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Deliverable D8.5: Report on business models assessment, market analysis, regulatory context assessment and preliminary exploitation assessment

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Abstract

This deliverable is to report on the expected exploitable and key exploitable results of the project, explain the relevance to target groups and give a first assessment of the target markets. The results of FEVER are described in detail and the preliminary exploitation strategy is explained. The regulatory framework of FEVER is evaluated and plans to develop draft business models further are described.

Keyword list

Target group, target market, exploitation strategy, business model, regulatory context, exploitable result, key exploitable result

Disclaimer

Executive summary

The H2020 project "*FEVER – Flexible Energy Production, Demand and Storage-based Virtual Power Plants for Electricity Markets and Resilient DSO Operation*" develops solutions for "Orchestrating flexibilities to enable the energy transition". The aim is to demonstrate and implement solutions that effectively use the potential of flexibility in generation, consumption, and storage of electricity. With the development of electricity systems from centralized power plants and supply structures towards distributed generation assets close to demand, opportunities as well as responsibilities in the system need to be assessed as well. Distribution System Operators (DSOs) will need have more close-to-real-time information about what is happening in their grids as well as more options to actively manage them not least by using flexibilities made available by customers in their grids. The FEVER project aims to create solutions both for actors in the system who can make use of flexibility as well as for actors who can provide it.

Communication and dissemination of the intended implementations and outcomes, and thus solicitation of feedback on the emerging individual outcomes and plans, began early in the project. Among other things, this has led to the development of initial utilization plans for the results and the project, which are presented in this report. Initial assessments of relevant regulatory frameworks were made and are described. Further analyses will follow as the project progresses. The results to be developed by the end of the project and the plans of the respective responsible partners to use these results are described. Target markets and groups within those markets for the outcomes are identified and described.

This work gives an overview of results developed within the project that are currently seen as Exploitable results (ER) or Key exploitable results (KER). These encompass energy management algorithms and systems and flexibility service providing solutions for flexibility providing actors, flexibility trading markets mechanisms and platforms as well as flexibility and grid planning and management solutions for system operators, especially DSOs.

Target markets to be addressed include target groups such as Aggregators, VPP operators, large industrial customers and energy communities which naturally pool generation assets and storages as well as different sizes of system operators facing the challenge of harnessing the flexibility increasingly available from distributed resources. Currently considered exploitation strategies focus on use of success stories towards partners' networks and customers as well as publication and promotion of results in journals, conferences, events and workshops – as learning from the Covid-19 pandemic - in personal, virtual and hybrid formats. The establishment of the FlexCommunity will be a valuable vehicle to create awareness of the results and to promote their use in the development of techniques, products and services for the energy markets.

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1 Introduction

The project "Flexible Energy Production, Demand and Storage-based Virtual Power Plants for Electricity Markets and Resilient DSO Operation (FEVER)" started in February 2020 and is in the process of implementation of solutions and services at the trial sites. In the coming phase of the project, trial site testing as well as dissemination and exploitation will be in focus.

1.1 Task 8.3 Market analysis and consortium preparation for market uptake

This deliverable is set in Task 8.3 "Market analysis and consortium preparation for market uptake" which tracks all results developed within the FEVER project and fosters the assessment of target markets and relevant regulatory contexts. An initial assessment of exploitable results, relevant target groups and markets as well as regulatory aspects is given in this deliverable. Work on these topics is planned to be intensified in the coming phase of the project and will be reported in a detailed (confidential) exploitation plan at the end of the project.

1.2 Objectives of the work reported in this deliverable

The purpose of this document is to provide a preliminary assessment of FEVER results, relevant target groups and markets as well as exploitation strategies and regulatory context based on discussions and developments in the FEVER project.

1.3 Outline of the report

The report begins with a list of all results for the FEVER project considered exploitable results. A description of the results as well as the target group(s), an assessment of the target market(s) and a preliminary exploitation strategy are given per result. After this, a list of key exploitable results (KER) is defined which resembles the results that will be further investigated in terms of business model assessment in the second phase of the project. Activities and initial findings on the assessment of the regulatory context of FEVER are given before the report concludes.

1.4 How to read this document

This document builds on the FEVER Grant Agreement. While knowledge of the detailed technical results of the project to date is not a pre-requisite to understand the content of this report, it is clearly an advantage if the reader has perused the previous deliverables of the project. A "Final exploitation plan" will be described in deliverable D8.6 close to the end of the project.

2 FEVER exploitable results

In the H2020 text, a result is defined as: *"Any tangible or intangible output of the action, such as data, knowledge and information whatever their form or nature, whether or not they can be protected, which are generated in the action as well as any attached rights, including intellectual property rights"*.
A Key Exploitable Result (KER) *"is an identified main interesting result (as defined above) which has been selected and prioritised due to its high potential to be "exploited" – meaning to make use and derive benefits- downstream the value chain of a product, process or solution, or act as an important input to policy, further research or education. In order for you to select and prioritise your results, we would recommend that you use the following criteria: a) degree of innovation, b) exploitability and c) impact."* According to these definitions, exploitable results and KER developed within the FEVER project were identified.

The following Table 1 gives an overview of results currently considered as exploitable or key exploitable results. In the subsections of this chapter, more details about the results will be given with short descriptions of the developed tool or asset as well as the expected target group(s), an assessment of the target market(s) and currently considered exploitation strategies.

Table 1: List of FEVER exploitable results with TRL increase, target groups and KER relevance

Exploitable result	TRL start	TRL target	Target group(s)	Considered KER
Factory Energy Management System (FEMS)	7	8	large industrial consumers, public infrastructure managers, prosumer with large controllable assets	Yes
Flexibility Trading Platform (FTP)	6	7	DSOs, TSOs, BRPs, microgrid operators	Yes
Flexibility Service Providing Agent (FSPA)	7	8	Users with energy management system	Yes
Microgrid Operation Scheduler	n/a	4-5	microgrid operators, aggregators; operators of virtual power plants, energy communities, confined energy systems	No (to be re-assessed during project duration)
Algorithms for PV generation forecasting	6	8	Household with installed rooftop PV systems, Individual PV plants, DSOs, TSOs	Yes
Vehicle-to-grid (V2G) charger	4	6	Domestic users (small scale), small commercials, private and public parking lots	No
Energy Storage System (ESS) Energy Management Systems (EMSs)	6	8	DSOs, aggregators	No
Voltage compensation application (VCA)	6	8	DSOs, Local Energy Communities	No
Algorithms for Low	5	7	DSOs,	No

Voltage (LV) grid observability			Local Energy Communities	
Algorithms for optimized management of a Virtual Storage Plant (VSP)	5	6-7	Users with energy storage technologies, TSO, DSO, ES companies	No
Algorithms for flexibility prediction from specific assets	3	6-7	users who want to extract flexibility from assets and operate them flexibly	No
Critical Event Prevention Application (CEPA) / Loss Reduction Application (LRA)	5	7-8	DSOs	Yes
Algorithms for load forecasting	6	8	DSOs	No
Algorithms for fault detection and localization	5	7	DSOs	No
Self-healing application (SHA)	5	7	DSOs	Yes
Algorithm for fault detection	4	7	DSOs	Yes
DSO Toolbox	4	7 (part)	DSOs	Yes
Flexibility Service Consuming Agent (FSCA)	n/a	5	DSOs	No
Market mechanisms for day-ahead and intra-day flexibility trading	2	5	Market Operators, Flexibility Aggregators DSOs, TSOs	No (to be re-assessed during project duration)
Intraday market application	n/a	4	Market Operators, Flexibility Aggregators DSOs, TSOs	No
Flexibility Management System (part of AaaS)	1	8	Prosumers, aggregator users (DSOs, building operators, utilities, etc.)	No (to be re-assessed during project duration)
Peer-to-peer Flexibility Trading Platform (P2P FTP) - FlexTrading DAPP	1	8	Energy Communities	No (to be re-assessed during project duration)

2.1 Factory Energy Management System

2.1.1 Description

The Factory Energy Management System (FEMS) is a monitoring and control tool intended for larger industrial customers or commercial buildings to collect and monitor the energy consumption data and control the appliances. It is used to control production loads or energy production units in factories or commercial buildings of various industrial branches. It incorporates algorithms enabling simultaneous load control to achieve optimal consumption, peak levelling, external automatic demand response control or any other energy/cost saving goal. The initial TRL level is 7 and it targets 8 at the end of the project.

2.1.2 Target group(s)

The target group of FEMS are large industrial consumers, public infrastructure managers or prosumer with large controllable assets. The prosumer should have a not only the technical conditions like large energy adaptation capacity but the smart behaviour as well included in his or her energy management vision. The main motivation for using FEMS would be the inclusion of their processes in automatic demand response and corresponding cost optimisation.

2.1.3 Assessment of target market

The estimation assumes a working population where approx. 50% of the working population are employed in large enterprises with an average of 200 or more employees. Taking into account that more than 10% of those enterprises are suitable to address the flexibility it results in a pool around 100.000 of potential customers in Europe.

2.1.4 Exploitation strategy

In the pool of the demo sites the DSO company shall be assigned to list the appropriate prosumers from their address list, who will then be contacted individually.

This result is considered a Key Exploitable Result (KER) of the FEVER project.

2.2 Flexibility Trading Platform

2.2.1 Description

The Flexibility Trading Platform is part of the FEVER solution whose main task is to resolve congestions or other problematic issues that might appear in the network. It enables the user (i.e., the grid operator) to provide automatic demand response and stabilize the electricity grid, by having centralized control of consumers and producers on the electricity network. The initial TRL level is 6 and it targets TRL 7 at the end of the project.

2.2.2 Target group(s)

The product is relevant for grid operators (DSOs or TSOs), aggregators, balance responsible parties also microgrid operators. The tool can be used for various features and functionalities, like grid services (voltage levelling, frequency regulation, congestion management), energy balancing or energy trading.

2.2.3 Assessment of target market

In Europe there are 2556 DSOs of different sizes which is the target market of the product. A detailed assessment of DSO target market in Europe is given in section 2.16.3.

2.2.4 Exploitation strategy

The exploitation strategy is based on the demo-site results and referenced stories which are replicated into similar environments.

This result is considered a FEVER KER.

2.3 Flexibility Service Providing Agent

2.3.1 Description

The Flexibility Service Providing Agent is used for interfacing with different prosumer energy management systems. It connects to the prosumer's existing EMS and transforms its energy adaptation capacity into a flex-offer suitable for trading on the flexibility trading platform. The device may exist in hardware form or be hosted on the cloud. The initial TRL is 7 and it targets TRL 8 at the end of the project.

2.3.2 Target group(s)

The target group of FSPA are users with EMS, which has beside the monitoring functionality, also the ability to control the consumption or production assets. The main motivation for using FSPA would be the prosumer's active role in the smart grid system.

