buyer) but owned by the FSP organization (i.e. the seller). All resource configuration is editable by the DSO and viewable by the FSP.

Another update was separating the baseline data endpoint to allow for stricter validation, such as not allowing baseline values to be uploaded or changed after a flexibility trade has occurred on the market. This reduces the risk of baseline tampering by the FSP, whether intentional or not. A remaining challenge is the complexity of creating an accurate baseline for some resources, such as EV chargers or heat pump facilities. Empirically, even modern machine-learning forecast models may struggle to reach sufficient levels of prediction performance, due to the randomness of the consumption patterns. This can directly affect the remuneration of the FSPs, while also increasing the workload due to complex data handling. Potential mitigations include allowing simplified fixed baseline levels for qualified resources and moving the burden of baseline generation to SWITCH or the DSO.

Regulatory framework and procurement rules

In addition to the need of structured feedback loops between business stakeholders and software development team, the regulatory framework also sets the stage for aligning platform development with overall goals. As of now, the development of the network code on demand response currently under revision of ACER, will provide additional rules and guidance on how to establish local flexibility markets as well as to align with TSO balancing markets. This new regulation will have an effect on platform requirements as well as the responsibilities and roles of those acting in and operating the markets.

By closely monitoring the outcome of the revision from ACER of the network code, the project is trying to understand the direction in which some platform development requirements are heading.

Aligning with national regulation on how to procure flexibility services has initiated a revision of requirements in the recommendation agorithms for choosing bids. The revision aims to enable configuration of the assortment of bids recommended to the buying organization according to national procurement rules.

However, there are still moving parts which make it important to keep the platform flexible and easily adapted to not yet known requirements due to work in progress regulation, both on EU- and national level.

Hurdles for platform integration of SWITCH users

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Since the benefits of integrating and automating the market operations can be significant, reducing the technological barriers for FSPs has been a specific area of interest in requirements and specification work. Fully automated and standardized communication may also be considered a prerequisite to truly unlock the potential of flexibility solutions, as manual handling is not very scalable for either FSPs or DSOs. As a result of implementing support for availability-based flexibility products, full market integration became more difficult to achieve for FSPs. Alleviating measures such as simplified API endpoints are planned for the upcoming market season (2024/2025).

While collaborating with E.ON EIS on designing an MVP (Minimum Viable Product) for managing the full value chain of flexibility, it was clear that some parts such as the market and product requirements for resources were moving targets. This impacted both the planning phase and development for integration since there were dependencies between product characteristics and the basic communication flows. While it is necessary to continuously improve the market and product design, it is also important to include the FSP perspective as early as possible to reduce the risk of delays in implementing the integration solutions needed.

Based on overall feedback from FSPs and integrators there are clear challenges in understanding what resources and competencies are needed, what steps to do and in which order etc. during the onboarding process. Most of these gaps have been bridged with documentation, guide material and training sessions, but there still remains occasional delays due to misunderstandings or incorrect assumptions from either party. The generalized learning is to not underestimate the efforts needed to streamline the process of platform integration.

Standards for FSPs and market coordination

Related both to national standardization and barriers of entry for FSPs, another challenge is the potential lack of predictable rules and requirements when prequalifying for flexibility markets. As the markets mature, this issue should become less impactful, fostering more widespread adoption of a “flexibility first” mindset from DSOs and increased liquidity from a wide variety of FSPs. Meanwhile much of these impacts can be lessened by continuously adapting the market and product design based on KPIs and feedback from participants, which then directly feeds into the platform requirements and development.

One concrete example would be aligning and coordinating the local flexibility markets with other markets, such as the TSO balancing markets in Sweden. In this case, the TSO is a more mature purchaser than the typical DSO, i.e., the liquidity is more concentrated on their markets. To reduce the risk of unneeded competition or cannibalizing, the local flexibility products can be designed to fit into the existing timeline and allow for value stacking instead of forcing the FSPs to participate in either market rather than both.

7.2. E.ON EIS Development activities

During the D5.1 E.ON EIS have mapped and prepared the needed capabilities in D5.2 for demonstration of aggregation and offset of flexibility to external markets. Current focus is the development of the defined capabilities for deployment in the pilot sites, with priority on flexibility offsets from batteries and heat pumps. Furthermore, the project will demonstrate aggregated flexibility delivery through a partnership with 3rd party service provider, where we are deploying their aggregation and steering capabilities in a bundled service

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offering to B2B customers, to enable aggregated flexibility delivery to both TSO frequency control markets and DSO local flexibility markets.

In regards to the development of digital capabilities in E.ON EIS digital infrastructure, there is on-going development to strengthen the capabilities in the E.ON ectocloud™ platform with focus on ”on-site optimization” behind the meter and preparations for integration potential of ectocloud™ connected flexibility resources to deliver flexibility in front of the meter to the local flexibility markets operated with the E.ON Switch platform. E.ON ectocloud™ is a powerful IoT-platform that provides a range of services to its users. With further integration of the local flexibility market into E.ON ectocloud™, the platform will be able to provide even more value to its users and stakeholders.

7.2.1. Digital development

The integration of the local flexibility market into the ectocloud™ platform will enable the value drivers defined in section 2 by unlocking flexibility offsets from distributed heatpumps and BESS. A project team is activated and development is started based on requirement specification that was elaborated in the project team, with the target to start the pilots in the coming flexibility season 2024/2025. Capabilities to be developed is described in the requirement specification as key “agents”, which each perform various specialized tasks that all together will provide the minimal viable solution to unlock aggregated flexibility offsets. The agents are the Broker, Resource Scheduler, Forecaster, Executer which will enable communication, steering and aggregation of flexibility to Switch. Additionally, a UI for the Flexibility operator will be developed for monitoring and operation of the processes.

For the minimal viable solution, the scope is to develop:

1. A user interface (UI) for flexibility operator to manage, visualize and track the assets and the interaction with flexibility orders from the local flexibility market.
2. Capabilities for communication, scheduling and execution of aggregated flexibility in ectocloud and through the Switch API to secure the flexibility order to the local flexibility market.

