Market Analysis

Deliverable 7.3

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Technical References

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[1] PU = Public
PP = Restricted to other programme participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
CO = Confidential, only for members of the consortium (including the Commission Services)

Document history

V	Date	Beneficiary	Author
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2	2021	EMT	Georgios Stravopodis - Contributions to Section 3.4 and Section 3.4
3	7 Feb. 2022	AMP	Liudas Karalius, Ignacio Guerrero – Contributions to Section 3.2
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	21 Feb. 2022	TPS	John Boylan, Carlos Neves, Przemyslaw Lukasiak – Contributions to Section 3.5

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	17 March 2022	EMT	Sami Hammal – Contributions to Section 3.4 and Section 3.6
	20 March 2022	MGC	José Henriques – Contributions to Section 3.5
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4	May 2022	UNC, DTU	Anna Pinarelli, Francesco D´Ettore - Review
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Executive summary

The aim of the deliverable is to understand the market(s) in which the ebalance-plus solutions will be exploited. A market analysis was conducted as part of WP7, specifically task 7.3. This deliverable presents the results of this work. The objective of this task was to review the sector framework conditions, including entry barriers, players and competition, customers 'and investors` selection and assessment criteria. The market analysis contributes to the assessment of the exploitation potential of the ebalance-plus solutions (together with D7.2 Obstacles to Innovation Analysis).

The methodology of analysis was mainly desk research. Data was collected from different sources. Such as academic literature and conference proceedings, reports, webinars and other documents from think-thanks, associations, platforms, and consultancies, data from Eurostat, project deliverables from other Horizon 2020 projects and BRIDGE. Furthermore, the expertise of the ebalance-plus consortium members was collected through different templates, especially regarding the specific Key Exploitable Results (KERs) markets. Finally, three interviews with experts were conducted. The data from the different sources was triangulated, which ensured the validity of the findings.

First, the deliverable presents the market conditions for Demand Side Flexibility (DSF) in Europe (Chapter 2), showcasing the possibilities for DSF to participate in existing electricity markets, and discussing the upcoming local flexibility market. The perspective of different stakeholders in the DSF markets and their potential role (e.g., adopter, supporter, competitor) in the exploitation of ebalance-plus solution is also presented.

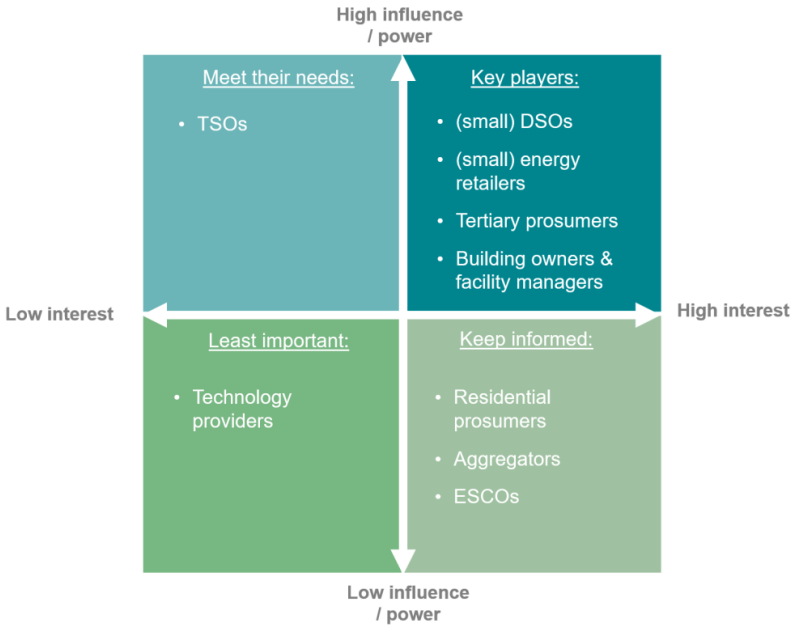

Figure 0. Diagram showing the power (to have influence on the electricity system) and interest (in the ebalance-plus platform).

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The results specifically highlight the (business) opportunities for DSF in the consortium countries: Denmark, France, Italy, Spain, UK, Germany, Portugal, Greece, and Poland.

Secondly, the deliverable provides in-depth insights in the specific markets for the project´s KERs (Chapter 3): a) the market for energy management mobile application; b) the market for energy storage; c) the market for energy prediction services; d) the market for so-called “Smart Hubs” (integrated solar car parking with battery energy storage and Vehicle to Grid (V2G) electrical vehicle (EV) charge management); and finally, d) the market for energy balancing platforms.

For each KER, the main market opportunities are identified, as well as the added value of the KERs in their reference markets, the opportunities / market strategy of and the market-related exploitation challenges.

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Abbreviations

AC	Alternating Current
ADMS	Advanced Distribution Management System
BESS	Battery Energy Storage System
BM	Business Model
BMS	Building Management System
BRP	Balance Responsible Party
BSP	Balance Service Provider
B2B	Business to Business
B2C	Business to Customer
CAGR	Compound Annual Growth Rate
CEER	Council of European Energy Regulators
CHP	Combined Heat and Power
CNIL	Commission National de l'informatique et de libertés
CNMC	Comisión Nacional de los Mercados y la Competencia
COTS	Commercial off-the-shelf
CRE	Comission de Régulation d l'Energie
DA	Day ahead
DC	Direct Current
DER	Distributed Energy Resource
DERMS	Distributed energy resources management system
DG	Distributed Generation
DMS	Distribution Management System
DNO	Distribution Network Operator
DR	Demand Response
DSF	Demand Side Flexibility
DSO	Distribution System Operator
E-DSO	European Distribution System Operators
EE	Energy Efficiency
EER	European Energy Retailers
EMS	Energy Management System
ENTSO-E	European association for the cooperation of transmission system operators for electricity
EPC	Energy Performance Contracting
ESCO	Energy Service Company
ETIP SNET	European Technology &Innovation Platform Smart Networks for Energy Transition

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ETNSO-E	European Network of Transmission System Operators for Electricity
EU	European Union
EUSEW	EU Sustainable Energy Week
EV	Electric Vehicle
GME	Gestore dei Mercati Energetici
HRP	Horizon Results Platform
ID	Intra Day
IEA	International Energy Agency
IED	Intelligent Electronic Device
IoT	Internet of Things
IRENA	International Renewable Energy Agency
IT	Information Technology
JRC	Joint Research Centre
KER	Key Exploitable Result
LDV	Light-duty vehicle
OMIE	Iberian Market Operator
OMS	Outage Management System
PER	Plan of Exploitation of project´s Results
PV	Photovoltaic
USP	Unique Selling Point
REE	Red Eléctrica Española
RTE	Réseau de Transport d´Électricité
SAS	Substation Automation Systems
SCADA	Supervisory Control and Data Acquisition
SiC	Silicon Carbide
ToU	Time of Use
TSO	Transmission System Operator
USEF	Universal Smart Energy Framework
VPP	Virtual Power Plant
V2G	Vehicle to Grid
V2X	Vehicle to everything

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1 Introduction

Europe´s electricity sector is changing rapidly because of the growing integration of renewables, causing challenges for the power system. This calls for new mechanisms to balance supply and demand. Ebalance-plus contributes with solutions centred around the ebalance-plus energy management platform. The hierarchical approach allows involving different smart-grid innovations (e.g., smart production, storage, and consumption technologies, etc.) and to realize distributed and scalable energy control strategies. The approach exploits the actual topology of the energy grid. The platform allows for the development of generic algorithms that can be deployed on the "management units" in the smart grid to realise different tasks & energy services. The main goal of these energy services is to increase the flexibility and resilience of electric grids. It contributes to ensure system stability and maximisation of profit and/or minimise CO_2 emissions. The modular architecture can support (business) solutions such as:

1) **Distributed energy resources management system (DERMS)**
2) **VPP for building and district solutions**
3) **Energy/flexibility management platform** (e.g. optimising smart production, storage, consumption technologies in buildings (integration of BMS) or districts taking weather and market prices into account.
   …or a combination of the three above.

In all three cases different value is created for the various stakeholders (e.g. prosumers, aggregators, energy retailers, Distributed Energy Resources (DER) managers, building facility managers, Energy Service Companies (ESCOs), Distribution System Operators (DSOs), technology providers).

A market analysis has been conducted to be able to assess the exploitation potential of the ebalance-plus solutions (task 7.3). Relevant market opportunities, barriers, market drivers, potential end-users, and competitors have been identified. This deliverable presents the results of that work conducted as part of WP7.

The focus of the market analysis has been twofold:

1. **The market for Demand Side Flexibility (DSF)** *(Chapter 2)*
   The conditions to use DSF in Europe are mainly set by regulations. The regulated market for DSF forms the core context for the implementation of the ebalance-plus energy balancing platform and the services and business cases it can support. The role of different stakeholders and opportunities for DSF in the consortium countries have been analysed in detail.
2. **Reference markets for Key Exploitable Results (KERs)** *(Chapter 3)*
   Each ebalance-plus KER has a specific reference market. The market conditions, entry barriers, players and competition of these reference markets have been analysed to identify exploitation opportunities for the project´s key results. Table 1 shows the KERs and the related reference markets. KER8 will only be exploited internally by the ebalance-plus partners in further R&D activities and follow-up projects and is thus excluded from the market analysis.

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Table 1. List of KERs and their reference markets.

Nr.	KER	Reference market analysed
1	Comprehensive energy balancing platform	Market for DSF → *Chapter 2* Market for energy balancing platforms (as a service) → Section 3.6
2	Home energy management mobile application	Market for Home Energy Management mobile applications → *Section 3.1*
3	Smart-storage solution	Energy storage → *Section 3.2*
4	Prediction models	Energy prediction services → *Section 3.3*
5	Cloud-based Microgrid Optimization Platform	DERMS / Substation and distribution automation market → *Section 3.4*
6	Integrated Smart Hubs	Smart hubs → *Section 3.5*
7	Grid control and automatization units	DERMS / Substation and distribution automation market → *Section 3.4*
8	Control and optimization models for energy management systems	N/A

Aims and relations to other activities in the project

The market analysis, together with the IPR management plan (D7.1) and the Obstacles to Innovation Analysis (D7.2), form the knowledge base for the creation of business models and exploitation plans (Figure 1). This document will help to provide critical information on relevant markets and will help to define best exploitation strategies for different application- and geographical contexts. This will be reported in The Plan of Exploitation of project´s Results (PER) (D7.4).

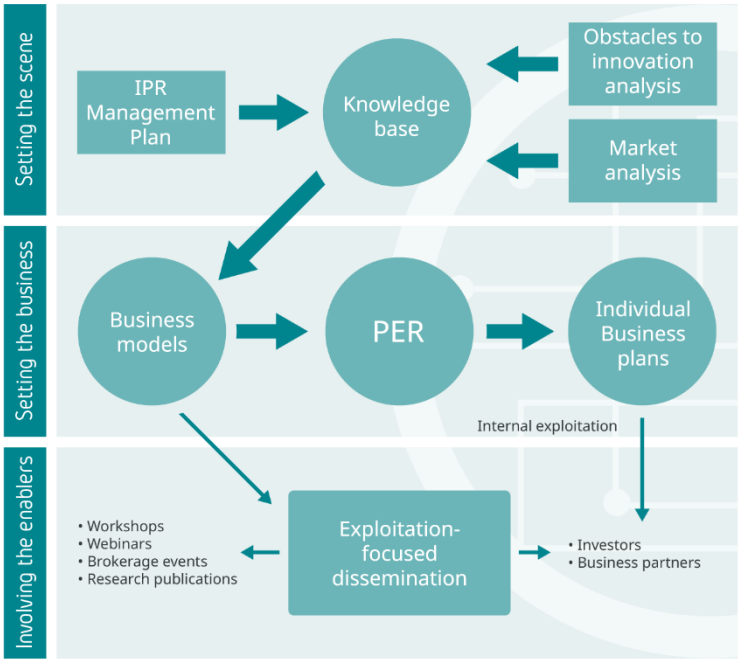

Figure 1. Overview exploitation activities ebalance-plus

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1.1 Methodology: data collection & analysis

Data collection

Data was collected from different sources. The core of the analysis was based on desk research and literature review. Different types of data have been analysed:

- Academic literature and conference proceedings found via Scopus.com, Google Scholar and ResearchGate
- Reports, webinars and other documents from think-thanks, associations, platforms, EU organisations, lobby organisations and consultancies, such as: smartEN, USEF, DR4EU, JRC, Eurelectric, ETIP-SNET, BRIDGE, DELTA-EE, IRENA, OpenADR, CEER, E-DSO.
- Data from Eurostat
- Project deliverables from other Horizon 2020 projects and the BRIDGE initiative
- Information from webinars and workshops (e.g. from smartEN, other EU-funded projects, BRIDGE workshops, etc.).

Furthermore, several partners in the ebalance-plus consortium (TPS, EMT, ENF, AMP, REE) have contributed to the analysis with their knowledge, experience, and data on markets for their KERs.

Lastly, 2 expert interviews and 1 informal talk (Table 2) were conducted with representatives from different backgrounds and industries. Experts were identified through the consortium's network and through webinars. All interviews were recorded and transcribed.

Table 2. Expert interviews & talks.

Nr.	Role	Type		Date
1	**Energy transition expert**	DSO (the Netherlands)	Informal talk	July 2020
2	**Regulation expert and business developer**	Industry – leading European aggregator	Interview	December 2020
3	**CEO**	Industry – leading European aggregator	Interview	January 2021

The data from the different sources was triangulated, which ensured the validity of the findings.

1.2 Methodology: connecting with relevant stakeholder base

Task 7.4 also included activities on reaching out and establishing contacts with stakeholders at large, including potential early adopters of the solutions. To reach that objective, several activities have been undertaken so far, and this is work is ongoing.

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Exploitation-oriented dissemination activities will take place in following months, increasingly towards the end of the project. The activities that have been undertaken so far:

- Publication of the KERs on the Horizon Results Platform (HRP), to reach out to potential interested stakeholders, potential customers, investors, and business partners. The following pages have been established:
  - "Smart Energy Storage System" (KER3) by AMP (Link to the page on the HRP)
  - "Power Grid Management Units" by EMT (KER7) (Link to the page on the HRP)
  - In the pipeline: "Prediction models" by ENF (KER4), "Cloud-based Microgrid Optimization Platform" (KER5) by EMT
- A series of expert workshops on demand-side innovation is planned around the key solutions of the project. The first event took place on 21st of April 2022, focused on IoT solutions.
- Participation in various events, fairs and workshops to present the solutions and reach out to potential interested stakeholders (e.g. India Smart Utility Week, Energy talks during the EUSEW, Sustainable Places, etc.).
- Several partners individually have started to discuss their solutions with potential customers.

1.3 Changing role of stakeholders in electricity (related) markets

Before we go into detail about market players, potential customers, and competitors. It is important to understand how the increasing use of DSF and introduction of new market mechanisms leads to changing roles of existing- and the introduction of new stakeholders in the electricity sector. Table 3 provides a short overview of the conventional and new role(s) of relevant stakeholders in the electricity market.

Table 3. Changing roles market players in electricity markets and potential new market players [1-4]

Stakeholder	Role in conventional electricity market	Role(s) in electricity market with use of DSF
Consumer / Prosumer	Passively receiving and consuming energy from the grid.	Generating, self-consuming, and storing electricity with help of DER and smart storages and devices. Prosumers can inject their RES generation surplus to the grid, shift load or react to prices, or offer flexibility in new and existing markets.
DSO/TSO	Grid operator, providing infrastructure and management to transport and distribute energy.	Increasingly using flexibility from prosumers to manage the grid assuring its safety, stability and resilience

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Stakeholder	Role in conventional electricity market	Role(s) in electricity market with use of DSF
Local flexibility aggregator / VPP	Did not exist	Flexibility provider: combining multiple consumers to form a new single market participant, trading energy from prosumers/consumers/producers with market players.
Wholesale market aggregator	Manging large amounts of load in a large area to meet requirements of producers, suppliers, BRPs in line with balancing requirements established by TSOs/DSOs.	Works with local aggregators/VPPs to acquire customers and local aggregators can offer local flexibility products to wholesale market aggregators who sell these at the wholesale market.
ESCO	Did not exist	- Flexibility provider: e.g. for consumer's energy bill optimisation (peak shifting and ToU). - Facility management company: for distributed generation; battery energy storage systems. Helping end-users with energy management and tool maintenance. Some ESCOs partner with aggregators, others not.
Energy retailer	Intermediary between consumers and producers (wholesale market). Sells electricity to the end-users and provides accounting services for the energy exchanges. Collecting fees for TSO and DSO.	Continuously settle between energy producers and users, using real-time data. Increasingly linked to end-user, informs end-user about changes in prices, energy purchase and bill optimisation. Contracts with aggregators.
BRP	Responsible for a specific portfolio to ensure balance between injections and offtakes. Contracted by a supplier or directly by large customers.	Same role but can additionally be contracted by an aggregator. Uses flexibility to optimize its portfolio (avoid imbalances, maximize revenue from generation and reduce sourcing costs).
Data service provider	Did not exist	Metering data platform, data operation, data access point, bookkeeping, analysis, advising, forecasting, data security. Administrative relieve.
Software companies	Did not exist	Delivering enabling products and services to set-up demand-side response.
Local market platform operator	Did not exist	Acts as a -local energy market enabler.
Intelligent Electronic Device (IED) Manufacturer	Did not exist	Providing intelligent energy devices and electronic solutions.

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Stakeholder	Role in conventional electricity market	Role(s) in electricity market with use of DSF
Weather forecast agency	Did not exist	Supplier of weather information for DER generation that can be useful for prosumers, DER owners, and DSOs/TSOs.
EV Aggregators	Did not exist	Energy aggregation focused on EVs.
Charging Station Operators	Did not exist	Operating EV charging stations.
E-mobility service providers	Did not exist	Providing additional services such as EV location, parking place, and price comparisons through mobile applications.
Home appliances developers	Did not exist	Offering home management services and smart systems in homes.

1.4 Market drivers & trends

There are several drivers that push existing electricity markets, stakeholders, and mechanisms to open-up for DSF. The following key drivers & trends lay behind the changes observed in the analysed markets:

Political / Legal:

(1) New EU legislation

The Clean Energy Package prescribes to open markets for DSF, and stimulates Member States to form open, transparent flexibility markets. However, the actual situation in individual Member States still varies a lot (See Deliverable 7.2).

Technological:

(2) Ensuring a stable grid

High DER and EV penetration rates causing imbalances and congestion in the distribution grid, DSOs & TSOs need to keep the grid stable. In the EU the share of renewable energy in gross final energy use has doubled since 2005 to 18% in 2018 [5].

(3) **Decentralisation**

Large centralized systems of generation and transmission are challenged by decentralisation of the energy system, for example through DER. To solve this issue, flexibility solutions need to be enabled and implemented.