2.3.3 Assessment of target market

The target market are energy consumers with energy management systems who want to play an active role on the market. In addition to large enterprises, this also includes SMEs and smart buildings.

2.3.4 Exploitation strategy

Using the experiences from the demo sites the additional corresponding prosumers from the distribution grid area will be addressed and involved into the pool.

This result is considered a FEVER KER.

2.4 Microgrid operation scheduler

2.4.1 Description

The microgrid operation scheduler is a software tool provided as a service that enables the planning and scheduling of microgrid assets. The focus of this tool is the coordination of controllable assets of a microgrid to reach an objective function which describes the desired internal operation and interaction with the main grid. This is a service that is developed within the FEVER project from UCY and contributions from INEA, thus the initial TRL level is not available. The component will be developed, tested and validated (targeted TRL 4-5) in the premises of the Photovoltaic Technology Laboratory (PVTL) of the Cypriot pilot.

2.4.2 Target group(s)

This service is relevant for all parties interested in centrally managing and optimizing a portfolio of distributed energy resources. The use of the scheduler unit makes sure that their operation is optimized according to the selected objective function. Interested parties are primarily microgrid/nanogrid operators and aggregators but can be extended for portfolio management and planning to operators of virtual power plants, demand-response providers, energy communities and confined energy systems.

2.4.3 Assessment of target market

The number of aggregators, energy communities and microgrid operators is expected to rise in the future as the electricity market is evolving to a decentralized model. Legislation in multiple European countries support the emerging role of the independent aggregator and energy communities and cooperatives are continuously growing. Indicatively, in Europe there are currently more than 1900 energy cooperatives registered in REScoop.eu network [1].

2.4.4 Exploitation strategy

For the purposes of FEVER, the microgrid operation scheduler will be integrated for the implementation and requirements of the High Level Use Cases (HLUCs) of the Cypriot pilot. For the non-commercialization part, UCY will ensure the exploration and exploitation of the methodology for further scientific and research endeavours, e.g., in future projects and scientifically disseminate the main findings through publications at conferences and in international journals. Regarding the commercialization of the service, UCY will investigate possible pathways to support a potential commercial product through various channels.

This result is considered a FEVER KER.

2.5 Algorithms for PV generation forecasting

2.5.1 Description

A short-term (hour-ahead) and medium-term (day-ahead) PV generation forecasting methodology was developed based on a non-parametric artificial neural network (ANN) model. The ANN model was optimized according to the input and output parameters (TRL 6). Additionally, the optimized model was evaluated against data sets from the outdoor testing facility (OTF) of the University of Cyprus (UCY) and also by providing PV production forecasts for evaluation to utilities and PV plants (TRL7). The fully optimized solution will be used as a service by utilities and other stakeholder to derive hour-ahead and day-ahead PV production forecasts (TRL 8).

2.5.2 Target group(s)

The target groups of the PV generation forecasting are:

- Household with installed rooftop PV systems: PV generation forecasting will enable household with rooftop PV systems to optimise their consumption patterns to minimise their electricity consumption and subsequently their electricity costs;
- Individual PV Plants: PV generation forecasting can be utilised from PV plant managers in order to schedule their corrective maintenance (e.g., schedule maintenance during low irradiance days). In addition, in advanced energy markets, it will enable the market participants (MP) to bid the forecasted energy into the different type of markets (day-ahead, intraday, imbalance etc.);
- Distribution system operators (DSOs) / Transmission system operators (TSOs): To moderate power quality effects postured through large shares of PV systems, utilities necessitate PV power production forecasts for core generation dispatch and scheduling operations. Forecasting is a key enabler, which can safeguard operational and monetary integration of PV through structured associations with multiple power system flexibility innovations.

2.5.3 Assessment of target market

The targeted market problem that the PV production forecasting is called to solve is directly connected to uncertain and variable in nature solar PV generation, which is of utmost priority in order to facilitate the reliable integration of PV at electrical networks. State-of-the-art accuracies are around 10 % and location dependent. The proposed PV production generation forecasting, which is a next-generation artificial intelligence (AI) powered PV energy yield forecasting system, will provide improved forecasting accuracies beyond the state-of-the-art (<5 %) by leveraging machine learning principles and advanced analytics.

Obtaining 5 % accuracy provides for a 1 MW PV plant savings up to 8,500 €/year, since the forecasting error reduction will result in 85.000 kWh/year not being curtailed from the total production of 1700 MWh/year at high irradiance regions or penalized at a typical bidding price of 10 €/MWh. The estimated cost of employing this solution is 1500 €/year reflecting a benefit-cost factor in energy trading profitability of around 6. For the global 700 GW PV market this translates to revenues of 6.000 M€/year.

The expected societal and economic impacts in the market include:

- Decarbonization and cleaner environment by reliably integrating more PV.
- Revenue loss alleviation for energy traders from penalties/curtailment by deviating from predicted commitments in energy markets.
- Decrease in electricity price since larger volumes of cheap PV produced electricity will be sold at a lower risk to the market.

In general, once the total installed PV capacity in an energy market exceeds 10% of peak demand, PV forecasts are needed. It is also mandatory in modern energy markets for the participation of renewable energy sources. We are already in contact with PV power plant operators and utilities around the globe to validate our solution with the prospect of potential collaboration.

2.5.4 Exploitation strategy

UCY can commercialise its product through the Software as a Service (SaaS) approach to the target groups. Therefore, UCY will exploit the end-product under the SaaS, also known as pay per user authorisation, which will provide to the end-users the visual environment of the SaaS. The service will be freely available for the project's partners during the period of the project, while organisations and stakeholders outside the project's network can benefit from the service via a pre-agreed remuneration.

This result is considered a FEVER KER.

2.6 Vehicle-to-grid charger

2.6.1 Description

The Vehicle-to-Grid (V2G) is a bidirectional charger capable of both charging and discharging Electric Vehicles (EVs), and hence, it is capable, together with an EMS, of extracting power flexibility from an EV. These V2Gs have been designed, tested, and commissioned for the FEVER project by the research centre CITCEA-UPC.

The single-phase chargers have an integrated 3.6 kVA power electronic converter that allows working independently of battery voltage level between 230 and 500 V each one. The AC rated voltage is 230V and the rated current is 16A. They are able to manage both active and reactive power, although no harmonic cancellation or power unbalances can be performed. The chargers use new semiconductor materials such as gallium nitride (GaN), and they have an anti-islanding function. The current TRL is 4, the target TRL is 6.

2.6.2 Target group(s)

The V2G charger is of relevance for the following groups:

- Domestic users (small scale)
- Small commercial users
- Private and public parking lots

Nevertheless, the target market is focused on EV users that have PV panels at home, as these users can take advantage of the bidirectional power flow of the charger, adding energy flexibility to household consumption.

The combination of the high efficiency and the low power scale (3.6kW), makes the charger ideal to have it where commercial chargers do not reach. In addition, the compact and small size allows it to be integrated in the same plug and cable.

The satisfied need is the easy installation and compact size of the charger, together with its bidirectional power operation capability.

2.6.3 Assessment of target market

The target market are all domestic users and small commercials, and it can be as big as the number of EVs sold.

The barrier is the cost of the equipment, the cheaper the device, the higher market we would be able to reach.

The market will grow in the future as the number of EVs sold increases as well.

2.6.4 Exploitation strategy

UPC owns the industrial secret of the design. The industrialization of the charger should be done by an industrial partner who will pay royalties for the design. The industrial partner is the one in charge of reaching the final user. The product will be disseminated through presentations and scientific articles.

The result is not considered a FEVER KER.

2.7 Energy Storage System and Energy Management Systems

2.7.1 Description

The V2G EMS and the two Battery EMSs have the main function of extracting energy flexibility, in terms of active and reactive power, of three different Energy Storage Systems (ESS). These ESS include two stationary batteries and the batteries of the connected EV. The EMS algorithms offer energy flexibility to the market to provide DSO services such as loss reduction or voltage compensation. Additionally, the algorithms implement an approach to minimize battery degradation, and hence, extend battery life. It is planned to raise the TRL from 6 to 8.

2.7.2 Target group(s)

The ESS EMSs are of relevance for the following groups:

- DSO (in the present not permitted by EU regulation)
- Aggregators (functional)
- Domestic users (small case) – only V2G EMS

The general benefit of the ESS EMSs is obtaining additional services from the storage devices installed in the grid. Depending on the business model applied in the EMSs, the objective function will be different, hence, the target group of the EMSs can vary.

Additional services could be used by the DSO for grid services; and the aggregator could obtain an economic benefit by selling the provided flexibility.

In the particular case of the V2G EMS, another target group would be those EV users who own a V2G charger at home and have for instance PV panels installed. Those users could manage their V2G chargers, adding energy flexibility to household consumption and minimizing the electricity bill and CO_2 generation.

2.7.3 Assessment of target market

The market size is limited by the number of DSOs and aggregators in Europe. In Europe there are 2556 DSOs of different sizes. A detailed assessment of DSO target market in Europe is given in section 2.16.3.

For the particular case of the V2G EMS for domestic EV users, the market is expected to experience an exponential growth since the concern for CO_2 emissions grows day by day, and so does the number of PV panels which can be sold.

2.7.4 Exploitation strategy

The algorithms will be sold to the target groups in the form of a software under a license number beyond the project duration. The target groups will be reached through presentations and scientific articles.

During the project duration the algorithms will only be accessible (freely) to the project partners.

The result is not considered a FEVER KER.

2.8 Voltage compensation application

2.8.1 Description

The function of voltage compensation in the distribution systems is to provide a stable supply voltage level within an acceptable range for all loading conditions.

The Voltage Compensation Application (VCA) enables the usage of any asset capable of providing reactive power connected to the electric system.

Under the FEVER framework of the flexibility market, these assets will have attached a Flexibility Service Providing Agent (FSPA) responsible for indicating their flexibility capabilities to the market. In this scenario, the role of the VCA is at the other end of the flexibility trading and it is the actor responsible for requesting flexibility from these assets in order to solve voltage issues. The TRL is targeted to be raised from 6 to 8.

2.8.2 Target group(s)

The VCA is of relevance for the following groups:

- DSO (in the present not permitted by EU regulation)
- Local Energy Communities (LECs)

The general benefit of the VCA is upgrading the quality of the grid supply voltage. This application could be used for the DSO for grid services providing a stable supply voltage level in defined problematic areas by activating flexible assets such as FEMS or ESS.

2.8.3 Assessment of target market

The market size is limited by the number of DSOs in Europe. In Europe there are 2556 DSOs of different sizes. A detailed assessment of DSO target market in Europe is given in section 2.16.3.

The market size of the second target group is limited by the number of LECs in Europe, which is difficult to determine, as the legal framework is still being developed in several European countries. However, during the following years, the number of LECs is expected to grow strongly. This will also be discussed in section 2.21.3.