7.2.2. UI features for flexibility operator

The UI for the flexibility operator will include the following key features:

- Ability to monitor the flexibility orders on an aggregated level
- Status on ongoing processes according to the process
- Status of all available orders, matched orders, unsuccessful orders on the Switch market place
- Overview of flexibility volumes, revenues on an aggregated and distributed asset level.
- Overview of asset performance
- Delivery and record, status and revenues

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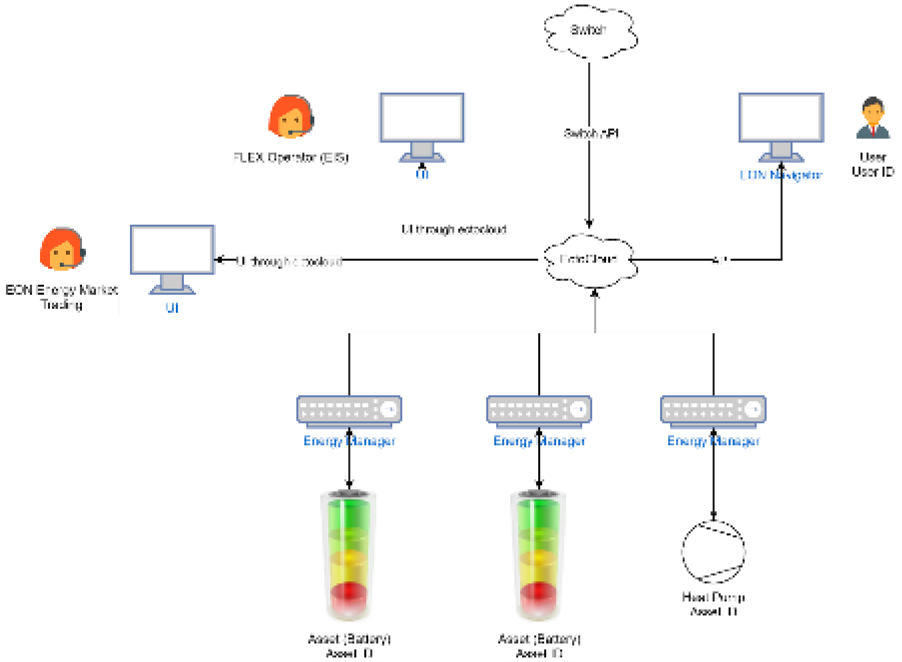

Figure 5: Overview of the UI ecosystem, Scope for fisrts stage minimal viable solution do not include trading and End user UI

7.2.3. Agent Actions

7.2.3.1. Answer an order request

Description:

The broker acknowledge the published order and request the resource scheduler to verify if the order can be delivered from the controlled asset. If positively confirmed by the scheduler, the broker should forward this specific order to the Switch Market for confirmation. If confirmed, the broker should forward to confirmation to the resource scheduler. The resource scheduler should book the corresponding operation schedule.

The resource scheduler must make sure the asset can answer a continuous activation during the order. Even though the real activation can be much shorter, the resource schedule has to schedule the asset by assuming the activation is for all the hours across the order with the ability to deliver on all.

7.2.3.2. Get the results of an accepted order

For the matched order, the activation request will be published. The activation request will include the hours that the flexibility needs to be delivered, e.g. battery asset needs to be discharged with the agreed magnitude stated in the order. The broker needs to retrieve such activation request and pass the information to the resource scheduler. The scheduler can then update the operation schedule.

7.2.3.3. Get the results of activation of an order

During the delivery day (D) of the flexibility offset, the executer is responsible for following the schedule decided by the scheduler at D-1. Operation deviations are anticipated due to the forecast inaccuracies and simulation model inaccuracies.

7.2.4. Deployment and demonstration

The development and deployment team for the coming demonstrations consist of the resources listed in below table and will make sure to develop the requirements for the minimal viable solution and deploy the features in the customer pilots.

Table 2. Overview of development resources engaged in the ectocloud development activities

Role	Responsibility
PROJECT MANAGER	Ensure alignment between development progress and the general development process, in terms of requirements and decision points. Facilitate collaboration and development e.g. product requirement. Participate in key events e.g. review, feedback and guidance to the development team. Backlog and business modelling. Ensure development progress.
PLATFORM ARCHITECT	Enable SW development, develop architecture before SW dev. Onboard developers.
SCRUM MASTER	Facilitate the digital development work in agile process, ensuring effective collaboration, and continuous improvement.
FE DEVELOPERS	Execute the development of frontend capabilities, participate in problem solving / solution creation for the digital development.
BE DEVELOPERS	Execute the development of backend capabilities, participate in problem solving / solution creation for the digital development.
UX DESIGNER	Execute the development of UX capabilities, participate in problem solving / solution creation for the digital development.
SWITCH INTEGRATION	Project engagement, -alignment, API integration. Provides input to the development in terms of flexibility strategy
TECHNICAL DESIGN HW	Ensure technical requirements on BESS and heatpumps for flexibility offsets. Provide assest expertise to ensure compatibility terms of operational and technical dependencies.
TRADING	Ensure process for trading capabilities and management
OPERATIONS	Ensure steering and monitoring of capacity & bidding data, ensure BESS & heat pump performance. Alignment and onboarding of asset owners.
FSP ENGAGEMENT	Customer engagement, recruitment strategies, value propositions and pilot set-up. Ensure plan for scale-up and onboarding of internal/external assets.
PLATFORM MANAGER	Securing overall product and platform strategy and prioritisation.

The first phase of demonstration of delivery to local flexibility markets will span over the comming market season. Activities cover important aspects to take into account when reaching results and determining a way forward for the solution, i.e. everything from software development to business modelling.

