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Report on Flexibility Availability

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About OneNet

OneNet will provide a seamless integration of all the actors in the electricity network across Europe to create the conditions for a synergistic operation that optimizes the overall energy system while creating an open and fair market structure.

The project OneNet (One Network for Europe) is funded through the EU's eighth Framework Programme Horizon 2020. It is titled "TSO – DSO Consumer: Large-scale demonstrations of innovative grid services through demand response, storage and small-scale (RES) generation" and responds to the call "Building a low-carbon, climate resilient future (LC)".

While the electrical grid is moving from being a fully centralized to a highly decentralized system, grid operators must adapt to this changing environment and adjust their current business model to accommodate faster reactions and adaptive flexibility. This is an unprecedented challenge requiring an unprecedented solution. For this reason, the two major associations of grid operators in Europe, ENTSO-E and EDSO, have activated their members to put together a unique consortium.

OneNet will see the participation of a consortium of over 70 partners. Key partners in the consortium include already mentioned ENTSO-E and E.DSO, Elering, EDP Distribution, RWTH Aachen University, University of Comillas, VITO, European Dynamics, Ubitech, Engineering, and the EUI's Florence School of Regulation (Energy).

The key elements of the project are:

1. Definition of a common market design for Europe: this means standardized products and key parameters for grid services which aim at the coordination of all actors, from grid operators to customers.
2. Definition of a Common IT Architecture and Common IT Interfaces: this means not trying to create a single IT platform for all the products but enabling an open architecture of interactions among several platforms so that anybody can join any market across Europe; and
3. Large-scale demonstrators to implement and showcase the scalable solutions developed throughout the project. These demonstrators are organized in four clusters coming to include countries in every region of Europe and testing innovative use cases never validated before.

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Table of Contents

List of Abbreviations and Acronyms

Acronym	Meaning
API	Application Programming Interface, which is a set of definitions and protocols for building and integrating application software
BRP	Balance Responsible Party
CAPEX	Capital expenditure
CM	Congestion Management
DSO	Distribution System Operator – responsible for the local distribution grid and the delivery of customer grid connections
DER	Distributed Energy Resource
DSR	Demand Side Response
FR	Flexibility Register
FSP	Flexibility Service Provider
IMO	Independent Market Operator
LV	Low Voltage
MO	Market Operator – Responsible for the market on which each product is traded. The MO can be TSO, DSO or IMO
MV	Medium Voltage
RES	Renewable Energy Source
Resource Provider	Consumer or producer of electricity, both households and commercial actors, owning and providing flexibility resources to the market.
SME	Small Medium Enterprise, a customer segment comprising smaller business customers
SO	System Operator – responsible for providing the TSO-DSO Coordination Platform
TSO	Transmission System Operator – responsible for the national grid and the balance (frequency quality in the grid)

List of Figures

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957739

List of Tables

Executive Summary

The increased electrification of society requires the introduction of new methods in the electricity market, one of them is an increased use of flexibility. This report explores different aspects pertaining to the sources of flexibility available at the electricity consumers' level, the circumstances enabling the utilization and exploration of this flexibility, and the ways in which this flexibility can be unlocked through encouraging its valorisation and participation in relevant flexibility procurement settings. The report starts by introducing the different roles of the Flexibility Service Provider, the link between the customers providing flexibility resources and the market for flexibility. The main reason for customers to offer their flexibility is economic: The Flexibility Service Provider defines a rewarding mechanism which is attractive for the customer and a steering logic with minimal impact on the living comfort. The report identifies two main types of flexibility contracts, one which combines an electricity sales contract with flexibility and another which is for flexibility only.

The number and quality of resources with flexibility potential are increasing. This report identifies and describes some of the most important resources, including hot water boilers, electric vehicle chargers, solar power, and batteries. Private flexibility resources need to be aggregated, while commercial flexibility resources could achieve a relevant volume on their own.

The main drivers for market flexibility are described in this report. From a Transmission System Operator's perspective, the drivers are congestion management and balancing services, investment deferral and ancillary services. Similarly, the Distribution System Operator is also driven by congestion management and investment deferral. For the Flexibility Service Provider, the important aspects are economic value and market/system stability.

Although the current electricity system differs between the European countries, all the countries participating in the Northern Cluster Demonstrators see a similar development soon. The electricity demand will increase in all countries driven by the transition in heating, transport, and heavy industry. All countries have the potential and increasing flexibility to be utilised. EVs on the other hand constitute a transversal adoption trend which may unleash flexibility provision due to its distributed nature.

The report concludes with a country-specific description of the flexibility provision in the Northern cluster demonstration. In conclusion, the report finds that multiple resources for offering and using flexibility exist, with significant envisioned impact on the provision of system and grid services. However, the viability of large-scale implementation remains a challenge and is a long process.

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1 Introduction

While the electrical grid is moving from being fully centralised to a highly decentralized system, grid operators must change their operative business to accommodate faster reactions and adaptive exploitation of flexibility. The end goal of the OneNet project is to create conditions for a new generation of grid services that can fully exploit demand - response, storage, and distributed generation, while at the same time create fair, transparent, and open conditions for the consumer.

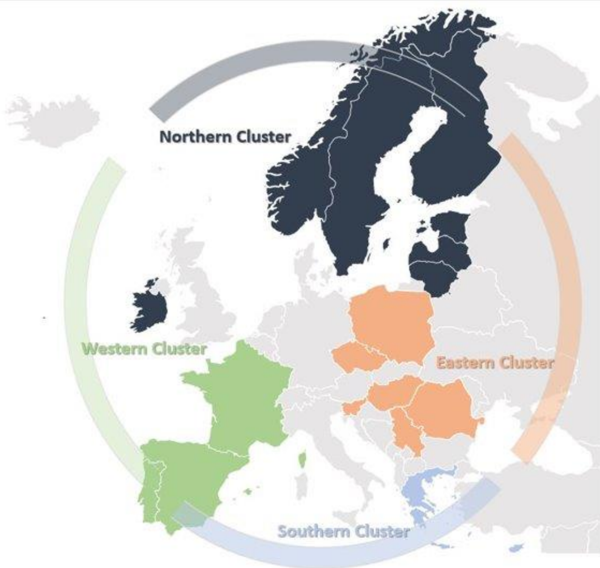

Figure 1 OneNet Demonstration areas

OneNet is divided into four geographical demonstration areas as described in Figure 1. The Northern Demonstrator (OneNet Work Package 7) is an integrated effort by multiple stakeholders including TSOs, DSOs, MOs, research centres and technology providers to enable market-driven flexibility uptake by networks in a coordinated way through multiple markets, where liquidity can be reached due to scope or existing trade volumes. To reach the goal of the OneNet project, WP7 consists of a demonstration that will show the mapping and management of network needs in multiple use cases over multiple networks. Furthermore, WP7 will focus on how joint and shared mechanisms can be used by multiple networks, to demonstrate scalability and contribution towards a pan-European solution. The WP7 demonstrator is enabled by implementing the framework developed in the INTERRFACE and EU-SysFlex projects and scaling up both the number of networks and the capability of the flexibility enabling solution mechanisms.

To achieve the goal of the OneNet project and WP7, Task 7.1 (Driving availability of Flexibility) strives to achieve several goals. Since flexibility resources are owned by consumers of electricity (households, energy communities, commercial actors) there is a need to formulate templates of required contracts, terms and the rewarding mechanisms that motivate the resource owners to allow the control of their flexibility resources. In

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this report consumers, both households and commercial, are defined as flexibility resource owners. Furthermore, one of the key aspects of a successful partnership with the owners of the flexibility resources, is efficient communication to ensure that the consumers fully understand the effects of allowing control of their resources. Therefore, concepts for simple and understandable communication will be proposed. These concepts will be based on an analysis of the perceptions of the resource owners, as this forms the basis for communication and the development of templates and structures that are understandable and accepted.

All individual flexibility resources can be registered in the flexibility register regardless of size, but to reach a flexible capacity that is large enough to generate an attractive business case, when offered to the market, several small resources of flexibility need to be aggregated. To achieve this, practices for aggregation and evaluation of the behaviour of the aggregated resources will be defined in this report. A definition of the requirements set on the individual resources will also be formulated. Additionally, practices and processes need to be developed to derive the parameters of the aggregated resources, to be registered in the flexibility register.

The results are then used and tested against simulated as well as real markets to formulate a realistic business case. This business case will be used to verify the motivation of the flexibility owners and market utilization of the aggregated resources, as well as verify the economic feasibility by providing information on what levels of flexibility could be available, especially but not limited to the consumer and SME markets to the emerging needs of both the TSO and DSO. This report describes the uptake and participation of end customers and addresses the routes and means of flexibility to reach the markets and network needs.

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2 Consumer flexibility market framework

This chapter describes the framework for the market with consumer flexibility. Describing the role and responsibilities of the Flexibility Service Provider (FSP) aggregating flexibility from resource providers. The chapter describes types of contracts and rewarding mechanisms toward the resource provider, the concepts for communication and the flexibility register.

2.1 Market role of Flexibility Service Provider (FSP)

The essential role of the Flexibility Service Provider (FSP) is to connect the owner of the flexibility asset (Resource Provider, consumer), with the demand side, TSO and DSO (Market Operator). The exact methods and processes needed to fulfil this role can vary, this section will describe the general aspects and responsibilities of the role.

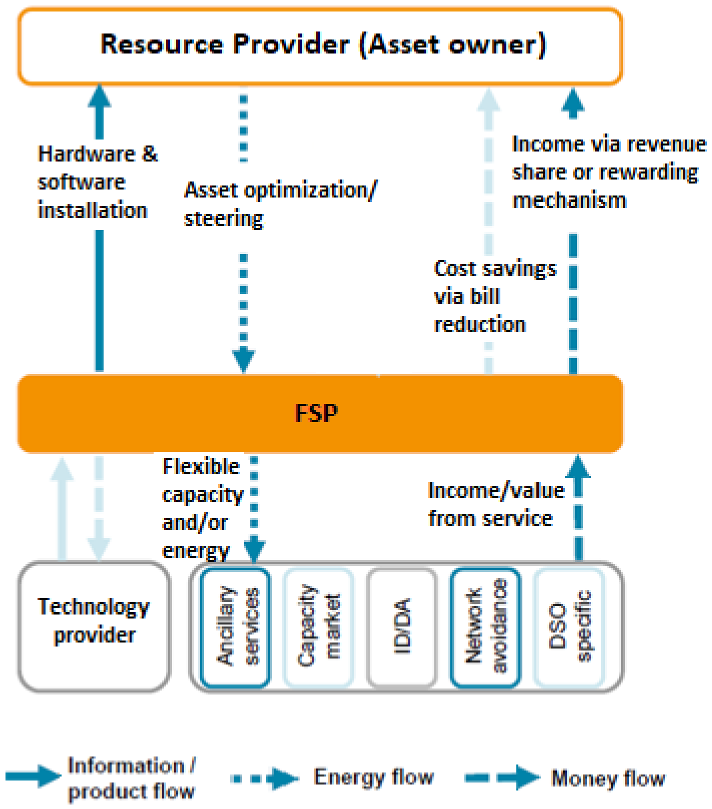

Figure 2 Overview of FSP's interfaces

Resource Provider counterpart - The FSP is responsible for securing that the flexible asset is compliant with market and commercial regulations. As described in Figure 2 above the FSP is the link between the resource

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provider and the flexibility different markets. The contract with the customer (flexibility resource provider) shall also cover the rewarding mechanism and what commitments each party takes for delivering the flexibility to the MO (Market Operator). More details regarding the agreement with the flexibility resource provider are described in Section **Error! Reference source not found.** which focuses on consumer engagement.