(4) Digitalisation / Smartification

The increasing penetration of smart meters, construction of smart buildings, and smart devices and appliances enable possibilities of using DSF. Small scale players are becoming smarter, and flexibility can be rewarded through aggregation.

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Environmental:

(5) **Need to decarbonize**

Environmental concerns lead to closing of nuclear and coal power plants. The electricity system needs to contribute to sustainability by reducing its environmental impacts following the Paris Agreement and EU Green Deal. Therefore, even more DER is being installed, stimulating point (2) and (3).

Social:

(6) Energy poverty / security in EU

Energy security in the EU is threatened, it is defined by the IEA as: he uninterrupted availability of energy sources at an affordable price" and "the ability of the energy system to react promptly to sudden changes in the supply-demand balance." As a result of this, energy poverty is still present in the EU, flexibility and self-consumption can help to solve this issue.

Economic:

(7) Electricity prices (level & volatility)

Increasing electricity prices and volatility of wholesale electricity prices drive DSF. Household electricity prices in the EU have risen significantly in the last years, which large differences between countries. High peak rates can be a market driver for DSF mechanisms, especially if financial benefits for customers and aggregators will be in place.

(8) Increasing customer spending on new energy technologies

Another driver of the markets for ebalance-plus solutions comes from EU consumers who spend increasingly more on key enabling energy technologies like private EVs, home changepoints, residential solar PV and batteries, residential heat pumps and smart thermostats. Differences can be observed between countries regarding the technologies that are invested in, influenced by policies and differences between national energy systems. For example, spending on e-mobility technologies in 2019 was high in the Netherlands and Germany, whereas consumers in France have spent most on new heating technologies. Consumer spending on enabling energy technologies will continue to increase [6].

(9) Increasing financial returns

The financial benefits of DSF are increasing, for example at building-level it is increasingly possible to get rewarded for DSF in several EU member states.

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2 Market for DSF

In the last years, more-and-more attention has been paid to the flexibility that prosumers and local generation and local storage units can offer to electricity markets. Ebalance-plus can support enabling stakeholders (e.g. aggregators, DSOs) and prosumers to offer Demand Side Flexibility (DSF) in the different electricity markets. We understand the market context for DSF as being the existing European markets (e.g. balancing, wholesale) and new markets (e.g. local flexibility markets) in which explicit DSF can be offered and monetized. Furthermore, the market conditions for implicit DSF (e.g., the availability of dynamic tariffs) are also included.

Generally, "the market" for DSF in Europe is still immature and fragmented, with widely varying regulations in individual member states, because of the delay of implementation of directives and regulations of the Clean Energy Package (discussed in D7.2). As a result, the value of flexibility is still relatively low. Another reason for the low value of flexibility is that there is sufficient supply (e.g. fast-ramping generators and conventional power plants) in the market in many countries. But this might change soon, as more and more DER and EVs are connected to the distribution grid and markets are re-structured to allow for DSF to participate.

2.1 Types of DSF

There are two types of DSF used in the market: implicit and explicit. Explicit DSF is mostly used by demanding parties (e.g., TSOs, DSOs, and BRPs) for short-term operational purposes, while implicit DSF is used for more long-term expectational purposes (Figure 2). Renumeration for explicit DSFs is typically receiving a *direct payment*, while through the participation in implicit DSF programs consumers will *lower their electricity bill*. The two forms of DSF do not replace each other, customers may participate in explicit DSF through an aggregator (when electricity markets are open), and at the same time in an implicit DSF program through for example a day/night tariff or dynamic tariffs using smart meters [7, 8].

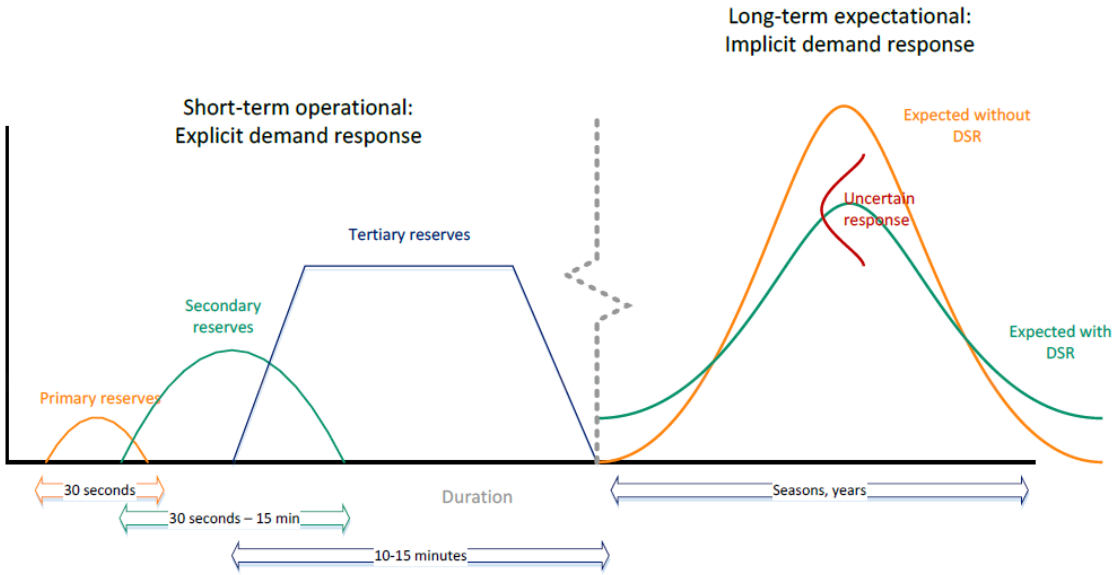

Figure 2. Characteristics of explicit and implicit flexibility (vertical axis: MW load) [9]

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Implicit DSF is based on variable tariffs that, compared to traditional flat tariffs, are more cost-reflective of the generation and network cost. Customers respond to these tariffs, often supported by an ESCO [10]. The following time-varying tariff structures can enable implicit DSF:

- **Static Time of Use (ToU)** - different prices in specific blocks of times (e.g. day and night).
- **Dynamic:** Real-time pricing - prices are continuously adjusted to the costs of supply in wholesale markets.
- **Mixed:**
  - **Critical peak pricing -** artificially higher prices during times that wholesale market prices are predicted to be high.
  - **Critical time rates -** in times of critical events, customers can be renumerated for a reduction of their consumption.

Explicit DSF can be deployed in many different markets and serving different purposes. There is no standardized market where flexibility can be sold, each market is unique based on national or regional structural and regulatory characteristics. To clarify the general principles of different markets and services, we adopt most of the language of the USEF framework. USEF distinguishes the following explicit DSF markets and products: wholesale, adequacy, balancing, and constraint management (Figure 3). In **wholesale markets** mainly BRPs (energy suppliers) themselves are active, as large amounts of energy are needed to participate. Aggregators can theoretically participate in this market when they have big enough energy shares. The **balancing markets** are there to offer balancing services to TSOs, these are the only European markets currently open to DSF. Offering flexibility services to the DSO (constraint management), could be enabled by **local flexibility markets**. But such markets beyond pilot scale do not exist yet in Europe.

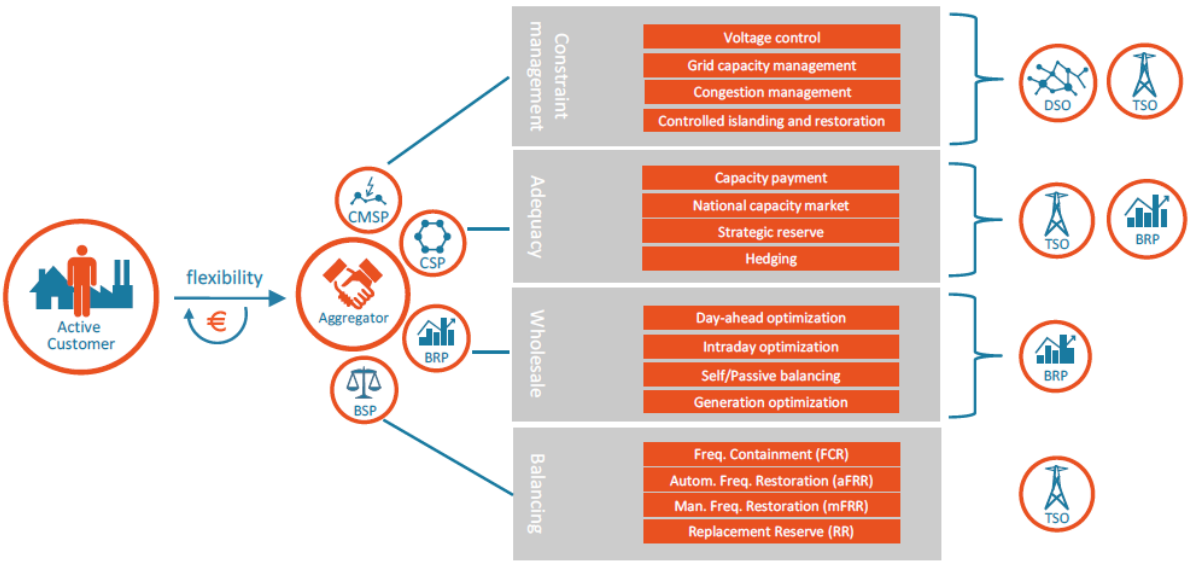

Figure 3. Types of services based on explicit DSF [4]

The ebalance-plus energy balancing platform can enable both explicit and implicit DSF services and provide services to the relevant stakeholders involved (prosumers,

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aggregators, ESCOs, DSOs).

2.2 DSF in existing electricity markets

Traditionally, electricity markets and rules have been designed for centralized power production, and large industries as the main market participants. To enable the value of flexibility, market operators should provide products that are sufficiently small in size and for aggregation of smaller assets to allow for DSF, storage and small-scale renewable participation in the market. The main possibility to monetise DSF in existing energy markets in Europe are on the **wholesale markets** and **balancing markets,** with large differences between countries.

2.2.1 DSF in balancing markets

The most important market for aggregated DSF from DER and DR at this moment is the **balancing market**, which has opened-up for DSF in several countries (Figure 4). For most European aggregators participation in the balancing market is the most lucrative revenue stream [11]. The balancing market corrects the imbalances caused by the difference between the contracted amount of electricity supplied or demanded and the actual physical amount for each market player in real time. The balancing markets are run by TSOs. The Electricity Balancing network code (2017) subscribes to harmonize the balancing markets across Europe. The network code, ENTSO-E, defines several balancing products that are represented across markets in Europe. Its implementation is however still infant, and there are many differences between countries. The three main products in which flexibility is currently traded in specific countries are: the Primary Reserve (FCR), the Secondary Reserve (aFRR) and the Tertiary Reserve (mFRR)[1] [12]. Additionally, ENTSO-E is implementing a Replacement Reserve (RR) called the Trans European Replacement Reserves Exchange (TERRE).

[1] The terminology for these markets is taken from ENTSO-E's network codes https://www.entsoe.eu/network_codes/eb/. For more information on these markets, see Annex 1.

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Figure 4. Balancing markets openness to DR and DER in Europe [12]

Several market barriers for DSF aggregators remain (elaborated in D7.2). For example, in many countries, aggregators need to offer a certain size which hinders small players. There are only a few DR service providers exist in Europe, and in most member states only the largest industrial consumers with their own bilateral power purchasing agreements can participate in DR programmes.
To optimize the situation for DSF on the balancing markets, the Clean Energy Package highlights that energy should be procured at marginal price and bids should be as close to real time as possible. The imbalance settlement period of 15 minutes should be introduced in all market regions by 2025 [13]. This is not yet the case in the demo countries of this project, only in Italy. (In Spain the imbalance settlement period is 1 hour, in France 30 minutes, and in Denmark it will only be 15 minutes from 2023 onwards as part of the Nordic electricity market[2]).

The ebalance-plus energy balancing platform is first and foremost focused on unlocking and managing flexibility in the distribution grid. As the balancing markets are run by the TSOs, this market is less exploitable for many of the ebalance-plus applications. However, when aggregators are allowed as intermediaries, this opens-up possibilities in the balancing market as well. As balancing markets are the most open market to DSF and most (monetary) value can be gained from balancing markets in Europe today, we will include relevant opportunities in the balancing markets in this deliverable.

2.2.2 DSF in wholesale electricity markets

In the wholesale electricity markets competing generators offer their energy outputs[3]. Wholesale markets consist of day-ahead and intraday markets. The **day-ahead**

[2] https://nordicbalancingmodel.net/go-live-date-for-15-minute-imbalance-settlement-period-has-been-confirmed-22-05-2023/
[3] The major electricity markets in Europe are: **Nordpool** in Scandinavia and the Baltic states, **EPEX Spot** in Central Europe, **EEX** in Germany, and **OMIE** in Spain and Portugal.

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market is an auction held the day before the delivery of electricity, while the intraday markets are continuous with possible complementary auctions [14]. The hourly day-ahead auction market has been coupled in the EU and closes every day at 12:00. In the intraday markets, power is mainly traded to limit shortfall of surpluses and maximize profit and stability within the system.

Theoretically, DSF can play a role in wholesale market through aggregators, who can offer wholesale services based on DSF to BRPs (which are often energy suppliers themselves) to optimize their portfolio in the day ahead and intraday markets. In practice however, DSF plays a minor role in the wholesale markets in most EU Member States. The prices on the wholesale market are low and market players should be able to offer large loads over a period of time, which does not fit small aggregators of demand-side loads very well. One solution for this problem would be if one party plays the role of aggregator and BRP (this could be the current energy retailers), this could also avoid the difficult setting between BRPs and aggregators[4]. Furthermore, minimum bid sizes are still often too high (1 MW), despite regulation sets the limit at 500kW. Aggregators in most countries also still need prior consent from the consumers' supplier to engage with them.

The main country where DSF through aggregators plays a role in the wholesale market is **France.** France has elaborated a compensation mechanism between aggregators and suppliers. This, however, does lower the sustainability of the business case for aggregators to a certain extend. The CEO of a large European aggregator argues that a level-playing field **day-ahead wholesale markets** is of key importance for aggregators:

> *"The key discussion is simply to open the day-ahead wholesale market as per the European directive, and this should be transposed, so implemented in all countries since the 1st of January of this year [2021], and it is not in most countries, not yet, but many of them are working on that. And it's all about will they be able to actually transpose it and open the market? Or will generators be strong enough to impede that and avoid competition from the demand side? And this discussion is going on in every country."* (Interviewee 3)

The wholesale markets are thus not a key DSF market for the exploitation of the ebalance-plus solutions in most countries, yet.

2.3 Local flexibility markets

Local flexibility markets in which DSOs purchase flexibility services for their constraint management, are a key market context for the ebalance-plus solutions, as these markets deal with local problems in the distribution grid.

DSOs are challenged by higher levels of DER, which threatens the reliability of the distribution grid. To guarantee safe grid operation and to manage grid constraints, DSF could be used and offered as grid services to DSOs. Local flexibility markets are recognised as an important tool to make better use of existing distribution grids and

[4] The participation of aggregators in wholesale markets is contested by electricity suppliers / retailers because aggregators turn off / lower the energy consumption of their clients.

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thereby reduce grid investments. DSOs can use flexibility to avoid network reinforcements and manage their systems. “Given the locational characteristics of these constraints, information on the location of flexibility service providers is required by DSOs when activating local flexibility. This information is not usually available in existing energy markets, day-ahead (DA), intraday (ID), nor in balancing markets managed by TSOs, and therefore specific local flexibility mechanisms are required.” [15]. The role of DSOs would move from exclusively investing in grid improvements, to procurement of flexibility from local resources for a more active management of the grid to cope with local congestion problems and capacity requirements [1, 16]. This phenomenon is only beginning to emerge, mainly in the form of DSOs procuring DSF for constraint management. Local flexibility markets in Europe are immature and are mostly in trial phase at the moment[5] [17]. In most European countries, Aggregators cannot offer flexibility to DSOs as a business case yet. Together with the **UK**, the **Netherlands** is the most advanced country for DSO flexibility markets [18].

A few markets in Europe are mature enough to be used on a wider scale or across multiple DSOs in projects: 1) **Flexible Power** in the UK; 2) **Piclo** in the UK; 3) **GOPACS** in the Netherlands; 4) **NODES** in the Nordics, Germany, and the UK. All others are single projects [15, 18]. Table 4 provides more details about these markets.

Next Page*: Table 4. Local flexibility in markets in different countries [15, 18, 19].*

[5] Remaining questions and unclarities around local flexibility markets are listed in Annex 2.

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Platform	Description	Countries	Initiative	Buyer	Seller	Services (products)	Integration with other markets	Settlement	Long- or short-term procurement
Flexible power	DNOs publish their flexibility needs in Constraint Management Zones (CMZs).	UK	UK DSO, Western Power Distribution	DNO	N/A	Congestion management	None	N/A	Long-term markets as this is the predominant way British DSOs procure flexibility
Piclo Flex	Independent marketplace enables energy and capacity trading. Over 300 flexibility providers (e.g., Kiwi Power and Open Energi).	UK	Piclo company	DSO	Aggregators, asset owners, consumers, community, and municipality, EVs and generators	Congestion management (capacity and activation)	None	Renumeration: dispatch payment, availability payment	DSOs can procure long-term flexibility commitments
GOPACS	Congestion management for DSOs and TSO redispatch extended to DSOs. Acts as an intermediary with settlements in the in the existing intraday market	NL	Dutch DSOs collaborating with TSO	TSO and DSO	FSPs, Residential, commercial, industry and energy companies	Congestion management (activation), Relation with the ID Market	Coordination with TSO congestion and TSO balancing and imbalance markets, fully integrated with the ETPA	Carried out by the market platform	Operating for short-term procurement
NODES	Congestion management for DSOs.	Norway, UK & Germany	Nodes company (owner is Nord Pool)	TSO, DSO and BRP	FSPs, BRP, microgrid, and aggregators (prosumers, active demand-supply).	Balancing (mRR, RR), Congestion management (capacity)	Integration to mFRR (TSO led market), services to BRP for portfolio balancing in intraday market.	Settlement takes place monthly. The FSP submits the baseline for its asset.	Nodes is testing short-term markets in the UK together with Western Power Distribution.

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Other pioneering projects implementing flexibility markets in Europe (all in very early stages): (1) **ENERA** in Germany – pilot project, local congestion management for DSOs, among others). Enera was an initiative of Epex Spot and Nord Pool [20]. Together with Nodes, Enera are the only local flexibility markets promoted and managed by actual market operators (Nord Pool and Epex Spot) [15]. (2) In Spain, TSO redispatch is extended to DSOs in the **IREMEL** project of OMIE and IDAE (The institute for the Diversification and Saving of Energy). (3) In France, Enedis (French largest DSO) runs a flexibility pilot for DSO-only procurement of flexibility. (4) In addition to these real-life pioneering projects there are also several Horizon 2020 projects developing flexibility market platforms [21].[6]

In conclusion, first steps (mostly in terms of pilots) towards local flexibility markets have been set in some Member States, but none of these markets have reached maturity yet.
The market requirements for local flexibility markets in the context of one of the use cases of ebalance-plus have been identified in Deliverable 1.1.