2.8.4 Exploitation strategy

The algorithms will be sold to the target groups in the form of a software under a license number beyond the project duration. The target groups will be reached through presentations, trade shows and scientific articles.

During the project duration the algorithms will only be accessible (freely) to the project partners, being these within the DSO toolbox, meaning for the DSOs involved in managing the pilots.

The result is not considered a FEVER KER.

2.9 Algorithms for low voltage grid observability

2.9.1 Description

The algorithms for LV grid observability (or Local Observability Services (LOS)) enable the DSO to control normally un-observable LV grids. The tool leverages AI and data-based techniques to carry out the grid monitoring task through the estimation of the network state. It is planned to raise the TRL from 5 to 7.

2.9.2 Target group(s)

The LV grid observability is of relevance for the following groups:

- DSO (in the present not permitted by EU regulation)
- Local Energy Communities

Typical users of such services are mainly the Distributor System Operators DSOs. They can potentially turn into customers and clearly represent the most important target group. It is well-known nowadays that DSOs typically struggle in having control and knowledge of their LV grids. This service/product directly tackles the problem of un-observability, by performing a low-cost, scarce measurement monitoring of LV grids and feeders.

It is based on the principle of scarcity of measurements: the presence of (more-or-less) intelligent measuring devices in LV grids is still weak and it is an economically non-viable option to build up the required infrastructure. To respond to this need of the DSO to perform an efficient and viable monitoring of currently un-observable parts of the distribution grid, this set of algorithms leverage the digital twin concept of power grid and AI to perform the task with a minimal measuring infrastructure and capital investment.

Local Energy Communities might also be included potentially in the customer list and form another target group, but only if they own the distribution grid (which depends on the legal framework). The national implementation of the EU directive respective of LECs is under develop, and it is still not clear how this implementation will affect the business model.

2.9.3 Assessment of target market

The target market is represented mainly by the group of all DSOs or any network operators that manage grids at low voltage (LV) level. Unfortunately, this is a limit under the point of view of market access as the list of potential customers is restricted mainly to national and local network operators.

Despite the current and actual DSOs need to regain control on LV un-observable grids, grid intelligence and similar algorithms which leverage on AI and simulations are still a hard marketable solution: the process of turning leads into customers is still difficult with the current market scenario. Only a few “enlightened” grid operators, who make innovation strictly integrated within their business strategy, are willing to take on this digital transformation of their monitoring and control operations. Nevertheless, the interest around digitalization, founded around big data and AI, is expected to grow in the next years and decades, along with related market opportunities.

The market size of the second target group is limited by the number of LECs in Europe, which is difficult to determine, as the legal framework is still being developed in several European countries. However, during the following years, the number of LECs is expected to grow strongly.

2.9.4 Exploitation strategy

For the duration of the FEVER project, the software product will be offered within the DSO toolbox, meaning for the DSOs involved in managing the pilots.

The algorithms will be sold to the target groups in the form of a software under a license number beyond the project duration.

The target groups will be reached through presentations, trade shows and scientific articles.

The result is not considered a FEVER KER.

2.10 Algorithms for optimized management of a Virtual Storage Plant

2.10.1 Description

The Virtual Storage Plant (VSP) is an IT-based virtual structure that aims to aggregate flexibility potentials of different energy storage systems in a coordinated way and then integrate them into whole energy markets through smart grids.

The VSP uses different energy storage technologies including:

1. Electrochemical storage, e.g., electrical batteries of Plug-in Electric Vehicles (PEVs).
2. Electromechanical storage, e.g., flywheels.
3. Electromagnetic storage, e.g., capacitors.
4. Thermodynamic storage, e.g., heat water tanks.

Although individual storage units may be discussed, the VSP conveys coordination of a significant number of storage units. Therefore, the energy systems may not benefit from segregated and/or uncoordinated storage units.

The energy systems, including power grids, gas networks, and District Heating (DH), can take advantage of VSP. Also, multi-carrier microgrids benefit from the coordinated operation of power, gas, and DH networks. In this way, the main VSP applications can be stated as follows (but not necessarily limited to):

1. Voltage regulation (reactive power service).
2. Power quality improvement.
3. Congestion mitigation in power lines (transmission and distribution grids).
4. Power loss minimization.
5. Global power regulation (up/down).
6. Power frequency control.
7. Ancillary services,e.g. spinning reserve, non-spinning reserve, and supplemental reserve.
8. Facilitating the integration of renewables into energy systems.
9. Improving the power system reliability.
10. Peak demand shaving and valley filling.

Figure 1 sketches a general overview of the VSP with key applications in energy systems.

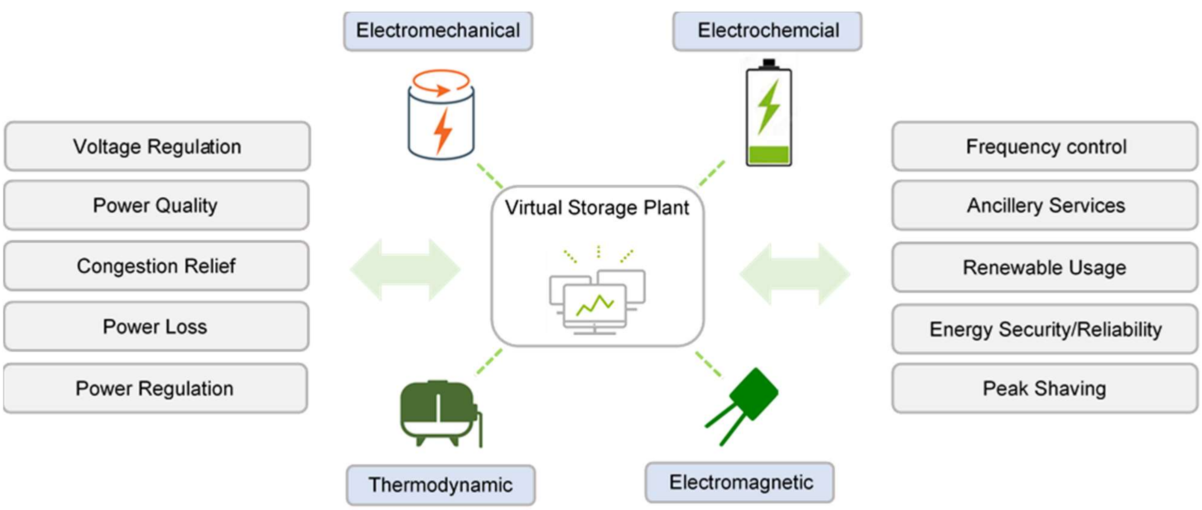

Figure 1: The VSP structure with key applications

2.10.2 Target group(s)

The VSP has energy transactions with the following sectors:

- Residential: Home Energy Management Systems (HEMS).

- Commercial: Supermarket refrigerators, commercial parking lots of PEVs.
- Industrial: Light and heavy factories, e.g. food industries, cement manufacturing plants.
- Agricultural: Irrigation pumps.
- Municipalities: DH systems.
- Energy markets/utilities/companies: Electricity market, TSO, DSO, ES companies.

The value proposition conveys reasons why customers should be attracted by the VSP. Some value propositions of VSP are as follows:

- Lower energy cost/bill (electricity, heat, gas).
- Increase energy security and reliability, higher stability, lower energy cuts, enhanced power quality: this is subject to critical loads with high power quality needs.
- Facilitate RES usage: interesting for power system operators.
- Increase profit: attractive for energy markets/utilities/companies.

2.10.3 Assessment of target market

The target market includes DSO, electricity markets, demand response providers, power system operators, and energy companies. The market size is currently limited due to the limited number of storage devices in energy systems worldwide. By increasing the penetration of EVs in near future, the market size is expected to increase significantly to manage the operation of smart charging stations in both private and public parking lots. Meanwhile, in the future model of energy systems, the penetration of Power-to-X plants increases. Therefore, the need for storage devices, e.g. electricity, hydrogen, methane, increases to counterbalance renewable power fluctuations. Consequently, the regions with high numbers of Power-to-X projects exhibit more interest in VSP technologies. Based on [2], currently, 20 EU countries are developing Power-to-X projects. Germany, Netherland, Spain, France, the UK, Denmark, and Switzerland are leading countries. Among them, Germany is the most pioneer country which is involved in 44% of identified projects.

From a geographic viewpoint, Europe exhibits one of the largest market shares in the RES and VSP markets in the last decade due to the significant number of pioneer companies and increased governmental interest/investments in carbon-neutral energy systems. In addition to Europe, the USA, and East Asia, e.g., South Korea and Japan, hold a high market share. To provide a general view, Table 2 introduces some leading companies and potentials for the market growth of VSP technologies.

Table 2: Some leading companies in the VSP technologies worldwide

Leading Companies	Location	Main Related Fields	Home Page
China Everbright Greentech Limited	China	(1) RES (2) ES (3) Waste Treatment (4) Environment	https://www.ebgreentech.com
General Electric Company	The US	(1) RES (2) Power (3) Digital Energy Transition (4) ES	https://www.ge.com/
Toshiba Corporation	Japan	(1) RES: PV, Geothermal (2) Smart Grid (3) ES-Batteries	https://www.toshiba.com/
Enel S.P.A	Italy	(1) Energy Digitalization (2) RES (3) PEV Solutions (4) Smart Cities	https://www.enel.com/
Schneider Electric SE	France	(1) Microgrid Services (2) ES units (3) IoT of VSP and VPP	https://www.se.com/

		(4) Buildings and Industrial	
ABB Ltd	Switzerland	(1) PEV Charging Stations (2) ES Units (3) Energy and AI (4) AMI	https://global.abb/
Hitachi, Ltd	Japan	(1) Energy IT (2) RES (3) Energy Management (4) ICT	https://www.hitachi.com/
Siemens AG	Germany	(1) Smart Grid (2) Smart Building (3) Energy Digitalization (4) Energy and AI	https://www.siemens.com/
Bosch Ltd.	Germany	(1) Smart Home, Heating, and Appliances (2) Carbon-neutral (3) PEV and Net-zero Mobility Solutions	https://www.bosch.com/
AutoGrid Systems	The US	(1) Demand Response Aggregator (2) Energy Management Systems (3) ES Management Systems (4) Energy Internet	https://www.auto-grid.com/
Advanced Microgrid Solutions Inc	The US	(1) Energy and AI (2) RES (3) ES Units (4) AI-powered Software	https://www.advancedmicrogridsolutions.com/
CISCO Systems Inc	The US	(1) Smart Buildings (2) ICT (3) Grid Security, IoT (4) Digital solutions	https://www.cisco.com
Enbala Power Networks Inc	Canada	(1) RES (2) DER (3) Market Integration and Monetization (4) VPP Management	https://www.enbala.com/

2.10.4 Exploitation strategy

In the first step, the ERs are listed in Table 3.

