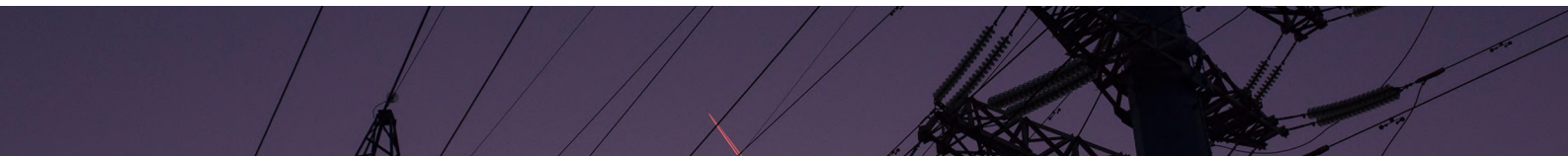


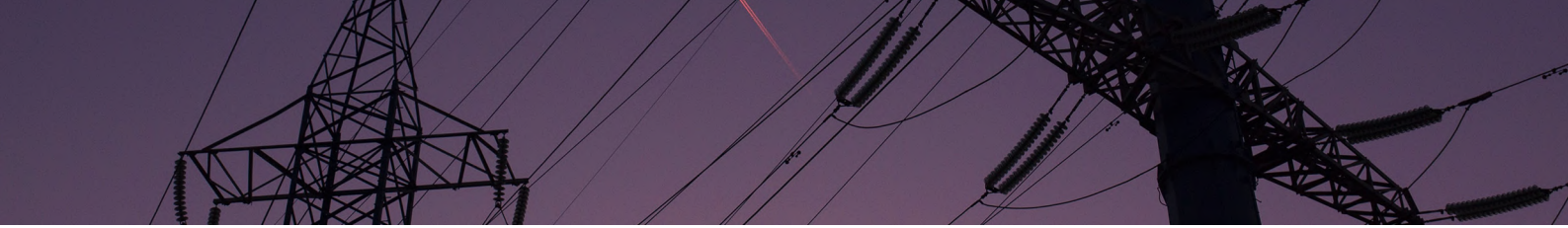
Local flexibility markets

WHITE PAPER FROM POWER CIRCLE



APRIL 2022





Flexibility must be built into the power system

The consumers themselves must be able to participate in delivering flexibility to the system

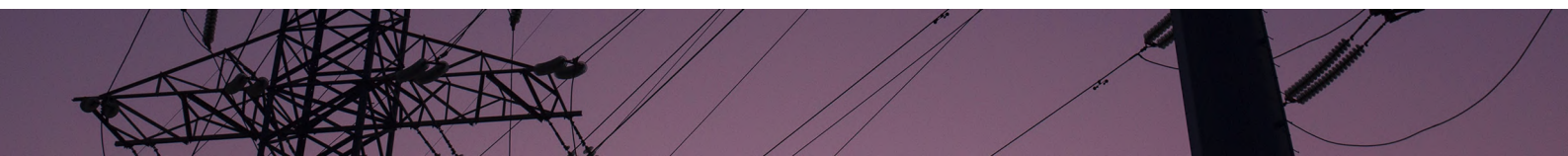
Flexibility Development

In order to achieve full electrification, the government introduced a national strategy¹ for the development of the power system in February 2022. The strategy calls for flexibility, as the future power system must consider the possibility of incorporating flexibility when demands are connected to the grid. This applies not only to the new industries, but also the transport sector with the help of smart technology. The advancing smart charging² infrastructure from transportation and the smart control in electric heating from properties are expected to be important sources of flexibility.

In addition to measures to build flexibility sources into the system, the strategy also suggests for end consumers to participate in delivering flexibility. This can be realized through automation, digitization and communication between the actors in the power system, and encouraged by effective price signals. At the same time ancillary service markets and local flexibility markets needs to be developed. In this white paper, we will provide insights on local flexibility markets: such as which markets exist in Sweden today, who are the stakeholders, what are their incentives to participate, and how the market process works. Furthermore, this white paper will end with an outlook towards the future development of the local flexibility markets.

¹ Regeringen (2022), [Nationell strategi för elektrifiering](#).

² Power Circle (2021), [Vad är smart laddning?](#)



How do local flexibility markets work?

Flexibility resources

Demand side flexibility: Means to regulate and shift the power consumption from the consumers' side or to generate more or less electricity in their facilities per requested.

Energy storage: Such as pumped hydro power, capacitors, hydrogen, battery storage.