Market Operator counterpart – The FSP is the counterpart towards the market, thus working as the bridge between the resource provider and the market operators. In the relationship between the FSP and the MO, the FSP is not driving the development of the contractual terms.

Enabler of steering – The FSP usually takes on the responsibility to provide the necessary hardware equipment and/or necessary software to enable controllable steering of the Resource Providers asset. If the FSP does not have the hardware and software in-house, they can source this service from a third party (technology provider) and present it to the Resource Provider. Whether the FSP, provides the technical solution themselves or through a technology provider, or if the Resource Provider source these services themselves, it is important that all parties are covering the liability issues and risks with adequate insurance. If the FSP uses a third-party solution for enabling steering, they are also responsible for transferring the proper training and technical know-how from the technology provider to the Resource Provider.

Assuring flexibility quality for delivery - The FSP is responsible for making sure that the flexible asset is fulfilling the right technical and commercial requirements before participating in any flexibility market. This needs to be tested and for some markets a prequalification is required. Not until after necessary testing and prequalification, can the asset be offered to the market. During this flexibility quality assurance process, the FSP can find insights about the asset that make it necessary to change technical- or strategic approach for the asset, to ensure that the asset can provide the required deliverables for the intended market. If possible, these potential changes should be considered in the FSPs contract with the Resource Provider.

Present bid to the market – The FSP also has the role to present the bid of their flexible assets to the market. By assessing the flexibility assets characteristics in its portfolio, and matching these with the different product requirements, the FSP decides on the markets to which they want to sell the flexibility. Most of the time, this is dependent on where they estimate the largest economic incentives to be. There can be other factors behind the decision as well.

Pricing of the flexibility – The FSP is responsible for the commercial rewarding mechanisms towards the asset owner. The FSP is also ultimately responsible for pricing the flexibility offer to the market. How to price a flexibility asset is described in more detail in section 3.1 which describes the pricing of consumer flexibility.

Aggregation – When multiple flexible resources are pooled together. By aggregating the capacity of several assets, with similar technical characteristics, the FSP can ensure the capacity of abiding by the technical requirements to enter the market and increase the likelihood of presenting more competitive bids to the market.

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All commercial flexibility markets today have a minimum limit on how small a bid can be, for it to be accepted. For example, the smallest bid on the Day Ahead and Intra Day-markets is 0,1 MW (Nord Pool AS , 2022). If the singular asset is smaller than that, the aggregation is necessary for participation. Since the FSP is responsible for presenting the bid to the market and ensuring it can fulfil as promised upon delivery, the FSP is responsible for the aggregation even if it is done by a technology provider.

Customer reporting and customer invoicing – Settlement for delivered flexibility does not lie within the responsibility of the FSP, but the result can be used in invoicing towards the customer, depending on the commercial setup and what rewarding mechanisms are agreed upon. However, most of the time, one can assume that there is a connection between the settlement of delivered flexibility and an economical compensation delivered to the asset owner from the FSP.

On the other end, the FSP is responsible towards the Market Operators for the delivered flexibility to the market. If the settlement shows that FSP has failed to deliver as promised the FSP should be held accountable for this.

One challenge with the introduction of new roles, such as the FSP, to the market is the effect that it may have on the existing market and its functionality. FSPs would, by taking control of the customers' electricity consumption, interfere with the forecasted delivery that the customers BRP (balance responsible party) has sourced for the customer, and may also interfere with different hedges that the customer's Retailer has purchased for the customer. It is not expected that the customers themselves can know how this will affect the different actors. A clear regulation that eliminates the impact of an FSP steering towards the BRP and the Retailer needs to be implemented before aggregated flexibility can be used on a larger scale. Steering done by the FSP cannot affect the customers' Balance responsible party and/or electricity supplier in a negative way or without them knowing. This would cause large unwanted effects on the electricity retailer market, as it is today. One consequence would be that fixed prices would become more expensive or maybe not offered at all, due to lack of control and unforeseen electricity use patterns for the supplier, which creates a risk, where the supplier may have purchased too much or too little electricity at a specific time. Trying to price this new risk of FSP steering would force the Supplier to increase the risk margin on all customer contracts.

The new market risks mentioned above are most obvious if the FSP is an Independent Aggregator, meaning the FSP can contract any potential electricity consumer, without having any obligations toward the consumers' current electricity Supplier or BRP. An alternative solution is to have Contractual Aggregation, where the FSP has a contract with the Supplier and/or BRP, thus creating an opportunity to manage some of these risks between Supplier and FSP. Suppliers that already have a customer relationship with some of the potential flexibility customers, can also themself have the role of FSPs, Supplier and BRP, thus also being able to control the risks of creating imbalances due to steering of the resources.

2.2 Consumer engagement

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This section describes types of flexibility contracts and contract terms for household and commercial consumers. Different rewarding methods are presented as well as concepts for communication with resource providers.

2.2.1 Types of flexibility contracts and rewarding mechanisms

To attract consumers to provide their flexibility, feasible contracts and rewarding mechanisms need to be in place. The consumer benefit will depend on the type of contract, flexibility potential, and delivered flexibility.

The consumer will require a certain level of compensation for providing their flexibility. Typically, the smaller the interference of the customers' daily routine or comfort of living that the steering and optimisation result in, the lower compensation the customers may require. If the steering starts to affect the temperature of the home, or when the lights are on, or when the electric car is charged, the price or rewarding mechanism needs to go up, to cover the discomfort for the consumer. The FSP is responsible for attracting the consumer and needs to find a level of compensation that is mirroring or exceeding this expectation from the consumer. The FSP also needs to scan the market and consider the compensation other FSPs are offering to their flexibility resource providers. The consumers are free to choose any FSP and the competitiveness of the market plays a big role in what the flexibility resource provider expect in compensation for their flexibility.

Previous experiences with flexibility, such as a pilot with the Finnish DSO Elenia (Elenia Oy, 2020) during 25.6.2019–31.2.2020 to test steering via meters, compared to traditional night tariffs, have shown that the flexibility resource providers' financial benefits from the steering against spot prices are relatively low when only heating is being steered. This requires simplicity, as the consumers' interest in investing time to understand the product is low, when the potential benefit is also low. Essentially the steering should be something as simple as the night tariffs, with an easy-to-understand benefit to the consumer without risks. The financial benefits may, however, be higher when steering includes other markets than day-ahead spot tariffs, that were utilized in the Elenia pilot. The results from the pilot showed that there is also potential for faster steering using the metering infrastructure.

Flexibility contracts

For an FSP with only a role as an aggregator, the standard contract is one in which the consumer (flexibility resource provider) gives the FSP the right to control the consumer's load and generation. The benefit for the consumer for providing their flexibility, could be a fixed monthly compensation and the benefit received when the consumer has a spot-priced sales contract and loads are moved from expensive hours to less expensive ones. Another solution is that the compensation is volume-based. This requires additional administration and is therefore feasible when the flexibility volumes are sufficiently large. The contract can be paired with ancillary services, such as home energy optimisation or electric vehicle charging. The contract can be fixed term or open-ended. A challenge with a volume-based compensation is that the FSP needs to keep track of delivered flexibility

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on a resource provider level. This requires a solution for calculating flexibility delivered and invoicing which is more cumbersome than the passive benefit the flexibility resource provider has from load control.

The flexibilities offered by companies have a greater variation and thus need to be defined in greater detail. For example, the steering of the flexibility resource should not interfere with business. The commercial resource owner's liabilities and baseline consumption should also be considered. The technical equipment for load control might be more advanced and therefore more expensive than for a household consumer. Consequently, the contract should define who owns the activation and monitoring equipment; the flexibility resource provider or the FSP. The advantage of the flexibility resource provider owning it, is that it enables a more efficient and easier change from one FSP to another. The rewarding mechanism for B2B consumers, can be either standard pricing, the same as for consumers, or it can be flexibility resource provider -specific, sharing the profits with the FSP.

A challenge is that the Aggregator and Balance Responsible Party (BRP) are separate. The Aggregator will steer the flexibility resource providers' loads and will thus, affect the BRP's electricity balance. Different solutions are described in a report by consulting firm Pöyry (Afry) (Pöyry, 2018).

Combined electricity sales and flexibility contract

A contract that combines both sale of electricity and flexibility is used when the FSP is also the BRP. . The contract can be both fixed term/fixed price, or with a variable or spot-based price. If the price is fixed the probable reward to the flexibility resource provider for providing flexibility is through a reduced fixed monthly fee. Volume-based compensation is another possibility but would require more administration in the invoicing process. The volume-based reward can be a fixed amount per kWh or be based on the actual outcome of the price of flexibility. When combined with spot pricing the flexibility resource provider benefits through loads being moved from expensive hours to cheaper ones and/or by monetary compensation in the form described above.

2.2.2 Contract terms

Contract in the Finnish demo

In the Finnish demo, the contract (Appendix 9.1 OneNet Finnish Demo Contract Terms) is a flexibility only-type contract and offered only to private households. The flexibility resource provider signs a contract with FSP for the duration (fixed term) of the project and gives the FSP the right to control the load of the flexibility resource provider. The flexibility resource provider has the right to terminate the contract (14 days' notice) to enable the flexibility resource provider to move or for any other reason. The contract stipulates that the flexibility resource provider gives access to historical metering data and that flexibility resource provider data can be shared within the Northern Demonstrator.

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The flexibility resource provider's requirements are a valid contract with the DSO and that the new smart electricity meter is installed. The contract is compatible with the data protection description in the Consortium Agreement and GDPR.

Contract terms for commercial product

When considering the contract terms for a commercial product several possibilities are available. If the references to the OneNet project are excluded, the basic information can be the same as in the demo contract. The form and content of the contracts depend on the country-specific legislation and market attributes. The commercial contract reflects the commercial contract types and rewarding mechanisms described above.

Since commercial flexibility resource providers are not protected by GDPR additional clauses regarding confidentiality, it needs to be defined. The load control functionality probably needs to be tested and this should be mentioned in the contract terms.

2.2.3 Concepts for consumer communication

Communication with the resource providers, mostly consumers, is essential for the consumers to understand the effects of allowing the control of their resources. If the FSP is also the BRP the communication could take the form of reports available in the BRP's online reporting portal. Most BRPs have a portal where consumers can access their measured consumption on an hourly level. The data is usually available the day after delivery. In Finland, measurement data is available in the Datahub and thus an FSP with only an aggregator role can provide a reporting portal of their own or integrate the reporting to apps or other channels linked to their services.