Table 3: The list of ERs with main contributors

ER No.	Exploitable results	Partner/contributor
1	Public parking lots of PEVs and charging stations	AAU / Hessam Golmohamadi
2	FlexOffer: Photo-Voltaic based Thermodynamic Storage	AAU / Arne Skou

After determining the ER, the exploitation routes should be discussed. The routes include the following items (but not necessarily limited to):

1. Further research to investigate technical possibilities.
2. Using real data to validate the applicability of the suggested algorithms and ER in practice.
3. Developing and/or offering new services and products.
4. Possible Commercial spin-off from the representative studies.

5. Cooperation agreement and/or collaboration with data owners of living labs.

Regarding the five aforementioned points, the exploration routes of the ERs are illustrated in Table 4.

Table 4: Exploitation routes of the ERs

ER No.	Exploitation Routes
1	(1) Investigate practicality of flexibility management in large-scale parking lots using real traffic data (2) Main benefits of applying the algorithm in short term electricity markets and TSO/DSO as byproducts (3) Offering market services/products to bid in ancillary service markets
2	(1) Experiment on how probabilistic FlexOffers may interact with the relevant components of the FEVER platform. (2) Good line of investigation regards how generated FlexOffers can be exploited to generate Probabilistic FlexOffers from the concrete FEVER use cases.

Technology readiness level (TRL) is an approach to estimating the maturity of new technologies during the development/assessment phase. The TRL is comprised of nine levels in which level one denotes the "basic technology research" and level nine refers to "system test, launch, and operation". The TRL status of the suggested ERs is stated in Table 5.

Table 5: TRL status of the proposed ERs

ER No.	Current TRL	Expected TRL
1	5	6
4	5	7

The results are not considered FEVER KERs.

2.11 Algorithms for flexibility prediction from specific assets

2.11.1 Description

AAU has developed several algorithms for flexibility prediction from specific assets. Until now, algorithms were developed for heat pumps and batteries. In the future, algorithm(s) for EVs are planned. The algorithms use time series data from asset installations (e.g., in- and out-door temperature, heat pump power consumption for heat pumps). This data is fed into deep learning models with the aim of predicting variables relevant for the available flexibility. For the heat pump prediction, how the indoor temperature will change over the next time units if the heat pump is run in one of the Smart-Grid-Ready standard modes (*Off, Normal, RecommendedOn, ForcedOn*), e.g., how quickly will the room/building heat up if running in *ForcedOn*, and how quickly will it cool off if run in *Off*. This can in turn be used to predict how long time (how many hours) the heat pump can run in those modes before reaching the upper, respectively lower, bound of the set comfort range, e.g., 20-24°C. For battery flexibility prediction, we predict the State-of-Charge (SoC) of the battery in future timesteps, given a certain schedule of charging/discharging the battery in the past timesteps. This can be used to predict how much energy flexibility the battery can provide, e.g., how many kWh it can (dis)charge in the next timesteps.

Overall, these predictions will be used to generate FlexOffers for the flexibility offered by a specific asset (planned) and this functionality will be integrated into the WP2 flexibility platform in cooperation with INEA and FLEX. The initial TRL was 3, the targeted TRL is 6-7.

2.11.2 Target group(s)

The algorithms are of relevance to (technical) users who want to extract flexibility from assets and operate them flexibly, e.g., to get the benefit of minimizing CO_2, cost and/or grid load. The main advantage of the algorithms is that they learn a model of the flexibility purely from easily available data, without the (until now) need of providing specific characteristics of the building, e.g., insulation level or battery. This makes deployment simpler and cheaper. Such technical users are found within energy technology researchers, energy platform providers, operators of assets, etc. Another way to say this is that the target group(s) are a super-set of the target group(s) for the FEVER project in general.

2.11.3 Assessment of target market

The target market is similar to the target market for the FEVER project in general. Thus, we refer to the overall FEVER market assessment.

2.11.4 Exploitation strategy

The algorithms will form only a small part of the necessary value chains, and the associated technical frameworks, to exploit flexibility from assets at scale. Furthermore, the algorithms will require a lot of fine-tuning and adaption to be valuable in real products. Thus, it is not deemed feasible to exploit the algorithms as a standalone ER. Thus, the exploitation strategy is to make sure that the algorithms are easily available for such frameworks, first and foremost by making them freely available as open source. The target group will be reached in collaboration with the overall FEVER effort and relevant partners.

The result is not considered a FEVER KER.

2.12 Critical Event Prevention Application / Loss Reduction Application

2.12.1 Description

Critical Event Prevention Application (CEPA) is an application implementing the orchestration mechanism of data management and executive actions for the prevention of critical events by requesting flexibility service. It identifies potential violations of the network operational constraints, proposes, and evaluates mitigation actions.

If no critical events were detected, the same mechanisms are used to optimize the grid - Loss Reduction Application (LRA). LRA is responsible for extracting the flexibility needs to minimize the network technical losses by flattening of the network demand curve. It identifies the unbalances between generation and demand in terms of time, amount of energy and related grid area. The aim is to raise the TRL from the initial 5 to the target value 7-8.

2.12.2 Target group(s)

The principal target group for CEPA and LRA are Distribution System Operators (DSO). CEPA allows for early detection of possible congestions and their avoidance thanks to implementation of mitigation plan by demanding flexibility. Grid congestion occurs due to transmission constraints, for example, as transmission lines reach thermal capacity, line losses increase. Since every line loss also means loss of money, early detection of congestions helps to decrease the cost of energy transmission.

LRA helps optimizing exploitation of the existing grid capacity reducing the losses. The presence of high peaks on the power profile of the substations has disadvantages such as high-power losses in the transmission lines, which increases the maintenance costs or generates high emissions of carbon dioxide. Performing peak shaving on the distribution feeders can have several benefits at different levels, reducing the aforementioned disadvantages and even the economic costs, since the price typically is higher with a high demand of energy.

2.12.3 Assessment of target market

In the year 2020, there were 2.556 DSOs in Europe, of which 182 had more than 100.000 customers. In countries where CEPA will be tested within the framework of FEVER project, namely Spain and Germany, the number of DSOs was 354 and 883 respectively. [3]

Growing number of Distributed Energy Resources (DER) and related possibilities of flexibility exploitation to optimise losses and energy consumption is granting to DSOs a fundamental role in making the electricity market work. This provides wide possibilities of CEPA exploitation in the future.

2.12.4 Exploitation strategy

As a public institution, UdG cannot directly commercialize its product. Thus, the exploitation ambition of UdG is to exploit the final product under a pay per use licensing strategy. A licensing strategy is under consideration, providing users a limited, nonexclusive, restricted use to specific territory, non-transferable right and license to use, execute and display the object code version of the software. The target group for further development will be reached through the XRE4S Lab2Market programme.

This result is considered a FEVER KER.

2.13 Algorithms for load forecasting

2.13.1 Description

Load (consumption) forecasting uses machine learning approach to obtain forecasting models in order to predict energy demand for next day (day-ahead) at specific points of the power grid. It takes advantage of historical consumption data from energy metering infrastructures as well as weather data. It encompasses two operation modes: training and forecasting. The initial TRL was 6, the target TRL is planned to be 8.

2.13.2 Target group(s)

The principal target group for Consumption Forecasting algorithms are Distribution System Operators (DSOs). DSOs can benefit from load forecasting to support grid operation, i.e., fault detection and self-healing. Other examples include organization of distributed generation sources in relation with energy storage system; reduction of operational costs of microgrids; or reducing the need to include the cogeneration in electricity balancing and grid stabilization.

2.13.3 Assessment of target market

The target market is considered the same as the one relevant for the “Critical Event Prevention Application – CEPA / Loss Reduction Application – LRA” described in Section 2.12.

2.13.4 Exploitation strategy

The exploitation strategy is the same as described in Section 2.12 about “Critical Event Prevention Application – CEPA / Loss Reduction Application – LRA”.

The result is not considered a FEVER KER.

2.14 Algorithms for fault detection and localization

In FEVER two partners implemented algorithms for fault detection, namely UGR and UP. Their approach for exploitation is being described separately in the following sub-sections.

2.14.1 Algorithms implemented by UGR

2.14.1.1 Description

Fault Detection (FD) aims to detect, diagnose, and isolate faults (e.g., short circuits) or other grid disturbances characterized by large and sudden variation of electric variables (e.g., loss of mains, connection/disconnection of large loads, high impedance transient faults, etc.). FD continuously analyses field data, comparing them with the expected normal operation conditions for a given configuration of the grid in order to detect possible inconsistencies (faults). The initial TRL is 5, the target TRL is 7.

2.14.1.2 Target group(s)

The principal target group for Fault Detection are Distribution System Operators (DSO). DSO can benefit from FD by enhancing monitoring and automated control of the distribution grid to significantly reduce the duration of power outages. The traditional methods used for fault detection in a distribution network are based on visual inspection after receiving the complaint from customers. Hence, traditional fault detection methods are unable to locate faults quickly. Once a fault has occurred and reported, a crew is sent to locate it and fix it. All the actions required from fault occurrence to fault restoration usually are measured in hours causing significant loses for the operators and inconvenience for customers. Automatic fault detection methods allow for substantial reduction of this time.

2.14.1.3 Assessment of target market

The target market is considered the same as the one relevant for the “Critical Event Prevention Application – CEPA / Loss Reduction Application – LRA” described in Section 2.12.

2.14.1.4 Exploitation strategy

The exploitation strategy is the same as described in Section 2.12 about “Critical Event Prevention Application – CEPA / Loss Reduction Application – LRA”.

The result is not considered a FEVER KER.

2.14.2 Algorithms implemented by UP

2.14.2.1 Description

This tool provides fault detection and location identification capabilities to DSOs, by employing advanced AI-based and specifically deep learning-based architectures. The TRL before the project initiation was in 4 and it is envisioned to reach 7 after the demonstration activities. The algorithm and the service are developed by UP partners and the demonstration activities will be conducted in both Spanish and German pilot.

2.14.2.2 Target group(s)

This tool provides the opportunity to DSOs to conduct fault detection and location identification in LV smart grids by leveraging state-of-the-art techniques. In the new era of high res penetrated active distribution grids, it is vital for DSOs to have full grid observability in order to respond fast in fault occurrences, and thus ensuring the security of supply for the end-customer. This tool is considered as the first step towards a complete self-healing application.

2.14.2.3 Assessment of target market

The target market is considered the same as the one relevant for the “Critical Event Prevention Application – CEPA / Loss Reduction Application – LRA” described in Section 2.12

2.14.2.4 Exploitation strategy

During the project’s lifetime, the tool will be provided in the form of Software as a Service (SaaS) to the DSOs, through the utilization of DSO toolbox. Beyond the project’s lifetime, UP’s ambition is to make the core algorithms used for the tool’s development publicly available, and thus increasing transparency across academia. Potential exploitation and commercialization of the tool could be explored, offering a SaaS approach to DSOs.