Sector coupling: Such as control of district heating or hydrogen production.

Learn more about flexibility resources in Power Circle's previous white papers on [stödtjänster](#), [batterier i elnätet](#) and [vehicle-to-grid](#).

Historically, the main tool for creating grid flexibility has been investing in new power lines. Today, with the access to modern technology, digitization and forecasting models, power system flexibility can be made available in several ways. For example, through flexible resources that can be reduced, increased or shifted within a specific duration. In order to use a large number of flexible resources in grid operation in a technology-neutral and efficient way, local marketplaces for flexibility have been developed and tested in Sweden in recent years.

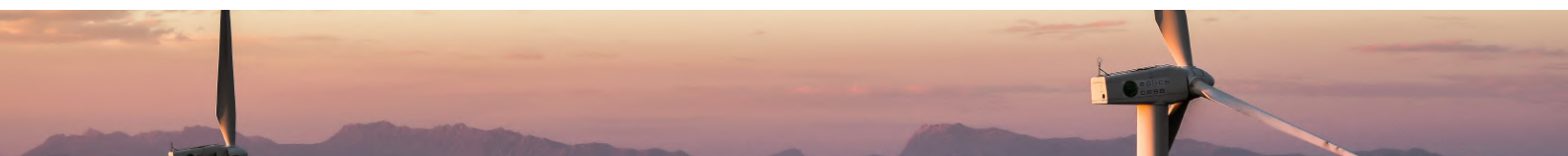
In local flexibility markets, participants with flexibility resources, so-called flexibility providers (FSPs), can trade flexibility as a service to actors in need of power or capacity. Today, the actors who buy the flexibility are mainly the regional and local grid owners (DSOs). The marketplaces are designed and administered by the market operators, who can be both independent participants or a DSO. To partake in trading requires knowledge and time from both the sellers and the buyers. The participants need to have access to data and forecasting tools. And a test trading may be required before an FSP can become active on the market. In the flexibility markets, buyers and sellers then place bids on the desired volume, price and time they wish to buy or sell flexibility.

Abbreviations

FSP: Flexibility Service Provider, flexibility provider. They have the access to flexibility resources.

DSO: Distribution System Operator. In Sweden it is divided between regional grid companies and local grid companies.

TSO: Transmission System Operator. In Sweden it is Svenska kraftnät.





Grid owners need to invest in more grids or buy flexibility for congestion management

Svenska kraftnät sees benefits from end consumers providing more flexibility

Markets stakeholders

Buyers of flexibility

Today, the DSOs are the main buyers on the local flexibility markets. DSOs are increasingly challenged by peaks in power demand, usually in winter, while trying to ensure the supply to their end customers. The amount of electricity that can be transferred is limited both due to the technical capacity of the grid, as well as the subscribed volume from the overhead grid. To avoid penalty when subscriptions are exceeded, DSOs can apply for temporary extended subscriptions when the demand is expected to be high. However, the solution does not work if there is not enough capacity in the overhead grid. In these situations, DSOs need to either invest in more grid components or buy flexibility. Buying flexibility may also be cheaper than increasing the annual subscription, and this is where the local flexibility markets come into the picture.

Svenska kraftnät, the TSO in Sweden, is responsible for power system reliability and grid balancing. To do so, Svenska kraftnät has created its own markets for ancillary services. Some flexibility resources in the local flexibility markets may also contribute to these markets.

Market operators

Market operators manage the marketplace by matching the buying and selling bids. The market operators also perform functions in writing contracts with the FSPs and DSOs, monitoring compliance with market rules, validating flexibility transactions and billing buyers. Currently, market operators receive their revenue from DSOs for operating the marketplaces.





Selling flexibility can generate additional revenue to those with flexibility resources

Aggregators help those with small resources or lack of skills to participate in the markets

Flexibility Service Providers

Flexibility service providers can forecast and control the flexibility resources, by reducing, increasing or shifting demand when needed. By managing the resources, the obtained flexibility becomes a commodity that generates revenues to the providers (e.g., facilities that consume or produce electricity). In order to become a flexibility service provider, the resources must satisfy the markets requirements and create value for a buyer of flexibility. It also need to meet the minimum bid size when entering the bids (today 0.1 MW).