Depending on the type of consumer, the need for information can be different. One possible reporting solution for the FSP is to send regular newsletters, with an overview of the flexibility market, how much has been utilised and what the aggregate benefit for the electricity system the flexibility has contributed. In general, it might be assumed that smaller residential consumers demand less information than companies with greater flexibility potential. Data for consumer reporting can be made available by the FSP for third party use via an API. An example could be a situation where the consumer receives information about provided flexibility through a home automation system or an EV-charger application.

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2.1 Flexibility register requirements

The Flexibility Register (FR) is envisioned in the Northern Demonstrator of the OneNet project as one of the main building blocks to enable future flexibility markets. The FR facilitates information exchange, data storing, and processes related to flexibility resource management and flexibility settlement. This makes it possible to use the flexibility resources in different markets and for different purposes, and thus enable greater value creation for the resource owner and the FSP.

FSPs use the FR to manage the flexible resources at their disposal, including information about the contracts made with resource owners, enabling the FSP to use them in the markets. The FSPs also send information regarding verification and settlement (e.g., metering data) and get access to the settlement results.

The information gathered to the FR about flexible resources is dictated by the need of the processes of the flexibility markets. First, the resource information is needed for product prequalification, which ensures that the resources used for offering flexibility services fill the technical requirements of the respective product. These information attributes come from the product definitions of different markets. Also, information is needed about the location of the resource, typically the metering point information, which connects the resource to the grid model, and makes it possible for the SOs to use the flexibility resource for their local flexibility service's needs.

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3 Flexibility resource potential

This chapter describes the flexibility resource potential concerning the different important aspects; pricing, principles for aggregation, types of available flexibility resources, connecting flexible resources to an FSP and measurement of flexibility.

3.1 Pricing of resource providers' flexibility to the market

In this paragraph the pricing of consumer flexibility is described. The cost components are divided into three areas. Barriers of entry, activation and operational costs and margin for FSP and reward for resource providers.

Entrance costs and barriers

Most flexibility market's today work as auctions and the price of flexibility is set by supply and demand. More complex product with higher entrance barrier due to complex technical requirements, prequalification process and operational setup etc. usually drive more costs for the asset provider and the FSP. Generally, these more complex products also have a higher market price.

Another parameter to consider when entering a flexibility market is the cost of steering and optimisation. To enable flexibility from a resource, the resource needs to be metered and controllable. This is usually done by sending a signal from a centrally controlled platform to each resource. It can, in some cases, require specific hardware and installation costs and it will, in all cases, require some software for steering. These software, are often expensive to develop and maintain and require a high level of IT-security, that needs continuous development. For operational costs, scalability is an important factor. The larger the resource group gets the lower the cost per unit of flexibility.

Activation cost

Assessing the cost aspects of delivering flexibility gives the minimum price that needs to be considered to deliver a unit of flexibility to the market. If this is too high to be competitive in the flexibility markets the FSP needs to go back and adjust the cost parameters or the strategy to continue.

Market prices for flexibility will constantly vary and are usually also connected to the price of electricity. The FSP will want to maximise the price for the flexibility but setting a price too high will risk that the flexible volume will not be called off and no revenue is created. So, the FSP needs to balance the price with the risk of not getting called off. The alternative cost for a DSO is not to solve the congestion by buying flexibility.

One way is to look at historical prices for the relevant product or market and try to identify what aspects are driving the price on the market. Examples of price drivers for flexibility, depends on the need and product but

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can range from weather, time and date, transfer capacity in grid connections, Day ahead price, intraday prices and regulation price etc.

FSP margins and rewards for resource providers

For the market to work there also need to be incentive for the roles. Depending on the strategies of the FSP, the margins vary, but for any business to be sustainable, there needs to be a strategy for making a profit. In general, stakeholders expect a few percent in return on investment, depending on the relative performance. The differentiation aspect of competition will depend on the correct allocation of assets to the most rewarding markets, effective software, portfolio recruitment, efficient running costs, accurate forecast, and matchmaking tools.

A pricing scheme for individual flexibility resources should be derived from the value it brings to the market, and the scheme needs to be applicable in practice. Since an FSP aggregate several resources into each bid and activation it can be difficult to retrieve accurate data for each resource, thus making it difficult to offer a pricing scheme completely based on each individual resource's contribution.

Creating a pricing strategy per individual resource provider would require a lot of time and resources; thus, pricing is done on a resource group level. FSP will look at all their flexibility resources and group them in resource groups, by their characteristics (e.g., power, response-time, repetitiveness etc). The price will then be decided for each resource group. Depending on the product there can be an issue to see how much each resource contributed to the delivered flexibility. That is another reason to give a price for a whole resource group.

3.2 Practices for aggregation

To form a flexibility bid that is large enough to be submitted to the market, several small sources of flexibility need to be aggregated. Practices for aggregation and evaluating the behaviour of the aggregated resource need to be developed.

For the aggregation to work, the FSP needs to understand the flexibility resource providers' technical attributes. Already before starting a marketing campaign of the flexibility concept towards potential resource providers, the FSP can make a first estimation (qualified guess) of the flexibility potential of the resources based on their attributes e.g., type of house and heating system, type of car, solar panels, grid area etc and an investigation of grid problematic zones. Based on these assumed characteristics, the FSP can group the resource providers with similar flexibility attributes (e.g., power, response time, possible activation times) to fit the different markets. Once the FSP has a better understanding of how the resources can be activated, it is possible to create a logic and activate resources in a special sequence to deliver a product. When the flexibility asset is tested and assessed, a final grouping will be done based on the attributes and steering method. Steering done on an aggregated level requires that assets are compatible with the steering logic. The steering logic refers to the

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timing and sequency several resources are activated, depending on the product and activation it could be that only part of the total portfolio's assets needs to be activated. The aggregation logic will also need to be customised to fit the market requirements. Figure 3 shows the high-level architecture of the aggregator platform, while Table 1 describes the functionality of each block in the aggregator platform. The steering of smart loads will be part of Kamstrup's smart meter management system

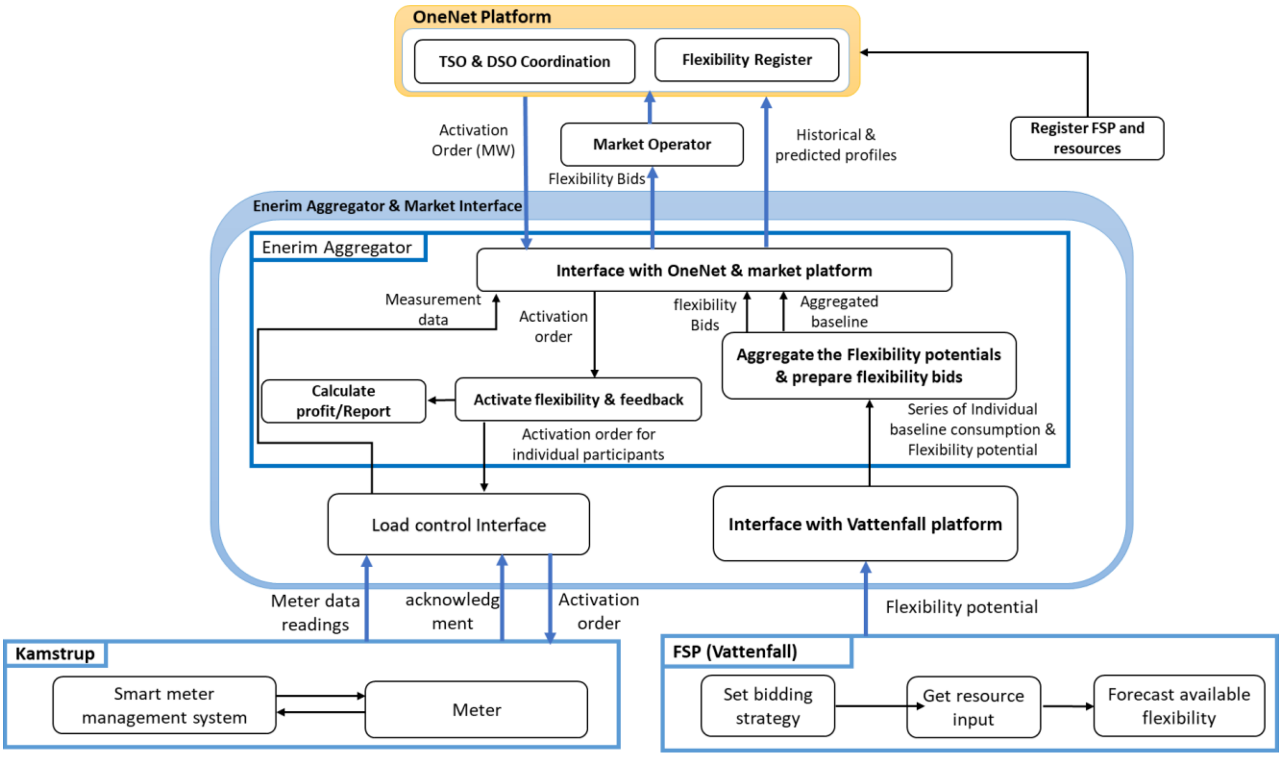

Figure 3 High level architecture of the aggregator platform

Table 1 Functional Requirements of the aggregator platform (Finnish demo)

Functional requirements	Description
Interface with OneNet & market platform	Submit the (aggregated) flexibility bid to the market operator and OneNet platform. Starting with one product, e.g., ST-P-E.
	Submit or update related data, such as historical info or predication profiles to the flexibility register, as the source of baseline calculation.
	Receive the activation signal from the market/system operator and pass it through the [FN-DR-09], Flexibility Activation functions.
Aggregate the Flexibility potentials & prepare flexibility bids	Aggregate flexibility potential of different resource to create an appropriate bid for the market/product. Preparing the flexibility bid for the optimum market/product, including the price and volume. This could be a very advanced function but in the first implementation can be done by simply adding different flexibility

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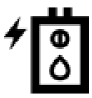
Functional requirements	Description
	potentials together, without any optimisation and aim just one product, e.g., ST-P-E. Still finding the price for one product need some advanced decision process.
Activate flexibility & feedback	Dispatch the flexibility activation: Calculate the amount of Flexibility need to be activated for each participant. In the first implementation, it can be done by simply dividing the need among all participants.
Calculate profit/Report	Calculate the share of each participant from the revenue of the Flexibility market
	Report the flexibility availability and activation of each participant
Interface with flexibility resource provider level	Send flexibility activation Signal to each participant, in this implementation, there will be an interface with Kamstrup's smart meter management system and the activation order will be send to it.
	Receive the measurement data (meter reading) to calculate the real flexibility for invoicing and sending to FR
	Receive the Flexibility potential from several participants (building)
	Receive acknowledgment (activation feedback) from all participants

3.3 Types of available flexibility resources

The new and emerging sources for flexibility, such as solar-coupled batteries, EV charging and hybrid energy storage systems, may have a significantly higher potential and allow for more complicated offerings. This is partly due on one hand, to the higher potential savings and partly due to the increased awareness of the consumers, investing in batteries or electric vehicles today. On the other hand, the driver for these investments may be something else than the use of these resources on the electricity market – for instance, a battery may be mainly purchased to improve net independence or to enable continued use of appliances during outages.