2.4 Stakeholders

In this section we analyse the primary stakeholders in the DSF markets in the consortium countries. These stakeholders could be potential users of the ebalance-plus solutions. The primary stakeholders are aggregators, DSOs, electricity retailers, ESCOs, building owners and facility managers, prosumers, and technology providers.

2.4.1 Aggregators

Aggregators may use the ebalance-plus platform to manage a Virtual Power Plant (VPP), creating services that build on prosumer´s assets, DER, and storage, and offering these to different markets.

The opening of energy markets and favourable regulation has led to the proliferation of aggregators worldwide in the last years [22]. However, as the market for DSF in Europe is not mature yet, competition in most countries is still relatively low. Stakeholders that are dominating the markets as DSF providers are aggregators (VPPs) and energy suppliers / retailers. There is no country that has more than 50 players yet. However, this is rapidly changing with more and more players moving into DSF services based on “energy-as-a-service” business models [23]. The most competitive (mature) DSF market in the UK has 45-50 players [24].

The landscape of aggregators in Europe is very diverse. Many aggregators in Europe started as software-based start-ups and have increasingly attracted investors to grow. Start-ups increasingly partner with retailers or are even acquired by them (e.g. *REstore* by *Centrica, EnerNOC* by *Enel, and Tiko by Engie*). Large players such as *Eneco*, and *EDF* are also entering through the acquisition of existing start-ups (Figure 5). Other market players are subsidiaries of big electric utilities (e.g. *Enel X*). Start-ups are also acquired by big players coming from outside the electricity sector (e.g. *Shell* acquiring *Limejump, Sonnen* and Next Kraftwerke). 35% of sampled aggregators researched in [11] was acquired or spun off by large utilities in the last few years. Such acquisitions

[6] Among others: GOFLEX, INTERRFACE, EU-SysFlex, OneNet, EUniversal, InteGrid, Flexigrid, Interflex, Flexgrid, INTERFACE, CoordiNet, INVADE, EMPOWER,

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help start-ups that have developed specialised software to access the market and get access to large consumer portfolios. Other aggregators are newcomers with a core business in another sector such as IT (e.g. *A1 Energy solutions*) or technology development (e.g. *Sonnen*) [11]. For remaining independent aggregators competition from traditional retailers and these big players entering the market is increasing [22].

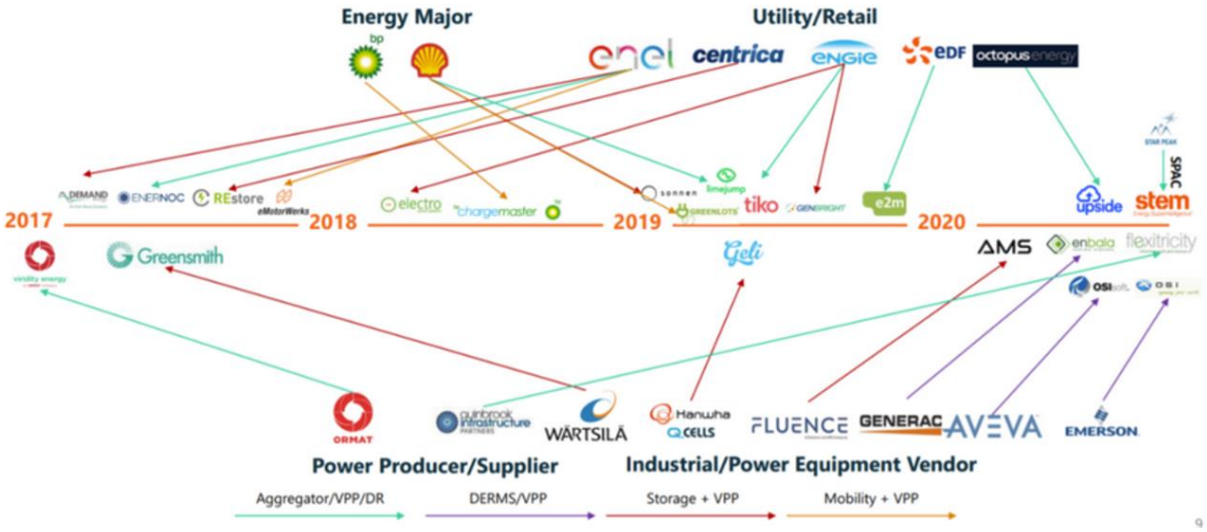

Figure 5. Big cooperates got increasingly involved in the DSF market (Figure source: [25]).

Table 5 shows an overview of prominent aggregators in selected ebalance-plus countries. Most aggregators use **both flexibility from demand and generation**. Behind-the-meter aggregation is still extremely rare. There are only a very few aggregators that aggregate household DR and electricity supply of end-users (B2C) and most of them stem from Germany: *BayWare, Lichtblick, Markt-E, Sonnen* (Germany), and *Ecotricity* (UK) and *Voltalis* (France) [11].

Two-third of the aggregators analysed by [11] explore the potential to provide flexibility to DSOs. However, as outlined in 2.3, there is a lack of established local flexibility markets and mechanisms.

Revenues for aggregators (and thus prosumers) from flexibility are still instable / volatile, which makes the business model uncertain. Aggregators need to be able to respond quickly to changes in the market, as constant changes are implemented [22]. Furthermore, value stacking is key for long-term profitability, for example both from the business to customer (B2C) and business to business (B2B) side. Additional revenue streams should be established, for example based on software-as-a-service. More and more platform companies and aggregators white label their services to energy suppliers, removing the need for dealing directly with residential customers (e.g. Kaluza, Tiko, EliQ) [26]

Table 5. Selection of aggregators active in the consortium countries. Most aggregators only aggregate DER for B2B segment. Blue contoured aggregators are explicitly B2C aggregators for prosumer &

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consumer assets. Green contoured aggregators are focused on EV aggregation and V2G (own selection based on various sources [26]).

Country	Aggregators
Denmark	kiwi power, NUVVE
France	NEXT KRAFTWERKE, reactive technologies, kiwi power, REstore, Energy Pool, Actility, EnerDigit, enel x, SMART GRID ENERGY, eqinov, ENGIE, EDF, centrica, tiko, BayWa r.e., BHC ENERGY, valoris ENERGIE, METRON, Flexitricity, Voltalis
Germany	BayWa r.e., NEXT KRAFTWERKE, kiwi power, tiko, Entelios, enel x, Energy Pool, Actility, REstore, e2m, KIWIGRID, LichtBlick, EQUIGY, THE MOBILITY HOUSE
Italy	NEXT KRAFTWERKE, enel x, kiwi power, EDF, evolvere, sonnen, EQUIGY
Spain	edp, enel x, BayWa r.e.
UK	NEXT KRAFTWERKE, reactive technologies, kiwi power, REstore, Energy Pool, VPS Virtual Power Solutions, enel x, open energi, Flexitricity, e.on, EDF, limejump, ENDECO TECHNOLOGIES, npower, ukpowerreserve, Actility, GreenSync, KALUZA, open energi, BayWa r.e., REstore, Origami POWER OVER ENERGY, sonnen, stemy, smsplc, octopus, EDF, KALUZA, ecotricity, ev. energy, myenergi
Poland	Energy Pool, NEXT KRAFTWERKE, ENERNOC, e2m, Enspirion, teraz energia, ENERGY DataLab

Important for the exploitation potential of the ebalance-plus platform: 22 of the 26 prominent independent aggregators in Europe analysed by [11] have their own hardware / software, and 15 aggregators even focus on software development. 73% of the companies offer their solutions as white-label solutions to other market players. Until recently, product innovation has been the most realistic business model for aggregators, because of market entry barriers [11]. This means that the existing independent aggregators in Europe have their mature software product solutions. The demand for complete platform solutions like ebalance-plus will be limited among these existing independent aggregators. For the exploitation of the ebalance-plus solutions for aggregation, focus should be on (1) new players (e.g., start-ups) in the sector that want to develop aggregation capabilities and lack specialised (software) solutions; (2) (small) energy retailers that want to develop their aggregation capabilities and can still benefit from adaptable specialised (software) solutions like ebalance-plus. The latter category seems the most interesting for the exploitation of ebalance-plus solutions for aggregation. Also, offering modules or partial solutions based on the ebalance-plus concept to solve specific problems could be a good exploitation strategy.

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2.4.2 DSOs

DSOs may take direct advantage of the ebalance-plus platform to optimize their grid management, or indirectly to defer or avoid grid reinforcement costs. Furthermore, the ebalance-plus platform can enable market parties like aggregators to participate on the market, and this can indirectly benefit DSOs in terms of local services (e.g., congestion management), as well as ancillary services (frequency and voltage control).

In the EU27 there are estimated 2556 DSOs, the majority are small and medium sized. Less than 10%, 182 DSOs, are large and have more than 100.000 customers [27] (Figure 6). The number of DSOs in the consortium countries can be seen in Table 6. DSOs are heavily regulated, and competition is very limited in most countries.

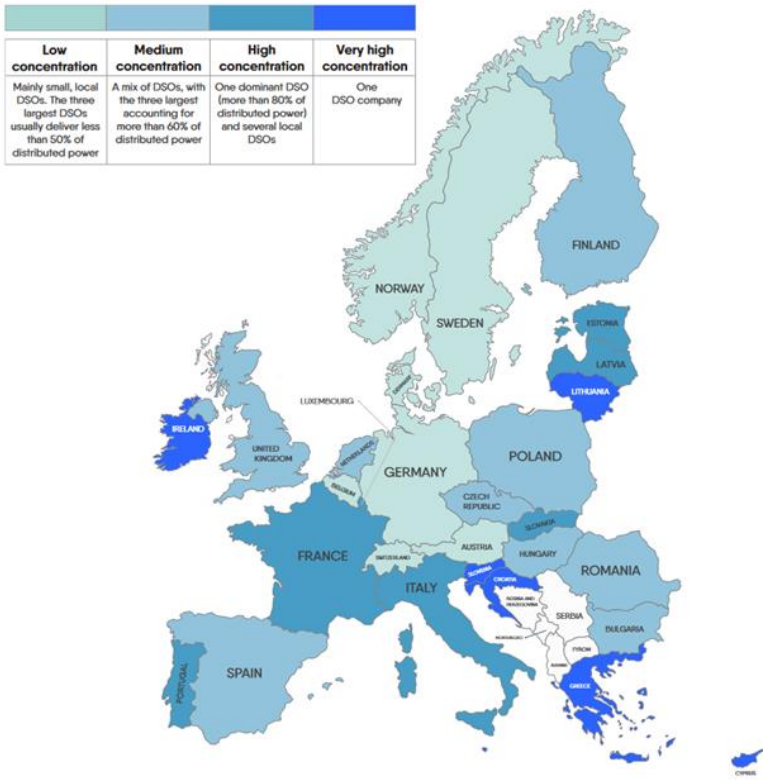

Figure 6. Level of DSO concentration in Europe [28].

The level of DSO concentration is different in all consortium countries (Table 6). In **Italy** and **France** there is one main DSO, which is the former incumbent electricity company, that covers more than 90% of customers, plus some smaller DSOs. In France, you find a quasi-monopoly of the largest DSO Enedis. **Spain** and **Poland** have 3 and 4 large DSOs that cover more than 90% of the customers, plus a medium DSO (for Poland) and two small ones (for Spain). Only in **Denmark**, DSOs are small and plenty. In **Greece** there is one single big DSO, and **Germany** has 75 big DSOs [29].

Table 6. Level of DSO concentration on consortium countries [28].

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Country	Number of DSOs	Number of legally unbundled DSOs	DSO ownership
Denmark	40	10[7]	Majority of DSOs are customer-owned
France	77	9	Public, national
Germany	883	80	Municipalities
Greece	1	1	Public, national
Italy	128	8	Largely private
Poland	184	5	Public, national
Portugal	13[8]	1	Largely private
Spain	354	5	Largely private
UK	14	6	Largely private

All-in-all it is important to recognize the immense diversity of DSOs in terms of size and resources around the DSOs in Europe [30]. This means that DSOs have different capabilities to foster innovation. This has large consequences for individual DSO´s capacity to adopt solutions like ebalance-plus and use flexibility in their daily business.

The business models of DSOs are centred around tangible commodities (wires, cables) and intangible value (flexibility) has often been an afterthought [31]. Nevertheless, a JRC survey among the 44 largest DSOs in Europe revealed that 56% of the DSOs are already considering non-wired alternatives as an alternative to network infrastructure investments (even though 61.5% of these DSOs do not use DR or Demand Side Management at the moment). So, European DSOs are increasingly considering non-wired alternatives for their future plans [27]. Currently, 40% of DSOs have prosumers (owning storage or generating assets) in their network, and only 13% actively manages these prosumers. One third of DSOs that manages prosumers directly, does this itself, while others manage them through independent aggregators (15%) or energy suppliers / retailers (8%). One in 5 DSOs does not manage prosumers because national regulatory frameworks defines other market agents responsible (e.g. TSOs, BSPs, energy suppliers, and aggregators) [27].

DSO activity in DSF across Europe is highest in the **UK** (full commercial procurement of DSF by DSOs), followed by the **Netherlands** (early-stage commercial procurement of DSF / many live demonstrations). After that **Germany, France, Spain** and **Italy** follow, where DSOs recognises the need to use DSF, and some trials and many paper-based studies take place [32] (Figure 7). The exploitation potential of ebalance-plus solutions will thus be best among DSOs in these countries. DSOs that are open for the

[7] The figure represents the number of DSOs that are not part of a company with power retailing activities. All DSOs are functionally unbundled.
[8] In mainland Portugal 10 DSOs operate exclusively LV lines. Only 2 DSOs operate on the islands and do not have to be legally unbundled.

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use of flexibility and are not able to develop all technological solutions themselves, are the ideal target customers for the ebalance-plus solutions for DSOs, such as the DERMS.

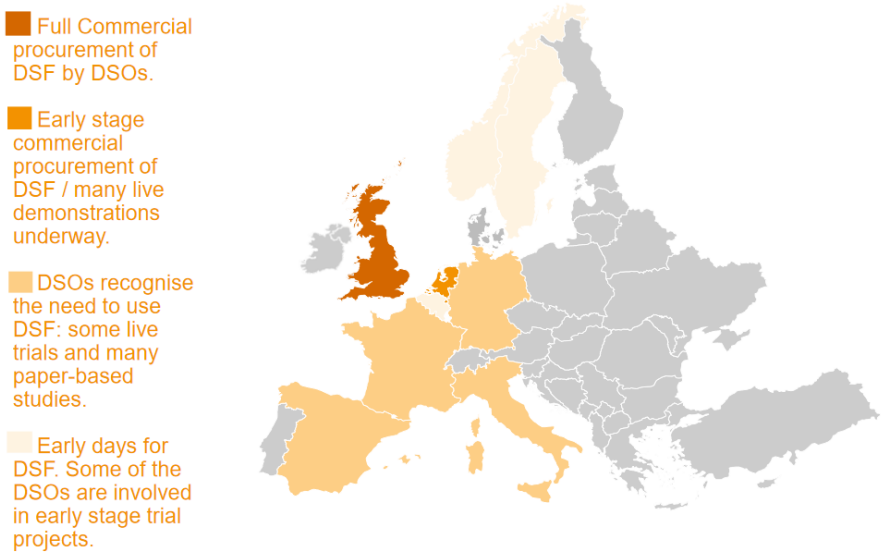

Figure 7. DSO activity in DSF across Europe [32].

2.4.3 Electricity retailers

Electricity retailers might be good candidates to fulfil the role of aggregators, as they have a strong connection to the electricity market and consumers. Changes in the retail electricity market create challenges for electricity retailers and forces them to develop their BMs further to stay competitive during the energy transition. The ebalance-plus platform provides the possibility to support retailers to perform the aggregator role.

A large **barrier** for energy retailers to provide aggregation services is the link many of them have to energy generators (conflict of interest). Also, they must change their BMs that have been centred around a tangible commodity (energy) to providing intangible value (flexibility). Traditional suppliers are hesitant to revise their own BMs. Instead, they prefer to build on BM extensions by outsourcing the innovation activities in subsidiaries or by using partnerships [33].

Electricity retailers have existing relationships with their customers and are expanding their interaction with customers through personal assistants, social media, websites, online chatting services, etc. [34]. They are used to have contact with customers about meter reading, queries over bills, information on changing tariffs, products, and services that they offer, questions about smart meters, and complaints. And energy retailers are becoming more customer-centric, helping the customer to untap additional value streams [34, 35]. Because of all these **opportunities** and dynamics, energy retailers are said to be the best candidates to fulfil the role of aggregators currently, as they have a strong connection to the electricity market and consumers [36].

Spain and **Poland** are the countries with the most nationwide electricity suppliers. Among the consortium countries, **France** has a very high market concentration with the 3 biggest suppliers supplying almost the entire market (Table 7).

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Most energy retailers venturing into using flexibility and providing aggregation services rely on partners to develop these capabilities. As mentioned in 2.4.1, for example. Centrica, Enel, EDF have made acquisitions of aggregators and their VPP platform. The independent aggregators that were acquired accepted the synergy potential with larger retailers to complement their capabilities [37]. Some other large retailers developed pure in-house solutions (e.g. Engie, Endesa, Eneco, British Gas, Vattenfal, Total).

For ebalance-plus, small energy retailers that want to develop in this direction are interesting potential beneficiaries of the project´s solutions.

Table 7. Electricity retailers / suppliers in the consortium countries [38].

Country	Number of nationwide electricity suppliers
Denmark	28
France	44
Germany	91
Greece	24
Italy	90
Poland	146
Portugal	29
Spain	232
UK	91

2.4.4 ESCOs

The market for ESCOs in the EU has been growing the last decades. ESCOs serve various type of industrial and public sector clients, using a variety of contract types. The energy performance contract is more and more regarded as the distinguished contract type [39].
In the context of ebalance-plus, the role of ESCOs in relation to using DSF is of interest. The EU H2020-funded Ambience project aims at extending the concept of energy performance contracting to “active buildings”; meaning that the project aims to develop BMs based on extended Energy Performance Contracting (EPC) BMs, namely including the use of DSF of buildings. In such a scenario, especially when using explicit DSF aggregators, TSOs and DSOs become additional actors in the EPC model [40]. In a traditional market model Energy Efficiency (EE) and DR are delivered separately by the ESCO and aggregator. In new market models ESCOs and aggregator roles are combined (as one single actor, or in a collaboration between two actors), the consumer will only have a single contract [40]. These developments towards combined ESCO-aggregator market models are relevant for the ebalance-plus project, especially for the

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use cases that connect the ebalance-plus platform with existing BEMS, where the objective is to optimize both energy efficiency of a building as well as using the available flexibility. The ebalance-plus platform can support ESCOs to optimise the scheduling of behind-the-meter flexibility assets of prosumers based on market prices and prices forecasts. This is however a future scenario, as at the moment hardly any ESCO provides DR services combined with EPC, because it is difficult to define positive business cases in the current regulatory environment and existing tariffs and incentives [40].