Aggregators

Aggregators controls flexibility from many distributed flexibility resources. There are both commercial and technical aggregators, where the former manage the entire market process while the latter ones only provide the technical solution for delivering flexibility. Hence a market aggregator can also be seen as a flexibility service provider, while a technical aggregator helps a flexibility service provider. Aggregators can help actors that lack knowledge or resources to bring the flexibility to the market. Aggregators are crucial to bring small resources that are lower than the minimum bid to the market by pooling many resources. An aggregator makes money by selling their service.

Other stakeholders

Other stakeholders can play important roles to local flexibility markets as well; for example parties that provide system support in resource forecasting or service providers that assist buyers in purchasing flexibility.



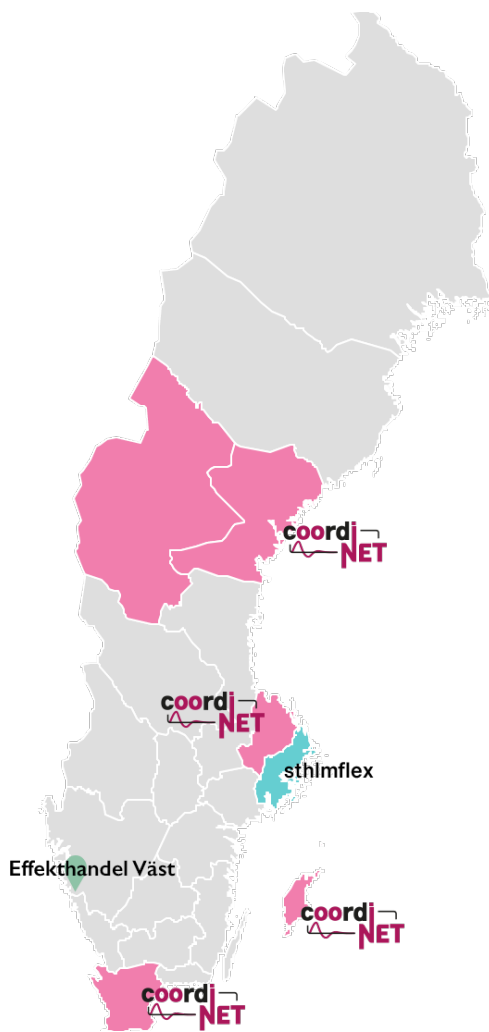


Figure 1: The geographic distribution of the markets in Sweden.

Fact box

P2P-market: A marketplace where the trading of flexibility does not take place between end consumer and DSO, but directly between equal parties (e.g. large consumers or between electricity producers) who are in need of flexibility.

Markets today

Currently, several local flexibility markets run as pilots in Sweden. CoordiNet and sthlmflex are the two largest projects, and they have been in operation for three and two seasons respectively. The latest flexibility market, Effekthandel Väst, was launched in January 2022. Together, all projects today cover 6 geographical areas in Stockholm (sthlmflex); Uppsala, Skåne, Gotland and Västernorrland/Jämtland (CoordiNet); and Gothenburg (Effekthandel West).

CoordiNet

CoordiNet³ is an EU-funded Horizon 2020 project that includes demonstrations of local flexibility markets in Greece, Spain and Sweden. In Sweden, CoordiNet is operated by Vattenfall Eldistribution, E.ON Energidistribution, Svenska kraftnät, and in cooperation with Uppsala municipality, Energiforsk and Expektra, among others. The project consists of demonstrations in four geographical regions with different underlying needs for local flexibility markets.

CoordiNet uses the market platform SWITCH⁴, which was created and administered by E.ON within the framework of the project. The buyers in the markets are mainly DSOs, but in some markets, P2P trading with blockchain has also been tested. The flexibility providers are energy companies, industries, property owners and aggregators. Market operators on CoordiNet are the respective DSOs. The Winter 2021/2022 is CoordiNet's third and final season.

³ CoordiNet (2020), [Site specific product portfolio to be used in Swedish demo](#). (A final report on CoordiNet will be delivered in spring 2022.)

⁴ E.ON (2021), [White Paper / SWITCH](#).

CoordiNet Uppsala 2021/2022

Flexibility resources:

- Reserve power (Region Uppsala and Akademiska Hus)
- Battery storage 20 MWh (Vattenfall Elanläggningar)
- Large heat pumps (Cytiva)
- Electric boilers and heat pumps (Vattenfall Värme)
- Cooling system from an ice rink and a swimming hall managed by Uppsala municipality (aggregated by Tvinn)
- 400 residential heat pumps in Upplands Energi's grid (aggregated by Ngenic)
- Heat pumps from Castellum, Riksbyggen and Uppsalahem (aggregated by Ngenic).