Table 2 Resources' pros and cons for flexibility usage

Resource		**Pros**	**Cons**
	Electric heating systems	Low impact on resource owner for short periods (hours) = Indoor temperature has good inertia Medium flexibility size	Complex product and many brands Only available during winter/cold season Uncertain response time
	Hot water boilers	Low impact on resource owner for short periods (hours) Medium flexibility size	Uncertain impact/delivery, only use power intermittent when water need heating up.
	Electric vehicles and chargers	Low impact on resource owner Fast reaction from battery Large flexibility size	Consumer reluctance. Car often unavailable due to use/travelling Market still small

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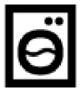
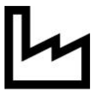
Resource		Pros	Cons
	Solar panels + stationary battery	Fast reaction from battery High probability of availability.	Battery needs recharge to repeat flex PV: Weather and seasonal dependence. Mainly downregulation.
	Home appliances	Small flexibility size Large potential	Resource owner impact: Requires consumer behavioural change Complex product mix and many brands Uncertain impact/delivery, only use power intermittent during use
	Commercial resource	Large flexibility size High probability of availability.	Should not interfere with business operations.

Electric Heating systems

Table 4 shows the share of heating systems per country in the Northern demonstrator. The share of electric heating systems differs between countries. Most of the Swedish houses have electric heating or district heating, a minor group use wood fired boilers. In Finland both electric heating and district heating are common. However, the share of oil-fired boilers and wood fired boilers is larger than in Sweden. In the Nordic countries heating and warm water production consumes the largest part of the energy in buildings. Private houses stand for the largest part (1 984 000 private houses in Sweden, 2016).

Table 3 Share of heating systems per country

Heating and hot water systems, permanent living	Electricity	Other types of heating
Sweden (2016) (Energimyndigheten, 2017) 80,5 TWh	26%	74%
Finland (2020) (Tilastokeskus, 2021) 39,2 TWh	38 %	62 %
Estonia (2020) (Statistics Estonia, 2022)	14 %	86 %
Latvia (2020) (Official statistics of Latvia, 2020)	4 %	96 %
Lithuania (2020) *	11 %	89 %

** Percentage estimated on Eurostat data from 2019*

Electric Heating systems: Heat pumps

Heat pumps come mainly in two types. First, the water borne systems (like a geothermal heat pump), apart from circulating heat in the whole house, also provide hot tap water and air-to-air heat pumps that only heat the air from one location in the house. In water-based radiators and/or floor heating the accumulated heat in the circulating water increases the thermal inertia of the house compared to electric radiators and/or air -to-air heat

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pumps. This makes them more suitable for flexibility services. The amount of possible flexibility is rather high, about 1-2 kW for air-to air and 10-60 kW for a geothermal heat pump. There are, however, a few potential drawbacks using them for flexibility services:

Large mix of products: They have quite a long lifetime (10-20 years) and thereby the market is a mix of old and new systems of different brands, some already connected to remote steering. This makes the verification process for flexibility quite extensive or includes only the connected already verified products, limiting the total amount of flexibility provided from residential consumers quite a lot. The most common way of handling this mix is to add a local generic steering equipment, but that comes with a high extra cost for the resource owner. One example of flexible steering of heat pumps is used on the Swedish DSO local market sthlmflex (Svenska kraftnät, 2021) (Vattenfall Eldistribution AB, 2021).

Seasonal product: Heating is mainly used during the colder months (October to April in the Northern countries). Waterborne systems are of course providing tap water all the year round, but the power used is much smaller and more intermittent. Air-to-air systems are usually shut off completely during summer if not used as an AC instead, but this is more common in the south than in the Northern demo area.

Slow/uncertain flexibility response: The response time varies. Some steering solutions only trigger the outdoor thermostat with a simulated warmer temperature and leave the actual reaction to the system itself (it might be slow). Many heat pumps are not built for rapid on/off at all according to the supplier. It's thereby uncertain how fast and how much flexibility they will deliver at a certain moment. But used for congestion management service, this could still be a very useful resource.

Electric Heating systems Direct electric heating (radiators)

Heating by electric radiators is sometimes used in households without a waterborne heating system, e.g., in summer/winter cottages. The total max power from this type of electric heat depends on the number of radiators but could usually be 2-5 kW. A temporary shut off for 1-3 hours is usually acceptable without indoor comfort issues. Direct electric heating is usually a larger controllable load for a household than a heat pump but the total number of consumers in this segment might be lower. This is a seasonal asset since heating is usually only used during the winter months and perhaps also mostly used in summer/winter houses (not heated up all the time)

There are also some potential obstacles regarding how to connect and control electric radiators from an external platform. Connection and potential steering differ depending on how they are installed. They are either connected one by one to the nearest wall socket or all connected to the same power line from the fuse box. With the simple wall socket connection, they could potentially be steered by a smart plug in each wall socket, so the more radiators, the higher cost for plugs. If they can be controlled directly from the fuse box, the cost will be more fixed. However, solutions for remote control of fuses are not so common and will most likely need an

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electrician to install and is thereby rather expensive for the consumer. Today, it's possible to purchase modern Wi-Fi-connected radiators which could simplify the technical solution. Some connected smart heating systems have products that fit electric radiators. This is probably a way forward for control by the FSP market

Electric Heating systems: Electric floor heating

The most common use of electric floor heating is for extra comfort heating in bathrooms while the rest of the house has another heating system. The max power is usually below 1 kW since the area is rather small in a bathroom.

These floors are always fixed installations with a local thermostat. It is nowadays possible to buy a connected thermostat which could make it possible to control remotely, usually then as part of smart control of the whole heating system of the house.

Electric Heating systems: Electric hot-water boilers

Houses without waterborne heating systems need to heat their tap water through a separate hot-water boiler. A common type (in the Nordic countries) is the electric hot-water boiler which comes in different sizes, usually between 80-300 litres for single family houses. The boilers are easy to control with a simple on/off relay/switch and already in the 1980's there were solutions in operation with time-of-use relays, usually allowing heating during nights. In Finland, this has been widely used by a relay connected between the water boiler and the electricity meter supplied by the DSO. Today there are also smart boilers available with different built-in operation modes like adapting to household profiles and holiday mode (anti-freeze level).

The electricity power used by a hot-water boiler is usually 1-3 kW depending on size and connection (1 phase or 2 phase) which is large enough to provide electric flexibility if aggregated by many resource owners. However, there is an uncertainty in the available flexibility since a hot-water boiler is a very good accumulator and the heating needs are very limited when no tap water is used. This means that controlling a boiler might not reduce or increase the electricity usage at the desired moment, even if it receives a steering signal.

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Electric vehicles

Electric vehicles are rapidly increasing all over the world and with larger batteries, vehicle to grid (V2G) and smart charging open for a large flexibility asset in a few years. Batteries have the advantage of fast response, which opens for markets like frequency control services.

The way of steering/providing flexibility is either by controlling the charger or by communicating with the car directly. There are already several companies providing this to the end customer. There are also companies developing API services for different car and charger brands that make it easy for an FSP to provide this service for a mix of brands.

These assets have in general few technical drawbacks, mainly to have correct info about the battery status (state of charge, SOC) which is solved by e.g., enode. Another difficulty is bidding into markets 1-2 days ahead and being sure the asset is available. The pool of aggregated assets will probably need to be large to secure enough flex.

There is still some reluctance from electric vehicle owners regarding the extra battery tear by the flexibility service. Concerns about battery lifetime, payback from investment and charge anxiety remain the main elements for low acceptance of flexibility provisions from users.

Stationary batteries (and solar panels)

The business case for installing solar panels in the Northern countries has during the last years improved due to lower panel prices with higher efficiency in combination with a higher electricity price as well as subsidiaries in some countries. This means that this consumer segment is growing but the consumers are mostly focused on local optimization of their self-consumption.

Many solar customers consider adding a battery to both increasing their self-consumption from the solar production but also to get backup power during power outages. The consumer could also benefit from spot price optimisation. From a market perspective, these batteries are also a good, fast flexibility resource if aggregated into a larger virtual battery that could participate on e.g., TSO FCR-D market. This could improve the battery business case for the resource provider quite a lot without removing the other benefits for them.

Stationary batteries are a more predictable flexibility resource compared to flexibility from an electric vehicle since vehicles are not connected to the charger all the time. There might also be less reluctance from the resource provider to provide the stationary battery to market than the from the vehicle.

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Home appliances

Different kinds of smart home automation systems are today used by at least some household consumers. The systems usually provide a mobile app, some consumptions visualization and remote control of e.g., smart plugs for control of wall-socket plugs, lighting control, temperature sensors, radiator control, water leakage and smoke detections.

Households usually have several large electric appliances which potentially could be valuable flexible assets. Products like dishwashers, stoves, and ovens, washing machines and tumble dryers are all using quite a lot of electricity.

The actual power used at a certain moment is however difficult to predict both because the electricity need differs depending on the use (what washing program, how many casseroles on the stove etc) but also because the products are not used all the time. New dishwashers and washing machines usually come with some built-in smartness that can be used by the consumer to lower the electricity need and/or cost, these are solutions like eco-programs and timers to shift starting into low-cost hours.

The most important consideration, in this case, is the end-customer himself who usually has difficulties in shifting his use over time based on the electricity prices, they need to have their meals cooked as usual. A consumer can usually make some adaptions to simple fixed steering principles, like grid tariffs with low price hours but to do steering based on e.g., hourly (or 15 minutes) spot prices will need new tools and a large awareness increase to get the behavioural changes. In general, the risks of direct control of home appliances from e.g., an FSP is higher than the value.

Industrial flex

Today the largest flexible capacities on the consumption side come from the largest energy consumers, the large industries. Industries like pulp and paper, metal, chemical production, and mining are using large amounts of electricity and a single site can have a momentary consumption of >100 MW. Naturally, it can be very effective to find flexibility within these industries. The technical set-up to steer an industrial size electric boiler or ventilation system does not necessarily need to be much more complex than a household heater. The resource needs to be individually metered and it needs to be automatic steering and communication with the resource. For frequency related flexibility markets a frequency meter needs to be connected to the automatic steering. The frequency meter can be either locally placed or a centralized metered if it meets the TSO's standards for delivering the service. In general, all same principles for steering, connectivity and aggregation apply to industrial flex. More and more common is a solution where the aggregator connects their platform straight to the resource provider's internal control system (SCADA). For either solution, sufficient data security is of the highest importance. Another key to attracting flexibility from industries is that the industries' core process and the product is not damaged by an activation. This makes the technical expertise about the industries processes and products essential.

3.4 Connecting flexible resources to an FSP

Internet of Things (IoT) is today a reality and the number of resources and appliances connected to Internet increase rapidly. A connected resource could, in theory, be able to be controlled from external platforms and FSP, but the diversity is high, which in many ways is challenging. There are different technical solutions on how to communicate with the flexibility resources, these solutions come with different attributes and challenges.

DSO-smart meter: In Finland, the smart meters have an embedded relay which can be controlled via the DSO platform on a steering signal from the FSP. This relay can only do on/off steering of one connected resource and is not giving any feedback on the power level, the success of steering or other measurements. It's most used for steering hot water boilers.