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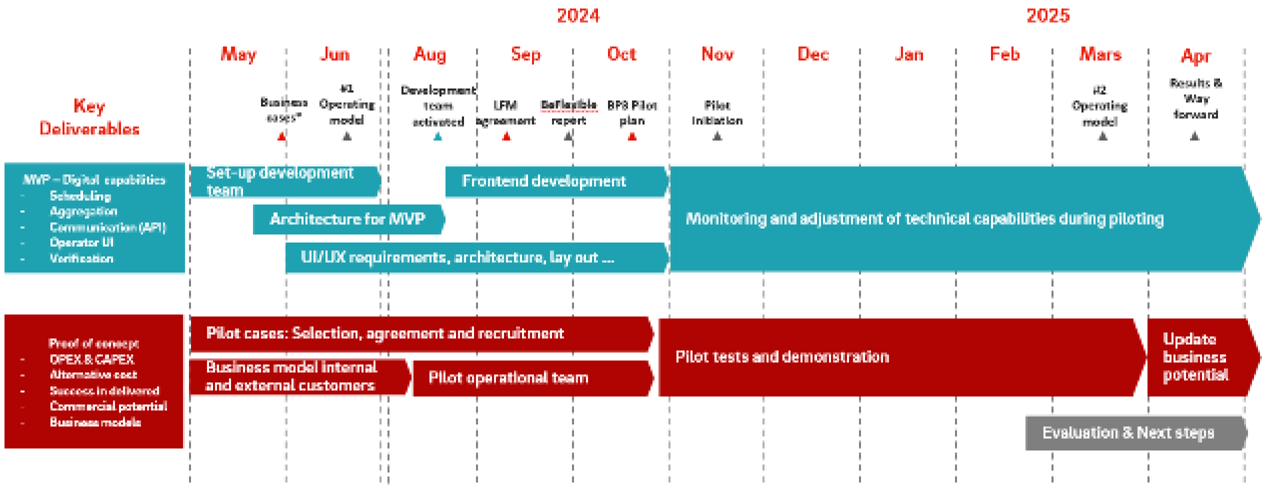

Figure 4: Time plan for development and pilot phase of ectocloud developed capabilities

The project team have ongoing dialouge with nine potential pilot sites with both batteries and heatpumps as flexibility resources. Below are the main objectives and key results stated for the pilot demonstrations;

Objective 1: Prove financial business case and profitability

Key results:

1. Determine business model and price structures
2. Onboard and define pilot and deliver required volumes for stand-by and activated flexibility
3. Assessment of total potential market

Objective 2: Prove technical feasibility

Key results:

1. Automated flexibility allocation and delivery from external and internal single assets at a time (>100kW)
2. Automated flexibility aggregation to deliver from multiple assets at a time (>100kW)
3. Stand-by and activated flexibility delivery from both batteries and heat pumps

7.3. Conclusion

From a Flexibility market platform point of view, creating the environment for well-functioning local flexibility markets encompasses adhering to business needs, law and regulation as well as facilitating smooth onboarding and operations for FSP's. Although the list of stakeholders in platform development can be extended and/or further detailed, the inputs from business, law and regulation, and FSPs are considered to be the main drivers.

Looking ahead, extending and fully realizing the collaboration with E.ON EIS within the scope of BeFlexible is a key focus, which in turn will provide further requirements to platform improvements.

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8. Congestion Forecast Improvement

This section provides a comprehensive exploration into the improvement methodologies in congestion forecasting within power systems. Congestion in power systems is a critical issue affecting the efficiency and reliability of electricity distribution across networks. As demand grows and the grid becomes increasingly integrated with renewable energy sources, the need for precise congestion prediction becomes paramount.

Furthermore, the document evaluates existing forecasting methods being used, identifying potential improvements to enhance accuracy and reliability. It also addresses the challenges faced in forecasting, such as data quality and computational demands, and suggests strategies for overcoming these obstacles.

Through a methodological assessment and the proposal of innovative solutions, this report aims to contribute significantly to the improvement of congestion forecasting, ultimately facilitating better management of power systems, increasing flexibility, penetration of renewables and fostering a more reliable energy supply framework.

8.1. Forecasting Methods

According to the modelling means of forecasting, the prevailing congestion forecasting methods are broadly divided into three categories, namely, physical, statistical, and artificial intelligence (AI). Table 1 shows the description and characteristics of these methods.

Table 3. Congestion forecasting models

Category	Description	Characteristics
Physical	Based on physical principles and measurements. Requires environmental and equipment data.	High accuracy under specific conditions; detailed data input needed.
Statistical	Utilizes historical data to identify trends through statistical techniques.	Data-intensive; less effective in variable conditions.
Artificial Intelligence (AI)	Uses machine learning and neural networks for prediction.	Adaptable, data-driven; computationally intensive.

A. **Physical Methods -** A physical model for forecasting congestion utilizes physical equations and models to predict the output [11]. Physical models consider the fundamental physics and engineering principles that govern the power systems. These models consider the dynamic properties of the atmosphere and utilize a set of numerical equations to mathematically describe and model the physical conditions and their interactions [12].

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B. **Statistical Methods -** Statistical methods for congestion forecasting leverage historical data and statistical techniques to model and predict future output [13]. Some of the commonly used statistical methods in this field include:

- Exponential Smoothing: This method assigns varying weights to past observations, with more weight given to recent data points and gradually diminishing weights for older observations [14].
- Autoregressive Moving Average (ARMA): This method has been extensively used in various applications consistently demonstrating high prediction accuracy [15]. It incorporates two polynomials, AR (Autoregressive) and MA (Moving Average), to predict output based on historical data.
- Autoregressive Integrated Moving Average (ARIMA): This is a widely used method for forecasting time series data; combining three components: autoregressive (AR), integrated (I), and moving average (MA) terms.