CoordiNet Skåne 2021/2022

Flexibility resources:

- Reserve power (Uniper Öresundsverket)
- Heat pumps (Krafringen Värme and Öresundskraft Värme)
- Battery storage (Vattenfall/Boliden Bersöe)
- Aggregation of heat pumps (Ngenic/LKF)

CoordiNet Uppsala

The market in Uppsala aims to free capacity in the regional grid. Vattenfall Eldistribution, who owns the local grid in Uppsala, decided to join CoordiNet when they could not meet the demands of the growing region. The possibility to buy flexibility has made it possible to connect new consumers to the grid in the area. The close collaboration with the municipality has been important in finding FSPs. Together with many different types of flexibility suppliers, Vattenfall Eldistribution developed both new working methods and competence.

CoordiNet Skåne

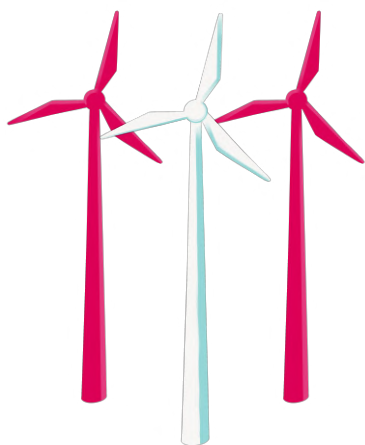
Similar to the case in Uppsala, Skåne is also experiencing an increasing demand for electricity, while the capacity of the overhead transmission grid is limited. The goal of CoordiNet Skåne is to reduce the need for more capacity from the overhead grid. Until the expansion of the transmission grid is complete by 2024, a combination of technical and market-based solutions are used to facilitate the capacity situation. Larger consumers are still being connected to the regional grid, even if the situation is strained in many places. The Scanian demonstration consists of three local flexibility markets: Sege-Arrie, which is operated by Krafringen in Lund; Barsebäck, which is operated by Landskrona Energi in Landskrona; and Söderåsen, which is operated by Öresundskraft in Helsingborg. Before 2021/2022, E.ON had the ambition to operate a market in Hässleholm, but failed to find any FSPs. A general challenge for the Skåne demonstration has been to find FSPs who want to participate.

CoordiNet Gotland 2021/2022

Flexibility resources:

- Heat pumps and electric boilers (GEAB Värme)
- Energy storage (Vattenfall Elanläggningar)
- Cooling system (Ryftes)
- Wind power curtailment (Gotland vind).

In Gotland and Västernorrland/Jämtland, flexibility is needed to transfer excess power production to other regions



CoordiNet Gotland

Gotland obtains its power through two HVDC connections, and unlike the rest of Sweden, Vattenfall Eldistribution is the system operator of the island, instead of Svenska kraftnät. Gotland's transmission is challenged by the limited capacity to both import and export electricity from the main land. Furthermore, as almost 50 percent of the annual electricity production is from wind power, there is an increasing need for flexibility, especially during maintenance. In the demonstration market in Gotland, trade is handled both at a local flexibility market operated by GEAB; and at a P2P market which is used during the maintenance periods when capacity is limited, thus reducing the need for wind power curtailment. In CoordiNet Gotland, the focus of the project lies on lessons learned for GEAB and the participating FSPs.

CoordiNet Västernorrland/Jämtland

In Västernorrland/Jämtland, a P2P market has been tested for a limited period of time. Same as in Gotland, there are difficulties transferring the occasional large power production to other regions due to temporary grid maintenance. Energy producers often have to cut back their generation.

Sthlmflex

The R&D project sthlmflex⁵ is a flexibility market in the Greater Stockholm area which is operated by Svenska kraftnät, Ellevio and Vattenfall Eldistribution. The DSO E.ON Energidistribution also participates as a buyer in the market. Different to other flexibility markets, sthlm-

⁵ sthlmflex (2021), [En rapport om sthlmflex: En lokal flexibilitetsmarknad i Stockholmsregionen.](#)

Sthlmflex 2021/2022

Flexibility resources:

- Large heat pumps (Skellefteå Kraft and Stockholm Exergi)
- Reserve power (Arenabolaget)
- Electric car charger, ventilation and heating system (Entelios)
- Disconnection of shorepower from ferries (Stockholms harbours)
- Schools and preschools (Myrspöven)
- Cogeneration (E.ON Högbytorp)
- Heat pumps (E.ON Järfälla)