Local gateway in the appliance: Some resources could be *Smart Grid Ready* meaning that they have an Internet connection and e.g., a possibility to download spot prices and then steer the resource with a local steering principle in the resource. It's mostly used on heat pumps. This is usually brand-specific solutions (proprietary) which makes it complex for the FSP to handle many brands and models. There is usually an extra cost for the resource owner to buy this *Smart Grid Ready* module.

Generic gateway for heat pumps: There are tech companies on the market which have designed a more generic solution which allows many brands and models of heat pumps to be steered with the same product. These products could be used by the consumer themselves for comfort increase and automatic control but can also be used in flexibility solutions through aggregation in a supplier platform. This is usually combined with some smart meter measurement (P1/HAN or blinking eye) to verify the action from the flexibility signal.

Generic Smart Home system: There are several different Smart Home solutions on the market (simple and more complex). Even though they are usually connected to the Internet nearly all focus on control by the end customer not by FSP. These systems usually focus on comfort and simplicity like smart lightning and sensors. Smart appliances acting according to electricity prices will probably increase in the future but are so far mostly seen on heat pumps.

Resources connected to Cloud platforms: Some larger assets as already connected to the supplier cloud and could without any additional hardware/gateway at the resource provider be easy to both control and measure data from. Typical assets are EV-chargers, solar and battery solutions (the inverter is connected). These can often be controlled by an FSP through an API provided by the supplier. Sometimes the supplier could also provide an aggregation platform making it easier for the FSP to send one signal for all resources and leave it to the supplier to do the actual steering.

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3.5 Measuring flexibility

The current smart meters can register the consumer's consumption per defined settlement period, currently one hour and 15 minutes in the future. Participation in markets that require faster adjustments requires another way to verify the actual power level that was activated and verify that the seller of the power change has delivered according to their promise.

While this may appear a small issue, in practice from the cost side the ability to measure and verify is currently a major obstacle for a smaller load to participate even in aggregated form on markets shorter than the settlement period. There are no standards to what kind of metering will be necessary nor standards for transferring or handling such metering data. Requirements are set by the buyer, currently mostly TSOs, later possibly also DSOs. Building a shared understanding and standard for verifying the delivery of bids is hence a key question to be solved to enable the wider participation of smaller loads in flexibility markets beyond the settlement period. The first step may be the ability to participate in intraday markets from the current day-ahead, as well as shortening the settlement period to 15 minutes.

Different options for going beyond the settlement period exist. Verifying the effect on an aggregate level within all DSO networks and comparing that to the bids provided by flexibility operators to the flexibility markets may work if most flexibility operators deliver what they have promised. A single operator that would not deliver according to promises might be identified from the aggregate data. This could be supported by diagnostic steering to the system that would not be announced to the participants. Potentially even added value of an operator's flexibility could be determined by diagnostics steering if the minimum bid size would be significant enough to be able to identify the effects of activating bids from each operator. This might eliminate the need for measurement of individual steering activation and power changes. However, there is little research where such statistical and system analytical methods would have been applied to electricity grids.

Ability to show power changes may also be based on a requirement to be able to show the fulfilment of activated bids based on random checks. This might make it possible to use less standardized equipment, where the data would require at least some manual aggregation and analysis work to be performed. For instance, electric cars can log their charging and pauses in it, but this data may require some processing and analysis before the effectiveness of steering can be verified. Hence it would not be feasible to analyse every activation.

Actual measurement on a near-real-time basis is logically the simplest solution. Smart meters are required to have a real-time interface and adding a device capable of reading this interface and sending the data to an information network is a certain way of verifying the effectiveness of steering at the level of each consumer. However, such devices have a cost and the data connection also has a cost, which may limit the minimum size

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of steerable loads relatively high, as the economic benefit from the steering will have to also cover the metering costs.

4 Market drivers for flexibility

This chapter analyses the different perspectives of the TSO, DSO and FSP describing what their main drivers for flexibility are. Giving insight to the different kinds of problems that can be solved and what the main benefits with the flexible resource are.

4.1 TSO perspective

For the TSO, flexibility services can be used to provide value in a range of different cases. TSO may procure location specific flexible capacity through timely auctions, tendering for fixed time bilateral contracts or flexible connection agreements. The resource may be used for planned or unplanned congestion management, investment deferral, redispatching, countertrading, or balancing. Location-specific capacity may be utilised for redispatching, counter-trading and balancing purposes as well. For forecasted congestion situations certain amount of capacity may be procured for a scheduled delivery during congestion. In addition, certain amount of capacity may be procured to manage interruption risk during the planned congestion. For an investment deferral, TSO may procure capacity through flexible connection agreements. TSO and the connecting party agree on flexibility delivery terms as a part of a connection agreement. The incentive for the connecting party is fast connectivity since a non-firm connection may be established without direct grid investments. Investment deferral may be established through timely auctions or bilateral contracts as well.

In the previous chapter, 3.3, different types of flexibility resources were described. Possible flexibility providers (EV chargers, electric heating etc) will come from the DSO network side. As presented in Figure 4, this flexibility potential or flexibility pool can be used by both operators (TSO and DSO). TSO use of these resources for ancillary services can be done in two ways. Firstly, direct access used for TSO as it can reach and activate resources by themself with bilateral agreements or markets which belong to TSO. If TSO would like to use integrated services, coordination between operators is needed. Secondly, for TSO to reach flexibility potential in DSO network and use it for them need new services and products must be developed. These integrated services can provide benefit to both operators using flexibility products which can ensure different needs from both sides (e.g., balancing need for TSO and CM need for DSO). By using this integration, the TSO can get economical value from that. The need for flexibility product type is case-specific. In the future, there is possibly need for frequency and non-frequency related services. As the need for the services is growing from TSOs’ side, more supply will be needed as well. Electricity networks are transforming from centralised to decentralised. This means that flexibility potential of generation and consumption will come mainly from DSO network, and that's why there is a need to have a coordination system between them to share the resources, which can be used for both operators (DSO and TSO). This will be done through Flexibility register (FR). FSP will provide flexibility to FR

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and after qualification (this means approval by both system operators) it will be sent to T&D coordination platform which can be reached by DSO and TSO for flexibility activation. Flexibility usage is done through different products and can fulfil some TSOs' system service need.

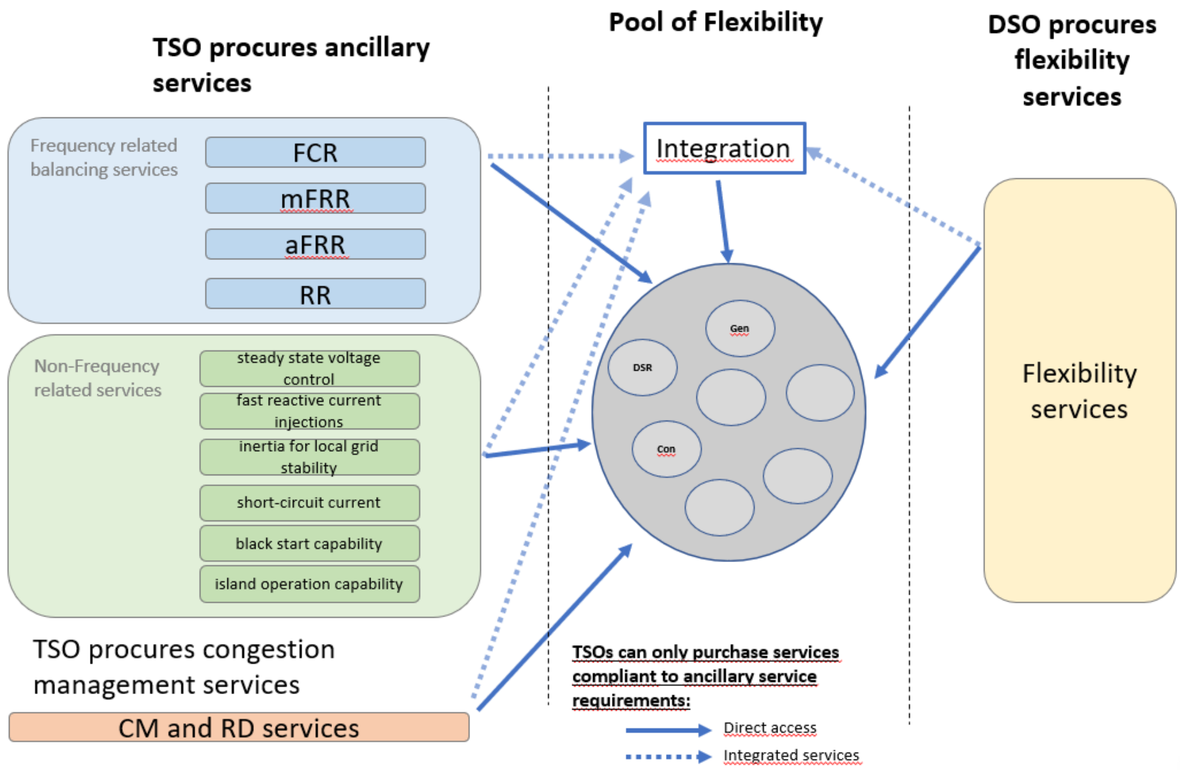

Figure 4 TSO ancillary services

The full potential of flexibilities is yet to be understood, however, the current view is that flexibility could provide a wide range of TSO ancillary services as well as create new market-based services that could be utilized not only by the TSO but also by the DSO.

Currently, the amount of available system resources for TSO ancillary services is limited, thereby one important aspect of flexibility is the increase of available system resources for these services by lowering the barrier of entry for these resources.

4.2 DSO perspective

Flexibility is going to be an alternative for grid investments or a possibility to postpone investments to the time when the DSO has better knowledge of target areas electricity usage. Because a DSO is the operator with the responsibility to decide whether to invest in the MV or LV grid or to use other solutions. Therefore, DSOs needs the information from customers in the target area about if they can provide services for the system operator. The DSO's role is to empower and facilitate the market.

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The main goal of the DSO is in general to maintain a distributed electricity quality and ensure grid readiness for the ongoing energy transition. The quality of the grid and its parameters can decrease with time, having more consumers and Distributed Energy Resources (DER) connected to the DSO grid. With increasing electrification, particularly of the heating and transportation sectors, DSO's witness a rise of local congestions which may result in poor voltage quality at some segments.

The traditional way of dealing with such versatile grid quality situation is to reinforce or reinforce the specific segment of the grid. That allows increasing the peak consumption limits, as well as generation, with a high degree of confidence. However, since the investment is oriented specifically in peak consumption/generation periods, the investment is not only raising the CAPEX, but it decreases the efficiency of the grid. Grid efficiency is determining how much of the grid capacity is being utilized to distribute average amount of energy. In the long term, such a traditional way is leading DSOs to end up operating over-sized and over-engineered grids with a high burden of costs applied to their customers.