C. **Machine Learning based Forecasting -** Artificial Neural Networks - Machine learning approaches can be employed to predict congestions in power systems by analysing weather conditions, historical energy generation data, and additional relevant factors [16]. An artificial neural network (ANN) is a computational framework designed to emulate the structure and function of neurons in the human brain. It is an effective machine learning method used for tasks such as forecasting, pattern identification, classification, and decision-making [17]. The most used ANN architectures include:

- Convolutional Neural Networks (CNNs): A convolutional neural network (CNN) is a type of deep learning algorithm specifically designed for processing structured arrays of data, making it particularly effective for applications in forecasting [18]. The core characteristic of CNNs is their convolutional layers that apply various filters to the input data. This process helps in extracting significant features from the data, which are crucial for making accurate predictions.
- Multi-layer Perceptron Neural Networks (MLPNNs): A Multi-layer Perceptron (MLP) is a form of artificial neural network (ANN) featuring multiple interconnected layers. Each layer consists of nodes connected to sub-sequent layers through unique weights, making MLPs suitable for complex data modelling tasks including time series forecasting. These networks have been proven effective in universal approximation and nonlinear modelling [19], with utility in predicting temporal data sequences. Even a single-layer MLP, if equipped with enough nodes, can adeptly capture complex nonlinear relationships inherent in time series data. However, expanding the node count within an MLP can lead to complications such as overfitting and training difficulties.
- Recurrent Neural Networks (RNNs): RNNs are frequently employed to analyse sequential data, such as voice or text, due to their ability to maintain a memory of previous inputs, which is critical for processing data sequences with temporal dynamics. These networks are particularly effective in applications such as forecasting, where their ability to predict future events based on past data is invaluable [20]. This paper discusses the Long Short-Term Memory (LSTM) and Gated Recurrent Unit (GRU), which are specific types of RNNs optimized for tasks like forecasting, due to their enhanced ability to capture long-term dependencies in data sequences.

Long Short-Term Memory (LSTM) is a powerful tool for time series forecasting tasks, especially when dealing with long-term dependencies [21]. Its internal architecture allows it to selectively retain or discard

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information from the input, ensuring that relevant information is propagated through the network while irrelevant information is filtered out [22].

Gated Recurrent Unit (GRU) is a type of RNN that is also commonly used for time series forecasting tasks. The GRU is designed to help overcome the vanishing gradient problem that is commonly encountered in traditional RNNs [23]. The vanishing gradient problem occurs when the gradients in the backpropagation process become very small, making it difficult to update the network weights. The GRU accomplishes this by introducing gating mechanisms that allow the network to selectively update and forget information [24].

The forecasting methods used for this task are:

8.2. RWTH Forecasting Model

Probabilistic Forecasting using Artificial Neural Networks - Probabilistic congestion forecasting using ANNs involves predicting a range of possible outputs and their associated probabilities, rather than a single value. This method enables the generation of detailed forecasts that provide not just predictions, but also the uncertainty bounds of these predictions.

A Recurrent Neural Network (RNN) to predict day-ahead time-series and prediction intervals for residual loads [25]. A detailed breakdown of the methodological approach used in the task is given below:

Model Architecture

The RNN used in the task follows an encoder-decoder architecture, which is a common setup for time-series forecasting problems:

Encoder: The encoder part of the RNN processes input sequences from historical data, which includes historical load data and relevant variables such as weather conditions. By sequentially processing this data, the encoder captures important temporal patterns and dependencies, compressing this information into a high-dimensional state vector.

Decoder: Following the encoder, the decoder uses the state vector to generate predictions for future time steps. It systematically unpacks this state, integrating additional predictive inputs (like upcoming weather forecasts) to enhance the accuracy of its output, which are the forecasts for future grid loads. The architecture of the forecaster is shown in Figure 1.

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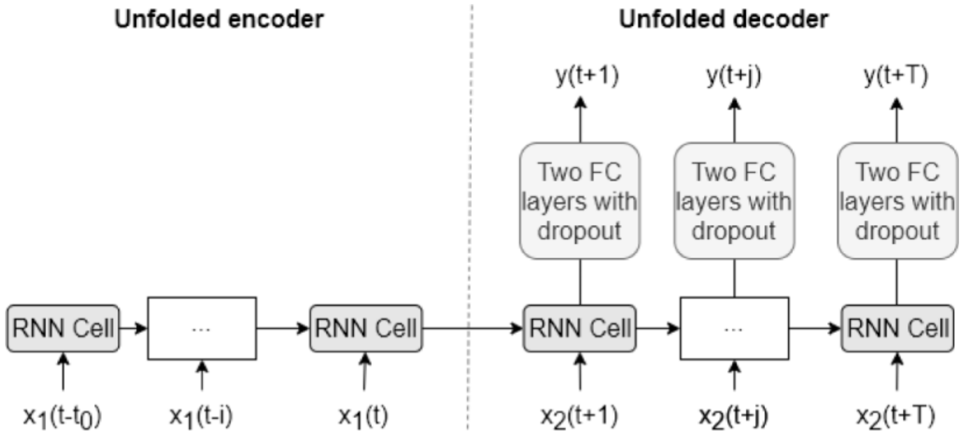

Figure 5: Architecture of the RNN

Input Data

The model utilizes various types of data:

Historical Load Data: Measurements from grid operations that provide a basis for understanding typical load patterns helps the model learn typical consumption patterns and identify deviations likely to cause congestion.

Weather Data: Includes temperature, wind speed, and other meteorological factors that significantly affect power usage and generation.

Predictive Data: Future weather forecasts and planned grid operations are also used as inputs, providing the model with a forward-looking view that is critical for predicting potential congestions before they occur.

Probabilistic Forecasting Approach

The method uses a probabilistic approach to load forecasting, which involves predicting a distribution of possible outcomes rather than a single point estimate. This is crucial for managing grid congestion as it provides a range of possible scenarios rather than a definitive outcome, allowing for better risk management. The methods described include:

Quantile Regression: Used for estimating the boundaries of prediction intervals, capturing the uncertainty in the forecasts.

Gaussian Distribution Assumptions: The model makes predictions based on the assumption that the load distributions follow a Gaussian pattern, where parameters of the distribution (mean and variance) are predicted by the model.

Loss Functions and Metrics

To optimize the RNN, the paper uses specific loss functions that are suitable for probabilistic forecasts:

Ignorance Score: This is used during the training phase to ensure that the model predictions adequately cover the range of actual outcomes.

Pinball Loss: This loss function is particularly useful for quantile regression, helping to fine-tune the estimation of prediction intervals.

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Training and Evaluation

Model Training: The neural network is trained using historical data, where the model learns to minimize the forecast error across multiple scenarios represented in the training dataset.

Evaluation Metrics: The model's performance is assessed using several probabilistic metrics such as the Continuous Ranked Probability Score (CRPS) and the Mean Interval Score (MIS), which evaluate both the accuracy and the reliability of the prediction intervals.