This tool can be considered as a FEVER KER due to the innovation it introduces in the fault detection applications using Deep Learning-based data-driven method, while leveraging both the advancements in Information and Communication Technology (ICT) and the vast amount of data stemming from the advanced metering infrastructure (AMI).

2.15 Self-healing application

2.15.1 Description

Self-Healing Application (SHA) is an application designed to mitigate negative impact of possible faults or critical events. Upon fault detection, the SHA performs a power flow analysis for limiting the islanded network area as close to the fault as possible and maximizing the number of electrified grid end-users. The mitigation plan considers the DER flexibility procurement. It is aimed to raise the TRL from initially 5 to target value 7.

2.15.2 Target group(s)

The principal target group for SHA are Distribution System Operators (DSO). DSO can benefit from SHA by enhancing monitoring and automated recovery after occurrence of a fault. During normal operation, the purpose of SHA is to optimize the operation and eliminate hidden troubles; whereas in presence of faults, the purpose is to minimize the outage area and its time. The second scenario encompasses the fault location, isolation, and reconfiguration of the grid and/or request of flexibility in order to minimise the impact of a failure in the affected area. Thus, the main benefit of the SHA is to decrease the boundaries of the faulted grid area and maximize the number of working electrified network users. It also significantly reduces the time of power outages due to mitigation plan that involve activation of flexibility assets.

2.15.3 Assessment of target market

In general, the target market of SHA is considered the same as the one relevant for the “Critical Event Prevention Application – CEPA / Loss Reduction Application – LRA” described in Section 2.12.

In addition, this tool directly targets the market of self-healing applications in smart grids. The global self-healing grid market both for transmission and distribution systems was valued at 1.58 bn USD in 2016 and is projected to grow at a Compound Annual Growth Rate (CAGR) of 9.07 %, during the forecast period, to reach 2.66 bn UDS by 2022. [4]

2.15.4 Exploitation strategy

The exploitation strategy is the same as described in Section 2.12 about “Critical Event Prevention Application – CEPA / Loss Reduction Application – LRA”.

This result is considered a FEVER KER.

2.16 DSO Toolbox

2.16.1 Description

The DSO Toolbox is a collection of applications and services that facilitate DSOs in their business. It is built upon a modular architecture enabling the introduction of and integration with components that realize specific applications and services for the DSOs. Such business intelligence components are part of the top layer of this architecture, namely the Business Applications & Services layer (see Figure 2). Such applications are being implemented by different partners in FEVER project, and each has a different target TRL at the end of the project. The bottom layer, namely the Integration Middleware layer facilitates the interactions among the different grid observability and control components of the DSO Toolbox as well as with the legacy applications and services of the DSO through standard and secure interfaces. The TRL of this part at the end of the project will be 7.

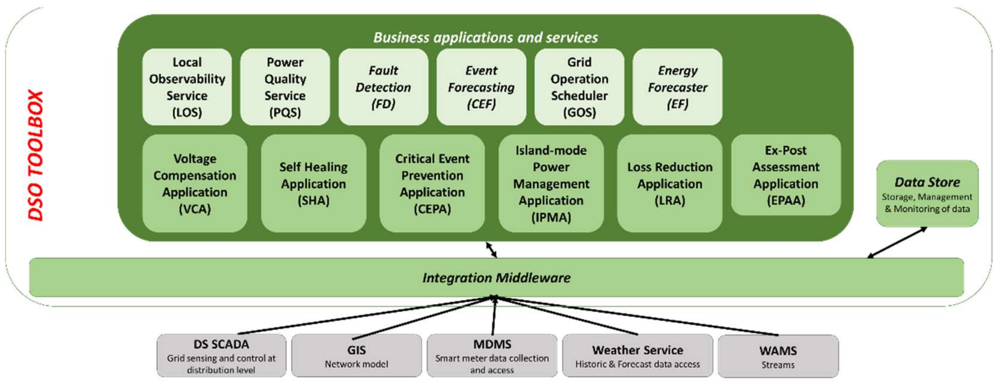

Figure 2: Layered architecture of a DSO Toolbox and indicative components of the applications' and services' layer

2.16.2 Target group(s)

Renewables and distributed generation play a major role in the transition to a clean energy system. Nowadays in several EU Member States (MS) more than 90% of the renewable distributed generators (which also includes roof-top solar panels) are connected to the distribution grid. This explosion of RES connections in certain MS has found an unprepared distribution system which was conceived to pass-on electricity from the transmission grid to end-consumers. This has led to fears over the impact that the deployment of distributed resources could have at system-level (e.g., that the costs of upgrading the network to integrate them would outweigh their combined benefits in other terms). Additionally, the present regulatory frameworks existing in the different MS often do not provide very often appropriate tools to DSOs to actively manage their networks [5]. Finally, by regulation, DSOs serving less than 100,000 connected customers can be exempted from the requirements of both legal and functional unbundling. In order to find other economies of scale, such small DSOs often integrate horizontally with other activities, such as distribution of water, gas or heat.

Overall, such stakeholders do not have the monolithic DMS systems that bigger DSO entities have. This renders them a particularly appealing customer for small and modular toolkits for active distribution management. DSO Toolbox is an IT solution blending different tools that can help DSOs in better monitoring and active management of their network. In that sense, the primary target group of this solution is the small-scale DSOs.

In the recent (2021) report of the JRC [6] one of the issues set to the participating DSOs was that of analysis of advanced technologies that the DSOs already use or find relevant and interesting. These technologies were divided into seven categories, namely:

- power flow tools
- data analytics for asset planning and investment strategies
- sensor technology for outage detection & prediction
- advanced load & storage management development
- DER visualisation and management tool
- drone technology for infrastructure monitoring
- (micro)-phasor measurement units

With respect to data analytics for asset planning and investments strategies, 82% of the respondents mentioned some related activity. In particular, some DSOs make HV and MV grid planning based on SCADA data, and some use predictive maintenance for cable lines, which is later used for asset planning exercises and for estimating investments. Some DSOs mentioned the existence of an analytic system that based on grid data can help with condition-based maintenance. In-house algorithmic tools are also used for instance to optimise the selection of transformers in the grid.

Sensor technology for outage detection and for outage prediction is also a common practice among operators. In fact, according to the collected replies, 74% of the DSOs have them in place. Protective relays and fault detectors for outage detection and short circuit indicators are a common choice. In certain cases, fault detectors are used in the MV part of the grid while for the LV part signals from the meters are used. With respect to outages prediction only few pilots are in progress. This signifies an opportunity window for the DSO Toolbox.

With respect to the advanced load & storage management developments, despite that 41% of the respondents has replied positively to this question, these experiences all refer to pilot projects except for one case. In this case, an energy management system uses an OPF module to determine the optimal grid state by minimizing selected parameters (e.g., reactive power losses, active power losses, active power generation cost). Again, this signifies an opportunity window for the DSO Toolbox.

With the increase of DERs, visualisation and management tools will become indispensable for DSOs. 38% of the interviewed utilities replied positively to the question of whether they have capabilities to tackle them. Although some DSOs use their SCADA system to visualise DER production almost in real time, automatic management tools are often not in place yet. Others have access to real time measurements of loads but can only monitor DER with an installed capacity over 1 MW.

With respect to phasor measurement units (PMUs), 21 % of the DSOs replied that they have them in place. Some use PMUs to send input to the SCADA system to operate the grid in a stable condition. Others for the observation of stability, for frequency measurements with high resolution, and for grid restoration. The remaining ones referred to pilot projects. It is expected that more PMUs will be deployed in the LV and MV grid in the years to come, which implies an opportunity window for the DSO Tools to leverage their data towards providing added value services.

The following table summarizes the answers of the DSOs that participated in the observational study of the JRC.

Table 6: Advanced technologies that the DSOs already use or find relevant and interesting (Adaptation from [6])

	yes (%)	no (%)	no answer (%)
Data analytics for asset planning and investments strategies usage	82	15	3
Sensor technology for outage detection and prediction usage in place	74	5	21
Advanced load and storage management skills	41	59	0
DER visualization and management tools capabilities in place	38	54	8
Micro phasor measurement unit technology usage	21	71	8

Another dimension of the study of JRC that is of special interest for the DSO Toolbox is that related to the collection, use, and exchange of data. And that is because the DSO Toolbox has a service in its backbone and a data integration middleware that can easily serve such needs.

The first category of data refers to forecasts of demand and generation. According to this study, almost half of the DSOs exchange such data at least on a yearly basis and more than a third on a daily basis, as well. About one in every four DSOs exchanges such data every month, whereas a few DSOs have answered that the exchange is weekly or hourly. Note that no DSO exchanges such data on a 15-minute basis.

The next category refers to data on the network conditions, and most specifically to the schedule of each power generating facility. The answers were equally distributed among yearly, monthly, weekly, and daily exchanges of data, with almost one-fifth of the DSOs for each answer, whereas no DSO exchanges such data on an hourly or 15-minute basis.

DSOs generate huge amount of real-time measurement data from their SCADA, which are deployed in multiple locations in their network (mostly substations). The value of such data is obviously tremendous for the secure and stable operation of the whole system, but this value is also time-limited. Thus, the exchange of such real-time measurement data, is done primarily on a 15 minutes basis, and to a lesser degree hourly or daily.

Besides the real-time data mentioned above, DSOs also generate large amounts of other metered data, which they can share ex-post. Such data are shared in different frequencies. More than one quarter of the DSOs shares data on monthly and/or yearly basis, whereas almost half of the DSOs share such metered data much more frequently on a daily, hourly or even 15 minutes basis. DSOs also receive data from TSOs related to the network conditions. Such data can be very valuable for the DSO to guarantee the security of supply to its customers and prepare for planned disruptions coming from the transmission side. One quarter of the DSOs have answered that they indeed receive such data from the TSO on a daily or hourly or 15 minutes basis.

2.16.3 Assessment of target market

Market size

Considerable are also the investments devoted to the integration of RES and storage into the distribution grids. Applications included in this category are:

- the network planning and analysis tool for assessment of network capacity for DG connections
- the active grid support (power-frequency control, voltage control) through smart inverters to facilitate DG connection
- the centralised vs decentralised control architectures
- the development of open and interoperable information and automation solutions for integration of DG&S
- the aggregation of controllable DG and storage into virtual power plants and microgrids.

Table 7 shows the total number of DSOs in each EU Member State and those serving more than 100,000 customers [3]. As shown, there is huge diversity regarding the number of DSOs in each Member State. Whereas some countries have only one (e.g., Ireland, Lithuania) or a few (e.g., Slovakia, Bulgaria, Hungary) DSOs, countries like France, Poland, or Germany with more than 150, 180 and 800 distribution companies, respectively, have a sector structure being shaped by the presence of many small-scale DSOs supplying a relatively small area with a limited number of connected customers.