The flexibility concept, as seen from the DSO perspective, is specifically created to tackle the over-engineering grid problem. Since the peak consumption and generation, which causes grid congestion, may happen for just a few days a year, it only seems logical that the deviation of consumption and generation at those moments would allow DSOs to operate with a more efficient grid. The main aspects that flexibility can contribute to DSOs activities are the following:

1. *Solve congestions in Low Voltage (LV) and Medium Voltage (MV) grid*. Due to poor prediction of electricity usage in a particular part of the grid or due to increased peak consumption DSOs occasionally witness grid congestions. These congestions can occur due to limitations of the conductor (cable), transformer capacity or a combination of both. Most commonly these congestions result in voltage deviations, especially in LV grid, and cause disruptions of equipment connected to the grid. Flexible generation or consumption (up or down regulation) can reduce or solve some of occurring congestion problems and postpone investments in grid expansions.
2. *Connecting more Distributed energy resources (DER).* With energy transition we see the rise of DER, especially PV systems, being connected to DSO grid. Increasing electricity generation is causing congestions, especially when we speak about the local grid: Peaks in Photo Voltaic (PV) generation occur on all prosumers connected to the same local grid at the same time. By utilizing flexibility services, for example, a DSO can start tendering for increased consumption on these hours to mitigate this accumulative effect, which in the end could result in the ability to connect more PVs with existing infrastructure. This feature will be contributing directly to the green course of the future energy industry that public policies, like the European Green Deal, are pushing for.
3. *Changes in grid topology.* While undergoing planned maintenance in specific areas of the grid, operation team must foresee an acceptable grid regime to withstand current loads. However, even

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though the grid is radial and there are ways to resupply electricity through other transformers or lines, the n-1 regime (Reliability criteria for the electricity system) may be lacking capacity in general. This situation may occur for a week or two every 3-6 years. With flexibility services DSOs can purchase decreased consumption services to mitigate these consequences and ensure high grid quality standards.

To be able to use flexibility as an alternative option for DSOs, there is a need for better metering to understand congestion on the grid and to clarify that flexibility can solve the problems which were usually solved with additional grid investments. Because DSOs' grid is used radially, the possible need for flexibility for DSOs is also limited to a certain area. That is the main reason why it is harder for a DSO to use flexibility options compared to a TSO which can use flexibility from larger areas. DSOs need to find out if there are locally available flexibility assets. A major concern for DSOs is if there is any flexibility available to use when grid improvements are needed. Therefore, DSOs need accurate planning tools to calculate and evaluate the effect of the flexibility on the grid, so that DSO can make the final decision to use flexibility.

4.3 Flexibility Resource Provider perspective

From a flexibility provision perspective (end customer), the main drivers are mostly economic, however, some other aspects are worth noting. The resource provider will, as described earlier in this report, be economically compensated for providing flexibility. The resource owner will benefit from increased price stability on an individual/resource level when loads are steered from high demand (expensive) peak hours. On an aggregated level this could increase the price stability on the spot market. For a commercial flexibility resource provider, the potential gains from offering flexibility are bigger as their steerable resources can be large. Additionally, there might be reputational gains for companies, some certifications of [office] buildings give higher scores for solutions optimising energy efficiency.

There is a value for the consumer in that the use of flexibility stabilises the electricity system. There is a lower risk of outages and grid fees are kept at a stable level as grid capacity can be optimised by using flexibility when congestion occurs. Flexibility reduces the risk of frequency control related damage of equipment and forced disconnection from the grid. When electricity consumption increases this tends to drive increased volatility, flexibility steering helps to reduce volatility.

Additionally, the use of flexibility generates value regarding the environmental impact of energy sources. Polluting emissions can be reduced because flexibility capacities reduce the need for fossil-fuelled power reserves, like gas turbines and diesel generators. Therefore, a functioning market for flexibility not only increases the efficiency of the electricity grid but also brings positive effects in terms of environmental concerns.

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5 Future flexibility potential

This chapter describes the possible future developments in the market for flexibility in the Northern demonstrator countries. Each country has a different starting point and different foreseen future development.

5.1 Estonia

According to the security of supply report (Elering, 2021) the annual total electricity consumption will increase by 10% from now until 2030 (to 9,5 TWh) and the peak load also by 10% to 1690 MW. In the future (no specific year set) the electricity demand may be increased to some extent by loads related to the Rail Baltic project and to the growth in the number of electric vehicles. "Replacing the entire internal combustion engine fleet with electric cars could, according to a rough estimate, impact the growth of power demand by 10-20% compared to today's level." Total average demand side flexibility has been estimated to amount to 200-400 MW (TTÜ, 2014), driven by households, office buildings and industry.

Estonia will need additional balancing reserve after desynchronising from Russia. It has been estimated (Pöyry, 2015) that in addition to existing capacities held by TSO as strategic reserve (not participating in the market) and by generators already participating in mFRR market, 125 MW extra reserves will be required. This can be either generating capacity or demand side response (DSR) or both. However, this is assuming that reserves in neighbouring countries would not be available to Estonia.

There is less clarity about the DSO needs for flexibility in coming years. According to the same report, less than 10% of substations where congestion management might be relevant in this decade.

5.2 Finland

In Finland, the energy transition of the electricity system is picking up speed by the rapid investment into new wind power while condensing and combined heat and power (CHP) plants are being decommissioned, electrification of industries and heating as well as the electrification of transport sector. This means more changing electricity transmission needs which also are becoming harder to forecast. These changes increase the need for flexibility, which will make it possible for the electricity system to be used more efficiently and avoid over-dimensioned investments.

The demand side has long traditions in Finland of participating in the markets as flexible assets. Still, the new demand resources require new methods and processes to be developed to use them as the large units are utilized. The expected rapid increase of these distributed resources makes them interesting towards the transmission and distribution system operators.

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According to several studies, the technical potential of electric vehicles (EVs) (even without vehicle-to-grid technology) is significant in the near future. In 2030 the technical flexibility capacity of EVs is around 1 GW and in 2035 up to 3.6 GW (Fingrid Oyj, 2021) (Valtioneuvoston kanslia, 2021) (Vanguard Consulting Oy and Rejlers Finland Oy, 2021)[1, 2, 3]. The Finnish authorities estimate the number EVs on the road is 600.000 in 2030 (Communication, 2021). This can be compared to the peak demand of the Finnish system today, which is around 15 GW. Electric heating could account for another 2 GW in 2035. These estimates present the technical capacity which doesn't yet estimate how a large amount of the potential will start offering their flexibility to the system.

This flexibility potential can materialize in the near future by different ways. In the so-called implicit demand response, the resource owner optimizes against its tariffs. This is already the case in Finland for around 10 % of the end customers who have supply contracts with varying hourly prices. The flexibility can also be used by offering it to different markets, i.e., explicit demand response. Today, it is possible to aggregate smaller resources to the reserve markets operated by the TSO. A considerable number of demand units participate in the markets today. In the near future when the independent aggregation models mandated in the EU's Clean Energy Package are introduced in the National legislation, the utilization of distributed resources might start to increase.

5.3 Latvia

The JSC "Augstsprieguma tīkls" (AST) (Augstsprieguma tiklis, 2021)"ANNUAL STATEMENT OF TRANSMISSION SYSTEM OPERATOR FOR THE YEAR 2020" report includes an annual consumption forecast in three scenarios up to the year 2031. In the scenarios, annual consumption forecast for the year 2030 ranges from 7535 to 8279 GWh and the peak load is estimated as 1454 MW. In 2020 annual consumption was 7135.52 GWh and the peak consumption was 1184 MW. Decade comparison shows an annual consumption increase by 6–16%, dependent on the scenario, and peak load increase by 23%. Together with the rise of consumption it can be foreseen that also the flexibility potential may rise due to the ongoing electrification of private and public transport, as well as shift in heating system technologies. However, there are no estimates for the current or future flexibility potential in Latvia.

After the desynchronization from Integrated Power System/United Power System (IPS/UPS), Baltic countries will need to ensure balancing reserves such as FCR, aFRR and mFRR. According to study "Baltic reserve capacity test study" (Elering AS, AS "Augstsprieguma tīkls", LITGRID AB , 2021), individually countries would not be able to maintain required reserve capacities. Therefore, the Baltic TSOs are planning to operate in a common Baltic Load Frequency Control (LFC) block to share the available reserves between the Baltic countries. However, the study also shows that the Baltic LFC block is highly dependent on reserve resource provider. Unavailability of a single reserve resource provider results in the insufficient or even absence of some reserve capabilities. Therefore, flexibility providers could be highly important to provide reserves for the system.

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In the next ten years, an increase in generation from wind power is expected. An example is the ongoing project ELWIND between Estonia and Latvia. If the development of offshore wind farms is developing according to plan and assuming that offshore wind farm projects, including the ELWIND offshore wind farm project is being implemented in full, that would be additional 500 MW of installed capacity for Latvia. Wind and solar power volatility are an aspect that could force consumption to become more and more flexible with time because of implicit demand response.

JSC "Sadales Tikls" (ST) in the end of 2021 reports above 300MW of distributed generation connected to its network, but only about 14 MW of this capacity was solar PV microgenerators below 11kW capacity. ST forecasts that by 2030 the installed capacity will increase to at least 100 MW of solar PV microgeneration and another 100MW of large solar power plants to meet the goals of Latvia's National Energy and Climate plan for 2030.

In the next years, new end-user engagement possibilities are expected to emerge. End-user will be allowed individually or by forming an energy community to install or acquire power generators and to generate electricity not only at the facility where it is consumed, but also remotely. Whilst end-users are becoming more aware of the possibilities to invest in renewable energy source generation and demand shifting, it opens the possibility for aggregators to engage end-users in flexibility provision.

AST and ST realize the system flexibility potential to mitigate intermittency effects from renewable energy sources, as well as to optimize the system investment and operation costs.

5.4 Lithuania

The Lithuanian energy ministry's strategy till 2030 is the same as the European Union's. Renewable energy source (RES) share in final energy consumption 50%, RES in transport 15% and RES in heating 90% by 2030. With these changes in the sector a lot of potential from consumer side (transport and heating) can be used for flexibility.

To see the real potential of flexibility Litgrid with ESO purchased "Lithuania demand response study" in 2018 (Litgrid, 2018). Based on the study, at that time, possible capacities of demand response (DR) services were near 200 MW and half of this potential comes from electric heating. In the future, electric heating will increase even more, as it declared in a report (Ministry of Energy of the Republic of Lithuania, 2018) from 2021 to 2030 heating installation power increase by 200 MW. The highest potential comes from electric heating (space heating and hot water) for demand response because of the thermal inertia: Electricity supply can be disconnected for a short time without any loss of comfort. From the consumer side, potential is rising and based on the "Lithuania demand response" study the survey indicated that 90% of companies would like to benefit from the management of electricity consumption if technical possibilities were available. Other main aspect without technical possibilities is the need for additional practical insights in DR, e.g., via demonstration projects, articles,

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and educational activities. This is seen as important as it will provide end-users with a better idea of what is required to participate in flexibility services, how it can be done, and what the potential benefits are.

Today, in Lithuania demand side response potential is used through independent aggregation in the balancing market. In the end of the project, new products will be created which enable flexibility in other markets, for example to manage congestion constraints in the grid, by procuring flexibility to solve problems in specific grid areas.

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6 WP7 Flexibility provision demonstration plans

This chapter describes the overall demonstration plans for the Northern demonstrator. The demonstrations will differ between each participating country. The accommodate the differences the country specific plans are described.