Table 8 indicates the number of ESCOs in the consortium's countries. **Italy** has a very large ESCO number and market value, followed by **Germany** and the **UK.**

Table 8. ESCOs in the consortium countries according to JRC in 2018 (EnS: Energy services; EnPC: Energy Performance Contract) [41]

Country	Nr. of ESCOs	ESCO market (EUR)
Denmark	4	70 million
France	45	13.5 billion (EnS); 40-60 million (EnPC)
Germany	560 (EnS); 138 (EnPC)	9 billion (EnS); 7.7 billion (EnPC)
Greece	86 (3 providing EnPC)	N/A
Italy	1500 (EnS); 340 (ESCO)	2 billion
Poland	25 (EnS), 20 (EnPC)	N/A
Portugal	12-15	50-100 million
Spain	70	1-1.5 billion
UK	136 (EES); 62 (ESCOs)	108.3 million

2.4.5 Building owners and facility managers

Building owners are the owners of the building(s) and make the decisions about for example investing in energy management systems or not. Facility managers mostly operate commercial buildings, such as office, retail, and leisure buildings. Their commitment is important for successful implementation of ebalance-plus solutions in a building to unlock flexibility and manage energy efficiency. The ebalance-plus platform can help to improve building energy management (e.g., through integration of the existing BEM) and can enable end-user participation in the electricity market (through intermediaries such as aggregators).

Buildings account for 30-40% of the total energy consumption in most developed countries, and a large part of the energy demand of buildings can be shifted in time and thus provide flexibility to the energy system. Especially the thermal part of energy demand can be shifted (e.g. space heating/cooling, ventilation, domestic hot water and

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hot water for washing machines, dishwashers) [42]. But white goods do not have a very large flex potential, compared to the high effort of integrating them into a flexibility management platform.

The main drivers for building managers to implement energy flexible operations are legislation and financial savings [43]. Buildings could best provide energy flexibility through building automation and DER. Aggregators can group the flexibility of multiple buildings together to generate enough flexibility volume for the market. But currently, energy efficiency is still the main focus for building managers, because of the national and international policies and the financial benefits that can be obtained [43]. Barriers for building managers regarding energy flexibility are: (1) the need for refurbishment, (2) the monetary benefits of providing energy flexibility are not significant, and (3) Building Management Systems (BMS) need to be upgraded [43]. The latter can be avoided with the ebalance-plus platform, that can be connected to existing BMS.

2.4.6 Prosumers

Prosumers can benefit from the user-friendly app interface connected to the ebalance-plus platform to receive transparent information on energy usage, production, and energy prices, based on advanced predictions. This can help them to save electricity and reduce energy bills, for example through participation in electricity markets, via an aggregator.

Prosumers come in different forms and sizes, for example households; commercial buildings; industrial sites; and communities [8]. Household prosumers that are connected to the grid mainly focus on the following three revenue-generating activities: 1) shifting electricity consumption based on price signals, 2) installing generation capacity (self-consumption, saving on monthly energy bill due to avoiding purchasing electricity from the grid), 3) actively offering their flexibility through an aggregator [44]. Prosumers connected to the ebalance-plus platform can be supported in activity number 1) and 3).

The research done in WP2 showed that the needs and wishes of prosumers can be different among different segments, needs are for example: 1) reducing complexity and better understanding of consumption; 2) increasing information; 3) increasing control; 4) connection to smart electronic devices; 5) better usage of the prosumer´s flexibility.

All-in-all, despite potential interest from households, involving them in flexibility services might be challenging, because of the low economic returns, their different needs and potentially high effort to integrate them in flexibility platforms (e.g. high transaction costs, possible lack of flex assets). While they might have a limited flexibility volume. Involving small-scale (tertiary) industry might be more attractive than households because transaction costs might lower, for a higher flexibility potential. Also, the economic incentive is higher than in the household sector.

In Chapter 3, some of the relevant markets for specific solutions in ebalance-plus, including key market players are analysed.

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2.4.7. Technology providers

Technology providers (both hardware- and software manufacturers and service providers) are important for the realization of energy flexibility potential of buildings or districts. They can deliver hardware, software or services that can be linked or integrated in the ebalance-plus platform.

There is a variety of players active in DSF markets. They include software companies, IED manufacturers, charging station developers, home appliances developers, etc. Various of the ebalance-plus partners are technology providers (e.g., AMP, REE, TPS, MGC, EMT). Technology providers are increasingly providing the following innovative services / products [25]:

- Providers of flexibility capacity, utilizing renewable generation, storage, and load capacity (like AMP).
- Grid-edge technologies and services unlocking the ability for flexible capacity to balance the grid (like the ebalance-plus platform).
- Technologies and services aggregating and dispatching fleets of flexible capacity from the bottom-up for economic optimization in wholesale and distribution markets (indirect contributors: TPS & MGC).
- Technologies and services for managing distributed energy resources from the top-down, helping grid operators predict and manage energy assets (like EMT).
- Platforms to enable revenue streams for other flexibility providers.

2.4.8. Stakeholder summary

The stakeholder analysis has only been focused on the primary stakeholders in the DSF market, which can potentially use the ebalance-plus solutions. The following secondary stakeholders are also part of the broader ebalance-plus ecosystem: policy makers, regulators, data service providers, local market platform operators, weather forecast agencies, charging station operators, e-mobility service providers, etc. They all have different roles in terms of supporting or hindering the ebalance-plus solutions and influence on the electricity system.

In the power-interest map (Figure 8) [45], we pictured the primary stakeholders based on their **power / influence** in the electricity system and their potential **interest** in using the ebalance-plus solutions. Categories distinguished in the diagram are:

1) **Key players, manage them closely:** high influence and high interest.
2) **Meet their needs:** high influence and less interest, consult in their interest area.
3) **Keep informed:** show consideration, potential supporter.
4) **Least important, monitor:** low influence and low interest, inform.

The key stakeholders are (small) DSOs, (small) energy retailers, (small-scale) tertiary prosumers, building owners & facility managers (the latter two categories are related). TSOs are included as influential stakeholders that should be considered as stakeholders whose needs should be met. Residential prosumers, aggregators and ESCOs should be kept informed, as they are potential supporters of the ebalance-plus solutions.

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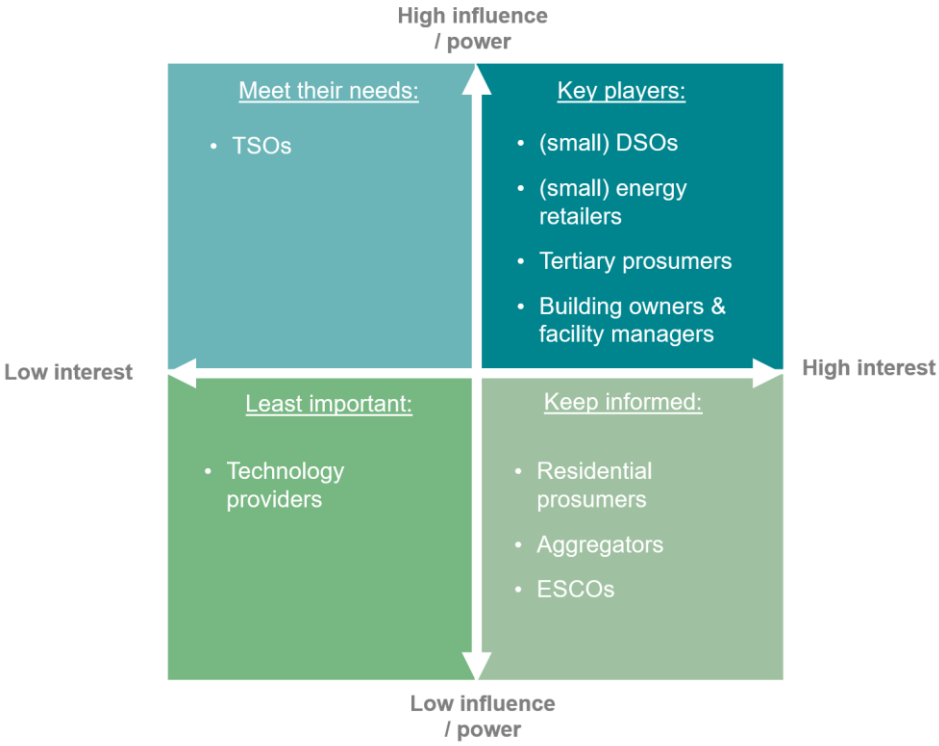

Figure 8. Diagram showing the power (to have influence on the electricity system) and interest (in the ebalance-plus platform).

2.5. Market location, size, and growth

Global: operational DSF & DSF potential

The International Energy Agency (IEA) estimates that globally, the current operational DSF is 40 GW and can grow to 200 GW in 2040 due to increasing penetration of EVs and the electrification of heat in buildings [46]. The theoretical potential of DSF is much larger, currently estimated at 4000 TWh and predicted to grow to 7000 TWh by 2040. The global demand response market is thus growing and is expected to continue to grow. Flexibility "hotspots" outside Europe are the **US**, **Japan**, and **Australia** [19].

Europe: DSF potential

Europe is in the process of opening-up for demand response BMs, which is quite some time later than the US where in 2008 market operators were already forced to acknowledge the growing role of demand response and more recently storage.[9] The theoretical potential for DSF in the EU could grow to **160.9 GW in 2030.** This EU-level growth mainly comes from the use of heat pumps and EVs [46].

Ebalance-plus countries: DSF activity

[9] https://cleantechnica.com/2019/06/09/the-time-is-ripe-for-aggregation-of-behind-the-meter-assets/

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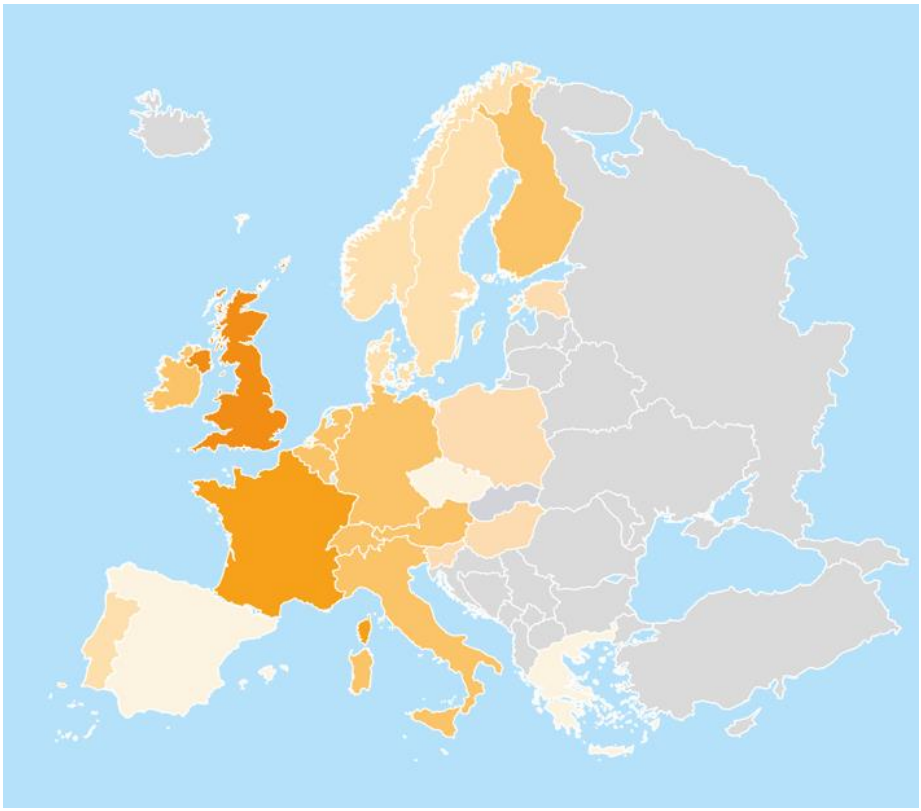

Figure 9. DSF activity in European countries [24]

According to SmartEN & DeltaEE (2020) current DSF activity in the ebalance-plus countries is as follows (on a scale from 1-5): France (4), UK (4), Germany (3), Italy (3), Denmark (2), Portugal (2), Poland (2), Greece (1), and Spain (1) (see Figure 9).

Figure 9 shows that overall, the markets for DSF in Europe are not mature yet. Market maturity is highest in: **UK, France, Ireland,** followed by **Netherlands, Belgium, Germany,** and **Finland** [17]. **Italy**, **Estonia** and **Poland** are opening-up their markets for flexibility [19]. Despite market growth in recent years, regulatory uncertainties in Europe have slowed down demand response market growth in 2019 [47]. But the use of flexibility needs to grow. For example, in the UK is expected that 1.3 GW of flexibility might be required in 2021. But the flexibility market´s growth in the UK has been slow over the past three years, it is however expected to gather pace [48].

More specifically for the consortium countries, the regulatory progress, potential market size of flexibility (ancillary services) and the situation for local flexibility and energy communities and the future of flexibility (markets opening to DSF by 2025) are summarised in Table 9 based on [49]. Regulatory progress lacks behind in all countries, slowest are Italy and Spain, followed by Greece and Poland. Bigger countries (logically) have the highest potential market size of flexibility (in terms of ancillary services). The situation for local flexibility and energy communities is best in the **UK**, where commercial offers for local flexibility exist (see Section 2.3). Interestingly, the future of flexibility (in terms of markets opening to DSF by 2025, 2030 renewable targets, and current monetisation of flexibility) will be developing most in **Poland**. Followed by Italy, Spain, Greece and Portugal [49].

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Table 9. Situation regarding DSF in consortium countries (dark green shade: Maturing Market, light green share: Emerging Markets, white shade: Early Market) [49].

	Regulatory progress	Potential market size of flexibility	Local flexibility and energy communities	Future of flexibility
France	4	5	4	3
UK	4	5	5	3
Denmark	3	2	2	2
Germany	3	5	2	3
Italy	2	5	3	4
Spain	2	5	1	4
Greece	1	3	3	4
Poland	1	4	0	5
Portugal	1	3	4	4

Europe: residential DR

The sub-market of residential DR in Europe has only developed slowly. First movers did not reach profitability. However, the market for residential DR is developing both in size and broadness of offerings. Still many hurdles remain, especially regarding customer acquisition and market access which leaves most residential DR business without profits. To solve this problem, the industry will need to scale [50]. DR programs aimed at small and medium scale customers mostly failed to meet their potential because of political, technical and behaviour challenges [40]. **France** has the biggest market for residential DR in Europe, with the leading provider of residential DR services *Voltalis* has assets of 900 MW. After France, the Nordics, the **Netherlands, Germany** and **Switzerland** are highest ranked [50].

2.6 Market dynamics

Increasing renewables and flexibility needs

The need to unlock, use, and include DSF in electricity markets to support the operation of DSOs will only grow in the coming years, because of the ever-growing amount of renewable capacity that will be connected to the distribution grids in Europe this decade (Figure 10) [30].

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1 510 GW of new renewable capacity would be installed at EU27+UK level,
b ~70% will be connected to the distribution grids

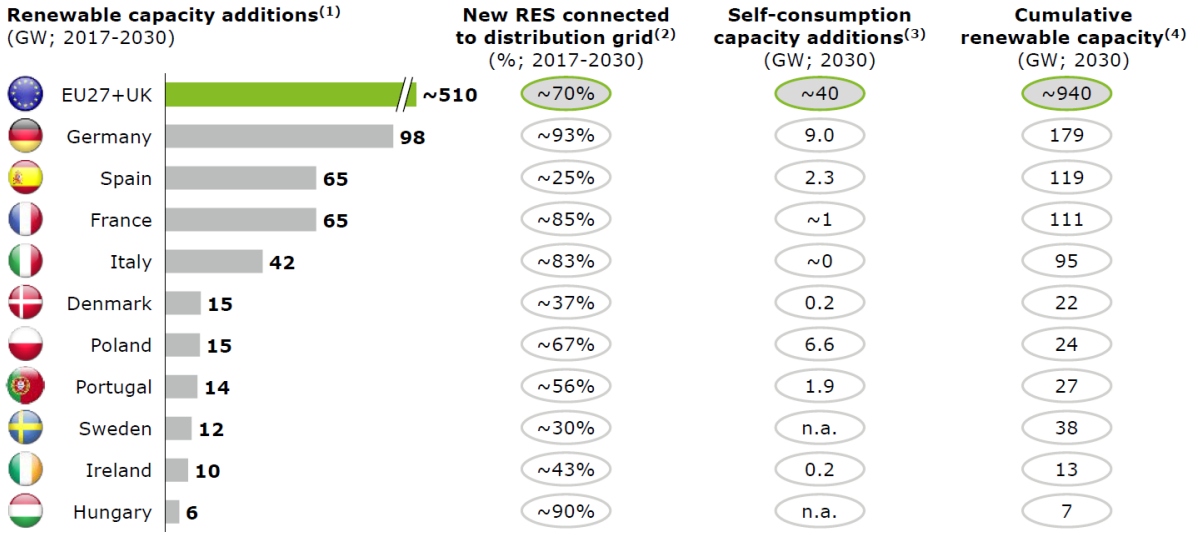

Figure 10. Increasing renewable capacity to be installed in Europe [10] [30]

The growth in renewables will lead to an increasing need for more flexibility in all regions of the world by 2040 (Figure 11).

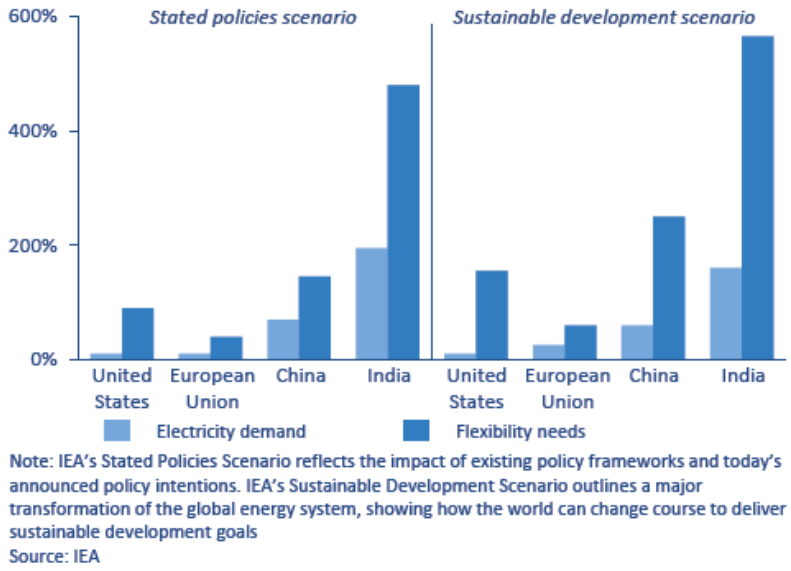

Figure 11. Growth in electricity demand and flexibility needs by region and IEA scenario, 2018-2040 [51]

Rising electricity prices

10 (1) Additional back-up generation capacity (e.g. gas turbines, nuclear, etc.) is assumed to be connected to transmission grids
(2) Power distribution grids` voltage levels depend on the country
(3) It has been considered renewable capacity connected behind the meter
(4) Renewable capacity comprises hydro, solar PV and CSP, wind onshore and offshore, biomass and other renewables

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As energy prices keep rising, this might lead to the uptake of more solar PV, heat pumps and storage solutions, enabling and demanding more DSF in the power system.