It is worth noting that the number of DSOs serving a relatively small number of customers (up to 150.000) – i.e., the primary target group of the DSO Toolbox – has increased from around 6 % to around 13 % of the total number of DSOs [5].

Anticipated investments

European networks require multi-hundred billion € of investment with an estimate that the two thirds of it will take place in distribution grids. The DSO share of overall network investments is estimated to grow to almost 75% by 2035, and to 80% by 2050 [7].

DSO investments include building new capacity and refurbishing and replacing existing assets as they reach the end of their technical lifetime. Investments are also driven by a changing distribution system, with a greater role for new loads like electric vehicles, for distributed generation like rooftop solar panels, and for smart meters. As regulated companies, the DSO investment framework is determined by regulation at the national level. Active load management will be needed to avoid network congestions and make use of e-mobility's potential for smoother network operation. Smart grids, including intelligent control systems, will help DSOs become more active and should accompany the expansion of distribution networks.

Although no specific numbers are available for the upcoming period, an idea of how the investments of the DSOs can be formulated by assessing the relevant numbers for the recent past period. The following figure [Figure 3] shows the investments that European DSOs have undertaken from 2004 until 2015 on Smart Grids projects. The terms private and total in the figure refer to the investments faced by the DSOs only and by taking into account also national and EC financing, respectively.

As expected, the highest investments have been undertaken in the smart network management category, which includes applications such as:

- tools for network observability
- tools for network reliability assessment
- advanced sensors on network equipment to identify anomalies and communicate with nearby devices when a fault or another issue occurs
- tools for grid self-controlling and self-healing that is, to automatically prevent, detect, counteract and repair itself
- new capabilities for frequency control, reactive control and power-flow control
- controllable distribution substations, smart inverters, smart protection selectivity (smart relays), dynamic line rating, deployment of leading-edge transformers, capacitors, VAR-control devices for reduced losses and voltage control.

Table 7: DSOs number per EU Member State (Adaptation from [3])

	Country	Total # of DSOs	# of DSOs >100k customers
1	**Austria**	126	11
2	**Belgium**	16	12
3	**Bulgaria**	4	4
4	**Croatia**	1	1
5	**Cyprus**	1	1
6	**Czech Republic**	290	3
7	**Denmark**	40	10
8	**Estonia**	34	1
9	**Finland**	77	9
10	**France**	144	6
11	**Germany**	883	80
12	**Greece**	1	1
13	**Hungary**	6	6
14	**Ireland**	1	1
15	**Italy**	128	8
16	**Latvia**	11	1
17	**Lithuania**	6	1
18	**Luxembourg**	4	1
19	**Malta**	1	0
20	**Netherlands**	6	6
21	**Poland**	184	5
22	**Portugal**	13	1
23	**Romania**	51	8
24	**Slovakia**	3	3
25	**Slovenia**	1	1
26	**Spain**	354	5
27	**Sweden**	170	6
	TOTAL	**2556**	**192**

Considerable are also the investments devoted to the integration of RES and storage into the distribution grids. Applications included in this category are:

- the network planning and analysis tool for assessment of network capacity for DG connections
- the active grid support (power-frequency control, voltage control) through smart inverters to facilitate DG connection

- the centralised vs decentralised control architectures
- the development of open and interoperable information and automation solutions for integration of DG&S
- the aggregation of controllable DG and storage into virtual power plants and microgrids.

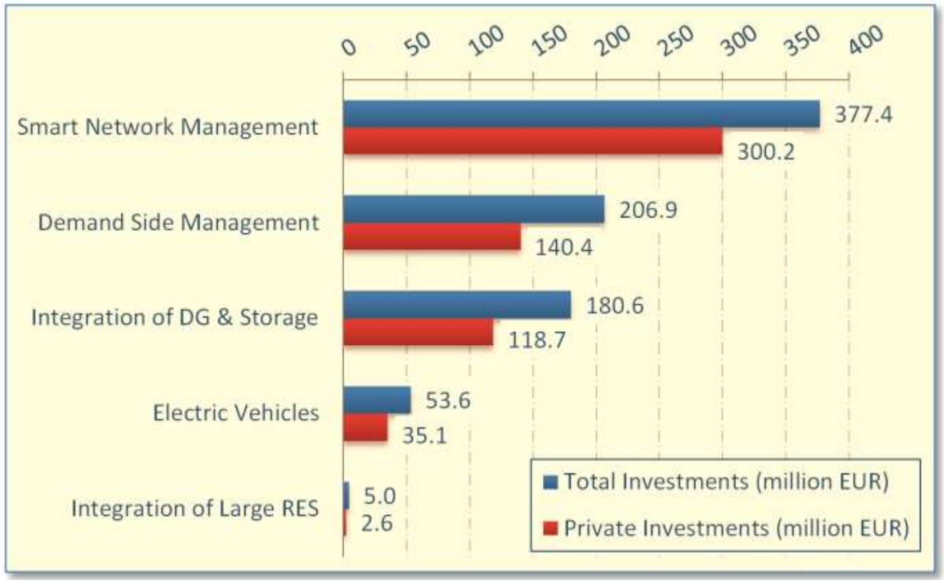

Figure 3: Smart Grid investments by category made by the DSOs in recent years [5]

2.16.4 Exploitation strategy

This result is considered a FEVER KER. An exploitation strategy is still under discussion.

2.17 Flexibility Service Consuming Agent

2.17.1 Description

The Flexibility Service Consuming Agent (FSCA) is a component used for transforming the flexibility needs that are required to address grid related problems (e.g., congestions, voltage variation) detected by the DSO Toolbox applications to flexibility requests and relayed to a flexibility market system or to systems of Flexibility Providers. The target TRL at the end of the project will be 5. For the needs of FEVER, the FSCA is a custom solution that adopted the FlexOffer communication protocol for the exchange of flexibility requests with the Flexibility Trading Platform of the partner INEA.

2.17.2 Target group(s)

The target group of the FSCA is described in Section 2.16 about the “DSO Toolbox”.

2.17.3 Assessment of target market

An assessment of the target market of the FSCA is given in Section 2.16 about the “DSO Toolbox”.

2.17.4 Exploitation strategy

The result is not considered a FEVER KER. An exploitation strategy is still under discussion.

2.18 Market mechanisms for day-ahead and intra-day flexibility trading

2.18.1 Description

The market mechanisms for day-ahead and intra-day flexibility trading developed in the scope of FEVER are intended to demonstrate the effectiveness of mitigating issues of the distribution grid with flexibility trading market mechanisms. The target is to deliver scalable operational mechanisms compatible with EU electricity markets. HEnEx leads the development of these mechanisms, with contributions from UP and ICOM.

The proposed day-ahead market mechanism consists of a two-level iterative mechanism. First the master social welfare optimization problem is solved on the Transmission level, determining the electricity prices and market schedules. Then, at local level, each DSO solves a local cost minimization sub-problem, introducing the technical constraints of their distribution grid and the flexibility offers they have gathered by Flexibility Aggregators. The updated market schedules will be resubmitted to the Market Operator in order to rerun the market and produce the final prices and market schedules.

The intra-day mechanism is a continuous trading mechanism operating on a distribution system level. The DSO performs short-term forecasts and can uses them to analyse the anticipated grid conditions using various analysis tools (i.e., power flow). In case any violations are anticipated, the Market Operator opens the intra-day market and the market participants can submit flexibility offers. The continuous market mechanisms match flexibility offers provided by prosumers that help alleviate any issues in the distribution grid.

In the beginning of the project, the day-ahead and intra-day market mechanisms, as presented in FEVER proposal, were at a conceptual level, therefore with an initial TRL 2. By the end of the project, the proposed mechanisms will be validated in relevant environment, using the data from the project's pilots. Therefore, the target TRL at the end of the project is TRL 5.

2.18.2 Target group(s)

The market mechanisms for day-ahead and intra-day flexibility trading developed in the scope of FEVER are intended to support the roles of the Market Operator, the Flexibility Aggregator, the Distribution System Operator (DSO), and the Transmission System Operator (TSO).

The proliferation of renewable energy resources in the distribution network has created new challenges for both the TSOs and DSOs, with the former facing system-wide energy balancing issues, and the latter often running an over-loaded network. A solution to both of their problems the operation of market mechanisms for flexibility trading, that allows the TSO to leverage the flexibility that lies in the distribution network for balancing purposes, and which respects the constraints imposed by the distribution network. The Market Operator expands their business opportunities by developing and operating the market framework that enables the cooperation between the TSOs and DSOs. Finally, Flexibility Aggregators can increase their revenues by aggregating flexibility offers from assets in the distribution grid and submitting them to the wholesale market.

2.18.3 Assessment of target market

The target group of the proposed market mechanisms includes the Distribution System Operators, the Transmission System Operators, the Market Operators and the Flexibility Aggregators in the EU. For the day-ahead market, the target market consists of the Distribution System Operators, the Transmission System Operators and the Market Operators. For the intra-day market, the target market consists of the Distribution System Operators and the Market Operators. As of the latest Distribution System Operator Observatory report of 2020, there are over 180 Distribution System Operators in the EU serving at least 100,000 customers that could fully leverage the capabilities of the proposed mechanisms. There are also over 40 Transmission System Operators, and 16 Market Operators operating wholesale spot electricity markets in the EU.

The future outlook of the proposed mechanisms looks promising. While the number of TSOs, DSOs and Market Operators is expected to remain steady, the liquidity and volume of the flexibility aggregator trading is expected to increase in the future. Indicatively, an operational independent marketplace for flexibility has already emerged in the UK and EPEXSPOT has announced its plan to launch a local flexibility trading platform in the near future. These projects can act as a proof-of-concept for the proposed mechanisms and raise awareness and the penetration for this type of markets.

2.18.4 Exploitation strategy

Due to the fact that the TRL of the mechanisms will reach its maturity during the final stages of the project, it is not expected that the mechanisms will be offered to the target group during the project duration.

Beyond the project duration, HEnEx will evaluate the feedback gathered by the dissemination activities undertaken during the project. Based on this, a business case will be formulated and analyzed, and a business plan will be developed, in which the proper channels to reach the target audience will be identified. At the same time, the TRL of the mechanisms will be further increased to reach the maturity levels needed.

As far as the dissemination beyond the duration of the project is concerned, HEnEx plans to continue its research on flexibility, using the findings of the project as a basis. Furthermore, the same findings can be used to issue policy suggestions.

The result is currently not considered a FEVER KER. This will be re-assessed towards the end of the project.

2.19 Intraday market application

2.19.1 Description

The Intraday Market Application is a web application related to the intraday market mechanism implemented in FEVER. The intraday market is a market positioned at the level of distribution market that operates via a continuous trading mechanism. The intraday market mechanism developed in FEVER is complemented with a power flow simulator and a grid disturbance simulator that enable testing/validation of the solution. The Intraday Market Application provides functionality related to the realization of test related to intraday market operation. It also acts as a prototype for a real-world application. The target TRL at the end of the project will be 4.