6.1 Northern Demonstration Overview

The Northern Demonstrator is an integrated effort by multiple stakeholders including TSOs, DSOs, MOs, aggregators, technology providers, and research centres from Finland, Estonia, Latvia, Lithuania, Sweden, Norway, Belgium, and the UK. The Northern Demonstrator will enable market-driven flexibility uptake by networks in a coordinated way through multiple markets, where liquidity can be reached due to scope or existing trade volumes. The objectives of the Northern Demonstrator are:

- Develop a seamless end-to-end process for market-based flexibility utilization for grid services
- Lower the entry barrier for flexibility by simplifying the process for flexibility service providers
- Ensure availability of short-term flexibility from multiple sources
- Service agnostic
- Market-based TSO-DSO coordination

In this regard, the Northern Demonstrator consists of a demonstration that will show the mapping and management of network needs in multiple use cases over multiple networks. The high-level Business Use case of this demonstration includes seven scenarios. Scenarios are

- Flexibility resource provider onboarding process
- Prequalification process of flexibility service providers, resources, and network needs
- Flexibility (energy and capacity) procurement process
- Conditional secondary trading process
- Activation process (in case of separate activation after the procurement is needed)
- Delivery and monitoring process
- Verification and settlement process

The business use case can be applied in the provision and procurement of balancing, network congestion management, and voltage control services. BUC includes new roles: Flexibility Register and T&DCP (TSO-DSO Coordination Platform). These new roles perform in the management of flexibility resources and procurement-related data and joint TSO-DSO coordination and network impact assessment.

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Furthermore, this demonstration will focus on how multiple networks can use joint and shared mechanisms to demonstrate scalability and contribution towards a pan-European solution. The summary of the initial functional requirements of the aggregator and market interface is listed in Table 1. The products to be demonstrated are short-, and long-term energy and capacity products, as listed in Table 4.

Table 4 Products proposed to be used in Northern Demonstration

Abbreviation	**Description**
LT-P-C	Long term active power product
NRT-P-E	Near real-time active energy product
ST-P-C	Short term active power product
ST-P-E	Short term active energy product

6.2 Estonian Demo

The Estonia implementation of Northern demonstrator will benefit from the Flexibility Register and TSO-DSO Coordination Platform as developed in the project. Also, the algorithms developed for grid qualification and bid optimisation processes will be applied. Integrations with existing and/or simulated components are required. Some internal systems may also be needed to develop or upgrade – for example, the system for collecting and providing relevant grid information.

The main product to be demonstrated is NRT-P-E (near-real-time active energy product). Also relevant for Estonia are short-term and long-term active power capacity products and near-real-time reactive energy product.

Elering would be the owner and operator of the Flexibility Register and TSO-DSO Coordination Platform in Estonia. Elering as TSO and Elektrilevi as DSO are flexibility buyers. Both can be also in the role of market operator for certain products if no independent MO is available. This is especially true for NRT-P-E product which can be used for both congestion management and balancing (mFRR). Independent MOs like Piclo and Nord Pool are welcome to operate certain products. Specific FSPs for providing the flexibility and testing the solution still need to be defined.

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6.3 Finnish Demo

Participants in the Finnish FSP demo are Vattenfall (FSP), Kymenlaakson sähköverkko (DSO) and Enerim (technology provider). The demo will show how resources can be steered by a smart meter installed by the DSO on a signal from the FSP through a platform provided by the SO. The target is to attract approx. 30 residential consumers to participate.

The DSO (KSOYV) has selected a target population of consumers based on their electricity load. The DSO will be in touch with these consumers to convince them to participate in the project. When a positive answer is received the DSO will forward the information to the FSP. The FSP will contact the consumer to get them to sign a flexibility contract. Thus, the risk of installing new meters in non-participating households is minimised. The FSP will inform the DSO that the smart meter with remotely controlled relay steering can be installed. Enerim will then install the meter on behalf of the DSO. Enerim, as a technology provider, will supply a system for steering resource provider loads. The consumer engagement activity is scheduled for Q1 2022 and meter installations will be carried out during Q2 2022.

The implementation part of the demo will start during the autumn of 2022. The partners will test the functionality of load steering in lab tests. Once these have proved successful the tests will be performed on the resources to confirm flexibility availability. The FSP will define a steering logic so that the loads are steered without interference with the resource provider's quality of living.

In the Finnish demonstrator, several flexibility products are piloted. Trading of products is enabled by the partners of the Northern Cluster which act in the role of Market Operator. These marketplaces are then connected to the common platform, which makes it possible for the SOs to procure flexibility for different timeframes in a coordinated manner. To act on these markets, the FSP offers its contracted flexible resources which first need to comply with the technical requirements of the respective product, i.e., the product prequalification. The different products to be tested are active energy products for long-term, short-term, and near-real-time, namely LT-P-C, ST-P-E, NRT-P-E, as the Northern Cluster describes them.

Enerim provides an interface between the Vattenfall as the FSP; smart meter management system of Kamstrup, installed in the KSOYV's grid; MO Platform, e.g., Nord Pool Intraday, OneNet Northern demonstrator platform, including FR and T&D CP. Figure 5 shows the high-level architecture of Enerim interface for Finnish Demonstration.

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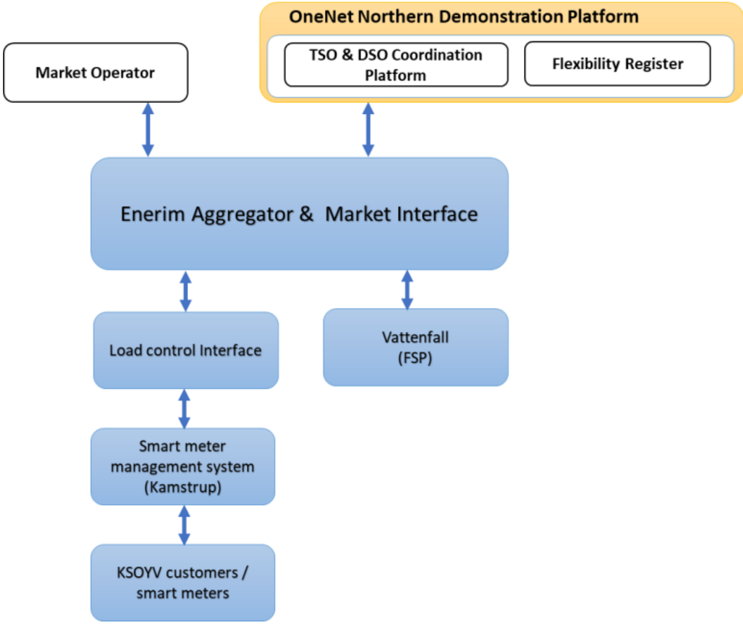

Figure 5 The high-level architecture of the Enerim interface for Finnish Demonstration

The aggregator and market interface will include different functionality to aggregate and prepare flexibility bids, register the resource into the FR, receive the activation request from MO or T&D CP, disaggregation it and send it to an appropriate flexibility resource, and remuneration report. The aggregator and market interface need to handle other FSP that may be connected to the Finnish demonstration as well. For example, a couple of flexibility resources, equipped with the iFLEX assistance (a type of smart energy management system) will join the Finnish demonstration as explained in the iFLEX corporation deliverable (Iflex-project, 2022).

6.4 Latvian Demo

Latvian demo is represented by partners AST (Latvian TSO) and ST (Latvian DSO). The demo is envisioned to show how sharing of available system resources could benefit multiple SOs, in this case, the TSO and the DSO. This will be tested through three flexibility products NRT-P-E, ST-P-C and ST-P-E, as they are described by the Northern Demonstrator.

For the demo, additional participants are expected to cover roles such as MO and FSP. SO is also expected to fulfil the role of a MO for NRT-P-E and ST-P-C products. However, additional MOs, such as project members PICLO and Nord Pool, are also expected to participate. PICLO has highlighted that products such as NRT-P-E and ST-P-C could be hosted by their test market platform intended for the project demonstration. Nord Pool, on the other hand, is the only MO in the project who can support the testing of ST-P-E.

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Regarding the FSP role, there are no FSP representatives in the project to be utilized in the Latvian demo and during the demonstration process, a theoretical FSP, created by the SOs, might be used to perform the envisioned process. However, during the project operation, real FSP candidates will be searched for with resources on a TSO or DSO network level.

Latvian demo scenarios

In the Latvian demo, it is planned to have two interlinked scenarios where main scenario covers system balancing needs through NRT-P-E and ST-P-C, and the secondary scenario covers system congestion management (CM) needs through NRT-P-E, ST-P-C and ST-P-E products. Both scenarios during the testing will intertwine as most of the products, excluding ST-P-E, are shared in the respective scenarios.

The system balancing is the main scenario due to its urgency considering the expected diverse flexibility resource influx in ancillary services and European platforms such as MARI and PICASSO. The scenario includes energy (NRT-P-E) and capacity (ST-P-C) products, where the capacity product is interlinked with the energy product, meaning the delivery of procured capacity is to be delivered in the form of energy bids. Moreover, what defines the balancing scenario is flexibility resource qualification and market bid filtering based on manual Frequency Restoration Reserve (mFRR) requirements set in the Baltics as per MARI guidance. In turn, this means flexibility resources participating in system balancing, currently only as mFRR under NRT-P-E or ST-P-C, must meet the defined Baltic mFRR technical requirements, and this compliance must be valid in resource qualification as well as market bidding to successfully participate under this scenario. While mFRR is not relevant to the DSO, it shall enable the provision of NRT-P-E and ST-P-C products by the clients connected to the distribution system.

The system CM scenario is the intertwined secondary scenario and is not the main scenario due to its lack of utility in the current situation. The participating TSO does not experience the need for internal network CM service; however, it is acknowledged as a potential future service and therefore should be investigated as such. Regarding the DSO, a recent increase in distributed generation has resulted in more than 10% of primary substations operating at or close to the transformer capacity limit. While there are no regulatory incentives for the DSO to implement CM today, this is likely to change in the near future enabling a new CM market both on the generation and demand side.

Similarly, as in the previous scenario, the CM scenario also has both energy (NRT-P-E, ST-P-E) and capacity (ST-P-C) products with additional energy product ST-P-E with a potential yet to be understood. Furthermore, CM scenario shared most of the Baltic mFRR technical requirements for the product as the balancing scenario, but what defines CM scenario bid quantity range. The quantity range creates the possibility for the CM service to be viable for TSO or DSO, although the DSO would, most probably, require smaller amounts to manage congestion than the TSO.

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As stated, both scenarios are intertwined as NRT-P-E and ST-P-C products can be provided by FSPs for both scenarios with additional limitations for the balancing scenario. Regarding the scenario utilization, the CM scenario is to be tested by both SOs, but the balancing scenario is only tested by the respective TSO, however in most cases, both scenarios are expected to work simultaneously.