One of the goals for Effekthandel Väst is to eventually use the market as a grid planning tool

Effekthandel Väst 2022

Flexibility resources:

- Battery system and steam turbines (Akademiska hus)
- Electric car charger (Tibber)

flex includes two DSOs, which provides an opportunity to exchange flexibility between two regional grids. Flexibility resources from the local market can be sold to both local and regional grids. Currently, the short term goal of the project is to free up capacity between the regional grid and the transmission grid. In the long run, the flexibility market is expected to contribute to congestion management between the regional and local grids in the area. Sthlmflex is operated by NODES, an independent third-party market operator. E.ON also partakes in the project as a supplier for the SWITCH system support, which helps decision making for the DSOs' operation centers. Winter 2021/2022 is sthlmflex's second season. The project runs until spring 2023.

Effekthandel Väst

Effekthandel Väst⁶ is a local flexibility market that operates in Gothenburg, and has its first pilot season from January-March 2022. On top of the market establishment, the goal for the season also involves gaining knowledge on how a local market works in practice, and how to involve FSPs. Long term, the aim of trading flexibility is also to free up capacity in the local power grid, but also to use the market as a tool for grid planning. Göteborg Energi Nät is the buyer of Effekthandel Väst, and NODES is the market operator. Effekthandel Väst is the first local flexibility market in Sweden that was established without the TSO. Winter 2022/2023 will be the next pilot season for Effekthandel Väst.

⁶ Göteborg Energi (2022), [Effekthandel Väst](#).

Markets rules

The market rules and processes for all Swedish local flexibility markets largely follow the same structure. The participating FSPs must first pass through pre-qualifications to enter the market, usually before the market is open for the season. The purpose of the pre-qualifications is to ensure that the flexibility providers meet the criteria to deliver according to market rules.

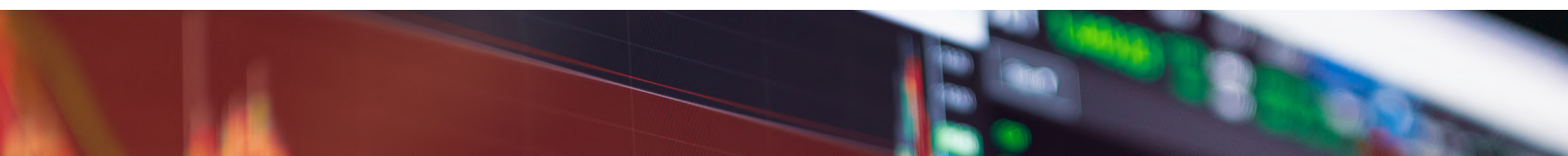
A minimum bid size of 0.1 MW applies to all flexibility markets. Above 0.1 MW, bids can be made with increments of 0.01-0.1 MW, depending on the market. The size of the bid steps is called granularity. As all markets permit aggregation, multiple resources can be pooled to reach the bid limit. The minimum delivery time for all the flexibility markets is 60 minutes, which means the flexibility provider is obliged to supply service for one hour. Nevertheless, the delivery can also be made shorter than 60 minutes, as long as the promised amount of energy is delivered.

All markets suppliers have to use an effective validation method to guarantee the committed delivery as requested. Today, the validation is being done against a baseline, which is a forecast of how the power demand would have been if no flexibility was delivered. In validation against the baseline, the delivered flexibility is calculated as the difference between the forecast power demand and the measurement data from actual power demand. There are different methods to estimate the baseline⁷.

Actors who want to deliver flexibility must meet the pre-qualifications in the markets they intend to participate

To ensure that the requested flexibility can be delivered, the suppliers need to perform a validation against the baseline

⁷ Energiforsk (2021), [Baselinemetoder för flexibilitetsprodukter](#).