It should be noted that the Intraday Market Application is not exploitable on its own and should be considered along with the intraday market mechanism implemented in FEVER by HEnEx.

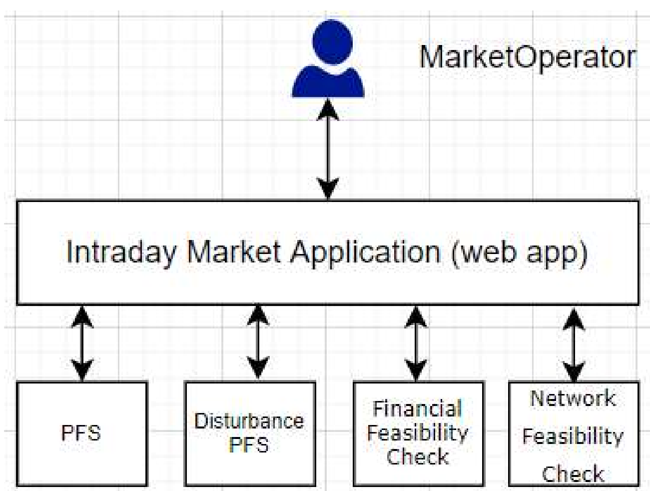

Figure 4: Place of Intraday Market Application in the system

2.19.2 Target group(s)

The target group of the Intraday Market Application is described in Section 2.18 on "Market mechanisms for day-ahead and intraday flexibility trading".

2.19.3 Assessment of target market

An assessment of the target market of the Intraday Market Application is given in Section 2.18 on "Market mechanisms for day-ahead and intraday flexibility trading".

2.19.4 Exploitation strategy

The result is not considered a FEVER KER. An exploitation strategy is still under discussion.

2.20 Flexibility Management System

The Flexibility Management System (FMS) is a part of the Aggregator-as-a-Service Platform (AaaS Platform) which serves as an overarching platform for using these tools in an integrated fashion in end-user applications. As for FEVER, the most relevant functionality is the FMS part of the AaaS Platform, the following parts focus on the flexibility management service.

2.20.1 Description

Generally, FMS is a software solution that:

1. Allows managing large pool of prosumers with different types of flexibility.
2. Aggregates different prosumer's flexibility assets, while considering location of these assets.
3. Disaggregates demand and supply schedules of these assets.
4. Make aggregated flexibility assets available for trading on FTP.

FMS is implemented as an integral part of the FLEXSHAPE's Aggregator-as-a-Service (AaaS) platform, in the form of 3 different platform applications (APPs) accessed by the platform users:

- **Aggregator Console** – this is the primary APP of FMAN, targeting *aggregator users*. It serves as a central console for accessing all relevant aggregator-specific functionalities. This APP allows organizing *prosumers* and their *loads* into so-called *portfolios*, which then could be made available in one of the selected instances of the *flexibility market* (e.g., FTP, WP2). It allows configuring loads, prosumers, portfolios, market instances and monitoring their state in (near) real-time. It is expected to raise its TRL from 1 to 8.
- **Prosumer Console** – this APP complements Aggregator Console and targets *prosumer* users. It serves as a central console for accessing relevant prosumer-specific functionalities and acts as both basic prosumer's EMS and FSPA – thus it allows prosumers sharing their selected flexible loads with their selected aggregator user (using *Aggregator Console*). An increase of TRL from 1 to 8 is planned.
- **Smart-Plug Loads** – this APP can be used by both prosumer and aggregator users to configure energy consuming devices, controller by so-called smart-plugs (e.g., TP-Link HS110), as well as setting associated parameters and constraints that allow operating these devices in a flexible manner. It is the aim to increase the TRL from 1 to 8.

2.20.2 Target group(s)

FMS targets prosumer and aggregator users. Prosumers will be able to get rewards (savings, discounts) for offering flexibility from their electrical appliances (smart-plug-connected for now) to an aggregator of their choice. Aggregator users will be able to create and make available for trading (in FTP) portfolios of various prosumer flexibility assets and thus generate profit by trading these assets in an aggregated form. When provided in a package with other AaaS platform APPs and connectors to other types of loads and generators (PVs, heat-pumps, EVs), FMS can be of great interest to progressive DSOs, BRPs, building operators, energy communities, utilities, which seek to practically implement demand-response by becoming *aggregators* and establishing active *prosumer* collaboration. For this target group, FMS is will be offered in a B2B and/or B2B2C setup.

2.20.3 Assessment of target market

It is anticipated that the EU demand response market will be worth $3.5 billion by 2025 [8]. With an anticipated 5% share of this market, AaaS (encompassing FMS) has a potential to be sold to an expected 50k number of potential customers (utilities, BRPs, energy communities).

2.20.4 Exploitation strategy

A few pilot deployments will be launched (also during FEVER), carefully validated, and further expanded with new features. Later, basic features of FMS will be offered for free on our public instance of AaaS, with advances features available only to paid users. Specialized deployments of FMS are planned as well. The target group will be reached through our network initially; demos and other exploitation strategies will be considered later.

The result is currently not considered a FEVER KER.

2.21 Peer-to-Peer Flexibility Trading Platform

2.21.1 Description

The P2P-FTP mainly consists of distributed applications (DAPPs) enabling P2P trading: the Community Management DAPP, the FlexCoin DAPP, and the FlexTrading DAPP. As the trading functionality is provided by the FlexTrading DAPP, this one will be focused on in the following subsections. The FlexTrading of P2P-FTP is a distributed application (DAPP) delivering a blockchain-based marketplace, where its participants (peers) are able to trade flexibility/energy products without an intermediary. It allows configuring trading parameters (contracts), monitoring and tracking statuses, histories, and states of several parallel P2P markets and individual peers, offering options for connecting third-party trading agents of market participants – for submitting or revoking bids automatically. It is planned to raise TRL from 1 to 8. FlexTrading DAPP builds up on FlexCoin and Identity Management DAPPs, and so it must be deployed though a collaboration between FlexShape and CERTH.

2.21.2 Target group(s)

FlexTrading DAPP targets existing and emerging energy communities, primarily those that require a solution for local electricity and flexibility trading between energy community members in order to save CO_2, increase utilization of locally deployed energy assets/maximize self-consumption, or reduce costs.

2.21.3 Assessment of target market

There are around 1900 energy cooperatives from all over Europe active in the REScoop.eu network [1]. According to an analysis of 24 case studies from 9 countries [9], there are up to 3750 community energy initiatives existing. With the Clean Energy Package, the European Commission is paving the ground to enable citizens and communities to take an active role in the energy system. The two directives – Renewable Energy Directive (EU) 2018/2001 [10] and Electricity Market Directive (EU) 2019/944 [11] – define energy communities. EU member states were obliged to introduce those Articles into national law by mid of 2021 resp. end of 2020. It is expected to result in a considerable growth of not only energy cooperatives but “real” energy communities as defined in mentioned EU directives.

2.21.4 Exploitation strategy

A pilot deployment of FlexTrading DAPP will start in FEVER. Based on its outcome we will consider (1) open sourcing FlexTrading DAPP and (2) developing commercial integrated applications based on FlexTrading DAPP. The result is currently not considered a FEVER KER. This will be revised towards the end of the project.

3 FEVER business model assessment

In Table 8, FEVER results currently considered key exploitable results (KER) are listed together with relevant target group(s). A business model assessment is seen only relevant for KER of the project or combination of KERs.

Table 8: List of FEVER exploitable results considered Key Exploitable Results with relevant target groups

Exploitable result	Target group(s)	Key exploitable result
Factory Energy Management System	large industrial consumers, public infrastructure managers, prosumer with large controllable assets	Yes
Flexibility Trading Platform	DSOs, TSOs, BRPs, microgrid operators	Yes
Flexibility Service Providing Agent	Users with energy management system	Yes
Microgrid Operation Scheduler	microgrid operators, aggregators; operators of virtual power plants, energy communities, confined energy systems	(Yes)
Algorithms for PV generation forecasting	Household with installed rooftop PV systems, Individual PV plants, DSOs, TSOs	Yes
Critical Event Prevention Application / Loss Reduction Application	DSOs	Yes
Self-healing application	DSOs	Yes
Algorithm for fault detection	DSOs	Yes
DSO Toolbox	DSOs	Yes

The development of business models for FEVER solutions already started in the proposal development phase of the project and lead to draft business model canvases for two FEVER solutions in the project proposal, one for DSO Toolbox and one for Flexibility Aggregation, Management and Trading platform.

With the first technical development phase in FEVER coming to an end and the implementation phase starting in the next month, these business model canvases will be re-assessed and transferred to the more commonly known structure (as shown in Figure 5). New insights and findings will be included.

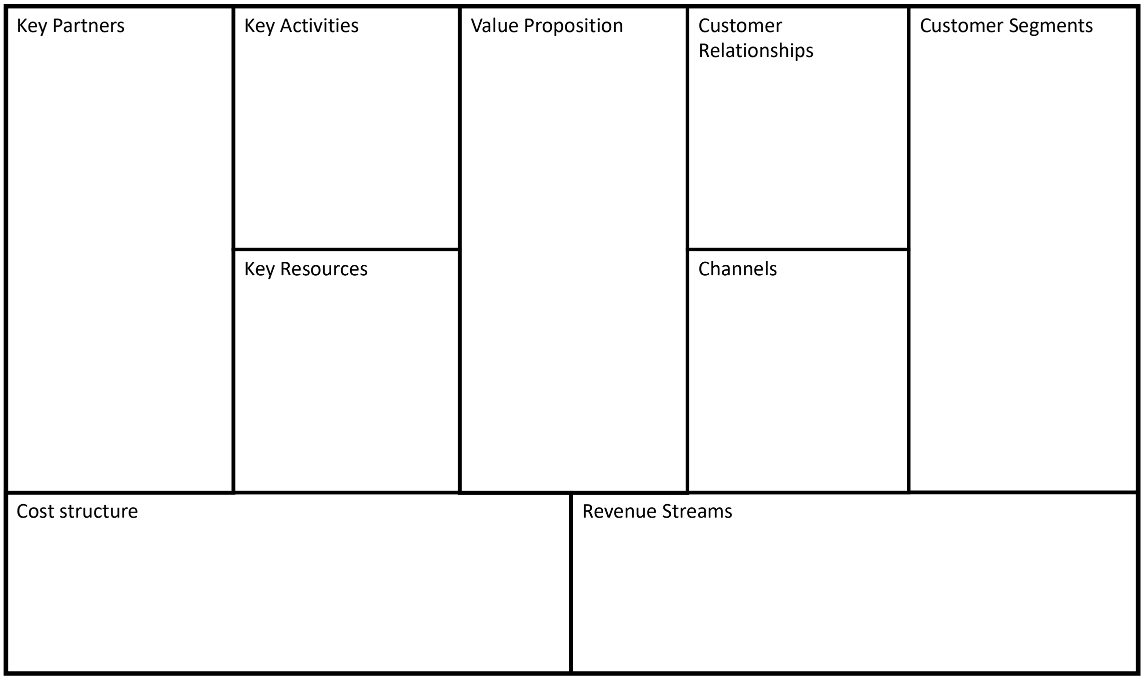

Figure 5: Structure of Business Model Canvas

Once all fields of the business model canvases are filled, relevant business models will be described in more detail and be driven forwards.