Changes in demand for DSF in electricity markets

Markets for DSF are constantly changing, new mechanisms are introduced or existing ones are being simplified [22].
Worldwide, it is expected that TSOs will constantly need more flexibility stimulating transactions in **balancing markets** [22]. However, mature markets such as the UK, Germany and California have seen the value of frequency regulation decline over time, because of faster increased offerings of flexibility compared to demand [51]. Also in the Netherlands, it is expected that the prices in the balancing markets will decrease, for example because of the increasing offer of flexibility from EVs. It is expected that the balancing market will lose its attractiveness for the explicit DSF business case on the mid-long term [52].
The **wholesale market** is an interesting future market for DSF. It has a high volume, but at the moment its price volatility is still low. Tennet (Dutch/German TSO) predicts (in their network area) that that the growth of demand for flexibility will be largest in the wholesale markets, driven by the need to balance solar and wind generation [53] (Figure 12). Expectations are that prices and volume of the wholesale markets will rise. Increasing price volatility may also translate in more dynamic prices for the customer, which increases possibilities for the implicit DSF business case (this also requires the need to remove double taxes on energy storage and the end of net-metering in countries that still have such mechanisms) [52].

The development of **congestion markets** or **local flexibility markets** is expected, as there is (high) demand for such markets, but the organisational and regulatory aspects of such markets are still unsure (Appendix 2) [52].

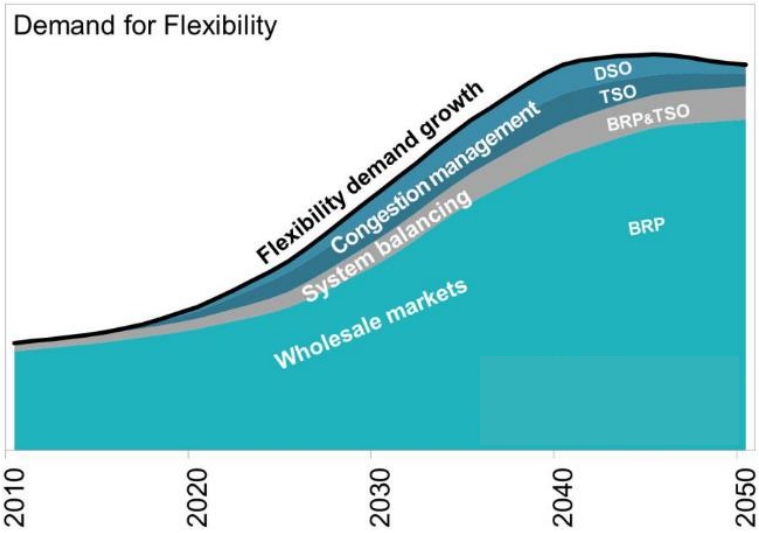

Figure 12. Expected growth in demand for flexibility in the Netherlands in MWh volume [53]

Changing roles of stakeholders

Lastly, regarding market players: **energy retailers** are expected to integrate aggregation more and more into their businesses, and will not need intermediaries anymore to get access to flexibility in the future [22].

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2.7 Investors criteria

Given the high number of stakeholders involved in the business models around DSF and the lack of standardisation it can be difficult for banks or investors to evaluate the credit worthiness of flexibility projects in the electricity sector. Businesses that want to access external capital should try to identify all risks and ways to mitigate them. It is easier for investors to evaluate risks when standardised contracts are in place. Fixed fees instead of usage-dependent charges guarantee payback periods. Also, fix cost savings will convince end-users to participate in the flexibility market [51].

Moreover, diversification of sources of revenue is important (e.g. revenues across different markets and different levels) [51].

2.8 Business opportunities for DSF in consortium countries

2.8.1 Denmark

An elaborate analysis of the situation in Denmark is included in Annex 3. The main outcomes are presented here:

Flexibility related business opportunities in Denmark:

- V2G business case possible based on asymmetric bids in FCR.
- High electricity prices (second highest in Europe after Germany in first half 2021) and high taxes stimulate self-consumption.

Flexibility business difficulties in Demark:

- Limited demand for flexibility from TSOs and DSOs.
- No good situation for independent aggregators because of barriers (registration as BRP and high minimum bid sizes).
- Low economic incentives from dynamic prices for Danish customers because of high taxes on energy bill.
- Only 10% of Danish end-consumers use dynamic prices, due to low impact of the energy component in the final electricity bill.

2.8.2 France

An elaborate analysis of the situation in France is included in Annex 3. The main outcomes are presented here:

Flexibility related business opportunities in France:

- France has a relatively high demand response participation, with electric heating as the key asset. Both the ancillary service and the wholesale market are open to aggregation and DR.

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- Aggregators can operate in “Block Exchange Notification of Demand Response mechanism”, or NEBEF mechanism (currently used by 23 independent aggregators), mostly during cold months.
- Aggregators can participate in balancing market (currently used by 10 independent aggregators).
- Relative high value for implicit DSF services, because of its weather-related price peaks which creates high energy prices within the wholesale markets. These peaks are driven by electric heating on cold days. However, implicit demand side flexibility is not used a lot in France.
- France has several different supply tariffs, including ToU energy pricing and critical peak pricing enabling implicit DSF programs. For residential customers there is only a day and night tariff. And for those with smart meters there are 4 different time periods with different tariffs, based on seasonal and peak and off-peak components.

Flexibility business difficulties in France:

- Feed-in-tariffs and low electricity prices provide low incentives for self-consumption.
- The conflict of interest between energy producers, aggregators, and distributors still hinders the business case for aggregators.

2.8.3 Italy

An elaborate analysis of the situation in Italy is included in Annex 3. The main outcomes are presented here:

Flexibility related business opportunities in Italy:

- In Italy static ToU tariffs are available. The ToU tariffs are the regulated default option in Italy, where millions of customers are on a default static ToU rate [54].
- Dynamic price contracts with hourly pricing are also available if a smart meter is present.

Flexibility business difficulties in Italy:

- The “Unità Virtuali Abilitate Mist” (UVAM) mechanism is open to DSF and since December 2021 also aFRR. But high metering and testing requirements still present a barrier for DSF [49].
- Flexibility in Italy is currently mostly fulfilled with hydro and gas and is not (yet) open for DSF in its balancing market. However, Italy is opening up its balancing market for pilot projects in the Replacement Reserve and is drafting projects for FCR and voltage regulations.

2.8.4 Spain

An elaborate analysis of the situation in Spain is included in Annex 3. The main outcomes are presented here:

Flexibility related business opportunities in Spain:

- High potential market value despite relatively few value streams accessible to DSF. Due to high electricity prices and the country’s limited interconnection there is a high need for flexibility provided locally [49].
- The main possibility for prosumers to use their flexibility in Spain at the moment is on-site energy management. The key financial incentive for prosumers in Spain is the reduction of electricity expense, because of the high taxes and tariffs.

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- Dynamic electricity tariffs are present. These dynamic tariffs are the default price in the regulated market for households. Nearly 40% of all residential consumers are therefore on such dynamic tariff contracts. These advanced electricity tariffs can also benefit EV users in charging [55].

Flexibility business difficulties in Spain:

- Implicit and explicit use of flexibility provide very little financial incentives in Spain.
- Electricity markets in Spain are not open for independent aggregators yet (might change in 2022).

2.8.5 UK

An elaborate analysis of the situation in the UK is included in Annex 3. The main outcomes are presented here:

Flexibility related business opportunities in UK:

- One of the largest uses of explicit DSF In Europe, in terms of volume and market participants. Relatively high value stream accessibility and multiple value streams. DSF can earn from participation in balancing and ancillary services and the capacity market, but also helping large electricity users to avoid network charges.
- All six DNO procuring flexibility. Also several market place platforms (e.g. Piclo) enable the participation of local flexibility and reduce complexity and streamline procurement [49]. Few players also participate in DSO services with residential assets.
- The UK has the highest number of ToU tariffs for EVs available in Europe [56].

2.8.6 Germany

An elaborate analysis of the situation in Germany is included in Annex 3. The main outcomes are presented here:

Flexibility related business opportunities in Germany:

- Germany is showing most innovation in EV ToU tariffs. And EV flat tariffs and bundles are relatively common in Germany, in contrast to other countries. For example discounts or upsells to third-party hardware are offered by Tibber, E.ON and aWATTar; and access to public charging services is provided by Lichtblick and E.ON [56] [56].
- Germany curtailed 5.5.TWh of renewables in 2017, at a cost of 1.4bn EUR. This means a commercial value for V2G to provide services to TSOs, as this would mean that 2m EVs could be charged for a year [57].

Flexibility business difficulties in Germany:

- Dynamic energy tariffs and on/off peak tariffs are available, but the lack of smart metering infrastructure makes that they are barley used [58].

2.8.7 Portugal

An elaborate analysis of the situation in Portugal is included in Annex 3. The main outcomes are presented here:

Flexibility related business opportunities in Portugal:

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- Developments for participation in DSF are slow, but markets have officially been opened to independent aggregation, Replacement Reserve is opening-up for aggregation and non-BRP stakeholders.

Flexibility business difficulties in Portugal:

- Portugal has no dynamic price contracts, prices are still regulated [59]

2.8.8 Greece

An elaborate analysis of the situation in Greece is included in Annex 3. The main outcomes are presented here:

Flexibility related business opportunities in Greece:

- Customers connected to the medium and low voltage network can participate in implicit DR [60].

Flexibility business difficulties in Greece:

- Smart meter installation is lacking behind, aggregators not active in market yet [60].

2.8.9 Poland

An elaborate analysis of the situation in Poland is included in Annex 3. The main outcomes are presented here:

Flexibility related business opportunities in Poland:

- Polish TSO “Polski Sieci Elektroenergetycnza” has ambitious plans to allow DSF in ancillary services over 2022/2023. Furthermore, Poland has a high level of existing industrial assets and high renewable targets, which create large opportunities for a market for DSF [49].

Flexibility business difficulties in Poland:

- Poland’s balancing markets are not open to independent participants, DR is not allowed and aggregation is not permitted [12].

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3 Markets for KERs

Closely interlinked with the markets for DSF, are the markets for the enabling technologies (related products and services). The scope of this paragraph is to assess the markets related to the project's KERs[11] which represent such enabling technologies, products, and services.

3.1 Market for Home Energy Management mobile applications

Related KER, #2: Home energy management mobile application.

Market for Home Energy Management mobile applications	
Short market description	Although the market for Home Energy Management Systems (HEMS) is not a very new, it has recently become an ecosystem where many different services and technologies are put into use.
Type of products / services	HEMS solutions initially started with mobile application solutions that offer residential energy consumption monitoring. In these applications, users monitor their housing consumption by means of metering devices installed in their houses and with a mobile application. The solution offered by the products was a detailed energy monitoring and invoice tracking. Then, more comprehensive energy management solutions were developed with the inclusion of distributed energy resources such as PV system, batteries, and flexible loads such as electric vehicle and HVAC units. Today, HEMS solutions evolve into an orchestral management of distributed energy assets as well as energy efficiency. HEMS can be combined with IoT solutions to enable the "smartness" of the electricity system, through insights from data collected from connected devices. New, real-time services can be developed.
Location of the market	REE who will exploit the KER, will focus on the **EMEA (Europe, the Middle East and Africa) region**. The overall home energy management market in Europe will grow, and the highest potential for growth will continue to be in the **Nordics** in terms of relative penetration (because of large uptake of heat pumps and dynamic tariffs) and **Germany** in terms of absolute numbers. France, the UK and Italy will remain behind. Spain, and its high amount of sun power, could have been better placed, but there is a lack of incentives for customers to install and self-consume solar PV [61].
Market size	Today in Europe, over 20 million homes are equipped with large electrical loads, which include electric heating, battery, EV, PV etc. Only 300k of these are connected to a HEMS today. But this is going to change**.** By 2023, it is expected that in the market 2.3M units are installed [61]. The global market for home energy management was worth 2.28 billion USD in 2020 and is expected to grow to 8.73 billion USD by 2030 (Compound Annual Growth Rate (CAGR) of 15.6%) [62].
Players / Competition	**Octopus** – Energy Supplier (e.g., EV charging app[12]); **Shine** - Energy Supplier; **E.on** – Energy Supplier; **Viessmann** – HVAC OEM; **Honeywell**

[11] A list of all the project´s KERs is included in the introduction.
[12] https://octopus.energy/blog/vehicle-to-grid/

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Market for Home Energy Management mobile applications	
	– HVAC OEM; **Smappee** – Tech SME; **GridX** – Tech SME; **GreenCom** – Tech SME
Customers / users	• Direct (end users, e.g. residential energy users, EV owners, prosumers) • Direct (building owners, facility managers, building complex, campuses) • Indirect (DSO - value added service to end users)
Entry barriers	• Interoperability solutions between energy assets • Technical and legislation adaptation • End-user engagement
Opportunities to enter the market	Home Energy Management can be a route to unlock access to different value streams and companies are starting to add electricity system values to their offerings. Tech SME's have an important role in gaps between stakeholders. Besides, electrification of both heating and mobility is growing exponentiality.

3.2 Energy storage

Related KER, #3: Smart-storage solution.

Market for energy storage	
Short market description	Energy storage market (including residential, commercial and industrial). The market is relatively mature.
Type of products / services	Energy storage devices, ranging in potential application as well as technology. Large-scale front-of-the-meter storage will dominate the capacity additions in the next decade, while one quarter will be deployed at residential and commercial & industrial scale [63].
Location of the market	Europe, north America, east Asia, wealthier parts of the middle east and Australia.
Market size & growth	The size of this market is ~100 billion EUR globally in 2022 (estimation AMP). The market is in between the stages of "emergence" and "rapid growth" [63]. Regarding the home battery market, this market is expected to grow with 16% by 2024 [64].
Drivers & trends	The transition towards renewables is overwhelming national grids which need to upgrade in order to cope with power spikes. The cost of installing this additional infrastructure is passed on to energy consumers in the form of higher energy distribution prices. As a result, it is becoming more economically sensible for consumers to start producing and saving up their own energy on-site, reducing the dependence on the grid. Strong drivers for energy storage at the consumer side are also the use of rooftop PV for electric cars and heat pumps [64].
Players / Competition & market share (% European market share home batteries) [64]	**Sonnen** offers a battery and a full suite of high-tech storage and home energy management products (18%); **LG Chem;** traditional battery producer (16%); **BYD** (14%); **Tesla** (3.6%); **GE; Siemens**; **Panasonic**; **ABB**; **Samsung**; **Huawei**.

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Market for energy storage	
Customers	• Generally: Energy consumers that are interested in developing energy independence from the grid. • Specifically for the KER developed in ebalance-plus: Energy retailers, medium-sized businesses, DSOs / DNOs.
Entry barriers	Technology development and product development costs.
Opportunities to enter the market	Research grants, investor attention, favourable legislation passing in new markets.
Similar, substitute or complementary products	Stable and controllable energy generation technologies that can generate base-load supply: namely fossil fuel combustion power plants, nuclear power plants and geothermal power plants. These solutions diminish the need for energy storage devices, hence all of them are substitutes.
Opportunities for ebalance-plus	This KER addresses the yet somewhat untapped sector of commercial/industrial energy storage by offering a mid-sized (120-240kWh) energy storge capacity. Furthermore, the high power offered by this technology and the support of its cloud platform allow creating a competitive aggregator service by itself. With the support of the ebalance-plus platform, even better for future DSO services.

3.3 Energy prediction services

Related KER, #4: Prediction models.

Market for prediction services	
Type of products/services	Consulting services (prediction and optimization of the energy produced (e.g. wind or solar) or consumed).
Location of the market	International market, in all countries there is a need to estimate the energy consumption and generation to plan day-ahead network operation in order to ensure the service in real-time operation.
Market size	The total “renewable energy forecasting revenue” based on 2020 estimated installed renewable plant capacity is around 37M€ (estimation of ENFOR based on estimated prices tariffs of the energy forecasting market).
Market dynamics	Forecasting service needs currently come from developed or developing energy markets where the price of energy is dictated largely by supply and demand. Each market has its own unique rules on how renewables are treated, but there is no question that forecasting renewable energy in the short-term becomes more important with each additional renewable power plant that is displacing old fossil fuel units.
Market growth	Globally, there is about 650 GW of installed wind and 580 GW of installed solar power capacity. For the last complete year of analysis of renewable energy global capacity statistics (2018), the annual capacity growth was around 10% for wind and 24% for solar [65]. The incremental annual growth for global market value of forecasting services assuming a 30 €/MW/year price is 1,9 M€/year for wind and 4,2 M€/year for solar. Of course, this figure will grow with each year as the installed capacity grows.
Market drivers	The development of the wind and solar technologies are making them more competitive against the traditional power plants in the

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Market for prediction services	
	electricity market. Moreover, they are the best options to deal with the climate change. Therefore, companies and countries are interested in integrating more renewable energy sources in their assets.
Players/Competition	Energy forecasting companies, for example: **Solargis** (Slovakia), **Meteologica S.A.** (Spain), **ConWX** (Denmark).
Customers	• Electric utilities: Vattenfall, RWE, ENGIE, Iberdrola. • Renewable Energy Plant Operators: Vattenfall, Acciona, Siemens, Npower, Statkraft, OMIE, Nordpool • TSOs: Energinet, Tenner, EirGrid, National Grid. • DSOs
Entry barriers	• Forecasting companies sometimes need local presence in a specific region. • Low price for the service due to the high competitivity. • Trial-based system: before a forecasting company gets the contract, they participate in a trial period competing with other companies. The best gets the contract. • High bar for experience: a forecaster must be a recognised company to be allowed to participate in a bidding process.
Opportunities to enter the market	The increasing share of renewable energy in the electricity market will bring more companies that require forecasting services and, therefore, the demand will increase. Especially also for long-term price forecasting.
Challenges for this market	The companies regulating the electricity prices need to adapt the regulations to the current needs and developments in the energy field. Until now, the energy was produced by conventional power plants, but now, due to the increasing share of renewable energy sources and local production, the rules will need to be adapted to the current needs of the electric system.

3.4 DERMS / Substation and distribution automation management

Related KER, #5: Cloud-based Microgrid Optimization Platform.
Related KER, #7: Grid control and automatization units.

The main focus of analysis is on the relevant market for EMT, who will exploit KER5 for isolated grids and KER7. The relevant market is the market for Distributed Energy resources Management System (DERMS) / Substation and distribution automation management.