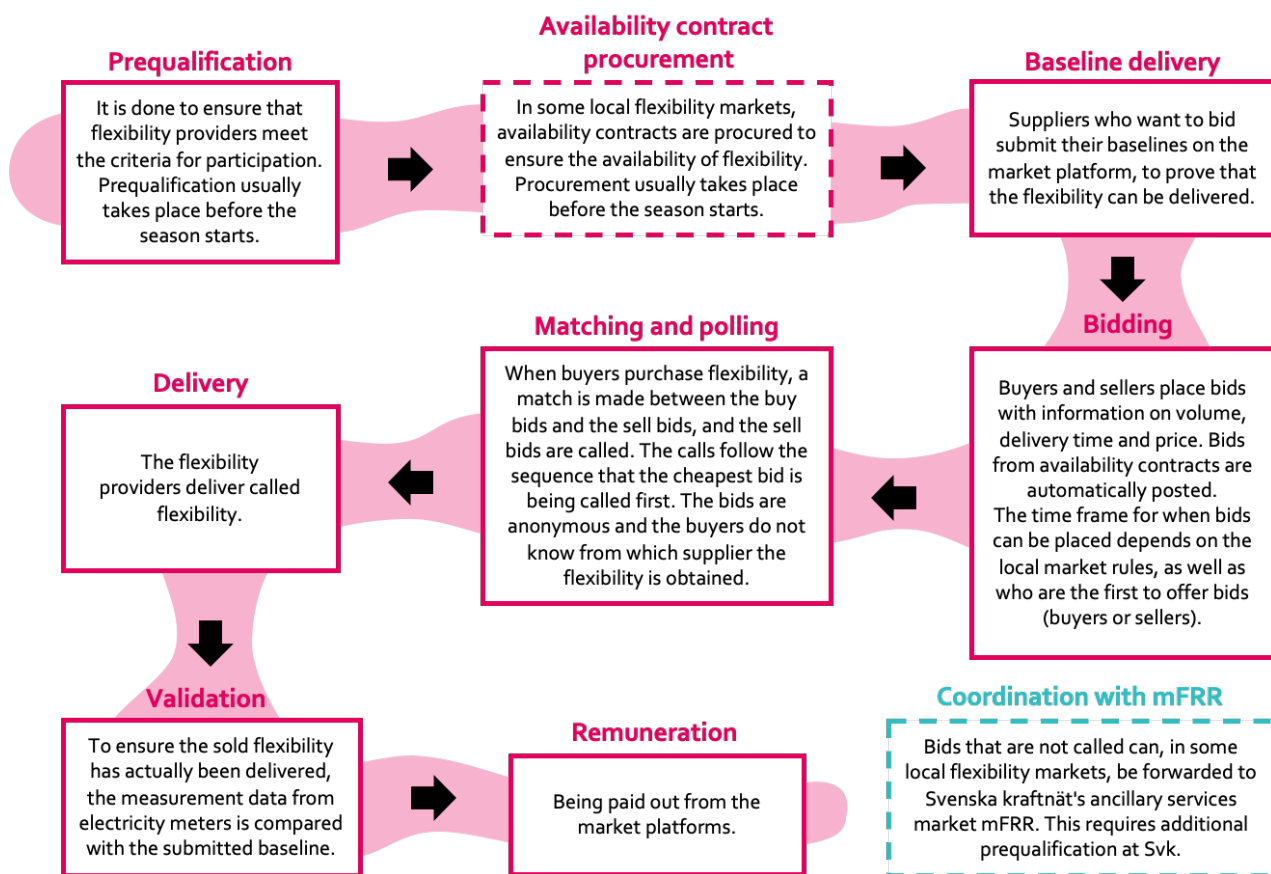


Figure 2: The market process.

Products in the markets

The main difference in today's local flexibility markets is the market operator. Sthlmflex and Effekthandel Väst use NODES as their marketplace while CoordiNet operates on SWITCH. Since market rules today are decided by the market operator this defines the main discrepancy in markets products and the market rules. At the moment, the flexibility is primarily sold through two categories: free bids and availability contracts. At Effekthandel Väst, flexibility is sold only as free bids.

The remuneration method for all free bids products in today's markets goes by pay-as-bid. Offered flexibility bids that are not called on CorrdiNet and sthlmflex, can be forwarded to Svenska Kraftnät's ancillary service market mFRR, if the supplier fit the pre-qualifications. The remuneration on mFRR is pay-as-cleared.

Reimbursement principles

Pay-as-bid: All winning suppliers are remunerated at their bidding prices, respectively

Pay-as-cleared: All accepted bids are paid the price of the highest accepted offer

Two product categories

Free bid: Flexibility is traded as average value per hour.

Reimbursement consists of activation price (MWh/h).

Availability Contract: Flexibility is traded on guaranteed availability for an entire week or season.

Market solutions

Continuous market: Bids can be placed continuously.

Day-ahead market: bids are called no later than 10:30 the day before the delivery.

Intraday market: bids are called no later than 2 hours before delivery.