Implementation Details

Hyperparameter Tuning: The model's performance is optimized through careful tuning of hyperparameters, including the size of the RNN layers, the learning rate, and the dropout rate, which helps prevent overfitting.

Software and Hardware: The model is implemented using PyTorch, taking advantage of its dynamic computation graph capabilities for efficient training on GPU-accelerated hardware.

8.3. E.ON Forecasting Model

As a more scalable approach than the previously implemented GRU-type of RNN, during 2023 E.ON developed a forecasting engine based on Temporal Fusion Transformers, or TFT. Originally a Google research project, TFT is a state-of-the-art model designed for multi-horizon time series forecasting.[2] It effectively combines the strengths of RNNs, transformers, and attention mechanisms to handle various complexities in time series data.

8.3.1. Model Architecture

- **Static Covariate Encoder**: This processes static features (features that do not change over time, such as product category or geographical location). It consists of an embedding layer followed by a fully connected network to transform the static covariates into an appropriate representation.
- **Time-dependent Covariate Processing:** This processes dynamic features (features that change over time, such as price, weather conditions). It includes embedding layers for categorical variables and linear transformations for continuous variables.
- **Locality Enhancement via LSTM:** This uses a sequence of LSTM layers to capture local temporal dependencies in the time series data. The LSTM layers handle the sequential nature of the data, allowing the model to learn from previous time steps effectively.
- **Static Covariate Encoder:** The static covariates' embeddings are used to enhance the temporal context learned by the LSTM layers. This is achieved by concatenating the static features to the temporal features at each time step.
- **Temporal Self-Attention Layer:** This layer captures long-range dependencies in the data by using a multi-head attention mechanism. It allows the model to weigh the importance of different time steps differently, thus focusing on the most relevant parts of the time series for forecasting.

[2] See original paper: https://www.sciencedirect.com/science/article/pii/S0169207021000637

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- **Gated Residual Network (GRN):** These networks are used throughout the model to enhance learning capabilities. They consist of several layers, including linear transformations, gating mechanisms, and skip connections, ensuring efficient gradient flow and effective learning of complex relationships in the data.
- **Position-wise Feed-forward Network:** These are applied to the output of the temporal self-attention layers. They consist of fully connected layers with non-linear activations, which further process the information extracted by the attention mechanism.
- **Multi-horizon Forecasting:** The final output layer is designed to produce forecasts for multiple time steps into the future. This layer typically includes a linear transformation followed by an output activation function appropriate for the forecasting task.
- **Variable Selection Networks (VSNs)**: These networks help in selecting the most relevant variables at each time step and for the entire sequence, providing insights into which features are most influential for the model's predictions.
- **Attention Weights:** The attention mechanisms provide insights into which time steps the model is focusing on, aiding interpretability.

8.3.2. Model Workflow

1. Input data (both static and dynamic covariates) are pre-processed to create embeddings and appropriate representations.
2. LSTM layers process the sequence data to capture local dependencies.
3. Static covariates are integrated into the sequence data at each time step to enrich the temporal context.
4. Self-attention layers capture long-range dependencies and interactions within the time series.
5. Gated Residual Networks and feed-forward layers further refine the information.
6. The output layer generates forecasts for multiple future time steps.
7. Interpretability modules analyze the contributions of different features and time steps to the model's predictions.

8.3.3. Application for E.ON flexibility markets

Similar to the RWTH method, TFT is used to predict power load levels for congested points, typically substations of various voltage levels in the local and regional Swedish grid. Due to the characteristics of the transformer-based architecture, the performance can often be increased by including more training data, assuming that the quality is adequate. Several years of power load meter readings provide the bulk of training input, together with relevant historic data from local weather stations.

Once trained, the model uses a combination of real-time power readings and weather data (both actuals and forecasts) to run inference and produce an output of the predicted hourly load of the next 48 hours. This is scheduled to run each hour to give operators and other platform users frequent updates on the expected grid situation. For some prioritized grid points a weekly forecast is also produced, to improve the ability of accurately assessing the capacity needs for the flexibility market. This capability is especially valuable since it unlocks the potential of automating the entire data flow of flexibility: calculating grid needs, creating capacity buy orders, clearing the market, validating flexibility delivery, and finally settlement of seller remuneration for invoicing.

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8.4. Technologies and Tools

The tools and technologies used in the described method for forecasting congestion in power systems are:

8.4.1. RWTH

A Recurrent Neural Network (RNN) with an encoder-decoder architecture is utilized for building a probabilistic forecasting model. The model is implemented and trained using PyTorch, taking advantage of GPU-accelerated hardware for efficient training. To handle uncertainty and produce accurate predictions, techniques such as Quantile Regression and assumptions of Gaussian Distribution are employed. The model's performance is optimized using loss functions like Ignorance Score and Pinball Loss. Finally, evaluation metrics including Continuous Ranked Probability Score (CRPS) and Mean Interval Score (MIS) are used to assess the quality of the forecasts.

8.4.2. E.ON

PyTorch with dedicated GPU is used for training, and the infrastructure is hosted in Microsoft Azure ML studio for quick deployments and seamless integration with the E.ON datalake. Some custom evaluation is done to fit with the specific use cases of flexibility, such as the ability to predict overload events for grid points, i.e. quantifying the congestion issues with enough precision to allow for efficient market operations. Good performance on this particular metric does not always coincide with e.g. MAPE, SMAPE, R2 and other common evaluation methods. What the acceptable boundaries for the overload prediction performance of forecast models in the E.ON use cases are is not yet fully known, partly due to the many aspects of flexibility markets a DSO must consider: how should the value of solving congestion issues be calculated, what are the acceptable risk levels of overloads for e.g. transformers, to what degree can the purchased flexibility be trusted to reduce congestion, etc.

8.4.3. Challenges and Limitations in Congestion Forecasting

Implementing a probabilistic load forecasting model for day-ahead congestion mitigation, discussed in this report, involves several complex challenges beyond those typically encountered in simpler forecasting models. The challenges and limitations are:

Data Quality and Availability

Completeness: Gaps in historical data can significantly hinder the model's ability to learn accurate patterns and predict future states.