Market for DERMS / substation and distribution automation	
Short market description	The market for these KERs is based in the energy market, mainly related to power distribution (primary & secondary distribution substations, and DER assets) Substation Automation Systems (SAS), and DER management systems (DERMS). The so called “substation and distribution automation market”, helps utilities / DSOs to remotely monitor, control and regulate assets and networks in real time. Such

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Market for DERMS / substation and distribution automation	
	systems ensure uninterrupted power services for consumers and fast and appropriate response to events, such as a power outage [66]. • **Substation automation:** use of data from IED within a substation, helps DSOs to comply with grid standards**.** • **Distribution automation systems**: set of intelligent sensors, processors and communication technologies downstream from a substation that enables a DSO to remotely monitor and coordinate its distribution assets, and operate these assets in an optimal manner [66]. A distributed energy resources management system (DERMS) is a platform which helps mostly DSOs manage their grids that are mainly based on DER. DERMS have a societal benefit as they allow the possibility of increasing power flexibility in distribution grids and may lower networking chargers for consumers as they enable non-wires alternatives to infrastructure expansion [64].
Types of products / services	Reliability and flexibility software for isolated smart grids and energy management, Intelligent electronic devices, and ICT hardware.
Market location	**Worldwide**, in Europe growth markets large markets be **France, Italy** and **Spain** [67]. For the exploitation of KER5: EMT focuses on Greece and other countries with many islands. In Greece alone, there are 27 compatible islands. In Europe there are around 2k and in Indonesia there are 10k islands. For the exploitation of KER7: EMT focuses on Greece and Eastern Europe, as their upcoming product targets isolated grids and aims to achieve energy management & balancing with maximum use of DERs.
Market size / growth	A main growth driver for the DERMS market is the growing penetration of decentralised renewable power sources. By 2027, DER capacity is expected to grow to more than three times the annual capacity of centralized generators. The global market for DERMS implementation spending is expected to grow to $956.6 million annually in 2027 (compared to $226.3 million in 2018, which is a CAGR of 19.8%) [68]. The **distribution automation market size** is estimated at USD 17.7 billion by 2025, from an estimated value of USD 12.4 billion in 2020, at a CAGR of 7.4% [69]. This growth will be driven by the need for effective equipment monitoring and preventive maintenance. Major growth opportunities are the advancements in IoT and communication technologies. The **substation automation market size** is estimated at USD 54.2 billion by 2026 from USD 39.9 billion in 2021, at a CAGR of 6.3% [70]. The growth is driven by the need to retrofit substations and increasing investments in smart grid infrastructure. The global estimated CAGR for the DERMS market is 18.4% for the period 2021-2027 [71]. Main growing market regions for distribution and substation automation is Asia Pacific followed by North America and Europe [72]. Energy distribution companies in **Europe** are estimated to spend USD 23.9 billion to automate or monitor secondary substations over the next decade. Utilities in **France, Italy** and **Spain** are expected to be the highest investors in equipment and services that will enable automation

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Market for DERMS / substation and distribution automation	
	of substations. In the rest of Western and Eastern Europe growth in secondary substation monitoring will be tied to smart metering deployments and the penetration of DG and EVs [67].
Market drivers and trends	Move towards renewable energy is a challenge to resilience and reliability in isolated grids. Digitalisation of the grid is needed, as well as remote monitoring and automatization. Generally, the higher penetration of RES increases the complexity of grid operation, which leads to higher operating costs and as a result the need for DERMS [64].
Prominent players	The **substation and distribution automation / DERMS market** is highly competitive. Large market players invest in R&D and innovative continuously to improve their products. They also expand their market through strategic mergers and acquisitions. The market concentration is moderate, with a relatively large number of major and smaller players. The market is dynamic and dominated by increasing pool of young, innovative companies (in contrast with the Advanced Distribution Management System (ADMS) market, which are offered by a dozen established technology providers worldwide). Europe is well represented among traditional ADMS market plyers, but DERMS players are predominantly non-European, most DERMS innovation takes place in the US and Canada [64]. Major players are: • **Siemens** (Germany, offers own DERMS and four additional grid-management applications that can be integrated with Siemen´s Spectrum Power ADMS). • **Schneider Electric** (France, partnering with **AutoGrid** (USA) offers DERMS as part of ADMS, can deploy SCADA, Outage Management System (OMS) and DMS with DERMS). • **GE** (USA, offers stand-alone own DERMS system for utilities and possibility to integrated with aggregators), • **ABB** (Switzerland, offers DERMS integrated with in-house ADMS, partnering with **Enbala** (Canada)) [64]. Furthermore, IT / Software Companies such as IBM, Accenture. Lastly, DERMS Start-ups: Spirae, OSI, Smarter Grid Solutions (UK, offers DERMS Strate software without inhouse ADMS, and comprehensive modular DERMS with possibility of DMS integration, used by Western Power (UK)) [64]. Other prominent vendors of DERMS are: Sunverge Energy, Vlue Pillar, Enernoc, Autogrid Systems, Open Access Technology International, Spirae, Enbala Power Networks, Doosan Gridtech. Key utility DERMS + DER planning providers are: OpusOne and Envello [25]. From the batch, the start-ups are considered more major competitors for EMT due to their smaller and more targeted solutions.
Customers	Regional suppliers, Integrators, Energy Infrastructure Constructors.
End users	The main end users are: **DSOs**. Three-quarters of European DSOs surveyed by JRC in 2020 had fewer than ten of their MV substations remotely controllable [73]. Most DSOs have a SCADA system in place. Among substation control activities performed by 44 large DSOs in Europe, 4 capabilities are key: voltage control at the bus level, overload control and transformers and buses fault protection [27]. Regarding feeder control, voltage control on feeders can be performed by 58% of the surveyed DSOs, and automatic

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Market for DERMS / substation and distribution automation	
	switching of feeders for network reconfiguration by 70%. Only 30% can control reactive power on feeders (VAR control) [27]. Thus, VAR control is a capability that many DSO still cannot perform and can be considered a market opportunity. Of the surveyed DSOs, only 38% has DER visualization and management tools in place. Some use their SCADA system to visualise DER production, but mostly automatic management tools are not place yet or real time measurements of loads can only monitor DER with an installed capacity over 1 MW [27].
Entry barriers	There are several barriers to enter this market. The high initial investment: platform procurement costs several million euros; the processing power, memory and input/output operations needed by ADMS/DERMS are extremely high; and staff costs for IT administrators who are required for maintaining the hardware and network, facilities cost for hosting the hardware and the administrators and finally hardware replacement costs every 5-7 years. Apart from the predictable costs, the energy market is essentially dominated by large companies that have been around for years. These companies provide many solutions and have the capacity to negotiate with the DSOs/TSOs to take their business that the smaller companies do not. Moreover, DSOs and TSOs are more likely to trust larger companies that provide them with guaranteed solutions and products supported by many years of development and maintenance, and they have strong marketing and brand name. This makes it very difficult for smaller companies who offer similar products to compete in the same market. Possible reluctance of customers to accept solutions from a small company. The complexity of the solutions poses a technological barrier.
Similar, substitute or complementary products	• Regarding the hardware devices (KER7), other existing Commercial off-the-shelve (COTS) devices in the market are available for DER management, distribution substation automation systems, capacitor bank control etc. However, these hardware devices are simply enablers and must be complemented with a corresponding software infrastructure that provide an integrated solution. • The product offerings of ADMS and DERMS have become increasingly modular, such that a DERMS can be offered by itself or as part of an overarching ADMS environment, this offer some freedom of choice for DSOs [64]. KER 5 does not require interoperability for ADMS, EMS, DERMS etc.
Opportunities to enter the market	• The need of green sustainable energy (reduction of CO_2). • Political decisions to fund and support initiatives in that regard. • European political instability leads to strengthened desire of European countries to move away from traditional gas and oil producers.
Opportunities for ebalance-plus	• The ebalance-plus KER7 hardware devices combine different features into a single device, thus decreasing the overall cost of the development and sequentially the cost of procurement by any potential DSOs and TSOs. • Typically, DERMS is identified as a software product and as such underlying devices needed to support it are supplied externally. The proposed solution KER 5 is vertical in the sense that it also covers the device infrastructure needed.

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Market for DERMS / substation and distribution automation	
	• The target of KER 5 is specialized in isolated grids and specifically islands. This specialization is applicable both from a technical standpoint (in terms of tailored algorithms) and from a business standpoint (by involving for example the local population in the energy gains). • Novell model of distribution / interaction among grid elements may offer a competitive advantage. Also, ebalance-plus enables edge processing, which is a key feature supported in all of the grid automation and control units in the project. • Greece is lacking in digitalization (specific opportunity for the project´s KERs owner EMT).

3.5 Market for Smart Hubs

Related KER, #6: Integrated Smart Hubs.

Ebalance-plus demonstrates a “smart hub”: an integrated solar carpark with battery energy storage and V2G electric vehicle charge management, delivering flexibility services. Its Unique Selling Point (USP) is the use of innovative Silicon Carbide (SiC)-based DC-DC V2G chargers, which are based on DC/DC topology, and can thus be integrated in DC grids with PV systems to charge and discharge the EV according to the needs of the electric grid. This system avoids non-beneficial AC conditions and eliminates conversion losses from conversion to/from AC.

Market for smart hubs: integrated solar carparking with battery energy storage and V2G EV charge management	
Short market description	Existing examples of smart hubs tend to be expensive and are aimed primarily at the residential market (e.g. Wallbox, DCBEL, and pilots like FLEXINet project) [74]. There is a much bigger potential, currently untapped, for smart integrated solar carport solutions to create new opportunities for private and public car park owners. The provision of EV charging infrastructure is becoming mandated in new car park planning applications and car parks provide an ideal ‘brownfield’ location for new renewable energy capacity. Furthermore, there is an emerging opportunity for integrated solar car parks to become local energy hubs within V2G smart-grid schemes. A key benefit of car parks and transport hubs that incorporate energy storage systems and V2G capabilities is that larger amounts of EVs can be charged without adding a strain to the grid and a new source of revenue. V2G could unlock low-cost energy storage at a huge scale [75]. However, services provided to DSOs are under-represented in the current global V2G projects. This might reflect the lack of DSO service maturity, rather than the V2G capabilities [57].
Target customers & end users	• Building owners, e.g., university buildings, office buildings, sport centres, leisure spaces, factories, etc. • Local authorities´ buildings • Public car park owners (association) • Airports, Stations (esp. long-term car parks) • Hotels

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Market for smart hubs: integrated solar carparking with battery energy storage and V2G EV charge management	
	• Fleet operators, EV Charge Point Operators • Small size energy producers • Electric mobility operators • Medium and big enterprises with EV fleets • Retail centres, shopping malls (a bit less suited because EVs do not stay parked as long as in office buildings)
Market dynamics and trends	**Growth of e-mobility** Electric cars and buses will be the default method of transport in the next years [75]. In Europe, the uptake of EVs increased to 11% of newly registered passenger cars in 2020 [76]. There are various car manufacturers that are trialling V2X capabilities in their cars: Nissan-Renault, BMW Group, PSA Groupe, FACA, Hyundai-Kia, and Honda and Tesla. **Potential of parking lots for smart hubs** The potential of using parking lots for smart hubs is significant. 26% of worldwide EV charging stations are located in parking lots and EV´s are parked 90% of the time [77]. This potential can be tapped by PV covered rooftops above parking lots. Smart hubs are a great potential to bring together the electricity and transport sector in an innovative way. **Lowering costs of technology** The costs of bidirectional chargers are falling quickly and is expected to reach near parity in the next five years. New EV chargers come with the communications to schedule charging, which helps enabling V2G at a low costs [78]. **Benefit of "EV Fleet-to-Grid"** As the financial benefits of V2G for individual EV users are still negligible, the benefits of fleet-to-grid have a high potential. Examples of fleets can be those of car manufacturers, city buses or school buses [79]
Market growth	The V2G market is at the end of the pilot and experimental phase. In 2 years the V2G market will start to operate at a consolidated operational level, estimating a market doubling every year. In 2050, price-responsive bidirectional charging is expected to provide 477 GW of power in the EU. Congestion management and ancillary services through EVs are expected to provide the EU with 307 GW of power in 2050 [64].
Location	**North America** is the leading region for the global V2G market [64], but promising projects are also found elsewhere. Of the 50 V2G projects globally, 25 are located in Europe, 18 in North America and 7 in Asia [57]. The **Netherlands**, **Denmark**, the **UK,** and **Germany** lead in pilot projects. **V2G possibilities in the market** As the Smart Hubs Demonstrator project shows that the **UK** market is getting ready for this type of solutions, although customers require the "DC Microgrid" concept "sold to them. **Denmark** is a forerunner country if it comes to V2G, as the country hosts several world leading V2G demonstration projects [80, 81]. In Denmark, DSO charges and double-charging have been removed for electromobility and EVs already participate in ancillary services (minimum requirement of 100 kW) [24]. **Spain** has a low number of EVs, but a high potential for PV usage and has no double taxation on bidirectional charging, which is an advantage. **EVs & EV growth** The largest EV markets in Europe are **Norway, the Netherlands, France, UK** and **Germany** both in terms of amount of EVs on the road and EV

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Market for smart hubs: integrated solar carparking with battery energy storage and V2G EV charge management	
	growth since 2019 [82]. The UK expects to have 9 million EVs on the road by 2030 [83]. These countries are also the frontrunners with the most developed V2G programmes.
V2G Service Readiness Level	V2G is currently still at pilot stage, as bidirectional chargers are rare and are more expensive than smart chargers [64]. The status of piloting V2G services is: • *Arbitrage*: only researched (France, Denmark) and tested (NL) • *Reserve:* only researched (France) • *Frequency response*: researched (France), tested (NL), proven (USA), commercial anywhere (Denmark), commercial competition (expected in UK shortly) • *DSO services*: researched (Denmark), tested (UK, NL, DE), proven (US), commercial expected in the US in 2019 • *Time shifting*: researched (Korea), Proven (USA, UK), commercial anywhere (Japan), commercial competition (expected in UK shortly) [57]. We can conclude that frequency response and time-shifting have been focused mostly on, because of their high value [57]
Prominent players	**DC/DC V2G chargers & projects** Commercially available V2G-ready charging infrastructure is still rare in Europe [64]. The majority of current V2G solutions are AC-DC products. Some manufacturers announce DC/DC using ISO15118 V2G chargers, but they are mostly prototypes and not commercial products. Ebalance-plus partner MGC is the worldwide leader in terms of number of V2G projects. Main competitors are **ABB**, **EVTEC** and **WALLBOX**. Other prominent players like Nuvve has implemented many V2G projects, among others it deployed V2G for school buses that contribute to DR during school holidays and peak shaving during the school year [84]. **Vehicle manufacturers** Vehicle manufacturers that dominate V2G projects are Renault, Nissan and Mitsubishi [57]. **EV charging for parking lots** EV charging integrator for car parks Circontrol in Spain. **DC V2G Hubs including PV** The leading UK company for DR (Flexitricity) has been involved in piloting smart hubs.
Business case	Despite the rapid growth, EVs still represent only approximately 1 in 500 light-duty vehicles on the road. Thus, smart solar EV charging remains at the early demonstration/pilot stage with no real commercial traction in the market. Identifying viable commercial models around V2G technology remains a struggle, and most initiatives are still pilots or trials. Large scale deployment remains a challenge [78, 84]. The business case for car park owners/operators has not yet been clearly established. Whilst the technology components are coming together, the challenge is turning these pilots into real commercial opportunities that are investible by a range of customers without subsidies or support. For the future monetization of V2G there is a need to stack different revenue streams across energy & grid ancillary service markets. For example, grid balancing, frequency reserve, day ahead & intraday energy arbitrage, solar PV self-consumption, etc. [85].

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Market for smart hubs: integrated solar carparking with battery energy storage and V2G EV charge management	
Entry barriers	A key barrier identified is the DNO resistance to DC microgrid due lack of understanding that this can be a safe way to operate. V2G requires large initial investments (larger than smart charging) [64].
Related demonstrator	"Smart Hubs Demonstrator" project. UK pilot demonstrating solar-powered car park with battery storage for EV charging, integrating V2G systems, launched in 2019. It will demonstrate how energy that is stored in EV batteries and bulk battery systems can be utilised by the electrical grid system during peak times. EV users can charge their cars while parked, but when not being used, the car remains connected allowing the power grid to utilise a proportion of the stored capacity in the vehicle during times of higher demand. Involved companies: Smart Power Systems, Flexitricity, Flexisolar (not existing anymore), **TPS** [75, 86].
Remaining barriers for market development	The main barriers for V2G that remain are regulatory and are related to market entry conditions for EVs and V2G aggregators, absence of dynamic tariffs, and standardisation (See Deliverable 7.2). Furthermore, services provided to DSOs are under-represented in the current global V2G projects, as the value and service specification of these services have not been clear. This reflects the lack of DSO service maturity [57].
Opportunities ebalance-plus	• Creation of a DC Microgrid is more efficient when integrated with renewables. It is also more reliable as there are possibilities that the microgrid could operate in certain circumstances without the grid connection. • Possibility to offer DC/DC V2G solution, which has advantages to current state of the art, including the possibility to connect directly to a DC input source, like a stationary power storage or a solar production. It also is much more efficient reducing conversion loses. The solution proposes is dual cable allowing that two vehicles may be connected per charger. • V2G constraint management and power quality services provision to DSOs possible in NL, UK

3.6 Energy balancing platforms

Related KER, #1: Comprehensive energy balancing platform.

Market for energy balancing platforms	
Types of products / services	Different type of platforms in the DSF really exist, e.g. marketplace platforms, VPPs, Energy management platforms and Energy market access platforms [26]. The ebalance-plus platform can function as a VPP and energy management platform. Platforms can offer long-term capacity products (between DSO (need) and flex provider (offer)); or short-term exchange (between TSO, DSO, BRP (need) and flex provider (offer) [32]. Software platforms are important drivers that have transformed nearly every major industry. They create value by reducing the costs for their multiple customer groups to come together and thereby enhance the value that each customer group delivers to the other. This is done through providing shared services – made available through APIs – that reduce costs for developers and users. Software platform vendors are part of a complex ecosystem that

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Market for energy balancing platforms	
	include end-users and, producers of complements (e.g. hardware devices, software applications, content) [87]. Several of the software platforms that have specifically developed for DR services that have been developed over the last decade have been developed "on the job" by aggregators themselves (e.g., KiWi platform), other platforms have been developed as open-source solutions (e.g. as Niagara platform). In addition, some of the platforms are combined with proprietary hardware that is installed on customer premises to allow for accurate metering and control of assets [88].
"As a service" segment in DSF market	In the **platform-as-a-service segment**, companies offer platforms that facilitate interaction among different independent customer groups, and thereby contribute to a more efficient system operation. The platform-as-a-service business model is gaining traction in different sectors resulting from advancements in IT. In the electricity sector, 14 out of 26 aggregators already offer platform solutions to utilities and system operators, for example: **Volatiles, Restore** and **Kiwi Power**. With the aid of an advanced communication infrastructure an aggregator may assist a DSO in voltage control, utilizing free network capacities more efficiently and shaving off or shifting load peaks.
Players & competition	Certain platform providers focus on specific assets and value stream, whereas others have wider functionalities and capabilities. For example, **Lime Jump** is a VPP and an Energy market access platform; **Enel X** and **Next Kraftwerke** provide a VPP platform, Energy management platform and Energy market access Platform. **Autogrid** and **Grid Beyond** provide both a VPP and Energy Management platform [26]. Other "Multi-service VPP Platform" (to monitor, manage and optimize energy assets in real time) providers are: **Kiwigrid, Greencom, GreenSync, C3.ai, Blue Pillar, Spectral, Opus One Solutions, Enbala** [19]. A very adaptable and market agnostic platform, just like the ebalance-plus platform comes from **Open Energi**. Their platform, Dynamic Demand 2.0, offers services across the entire digital energy value chain: from grid-scale assets to household equipment and everything in-between. It can connect to any distributed energy asset to any market.[13] See for more on stakeholders in the DSF markets Section 2.4, especially aggregators that provide platforms (2.4.1).