The availability contracts differ between markets⁸ and they are designed by the grid companies. At Coordinet, two different types of availability contracts have been tested. One is exercised by FSPs offering availability between 07-20 every weekday during the season, and the other one operates on suppliers offering a quota volume of flexibility that are spread out during the season's peak load hours. At sthlmflex, two availability contracts are: suppliers offer flexibility during certain hours throughout the season (seasonal flex), and suppliers offer flexibility during certain hours in the next week (weekly flex). Both contracts deal with hourly availability, therefore both can conclude flexibility resources regardless of the technology. The advantage to join availability contracts is that the compensation consists both the availability price (per MWh/h) - which is paid regardless of activation, and an activation price when a flexibility service is activated.

Today, all local flexibility markets run continuously, the majority of the trading is day-ahead and the rest on intraday. The minimum bid size on all markets is 0.1 MW.

Statistics 2021/2022	Number of FSP	Number of flexibility resources	Total called volume (MWh)	Average price per call (SEK/MWh)	Lowest bid price (SEK/MWh)	Highest bid price (SEK/MWh)
sthlmflex	8	2 500	878	883	10	10 000
sthlmflex veckoflex	5	-	144	3 159	-	-
sthlmflex säsongsflex	2	-	7 381	929	-	-
Coordinet Uppsala	15	369	109	248	100	314
Coordinet Skåne	5	7	9,8	2 767	1 000	3 500
Effekthandel Väst	2	340	0,83	2 602	2 000	4 000

Statistics 2020/2021	Number of FSP	Total called volume (MWh)	Average price per call (SEK/MWh)
sthlmflex	5	2 276	485
Coordinet Uppsala	11	6 596	235
Coordinet Skåne	9	122	1 503

⁸ SWECO (2022), [Kartläggning av lokala flexibilitetsmarknader](#).

Market developments

Financial, administrative, technical and regulatory obstacles need to be overcome

In order to move on from today's pilot stage, the existing markets need to be evaluated and upscaled. Obstacles from financial, administrative, technical and regulatory perspectives need to be overcome. As the Swedish markets are still in an early stage, several questions ought to be answered concerning the development path for today's markets. There is still need for increasing coordination between the local flexibility markets and Svenska kraftnät's ancillary service markets. This can be done through, among other things, the sequential time coordination that is currently being tested on CoordiNet and sthlmflex, where the bids on the local flexibility markets are primarily offered to the DSOs and then forwarded to Svenska kraftnät's ancillary service market mFRR. Another approach could be market-based coordination, where Svenska kraftnät is allowed to trade directly on the same local markets that local and regional grid owners trade on today.

Market coordination approaches

Sequential coordination: Bids are offered primarily to the DSOs that trade in the local flexibility markets, and secondarily being forwarded to the mFRR.

Market-based coordination: Both DSO and TSO trade simultaneously on the same local flexibility market.

Another issue for the development of the local flexibility markets is the standardization of the products. Standardization makes it easier for FSPs to participate in several different markets, therefore increasing liquidity and competition between the markets' flexibility providers. While standardization may bring benefits, there must also be room for products that are not fully standardized in favour of providing opportunities to individual suppliers and buyers. As today's markets are at an early stage, it is difficult to determine at what point standardization should take place. A first version of a Swedish product catalog has been developed in collaboration between DSOs and TSOs.





Obstacles for today's markets

Today, the profitability of flexibility service is too low to attract potential FSPs to participate

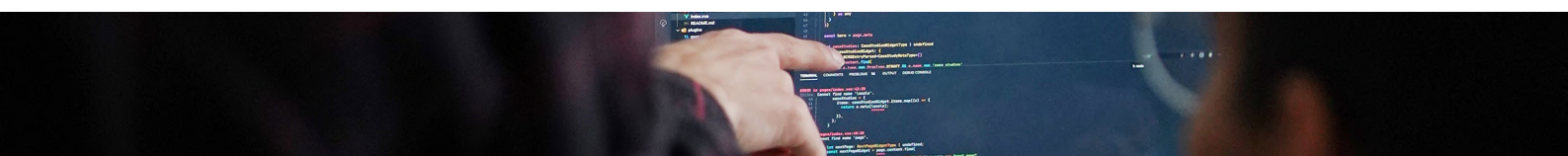
The primary financial obstacles for today's markets are the low profitability from the suppliers' side, and the limited amount of procured flexibility in the market. There is very little incentives to stimulate the potential FSPs to spend time and resources on participation. In order to increase the liquidity of the markets, DSOs need to have a higher willingness to pay for flexibility services, they must also be willing to commit resources and take financial risks to operate with flexibility.