The whole list of KERs will be revisited and assessed with regards to business model development. If applicable, further business model canvases as first steps in the business model development process will be produced and assessed.

4 Assessment of regulatory context of FEVER

In the following, the most relevant themes of FEVER affected by existing regulations will be listed (see Figure 6) and described shortly. The aim of this chapter is to give an overview of the aspects of FEVER identified as most relevant for an assessment of the regulatory context.

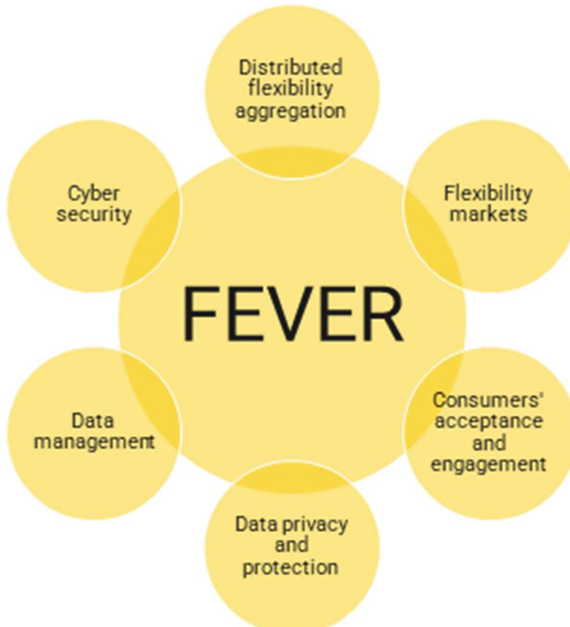

Figure 6: Identified themes in FEVER project for discussion of regulatory framework

The first topic that was identified is “distributed flexibility aggregation”. Among other goals, FEVER aims at making distributed flexibility options accessible for demand response to support distribution network management, either from larger single assets or by aggregation of smaller ones. In RESOLVD, one of FEVER’ predecessor projects, where some partners were involved, a whitepaper on the project’s contribution to standardization and regulation “*ICT services and energy storage for increasing renewable hosting capacity of LV distribution grids*” [12] was published which contains an analysis of the regulatory context which is still valid for the work in FEVER. The whitepaper analyses the Clean Energy Package and especially the e-Directive (EC 2019/944 [11]) and the e-Regulation (EC 2019/943 [13]) with regards to flexibility, relevant markets and participants as well as the role of aggregators and Energy Storage Systems (ESS). It becomes clear that there is a change of scope towards smaller loads and assets in the directive and regulation. As for ESS, DSOs will further on not be allowed to “own, develop, manage or operate energy storage facilities” and member states shall reduce hurdles for owners of energy storage systems to operate and market them. In addition, the whitepaper gives an overview of ESS-relevant Network Codes and works dealing with remuneration methods for DSOs. The analysis has been and still is being developed further in the FEVER project. Findings will be published later in the course of the project.

A closely related theme is “flexibility markets” and mechanisms for offering flexibility at these markets. An extensive analysis of operation principles including regulatory frameworks, participation of flexibility providing assets and proposition of new market operation approaches was made in deliverable D4.1 “*Flexibility – related European electricity markets: Modus operandi, proposed adaptations and extensions and metrics definition*” [14]. In this work, the analysis focused on all countries or regions of consortium partners of FEVER: Nordics (subdivided into Finland, Denmark, Norway and Sweden), Spain, Italy, UK, Belgium, Greece, Cyprus and Germany. This includes an analysis of the currently established regulations relevant for FEVER. It became clear that “*the Nordic countries (Denmark, Finland, Norway, Sweden), UK, Belgium and Germany are front-runners in promoting flexibility related services, while important progress is noticed in Spain and Italy. Southern countries like Greece and especially Cyprus are still lagging in allowing flexibility sources into the electricity market*.” [14]. The current situation in these European countries is very diverse as can be read in D4.1. Therefore, it is not possible to give one assessment for Europe as a whole. What can be stated is, that there has been and is still ongoing development all over Europe to enable more parties to participate in wholesale electricity markets as well as balancing markets.

The third topic identified is "consumers' acceptance and engagement" which in many cases is the basis for leveraging flexibility sources in the distribution grids to be managed or bought by DSOs. On European level, two types of energy communities are defined. In the e-Directive or EMD (EC 2019/944) [11], Art. 16, Citizen Energy Community is described, and in the "Directive on the promotion of the use of energy from renewable sources" or RED II (EC 2018/2001) [10], Art. 22, Renewable Energy Community is defined. The definitions of the two types of energy communities coincide to the extent that effective control may only be exercised by natural persons, local authorities including municipalities and SMEs. Even though, membership is open to all categories of entities in the case of Citizens Energy Communities, larger enterprises or utilities shall be excluded from decision making. In aspects such as the energy source, energy type and proximity of generation and demand, these two energy community types differ. EU member states were asked to include the main aspects of these directives for establishing energy communities in national law end of 2020 resp. mid of 2021. This becomes especially relevant in the case of the German trial site. Here it is planned to set up an energy community including testing of peer-to-peer trading solutions from the FEVER. In Germany, the Energy Industry Act (*Energiewirtschaftsgesetz, EnWG*) [15] sets the main regulatory framework in the energy sector, expanded by the Renewable Energy Act (Erneuerbare-Energien-Gesetz, EEG) [16] which sets the framework for investment in renewable energy sources. According to these acts, the opportunity to found some type of energy cooperative for collaborative investment into energy assets is already given in Germany, which is an important step to engage consumers in the energy transition. Still, a definition of energy communities in the sense of the above-mentioned EU directives cannot yet be found in German law.

In FEVER, "Data privacy and protection" concerns mainly the German trial since private persons are participating in this trial. All use of data from these persons will be done in accordance to the European General Data Protection Regulation (GDPR) [17] resp. the German *Bundesdatenschutzgesetz (BDSG)* [18].

"Data management" concepts are developed in FEVER since one goal is to improve grid operation especially for DSOs through digitization of their grid management structures and leveraging flexibilities available for grid management. The development is in accordance to the e-Directive [11] which defines data management in relation to the electricity system.

For FEVER, "Cyber security" plays a major role since new technologies such as blockchain are used for P2P-trading and smart algorithms are developed. At the EU level, cyber security is defined by the EU Directive on Network and Information Security [19], which was developed in 2016 and provides for large parts of this directive to be adopted into national law by 2018. Further measures will therefore be defined at the national level of each EU member state.

5 Conclusion

The list of target groups for FEVER results is very diverse – ranging from DSOs, TSOs, and microgrid operators over BRPs and market operators to VPP operators, industrial customers, and energy communities – it reflects the diversity of the project. The assessment of the respective target markets shows that markets are either expected to grow significantly in the future (e.g., numbers of VPP operators, aggregators, energy communities as well as other owners of PV systems, electric vehicles, etc.) or are estimated to have a moderate to small growth but have not yet started to be served (e.g., DSOs, TSOs). The exploitation strategies discussed are as diverse as the results. Depending on type of partner or result, these strategies include publications in journals, on conferences and use in further scientific and research projects as well as reach-out via established networks. For software solutions different licensing options are being considered. In the further course of the project, the establishment of the FlexCommunity is considered a most efficient path to reach relevant target groups.

A rather high number of 9 KERs were identified. One of these is the DSO toolbox which comprises three other KERs (Critical Event Prevention Application (CEPA) / Loss Reduction Application (LRA), Self-healing application (SHA), Algorithm for fault detection) into one platform especially relevant for DSOs when it comes to management of their grid. With the even more increasing focus on climate change on political agenda in Europe, DSOs' responsibilities will change, and FEVER offers a toolbox for DSOs to support them to live up to the responsibility. The KERs Factory Energy Management System (FEMS), Flexibility Trading Platform, Flexibility Service Providing Agent (FSPA) combine several components needed to communicate with each other for flexibility provisioning and trading. With the start of the field trials, business models will be developed further.

The assessment of the regulatory context relevant for FEVER was discussed around six identified themes. The identified themes touch several aspects such as structures and organisation of the electricity system on various levels, data privacy and cyber security. For some frameworks, the assessment also shows that legislative frameworks differ a lot across countries in Europe from which partners participate in the FEVER project, also when already defined in EU Directives. An analysis of European regulation relevant for ICT services and energy storage in distribution systems was and will be developed further. Here, it became clear that technological development is ahead of regulation. Development being ahead of regulation is the case for the regulatory context regarding Local Energy Communities in Germany as well, as there still seems to be potential to incorporate the far-reaching possibilities of energy communities under EU directives into German law.

All in all, the results emerging from FEVER will make a valuable contribution to all efforts taken in the energy system to address climate change by enabling DSOs to use flexibility in their grid for its management and with that supporting a secure and reliable electricity supply.

6 List of abbreviations

Abbreviation	Term
AaaS	Application as a Service
AMI	Advanced Metering Infrastructures
ANN	Artificial neural network
CAGR	Compound Annual Growth Rate
CEPA	Critical Event Prevention Application
DAPP	Distributed application
DER	Distributed Energy Resource
DH	District Heating
DSO	Distribution System Operator
EAC	Electricity Authority of Cyprus
EC	Energy community
ER	Exploitable Result
EMS	Energy Management System
ESS	Energy Storage System
FEMS	Factory Energy Management System
FMS	Flexibility Management System
FSCA	Flexibility Service Consuming Agent
FSPA	Flexibility Service Providing Agent
FTP	Flexibility Trading Platform
HEMS	Home Energy Management System
HLUC	High Level Use Case
ICT	Information and Communication Technologies
KER	Key Exploitable Result
LEC	Local energy community
LOS	Local Observability Services
LRA	Loss Reduction Application
LV	Low voltage
OTF	Outdoor testing facility
P2P	Peer-to-Peer
PEV	Plug-in Electric Vehicle
PV	Photovoltaics
PVTL	Photovoltaic Technology Laboratory
SaaS	Software as a Service
SHA	Self-healing application
TRL	Technology Readiness Level
TSO	Transmission System Operator
V2G	Vehicle-to-grid

VCA	Voltage compensation application
VPP	Virtual Power Plants
VSP	Virtual Storage Plant

7 List of figures

8 List of tables

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