[13] https://openenergi.com/

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Market for energy balancing platforms

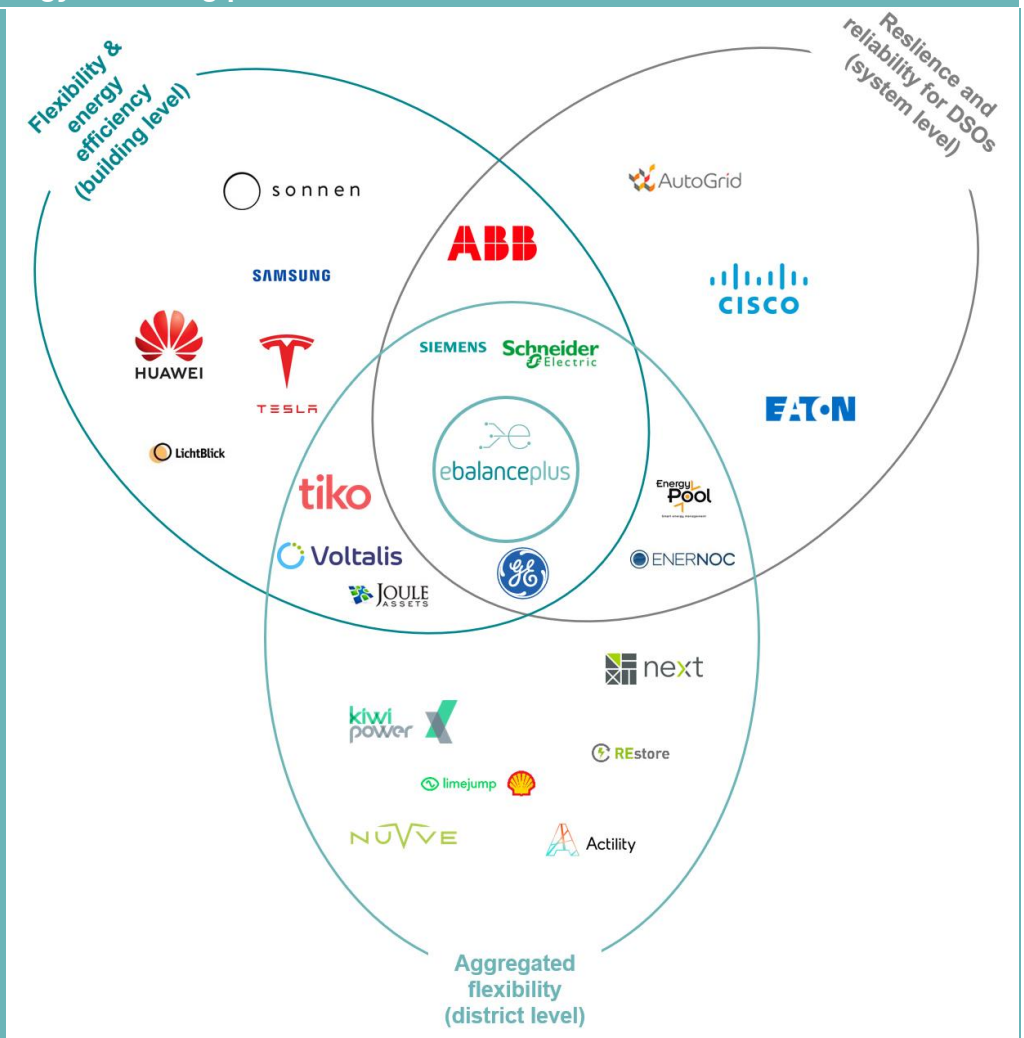

Figure 13. Non-exhaustive market player landscape for ebalance-plus energy balancing platform (more players mentioned in this deliverable in specific sections).

4 Conclusions

4.1 Market for DSF

Key opportunities: market situation for DSF

- Wholesale markets will be increasingly interesting to turn DSF into value.
- The market maturity for DSF in the consortium countries is highest in**: UK** and **France**. These should be the first target countries for exploitation of flexibility mechanisms enabled by the ebalance-plus platform. In a next phase Ireland, Netherlands, Belgium, Germany, and Finland could be targeted. Upcoming consortium countries are Poland, Italy, Spain, Greece and Portugal (in terms of potential market size of flexibility and expected future of flexibility).
- Local flexibility markets to offer flexibility to DSOs are only available currently in the **UK** and **the Netherlands.**

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Key insights: stakeholders

- Most operating **aggregators** (VPPs) in Europe stem from software start-ups, which are increasingly acquired by large energy utilities and other big players. Most active aggregators have their own hardware/software solutions and focus on software development. The demand for complete innovative platform solutions might be limited among these players, while modules to solve specific problems could be more interesting.
- **Small energy retailers** that want to develop aggregator capabilities and have no in-house solution yet could be interesting target beneficiaries of the ebalance-plus solutions.
- Many **DSOs** do not actively manage prosumers connected to their networks yet, but a majority of the DSOs do consider non-wired alternatives as an alternative to network infrastructure investments. This means, DSOs are potentially interested in ebalance-plus type of solutions to use flexibility for their grid management. As it might be difficult to get large DSOs interested in the ebalance-plus solutions (they have their own projects and developments), **small and medium DSOs** are more interesting targets for exploitation of ebalance-plus solutions. **Italy, Poland, Germany,** and **Spain** have an especially high number of small DSOs.
- Currently, already existing DSO activity in DSF across Europe is highest in the **UK,** followed by the **Netherlands.** After that Germany, France, Spain, and Italy follow.
- Even though the potential of combined **aggregator-ESCO** roles to optimize both energy efficiency and using flexibility from buildings has a high potential to lower energy use, CO_2 emissions and reduce energy bills, the business case is not positive in the current regulatory environment and tariffs.
- The power (to have influence on the electricity system) and interest (in the ebalance-plus platform) of key stakeholders is summarised in Figure 14.

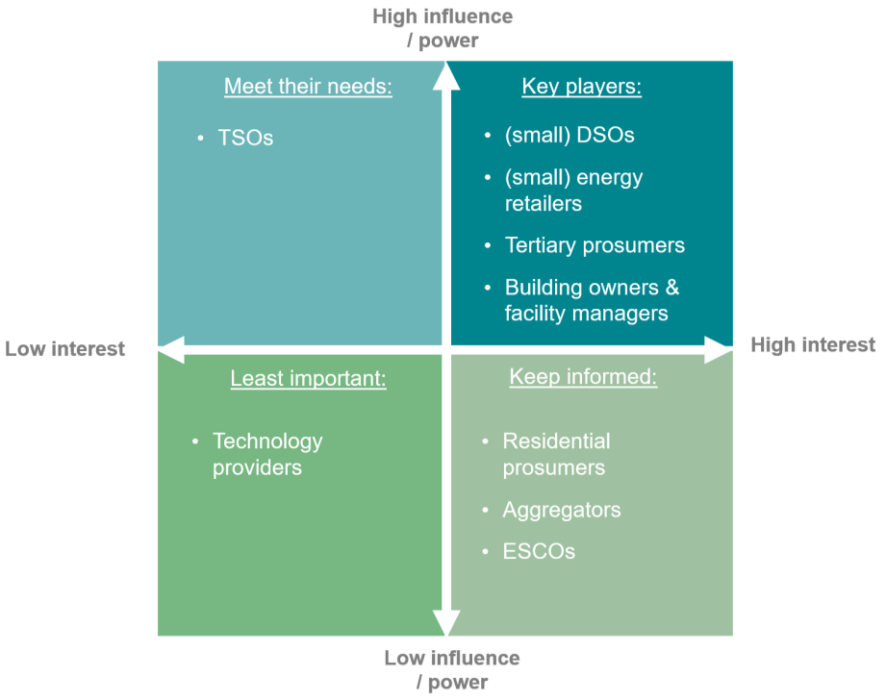

Figure 14. Diagram showing the power (to have influence on the electricity system) and interest (in the ebalance-plus platform).

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4.2 KERs markets

Table 10 concludes with the main market opportunities identified for the ebalance-plus KERs, this includes added value of the KERs in their reference markets, the opportunities / market strategy of each KER and the market-related exploitation challenges.

Next page: *Table 10. Summary of key insights KERs markets.*

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	KER	Added value KER in reference market	Opportunities / market strategy KER	Market-related exploitation challenges
1	**Comprehensive energy balancing platform**	• Fractal-like architecture, leading to decentralised decision making and computational effort. • Interoperability with external systems (highly adaptable) • Data-abstraction to improve (cyber) security. • Modular and scalable system • Plug-and-play solution	Exploitation the approach with a platform-as-a-service strategy to facilitate interaction among different stakeholders.	• Exploiting the complete platform might be difficult • DSF markets not ready in many Member States • Many aggregators / stakeholders already have their own platforms, many DSOs do not focus on flexibility yet
2	**Home energy management mobile application**	Customised interfaces for different stakeholders and their needs	Adaptable mobile app for both building and smart grid level, for both building facility managers, end users, and DSOs.	Various competitors active.
3	**Smart-storage solution**	Plug-n-play battery system, ready to be deployed at premises of a large consumer for their energy reduction for wide range of use cases (unique in the market).	The high power offered by this technology and the support of its cloud platform allow creating a competitive aggregator service by itself. With the support of the ebalance-plus platform, even better for future DSO services.	Competition in certain countries.
4	**Prediction models**	Innovative services: prediction of energy consumption, and forecasting and scheduling of EV charging, necessary because forecasting renewable energy and demand in the short term becomes more important with each additional renewable power plant that is displacing old fossil fuel units.	The increasing share of renewable energy in the electricity market will bring more companies that require forecasting services and, therefore, the demand will increase.	Low price for prediction services due to the high competitivity.
5	**Cloud-based Microgrid Optimization Platform**	• The novel model of distribution / interaction among grid elements and ebalance-plus enables edge processing. • The KER is “vertical” in the sense that it also covers the device infrastructure as well, and not just the software. • The KER is specialized in isolated grids and specifically islands.	• Country strategy: Greece and other countries with many islands. • Customers: Regional suppliers, integrators, energy infrastructure constructors. • End-users: DSOs.	EMT is a small company, and well-established companies may be preferred among customers.
6	**Integrated Smart Hubs**	DC Microgrid is more efficient when integrated with renewables. Also more reliable: the microgrid could operate in certain circumstances without the grid connection. Opportunity to offer DC/DC V2G solution.	V2G constraint management and power quality services provision to DSOs possible in NL, UK	• DNO resistance to DC microgrid due lack of understanding that this can be a safe way to operate. • Lack of standardisation.
7	**Grid control and automatization units**	• Different features combined into a single device, lower development and procurement costs	Country strategy: Greece and Eastern Europe (regions that lack digitalization and have many	Market dominated by large companies, who can negotiate

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	KER	Added value KER in reference market	Opportunities / market strategy KER	Market-related exploitation challenges
		• The novel model of distribution / interaction among grid elements and ebalance-plus enables edge processing, which is a key feature supported in all of the grid automation and control units.	isolated grids that need to be managed while maximising use of DER).	with DSOs/TSOs and receive trust.

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Annex 1. Balancing markets

Primary Reserve | Frequency Containment Reserve (FCR)

Reserves that are constantly used by the system operator to maintain system frequency as supply and demand constantly changes [17]. These are usually supplied by reserve providers (generators, storage, demand response). These reserves have to be operational within 30 seconds and are usually activated automatically [89]. FCR capacity is procured ahead [10]. The EU aims to increasingly integrate the market for procurement and exchange of FCR [90].

Secondary Reserve | Automatic Frequency Restoration Reserve (aFRR: PICASSO)

The reserves primary purposes are to continually: (1) balance the supply and demand, and (2) maintain system frequency [17]. aFRR can be activated by an automatic control device. aFFR capacity can be bought ahead (contracted bids), TSO check if requirements are met and charge penalties when needed [10].

Tertiary Reserve | Manual Frequency Restoration Reserve (mFRR: MARI)

This reserve is activated when a serious grid imbalance or congestion issues arises [17]. The mFRR's primary purposes are to resolve: (1) major or systematic supply and demand imbalance, (2) a significant frequency variation, and (3) major congestion issues. This reserve is activated manually. The objective of mFRR is thus the same as for aFRR (restoring frequency), but the requirements for the services are different: mFRR has a longer duration and larger ramp rate [10].

Replacement Reserve (RR: TERRE)

The TERRE project currently exists of 8 TSOs, and 6 Observing TSOs the expectation is that more additional TSOs will join the project as well (https://www.entsoe.eu/network_codes/eb/terre/).

Annex 2. Open questions local flexibility markets

Several key challenges and open questions related to the set-up of flexibility markets remain [20, 21, 91]:

1. Integration of the flexibility market into the existing sequence of EU electricity markets, or not?
2. What should be the market size? It should be small enough to solve location-specific issues and big enough to ensure market liquidity.
3. Who will be the flexibility market operator (third party?)?
4. Should there be a standardization of flexibility products?
5. Lack of regulation enabling DSOs to procure flexibility services: when and where it is more efficient?
6. What should be the level of coordination between TSO-DSO and DSO-DSO cooperation?

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7. Currently not enough demand and supply of flexibility services is available to set up such markets.
8. There is a lack of accurate forecasting and ability to measure or quanta available flexibility.
9. Is the technology ready? (Smart meters, suitable platform for trading, etc.)

Annex 3. Elaborate country-DSF market analyses

Denmark

National Regulatory Authority	Danish Energy Regulatory Authority (DERA)
Market operator	Nord Pool (shared electricity market with Norway, Finland, Sweden, and Denmark)
TSO	Energinet.dk
Number of DSOs	72 (16 major and 26 smaller DSOs)
Number of large DSOs (>100.000 customers)	6
DSO concentration	Low: mainly small, local DSOs. 3 largest DSOs <50% of distributed power
Energy generation	Wind is the largest source of energy, and combined heat and power (CHP) play a major role in Danish electricity production.

Sources: [92, 93]

Generally, Denmark has shown a progressive approach to market-based approaches in the electricity sector. State-owned industries play a far less significant role than in other European countries, which have helped to progress the liberalisation of the electricity sector in Denmark significantly [94]. Similar to EU policies, Danish policies on smart grids to develop DSF have a strong focus on market mechanisms.

Denmark has a relatively low share of electrified heating demand compared to other countries [95].

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Explicit DSF

The regulation in Denmark is open to independent service providers signing contracts with a customer or aggregator to provide demand flexibility. On paper, no specific barriers exist, but in praxis there still are.

Market size

The DR market in Denmark is relatively small as there is a limited demand for flexibility from TSOs and DSOs. The electricity market is well-developed and has sufficient capacity (because of the Danish interconnector capacity with Norway, Germany, and Sweden (approximately 6GW), together with the CHPs, is the main source of flexibility), so the price for flexibility products is low [12]. Because of the low demand for flexibility in Denmark, smart energy and load management systems in households have been very limited. The most widespread technologies used for DSF are CHP and electric boilers [24]. There are currently 35 electrical boilers connected to the grid as well as 150 local CHP units, which all participate in the ancillary markets [12]. Moreover, there are 1.5 MW of stand-alone batteries and 0.5 MW of electric vehicles providing balancing services.
Flexibility from households in Denmark will likely stay small in the future, compared to the large heat pumps and boilers in district heat production in Denmark that are expected to contribute much more to flexibility.

EVs

As a contrast to the slow market development for demand flexibility in Denmark, it is one of the top countries for EV flexibility trials with fleets and private vehicles [17]. It leads the way in Europe if it comes to V2G, EVs can for example provide flexibility to primary reserve market with asymmetric bids, thanks to the removal of the online measurement requirement for FCR delivery [12]. The FCR market has a lower threshold bid size than in most other European countries: 0.3 MW, which is however still relatively high and might form a barrier for EV aggregators to participate in the market [81]. It means for example that 30 EVs with 10kW chargers need to be aggregated. Despite that, EVs are already participating in ancillary services commercially in FCR [24]. The first commercial project of V2G market leader Nuvve took place in Denmark in 2016, in collaboration with Nissan and Enel [46]. Now, several companies (Nuvve, CELVER, E-On, True Energy) offer a range of services, such as fixed or reduced energy prices for charging and tariff avoidance to a state of charge guarantee. These companies use connected vehicles, pool them with other resources to provide ancillary services [8].

Market barriers

For small and medium prosumers, selling their flexibility to the market through aggregators in Denmark is a very small source of income, and is currently only possible through pilot projects [8]. In Denmark, independent aggregators must register themselves as suppliers and a Balance Responsible Party (BRP), which forms a barrier. This reduces the available offers, most ancillary services are provided by retailers [8][14]. Compared to the other four Nordic countries, Denmark has the weakest situation to stimulate users to provide DSF [9].

[14] More details on the barriers for independent aggregators to enter the electricity market in Denmark can be found in D7.2 Analysis of obstacles to innovation for flexibility solutions

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Implicit DSF

Market size

For prosumers, implicit use of flexibility is more available than explicit flexibility in Denmark. The adoption of renewable energy generation by prosumers (e.g. rooftop solar) in Denmark is steadily increasing, even without government support, due to high electricity prices and heavy taxation and tariffs [8]. The sales of EVs is also growing, with an increase of 330% in 2019 over 2018. The total EV stock is still relatively small, however, at 15.507 vehicles on the 1st of January 2020, this is only 0,56% of the total passenger vehicles [8].

Self-consumption

Denmark has no net-metering programme anymore, it only has the remains of two old programmes until 2032 (an annual net-metering programme that stopped tacking new applications in 2012 and an hourly net metering programme that closed in 2017). Since 2017, only the energy that is directly consumed is free from taxation. The main driver for self-consumption is avoiding these taxes, as they are one of the highest in Europe, up to 66% for residential customers [8].