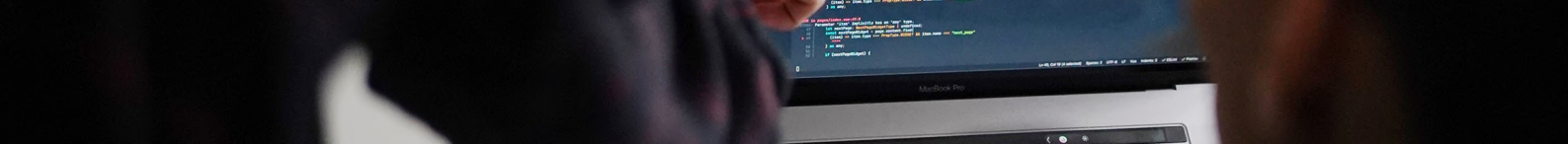
Administrative obstacles mainly consist of lack of knowledge, unfamiliarity, and slow processes. Currently, it is difficult to recruit flexibility suppliers and find a right proxy for the measurement data. Both flexibility suppliers and buyers consider it challenging to come up with methods for grouping resources, producing baselines and forecasts.

The current regulation gives stronger incentives for grid expansion than working with flexibility

Technical obstacles include lack of tools for decision support. DSOs need better capability to produce more reliable forecasts and suppliers need better abilities to manage resources. Digitization and automation are two prerequisites for activating certain flexibility resources, especially when the activation of bids happens close to the real delivery time. For industries and larger heating actors, manual processes are required. Standards for messages formats must also be developed to facilitate IT communication and information exchange between market players.

The regulatory obstacles mainly concern the DSOs, as there are more incentives to expand the grid rather than working with flexibility under today's electricity law and regulation.





Through the EU's new electricity market directive, DSOs are required to evaluate flexibility as an alternative to grid investments

Discussions about the development of regulations are being conducted in many countries under the EU directive

EU directives support the development

The promotion of flexibility and the development of local flexibility markets is supported by the EU's new electricity market directive⁹, which aims to create integrated, competitive and fair electricity markets in the EU. Through the directive, grid companies are required to evaluate flexibility and energy storage technologies as alternatives to grid investments. The Electricity Market Directive is to be implemented in Sweden through changes in the Electricity Act (1997:857), which, according to the proposal referred to the Council on Legislation¹⁰ from December 2021, is proposed to enter into force in July 2022.

There are several flexibility markets in Europe with different purposes today. In the Netherlands, Germany and Sweden, the markets are mainly used to manage grid congestions. In UK and France, they are also used as grid planning tools for DSOs that want to postpone investments. The markets enable small-scale resources to contribute balance and frequency services through aggregation, and help increase cooperation between DSOs and TSOs.¹¹ In 2022, an expert group was appointed on behalf of EU-DSOs with the aim of working on the design of the grid codes - common European regulations - for flexibility that the EU's regulatory authority ACER will produce in 2022 and 2023. With the grid codes, it will be easier for DSOs to work with flexibility and for FSPs to participate in the markets.

⁹ Europeiska unionens officiella tidning (2019), [Europaparlamentets och rådets direktiv \(EU\) 2019/944](#).

¹⁰ Regeringen (2021), [Genomförande av elmarknadsdirektivet när det gäller nätverksamhet](#).

¹¹ Accenture (2021), [An overview of local European flexibility markets](#).



Summary

At the moment, Sweden has local flexibility markets in six geographic regions: Stockholm, Uppsala, Gothenburg, Skåne, Gotland and Västernorrland/Jämtland. All markets are considered as pilot projects and they have been developed under different underlying needs in respect of regions' electricity grid areas.

The local flexibility markets engage several different actors in the electricity system: grid owners, market operators, flexibility providers, aggregators and system support providers. The actors have different incentives to participate. The participants partake in the process according to the local market rules, nevertheless, steps such as prequalification, delivery of the baseline, bidding, activation, validation and compensation are applicable for all markets.

Today's Swedish markets face various obstacles and several development paths. Among other things, there may be a need for new solutions for market coordination between DSOs and TSOs, as well as standardization of the products. The potential suppliers and buyers also need access to knowledge and experience.

Current grid regulation and the electricity law have to adapt in order to give grid companies increased incentives to use flexibility. The development of local flexibility markets is supported both by the government's national strategy for electrification from 2022, and the new EU directive for the development of electricity markets from 2019.

This white paper is produced by Power Circle in collaboration with our partner companies.