Accuracy: Errors in data collection or processing can lead to incorrect predictions, potentially causing suboptimal grid management decisions.

Handling of Non-Stationary Data

Dynamic Patterns: Energy consumption patterns and the influence of weather conditions on these patterns can change over time. This non-stationarity can degrade model performance if not continuously monitored and adapted.

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Model Drift: As energy usage habits evolve and new technologies or policies are implemented, the underlying data distributions may shift, leading to model drift. Continuous model recalibration and retraining are necessary to maintain accuracy.

Computational Complexity

Scalability: As the model scales to cover larger geographic areas or integrates more data sources, the computational load increases. Managing this without significant delays in forecasting requires robust computational infrastructure.

Optimization: Balancing the complexity of the model with the need for fast, actionable outputs is a challenge. More complex models, while potentially more accurate, may be computationally expensive and slow to produce forecasts.

8.5. Improvements in Congestion Forecasting

To propose enhancements to current forecasting techniques, a comprehensive and detailed evaluation of the forecasts generated using existing methods was meticulously carried out. This evaluation aimed to identify key areas for improvement and potential advancements in forecasting accuracy and reliability.

Based on the evaluation report provided, some potential improvements for the congestion forecasting model are given below:

- **Enhance Data Granularity:** From the evaluation, it appears predictions can vary significantly depending on the day and time. Increasing the granularity of data collection, possibly by including more frequent interval measurements, could help in understanding these fluctuations better and refining prediction accuracy.
- **Advanced Statistical Techniques:** The evaluation suggests that error follows a pattern related to the length of the forecasting interval and possibly the time of the year. Using advanced statistical methods such as time series decomposition could help separate seasonal trends, cyclical components, and irregular fluctuations more effectively.
- **Periodic Pattern Analysis:** The analysis mentions a periodic fluctuation with a period of approximately 20 days. Implementing Fourier analysis or spectral analysis could provide insights into these periodic components, helping to forecast based on recognized patterns.
- **Rolling Average and Moving Window Techniques:** To smooth out short-term volatility and reveal underlying trends, applying rolling average and moving window techniques could be expanded. These methods could be optimized to adjust the window size dynamically based on observed error patterns.
- **Systematic Error Correction:** There seems to be a systematic error depending on the forecast period. Implementing an error correction mechanism, such as an adaptive bias correction that learns from past prediction errors, could dynamically adjust predictions to improve accuracy.

8.6. Case Studies and Examples:

Dataset

The dataset is taken from the local grid of the southern parts of Sweden.

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The dataset comprises two CSV files: one containing actual load data and the other containing forecasted load data, both spanning one year. The forecasted load file includes the timestamp when each forecast was generated, forming a continuous timeseries. Each forecast in this file predicts the load one hour ahead of its creation time.

Results

The results are presented in this section. The graphs illustrate comparisons between actual values and forecasts across various days, at each time step. Additionally, accuracy is quantified using the Absolute Relative Error, which is calculated as follows:

$$\frac{\sqrt{(x_i - x_m)^2}}{x_m}$$

where x_i represents the individual forecasted values and x_m denotes the actual measured values. This metric helps in assessing the precision of the forecasts. The results are shown in Figures 2-5.