6.5 Lithuanian Demo

Lithuanian demo will test two products: Near real time active energy product (NRT-P-E) and short-term active power product (ST-P-C). These products will be tested respectively by Lithuanian TSO (Litgrid) and DSO (ESO). Without TSO and DSO, involvement of market operators is also foreseen, namely MARI and Piclo. In the best-case scenario Lithuanian demo would also like to include an FSP. However, there are no current active flexibility providers in Lithuania, therefore, there is a chance that finding of such actor will not succeed. In such a situation a theoretical FSP would be made. This FSP should be able to sell NRT-P-E product to Litgrid and at the same time sell LT-P-C product for ESO. Two different scenarios are made for Lithuanian demonstration. The first scenario is when Litgrid procures flexibility from FSP and the second one is when ESO procures flexibility.

First scenario:

The first demo scenario will provide how flexibility can be used in the balancing market. According to legislative changes in Lithuanian national law introduced in 2020, a new independent aggregator entity, separated from energy suppliers is allowed to aggregate consumers, by enabling independent aggregation, they can concentrate consumers and their demand, later providing this flexibility service to balancing market. From consumer side one of the major requests is smart meter installation for data monitoring and validation.

With independent aggregation bid in balancing market, the TSO gets more offers and higher competition. When the TSO activates an independent aggregator's bid in the balance market, the aggregator must activate it at the appropriate time. The balance of the independent aggregator's balance responsible party is calculated according to baseline calculation methodology. If consumers are in DSO network, they must provide baseline calculations to TSO. Based on the baseline calculation TSO evaluates results and provide the payments for delivered services.

Second scenario:

The second scenario will investigate how flexibility services could be used to solve congestion problems in DSO grid. DSOs must consider using flexibility services as an alternative for grid reinforcements as well to ensure more efficient use of the grid according to the changes in Lithuania Law on Electricity which were made in 2021. ESO considers to firstly try using flexibility services to solve congestion problems. The second scenario would be very similar to the first one. Most likely, the same FSP can be used to provide products for both scenarios. However, in the second scenario, there is no obligation that flexibility would be provided through aggregation, as much smaller amount of flexibility will be needed. Furthermore, FSP will have more time between the

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procurement and activation. The balance of FSP will be also calculated through baseline methodology, but it will slightly differ from the first scenario.

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7 Conclusions

An increased electrification is foreseen going hand in hand with an increased focus on sustainability. People and corporations are becoming more aware of the climate change driven energy transition and some behavioural changes regarding the perception of the electricity market can be witnessed. These trends, together with investments in assets with flexibility potential, indicate higher levels of flexibility potential. Both cars, batteries and electric heating are valuable flexible assets due to their characteristics. Their power level and a potential to shift loads in time open for different flexibility services that benefit the balancing of the market and the cost for the resource owner.

The following points are the main conclusions to be drawn from this deliverable:

- Based on statistics on heating systems used, there is a big potential for flexibility use in both Finland and Sweden. Currently the potential in the Baltic countries is smaller, as the share of electricity used for heating is modest.
- The trend of electrification of vehicle traffic, heating, batteries etc. will have a big impact on available flexibility potential in all countries during the coming five years.
- The Northern cluster will demonstrate different flexibility products (long term, short term, and near real-time) in all participating countries. However, the detailed implementation plan of FSP in each country need to be planned according to the physical distribution of flexibility resources.
- A challenge comes from the regulatory coordination between different market actors. Steering done by the FSP cannot affect the flexibility resource providers' BRP and electricity supplier. This could lead to enormous effects on the existing electricity retailer market. For example, fixed prices would become more expensive or maybe not offered at all, due to lack of control for the supplier which creates risks which are difficult to price.
- There are several challenges to overcome with flexibility from households. The economic potential from flexibility is limited for the single consumer but valuable to the market and the FSP on an aggregated level. The system solutions need to be cost-efficient and primarily based on what the consumer has already installed. The FSP can probably not verify if a single resource is available and can deliver flexibility when there is a demand for flexibility. Instead, large, aggregated groups to fulfil the flexibility requested should be used. Considering the difficulties with verifying each single flexibility asset there are benefits to offering resource providers rather straight forward contracts for participation, paying the flexibility resource owner a fixed remuneration for being available and not compensating for every activation.
- A challenge for the FSP is to attract smaller, household consumers, as the compensation model might not be incentive enough to participate. The number of counterparts (DSO, FSP, BRP and other

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service providers like EV- charging-, or smart home solutions) in the market might be confusing for private consumers.

- Household consumers are not always purely rational actors. Flexibility services should not impact the lives or businesses of resource owners. Flexibility services should be simple and fully automatic.
- It is worth noting that even though projects, such as OneNet, mark a great advancement in harmonising processes, products, services and definitions, the viability remains a challenge and is a long process.

This report is the result of studying the availability of flexibility from different sources and the capabilities of end customers. This report describes the uptake and participation of end customers mainly from the perspective of an FSP. It is important to understand what drives consumer participation and how the availability of flexibility and its' commercial attractiveness for the consumer is a key to a feasible flexibility market and for solving the network needs.

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9 Appendix

9.1 OneNet Finnish Demo Contract Terms

OneNet Contract

The OneNet service contract is a fixed-term service contract entered into between the Customer and Vattenfall Oy (Vattenfall). the contract enters into force on the agreed start date or on the first day when it is technically possible to start it.

The contract concerns the control of the customer's consumption. Vattenfall will have access to the customer's measurement data (as well as one year's measurement history) within the framework of the OneNet project. The contract does not affect the Customer's current electricity contract or the network service contract signed between the Customer and the distribution network operator.

OneNet

OneNet is an EU-funded project to develop a flexible market that focuses on market-based flexibility for transmission management needs at both the distribution and transmission grid level. The aim is to create opportunities for customers to participate more actively in providing flexibility.

The large-scale development project will develop the market structure and common IT architecture and test these solutions at several demonstration sites. The whole project has 72 partners from all over Europe.

Service description

The contract enters into force on July 1, 2022 and is valid until September 30, 2023.

The customer's electricity load is controlled via a relay in the electricity meter. A device with sufficient power is connected to the relay, such as a hot water boiler, direct electric heating, heat pump, car charging station, etc. The service is intended to monitor the Customer's electricity consumption and control the loads connected to the service based on supply and demand on the flexibility market. In this service, the customer is the provider of flexibility

As a thank you for participating in the project, the customer will be offered a gift card for Clas Ohlson stores. The value of the gift card is 40 euros.

(Vattenfall is not responsible for the effect of consumption control on living comfort. The Spot sales contract may affect the amount of the customer's electricity bill)

Measuring electricity consumption

The local distribution network operator is responsible for measuring electricity consumption. An hourly electricity consumption measurement must be available at the place of use for which the OneNet service contract is signed. It must be technically possible to use the measured hourly data for billing purposes. The contract requires that the hourly measurement of electricity consumption is always switched on from the main switch.

Requirements for the operating environment and functionality of the Service

The customer must have an electricity distribution contract with Kymenlaakson Sähköverkko Oy and the relay-controlled meter must be installed before the control of flexibility can be started.

Commitment to the contract

The contract is customer- and site-specific. The customer must notify Vattenfall of a change of location (move etc.) at least two weeks before the change by calling Vattenfall's customer service number 020 722 9000 or notifying Vattenfall by post or e-mail. When the place of use changes, the contract expires. The customer has the right to terminate the contract with two weeks' notice. Vattenfall may terminate the contract with one month's notice.

Personal data and data protection

Information on the use of the Customer and the Service is stored in Vattenfall Oy's customer register. The information in the register will be used to develop the Service, provide the Service in accordance with this Contract, anonymize usage data, and improve the operation of the electricity system and develop new services. The customer can exercise their rights under the Personal Data Act (523/1999) by contacting Vattenfall Oy. Contact should be made by email to: dpo.nordics@vattenfall.com.

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In urgent cases, please contact Lisbeth Svensson, lisbeth.svensson@vattenfall.com, +46 722 142 174. Vattenfall Oy's up-to-date Register Description is available at https://corporate.vattenfall.fi/site-info/rekisteriseloste/

Vattenfall reserves all rights to anonymous data collected and / or generated by the Service. Vattenfall may use such data without restriction for any purpose, provided that the Customer cannot be linked directly or indirectly to the data. Vattenfall may also disclose such data to third parties as part of the OneNet project. The data used in the project are mainly used by Vattenfall, Kymenlaakson Sähköverkko Oy and Enerim Oy. The Consortium Agreement of the OneNet project states that each participant must comply with EU and national data protection law. Vattenfall has unrestricted full ownership and control of this anonymous data. In the event of a failure of the Service, Vattenfall has the right to examine, process and record the information collected by the Service to the extent necessary for the correction and in accordance with Vattenfall's data protection guidelines. Vattenfall does not provide the Customer with historical data on the use of the Service.

The customer grants Vattenfall the right to process and exchange the necessary personal data in order to implement the control of flexibility and to resolve any error situations.

Service Provider Liability and Limitations of Liability

The control function of the service is intended to control the load of the device connected to the customer's electricity meter with a relay (e.g., hot water tank, car charging point, air source heat pump, etc.). The Customer must be aware that the Service may not work, for example due to a technical error or the characteristics of the place of use, during an electricity outage or telecommunications connections or for any other similar reason.

Vattenfall does not guarantee the implementation or operation of the flexibility steering. There may be too many steering attempts or no steering at all, so the customer should ensure that important equipment is heated by daytime electricity if necessary (e.g., hot water boiler). However, if the controls do not work as described, Vattenfall will reimburse the customer for the lost savings of € 1 / day when the controls did not work.

Vattenfall shall not be liable for any damages resulting from a breach of the Terms of Service or other instructions given by Vattenfall, such as changes made by the Customer in violation of Vattenfall's instructions.

The information provided by third parties is used to deliver the service. Vattenfall shall not be liable for any damages resulting from the fact that the information required to direct the Service was not obtained in a timely manner or was out of date or incorrect. In any event, Vattenfall shall not be liable for any damages caused by third parties, Vattenfall shall not be liable for the correct operation of the telecommunications network provided by the third party and for the effect this has on the Service.

Vattenfall shall not be liable for any damage caused to the Customer due to force majeure. Force majeure is an unforeseeable change in circumstances or other circumstances beyond Vattenfall's control which Vattenfall cannot reasonably be expected to overcome. Vattenfall will notify the Customer as soon as possible of any force majeure encountered by Vattenfall.

Vattenfall shall not be liable to the Customer for consequential damages, unless the damage was caused by negligence on the part of Vattenfall, and never beyond what is required by mandatory law.

Other terms and conditions applicable to the contract

Vattenfall has the right to change the terms and conditions applicable to the Customer's order. Vattenfall will notify the Customer of the change at least one (1) month before the change takes effect.

Vattenfall reserves the right to terminate the Service by notifying the Customer in person as soon as possible before terminating the Service. The agreement enters into force on 1 July 2022 and is valid until 30 September 2023, unless otherwise agreed with the customer.

Contact information for the customer and Vattenfall Oy

Vattenfall will deliver notices regarding the Service to the postal or e-mail address provided by the Customer to Vattenfall. Vattenfall's contact information is as follows: Vattenfall Oy, business ID 1842073-2, Konepajankuja 3 B, 00510 HELSINKI, telephone 020 722 9000. Website: www.vattenfall.fi. Up-to-date information can be found on Vattenfall's website.

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