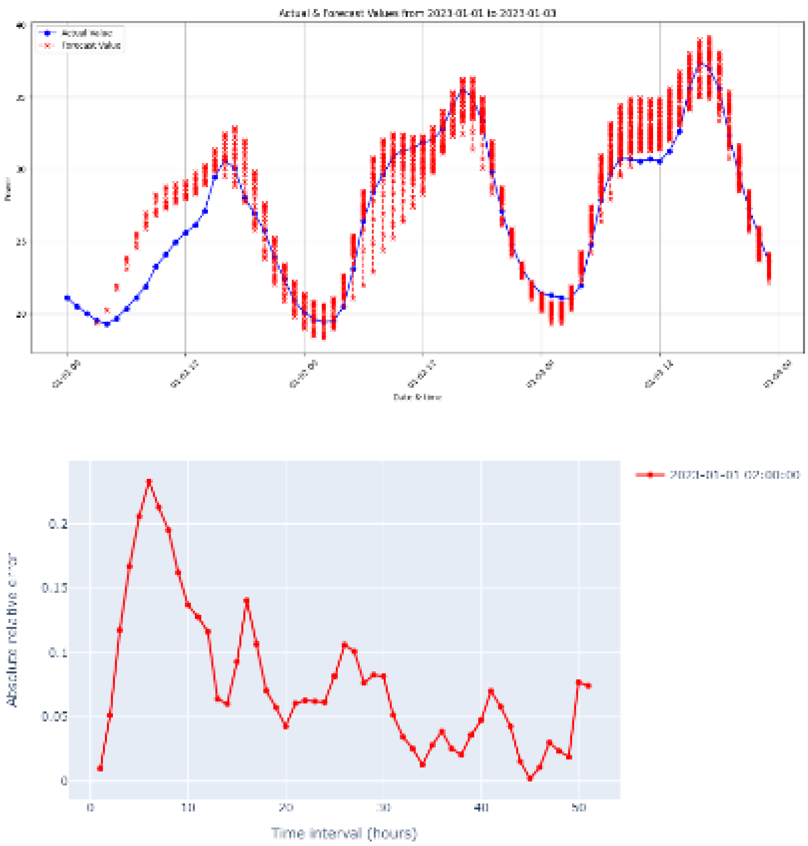

Figure 6: Forecast results and Relative Forecast Error for January 2023

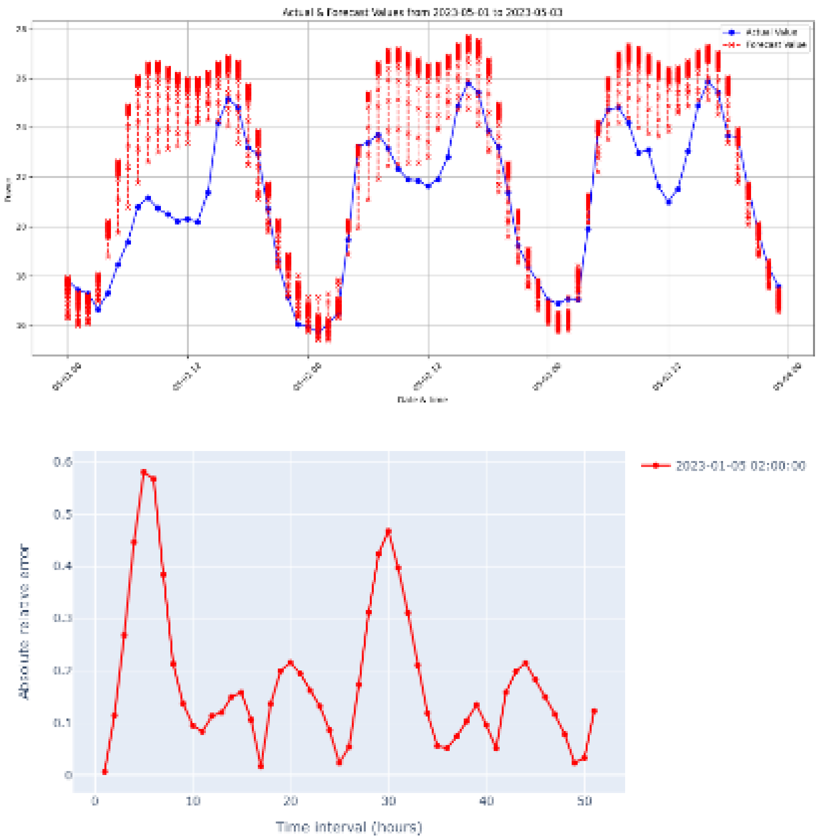

Figure 7: Forecast results and Relative Forecast Error for March 2023

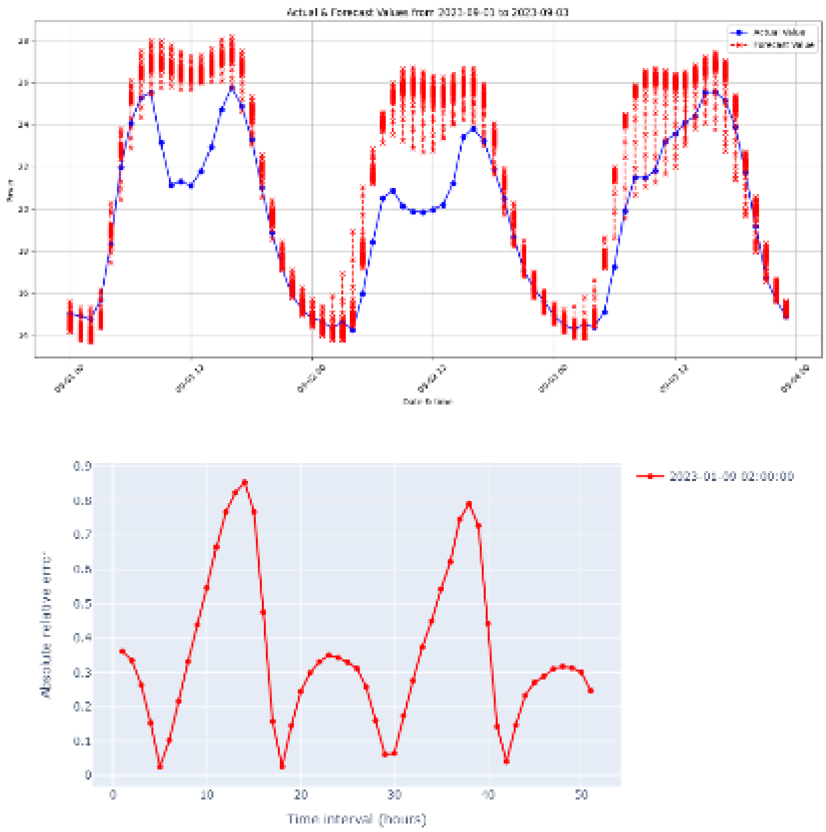

Figure 8: Forecast results and Relative Forecast Error for September 2023

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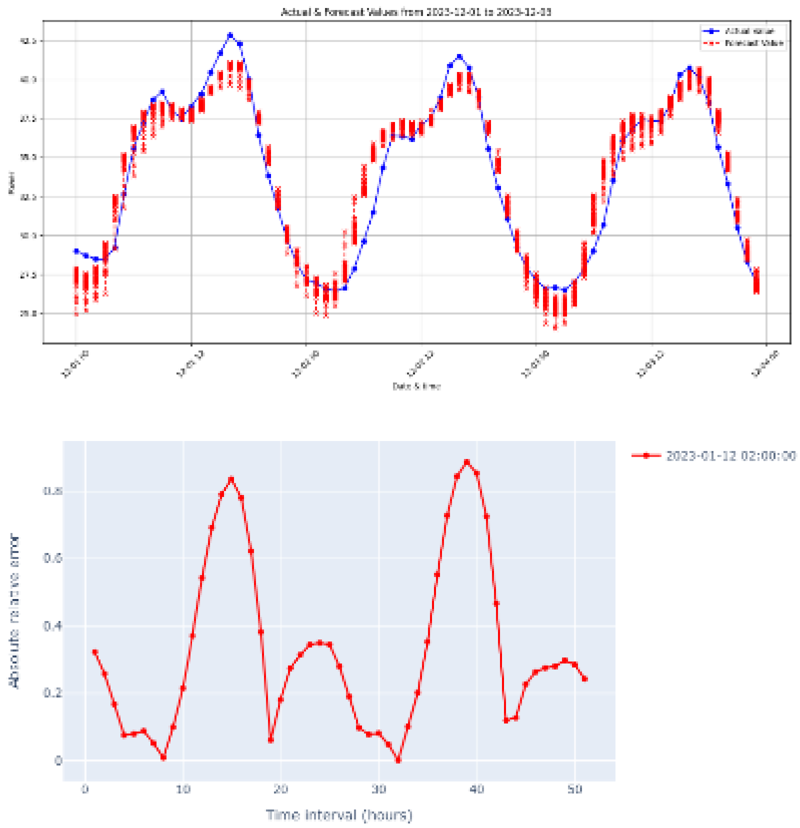

Figure 9: Forecast results and Relative Forecast Error for December 2023

The graphs above provide a detailed visual comparison between forecasted and actual values across different months in 2023—specifically January, March, September, and December. Each graph effectively illustrates the performance of the forecasting model over several days, highlighting the predictive accuracy at various time steps.

From these visualizations, it's evident that the forecasting models have achieved a high level of accuracy, as indicated by the very low Absolute Relative Error values. The small discrepancies between the predicted and actual values suggest that the forecasting model has been significantly optimized for better performance. Moreover, the consistent accuracy across different months and various operational conditions underscores the robustness of the forecasting tool. This consistency is crucial for managing grid congestion effectively, as it ensures that predictions remain reliable over time, regardless of seasonal variations or unexpected changes in grid behavior.

Overall, the graphs demonstrate that the forecasting model not only meets but exceeds expectations in accurately predicting grid conditions. The low error rates are indicative of an effective and efficient forecasting process, reflecting well on the methodologies used and the continuous improvements made in the model. This success points to a promising direction for future enhancements and the potential for even more precise forecasting as the model continues to evolve.

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8.7. Recommendations

- **Continued Data Enhancement**: Increasing the resolution and granularity of data collection could provide deeper insights into the underlying patterns and anomalies in grid behavior. This would involve collecting more frequent interval measurements, as well as expanding the types of data collected, such as more detailed weather conditions or real-time grid usage stats.
- **Incorporation of Advanced Machine Learning Techniques**: As machine learning technologies evolve, integrating more sophisticated algorithms such as deep learning and reinforcement learning could further improve the predictive accuracy of the models. These techniques are particularly adept at handling large datasets and complex pattern recognition, which could be beneficial for predicting grid congestion under varying conditions.
- **Enhanced Error Analysis and Correction Mechanisms**: Implementing more robust error analysis and automatic correction mechanisms can further reduce the forecast error. This might involve developing algorithms that can identify and correct biases or errors in real-time, perhaps through a feedback system that learns from past mistakes.
- **Scalability and Flexibility**: Ensuring that the forecasting models are scalable and flexible enough to be applied to different regions or adapted for various scales of grid management tasks. This involves optimizing computational efficiency and the ability to integrate with different grid management systems seamlessly.

By focusing on these areas, the forecasting systems can continue to evolve, providing more precise and reliable predictions that are crucial for effective grid management and planning. These advancements will also contribute to the overall resilience and efficiency of the power systems, accommodating future challenges such as increased renewable integration, flexibility and changing consumption patterns.

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9. Conclusion: Deployment and Planning

The strategic planning and deployment of the North EU flexibility market demonstration in Sweden relate to new ways of dealing with the growing demands and complexities of flexibility markets. Task 5.1, which focuses on flex market demo preparation, includes activities fundamental to the planning, preparation, and deployment of flex markets within DEMO 2.

The purpose of this report—to guide the strategic planning and deployment of a more flexible and sustainable energy system in Sweden—has been addressed through a detailed analysis of the current market environment, regulatory landscape, and technological advancements.

The comprehensive planning activities for the North EU demo are geared towards successfully preparing and deploying flexibility markets. This involves identifying and recruiting potential Flexibility Service Providers (FSPs), integrating required technologies, and setting up operational frameworks. The structured approach is designed to alleviate inherent complexities and potential delays in all phases. The definition of business models, technologies, and participant roles targets aligning market goals with the operational framework to ensure increased liquidity in flexibility markets. Business models that center around understandings of the FSPs to optimize their flexibility resources are supported by technologies, including AI tools, smart grids, and the SWITCH platform, which facilitate real-time data handling and market operations. Clearly defined participant roles are essential to ensure effective collaboration and contribution to the market. However, practical difficulties may arise when trying to align these components with market requirements and participant capabilities.

One of these difficulties is tendering and recruitment. Therefore, a tender and recruitment strategy is integral to this undertaking, emphasizing transparency and competitiveness in line with Swedish public procurement principles. This includes an iterative process designed for incremental approaches and trial and error of different strategies over the three consecutive years that the pilots will be taking place. This approach aims to refine the methods used in recruitment. However, the competitive nature and selection criteria may limit participation and potentially hinder market liquidity. These approaches, including trial and error methods, are adopted to continue refining and enhancing market operations. For example, pilot tests, stakeholder feedback loops, and performance evaluations are part of this process. The pilots will be run mainly during the winter, a critical period for congestion due to Sweden's cold weather, allowing for testing and adjustments. While iterative improvement is useful, the process can be time-consuming and might face resistance from stakeholders accustomed to more traditional methods. Market testing, performance monitoring, and stakeholder engagement are later stages necessary for upscaling market operations. The pilot phase serves as both a testing ground and an operational process, offering learning opportunities and information, though unexpected obstacles may require adaptive strategies to address them effectively.

It is hoped that the strategies proposed in this paper will spur market liquidity by creating an appealing and profitable market environment for FSPs and other players. Elaborate planning and well-defined business models provide the foundation for participation, but real-world complications may limit their effectiveness.

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In conclusion, Task 5.1 elaborates on the strategic planning and deployment strategies for the North EU flexibility market demonstration in Sweden. It provides a sound framework for dealing with market complexities. However, challenges remain in aligning business models, technologies, and participant roles with market needs. The potential of tendering and recruitment processes to enhance transparency and competitiveness cannot be overstated, but these processes may also slow down participation and market liquidity. Incremental approaches and pilot implementations offer valuable insights but are fraught with practical difficulties. The lessons learned from this demonstration will be crucial for informing the development of future market designs.

Finally, the BeFlexible project not only opens doors for collaboration among various stakeholders but also significantly enhances the quality and reliability of both preparation and decision-making processes. By bringing together diverse perspectives and expertise, the project ensures that all aspects are thoroughly considered, leading to more informed and well-rounded decisions. This collaborative approach reduces the risk of errors, increases the efficiency of operations, and ultimately contributes to the success and sustainability of the task that is increasing the liquidity of flexibility on. In essence, the project serves as a platform for synergy, where collective efforts lead to outcomes that are greater than the sum of their parts.

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12. Appendix

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