The feed-in tariff for renewables (a premium paid upon injection onto the grid) exists but is closed for new entrants. It is valid up to 10 years after the connection is established, in 2019 for renewable installations up to 6kW it was 0,06 EUR/kWh [8]. Self-consumption is thus stimulated, and is a very viable activity in Denmark, because off-take is guaranteed, but the prosumer must either pay for the off-take or find a commercial party willing to buy their electricity [8].

Dynamic prices and ToU tariffs

Most customers have dynamic price contracts available to them and many DSOs have implemented ToU tariffs. The adoption of these possibilities is still low, however, with only 10% of Danish customers using dynamic prices, because of the low impact of the energy component in the final electricity bill [8].

Hourly metering has been possible only to a very limited extend in Denmark. The country thus has had a very weak price signal transparency, with the price mostly appearing on invoices rather than real-time information. At the moment, smart meters are increasingly used and the possibility to react on price signals is thus becoming much better [9].

DSOs are implementing time-of-use tariffs [12]. Denmark has dynamic pricing based on spot market-based pricing through the monthly average wholesale price [96]. These dynamic tariffs will be available by 2021, it is expected that DSF from domestic assets will occur in the future [17]. So far, however, the economic incentive for households to switch to active short-term adjustment of demand responding to price changes has been very limited [95].

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France

National Regulatory Authority	Comission de Régulation de l'Energie (CRE)
Market operator	
TSO	RTE
Number of DSOs	158
Number of large DSOs (>100.000 customers)	5. Leading DSO is *Enedis* (95% of French connections)
DSO concentration	Medium: 1 DSO >80% of distributed power
Energy suppliers	46 suppliers. 70% of residential sites were supplied by EDF at regulated tariffs in 2019
Energy generation	Two-third of generation comes from nuclear power, intermittent renewable penetration has a share of 10% and fossil fuel share is below 10%.

Sources: [58, 92, 93]

Prosumage

France has the third-highest amount of rooftop solar PV installed in Europe (after Germany and Italy), because of a feed-in-tariff of 0,158 EUR/kWh which is an attractive price. Additionally, electric water heating and a special tariff for water heating have been widely adopted [8]. The attractive feed-in-tariffs and low electricity prices in France provide low incentives for self-consumption. Moreover, it is common in France that aggregators offer EMS to optimize on-site assets [8].

EVs

France's EV market is growing, thanks to a direct subsidy that has been renewed in 2020 together with tax exemptions. France is the second largest EV market in the EU, growing a 2,5% market share in 2019 to a 9% in June 2020 [8]. Smart charging is still small and there only a few offerings from charging providers. Chargers and smart chargers do also receive direct subsidies, and EV drivers can request the installation of a public charging station within 500 meters of their residence or workplace.

RTE and Jedix are working together on a project to ensure that EVs can balance the grid in France (in preparation of the aFRR market opening in France this year).

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Explicit DSF

Market size

France has a relatively high demand response participation (~6GW), of which large commercial and industrial participants provide ~5GW and residential consumers account for ~1GW flexibility, which electric heating as the key asset [97].

Both the ancillary service and the wholesale market are open to aggregation and demand response (Table 10). France is the only country in the EU that enables independent aggregation on wholesale markets using the NEBEF mechanism [98]. However, prices in the wholesale market have a relatively low price volatility [97], this does not contribute to the deployment of DSF [39].There are currently 23 aggregators active in the NEBEF mechanism. Participation is mostly during the cold months when the generation is tighter, and prices are higher. Around 10 independent DR aggregators are currently participating in the French balancing market [12].

The excellent DSF situation in France is enabled by its frontrunner-status in the global smart grid sector, with 10% of the global market share and >120 smart grid demos. The French sector has a national association “Think Smart Grids” [99].

Market failures

There is a transfer of energy mechanism active, that ensures that suppliers are compensated by independent aggregators that source energy [97]. This conflict of interest between energy producers, aggregators, and distributors still hinders the business case for aggregators.

Implicit DSF

Despite the relatively low-price volatility in the French wholesale market, it has a relative high value for implicit demand-side flexibility services, because of its weather-related price peaks which creates high energy prices within the wholesale markets. These peaks are driven by electric heating on cold days [100]. Electricity demand almost doubles from summer to winter months [97]. However, implicit demand side flexibility is not used a lot in France [8].

France has several different supply tariffs, including ToU energy pricing and critical peak pricing [97], enabling implicit DSF programs. For residential customers there is a day and night tariffs, and for those with smart meters there are 4 different time periods combining seasonal and peak and off-peak components [97]. The critical peak pricing means that customers can reduce their loads with a one-day notice signal for some days of the year. The French regulator (CRE) introduced this critical peak pricing for the medium voltage delivery (1kV-50kV) [101]. The uptake of demand response tariffs have been low [8].

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Italy

National Regulatory Authority	ARERA (Regulation Authority for Energy, Networks and the Environment)
Market operator	GME (Gestore dei Mercati Energetici)
TSO	Terna (Rete Elettrica Nazionale)
Number of DSOs	144
Number of large DSOs (>100.000 customers)	3
DSO concentration	Medium: 1 DSO >80% of distributed power. E-distribuzione has 86% of the market
Energy suppliers	70 electricity suppliers that operate in the free market and at least 5 companies in the protected market, that will end in 2022.
Energy generation	The total volume of energy generated in 2019 in Italy was 319,481 GWh (35.3% of renewable origin) with an installed capacity of 119,300 MW.

Inputs: [93, 102]

The energy market in Italy is highly liberalised, with no dominant electricity providers, which leaves room for new players to enter the market, or new technologies to be implemented by existing players. The electricity transmission network is completely owned by Terna, a state-owned company [103].

In Italy, increasingly small and medium sized prosumers focus on reducing the cost of their energy consumption and industrial customers on on-site optimisation [8].

Flexibility assets

Italy is a frontrunner in smart meter roll-out, the country is in the process of upgrading its 1st generation smart meter to 2nd generation smart meters, which it aims to finish early 2030s [104]. This is necessary because the 1st generation meters did not meet current requirements based on a standard open communication protocol. The second-generation smart meters enables consumers with more accurate information on consumption profiles and fosters their engagement in DR programmes. They will also allow the DSO to have detailed information for in-depth monitoring of the operating status of the grid as well as receiving real-time notifications [105]. The roll-out of these meters has slowed down because of the COVID-19 crisis and therefore, the adoption rate of dynamic tariffs is only at 14% for residential customers [8].

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The most prevalent technology used is solar PV and secondly, combined heat and power (CHP) for residential and commercial areas. Batteries are steadily growing, coupled with solar PV. Around 5000 batteries are currently installed in homes and at SMEs. The number of EVs is also growing, in January 2020 2% of all vehicle sales were EVs, stimulated by subsidies, such as an eco-bonus [8]. However, the lack of charging stations holds down this growth, there are only 9000 charging stations in whole Italy, of which 7000 private [8].

Prosumage

Feed-in-tariffs & Self-consumption

The National Integrated Plan for Energy and Climate (PNIEC) has specific objectives that will stimulate self-consumption for small plants. Namely the exemption of charges on self-consumption of small plants and the simplification of authorization for self-consumers and renewable energy communities [105]. The feed-in-tariff for solar PV with a capacity below 250 kW that was adopted in July 2019 incentivises users to adopt renewables, whether to inject into the grid or use it for self-consumption. Moreover, a tax exemption is in place [8]. There are also feed-in-tariffs for non-solar PV generators.

Net metering

The net metering scheme in Italy is called “Scambio Sul Posto” and can be used by producers who have a capacity lower than 500 kW. It renumerates the differences injected and withdrawn energy at a value based on the zonal price of the hourly wholesale market [8]. Italy has a so called “net-billing” mechanism. “The system allows prosumers to adapt their consumption and injection patterns more efficiently, basing their decisions on signals received from the grid, as the prices used in net-billing for injection and consumption are different” [8].

Explicit DSF

Flexibility in Italy is currently mostly fulfilled with hydro and gas and is not (yet) open for DSF in its balancing market. However, Italy is opening up its balancing market for pilot projects in the Replacement Reserve and is drafting projects for FCR and voltage regulations [12].

Italy has made a lot of progress in the last 3 years to open-up for DER, mainly the ancillary services market (operated by Terna) has opened for aggregation of generation and/or consumption points and storage systems (including e-mobility charging stations) [60].

Implicit DSF

In Italy static ToU tariffs are available. The ToU tariffs are the regulated default option in Italy, where millions of customers are on a default static ToU rate [54]. Dynamic price contracts with hourly pricing are also available if a smart meter is present The available two types of ToU tariffs allowing for implicit demand response in Italy are [105]:

- Bi-hourly tariff for residential users.
    - F1. Higher electricity price from 8.00 to 19.00 on working days
    - F23. Lower electricity prices from 19:00 to 8:00 during working days, weekend days and National holidays

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- Three-hourly tariff for small consumers and enterprises, but not for residential users:
  - F1. Highest electricity price from 8:00 to 19.00 on working days
  - F2. Intermediate electricity price from 7:00 to 8:00 and from 19:00 to 23:00 on working days and from 7:00 to 23:00 on Saturday
  - F3. Lowest electricity prices from 24:00 to 7:00 and from 23:00 to 24:00 on working days, and all hours on Sundays and national holidays.

The ability to use the latter asks for a smart meter reprogrammed on these three-time ranges.

Spain

National Regulatory Authority	CNE Comision Nacional de Energia
Market operator	*CNMC* (Comisión Nacional de os Mercados y la Competencia)
TSO	REE (Red Eléctrica Española)
Number of DSOs	349
Number of large DSOs (>100.000 customers)	5
DSOs concentration	Medium: mix of DSOs with the 3 largest accounting for >60% of distributed power
Energy suppliers	500 energy suppliers (free market) and 8 energy suppliers in charge of marketing the exclusively regulated tariff
Energy generation	The total volume of energy generated in 2020 in Spain was 264,843 GWh (36.3% of renewable origin) with an installed capacity of 110,226 MW.

Inputs: [92, 93]

The electricity market in Spain has undergone major changes in the last 20 years. Until 1997, electricity supply was a regulated business. The market has been liberalized (for generation and trading) but did not lead to low electricity prices for consumers [106][15].

[15] Only in Denmark, Germany, Belgium and Ireland people pay more for their electricity 106. EUROSTAT. *Electricity price statistics*. 2019 [cited 2020 9 July]; Available from: https://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_price_statistics.

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Transport and distribution of electricity are still regulated activities. The market is dominated by 5 companies: Endesa, Iberdrola, Gas Natural-Fenosa, EDP and Viesgo Oligopoly, which makes it not an easy market to implement flexibility solutions.

Implicit and explicit use of flexibility provide very little financial incentives in Spain so far. Prosumers have played only a minor role in Spanish electricity markets so far. The main possibility for prosumers to use their flexibility at the moment is on-site energy management. The key financial incentive for prosumers in Spain is the reduction of electricity expense, because of the high taxes and tariffs [8].

Flexibility assets

Spain almost finished its full smart meter roll-out and has a high potential for the use of PV due to the high values of solar irradiation during most of the year. However, adoption of solar PV has been slow in Spain because of legislative restrictions. Spain has very low amount of electric heating and the high stock of electric cooling has usually no capabilities to react to signals from the grid [8].
The number of EVs has grown over the years: by the end of 2019 Spain had 54000 EVs, which was 2% of the total amount of vehicles in Spain, as a result of a public subsidy scheme. Smart charging stations can also benefit from direct subsidies of 30% for installation [8].

Prosumage

Spain has recently created a favourable environment for implicit demand-side flexibility. Until 2019, self-consumption in Spain was discouraged, because of heavy administrative barriers and a so-called “sun-tax” on distributed generation [107]. The Decree that came into force in 2019 gave certainty to prosumers and introduced a simplified mechanism to get paid for any surplus energy injected back into the grid [108]. The injected electricity is sold in the day-ahead market at spot price [8]. Since the lift of the sun tax, solar PV has grew significantly.
Consumers with renewables below 100 kW can also access a net billing mechanisms with their retailer [8]

Explicit DSF

Market barriers

Spain’s system operation markets and especially its balancing markets, do not allow for DSF and aggregation to participate. Only conventional power plants and wind power plants participate in balancing services [7]. For now, only generation and pools of assets from the same technology are allowed on these markets. Spain is historically a closed country to explicit flexibility and has a stronger focus on implicit flexibility [12, 109]. No DR is participating in the Spanish Balancing Markets so far, most bidders are traditional generation and pumped storage units [12]. The only one available programme for explicit DR (the interruptible contracts) for electro-intensive industry managed by REE is barely used, and not open for aggregators [7]. Still Spain has a high potential market value despite relatively few value streams accessible to DSF. Due to high utilisation prices and the country’s limited interconnection there is a high need for flexibility provided locally [49].

However, since October 2020, prosumers can provide balancing services to the market through aggregation offered by suppliers and REE expects that independent aggregators will operate in balancing markets in Spain by the second quarter of 2022.

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Additionally, Spain has developed a data hub for the procurement of DER for flexibility, for the collaboration between TSO and DSOs [96].

Implicit DSF

In Spain, consumers have access to dynamic electricity prices. Even more, customers below 10 kW can only sign a contract based on hourly tariffs, thereby it was the first country in the world where the default price for households is based on hourly spot prices on the day-ahead market [105, 110]. This regulated default ToU option has resulted in nearly 40% of all residential consumers being on ToU tariff contracts, significantly more than in Europe as a whole [54].

Retail market Spain: half of the Spanish households (13 million) are on the free market and the other half are on the regulated market (the liberalisation of the market is not yet complete). But the free market is on the up, in fact in recent months it has overtaken the regulated market [111].

UK

National Regulatory Authority	Ofgem (Office of Gas and Electricity Markets)
Market operator (day ahead & intra-day)	EPEX SPOT & Nord Pool
Market operator (balancing and settling)	Elexon
TSO	National Grid ESO (NGESO)
Number of Distribution Network Operators (DNOs)	14
Major DNOs	UK Power Networks; Western Power Distribution; Scottish Power Energy Networks; Scottish and Southern Energy; Northern Powergrid; Electricity North-West
DNO concentration	Medium
Energy suppliers	40 electricity suppliers, of which 28 active in residential sector. The top 3 suppliers have around 40% of the market share.

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Energy generation	Gas and nuclear energy cover just above 50% of the generation, wind and solar energy contribute around 25%.

Sources: [58, 60]

Explicit DSF

UK has one of the largest use of explicit demand-side flexibility In Europe, in terms of volume and market participants (together with France, Germany and Finland) [8]. IT especially integrated three non-congenital sources in the system: demand, energy storage and distributed generation [60].

The UK has relatively high value stream accessibility and multiple value streams. Both in national markets and at regional level. DSF can earn from participation in balancing and ancillary services and the capacity market, but also helping large electricity users to avoid network charges [60]. Therefore, the UK has the most competitive market in Europe with 45-50 players. There are also players that operate in niches, participating in DSO services with residential assets [24].

The value streams for DSF are ca. 4.5 GW, of which 2 GW is monetised through electricity markets and 2.5 GW through network charges avoidance combined with supply tariffs. 90% of the DSF capacity comes from large industrial and commercial customers, the rest from SMEs and aggregators [60].

The first local flexibility procurement platform for DNOs is Piclo Flex, which had a total capacity of 4GW [60].

Overall, the UK market for flexibility is mature and competitive compared to most other member states.

Implicit DSF

UK (through the SEG) still has a net-metering scheme [8].

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Germany

National Regulatory Authority	Bundesnetzagentur
Market operator	Epex Spot
TSO	Tennet, Amprion GmbH, Elia, TransnetBW GmbH
Number of DSOs	883
DSOs concentration	Low
Energy suppliers	800 providers, majority by 4 big companies: E.ON, RWE, Vattenfall and EnBW 138 different electiricy suppliers (retailers). 66% of residential customers are supplied by local default supplier.
Energy generation	50% fossil fuels, coal and natural gas. Intermittent renewable generation has around 30% share.

Sources: [28, 58]

Explicit DSF

Germany has a very low smart meter penetration rate [28]. Balancing markets in Germany are open for independent aggregation (FCR, aFRR, mFRR) and demand side response can participate in wholesale markets within the BRP portfolio. But the regulatory framework limits the contribution of flexibility to balance the German energy market and transmission and distribution networks. [58].

There is a new regulatory framework and many pilot projects. The policy framework towards a flexible electricity market is ambitious, but much more action is required to integrated DSF into the electricity system. There are 30 explicit DSF players in Germany, dominated by aggregators and utilities, the aggregator business model and “energy services + DSF” model dominate [26].

“Enera” is the first operational exchange-based flexibility market [112]. Enera is developed by the German Federal Ministry of Economic Affairs and Energy. It aims to develop demonstrable scalable standard solutions with a high share of renewables in large showcase regions. A local market platform has been launched to tackle grid congestion problems. The market platform is available to system operators and flexibility providers in the project. The aim mis to develop a transparent market

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mechanisms together with EPEX SPOT and EWE, based on locational order books that centralize flexibility offers that can be used by TSOs and DSOs in congested areas [113].

Implicit DSF

Key implicit DSF value streams include self-consumption and tariffs for controllable loads [26]. Dynamic energy tariffs and on/off peak tariffs are available, but the lack of smart metering infrastructure makes that they are barley used [58].

Greece

National Regulatory Authority	Regulatory Authority for Energy (RAE)
Market operator	Hellenic Energy Exchange
TSO	ADMIE SA.
Number of DSOs	1 (HEDNO)
DSO concentration	Very high
Energy suppliers	The Greek electricity sector is dominated by the vertically integrated state-owned electricity company Public Power Corporation (PPC)

Sources: [60]

The Greek electricity market has recently developed towards the EU target model market with forward, DA and ID market and the balancing market operated by the Greek TSO (ADMIE SA) [60]. Greece has one DSO (HEDNO) that has the challenging task to distribute energy on many non-interconnected islands. The smart-meter roll-out in Greece lacks behind. It is a big challenge to replace conventional meters across the country, including the islands [114]. TO date, smart meters have been installed at medium-voltage customer sites and in a few low-voltage customer locations as a pilot [60]. This is affecting the possibilities for implicit and explicit DR in Greece. HEDNO is planning to use net-metering to support DER penetration, and also wants to focus on electro-mobility [114]. However, currently, the regulatory framework for operation of electromobility and energy storage is incomplete, restrictive, and procedures for their integration in the electricity market are too complicated [60].

Explicit DSF

Demand participation is mainly foreseen in the transmission and medium voltage network, and can be offered by consumers to the TSO, mainly in interruptibility and long-term capacity compensation schemes. Only large industrial consumers participate at the moment [60].

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The option to establish aggregators and energy communities is institutionally foreseen, but the participation of all electricity consumers in the electricity market will not be possible until the smart meters installation project is finished, expected in the next decade [60].

Implicit DSF

Customers connected to the medium and low voltage network can also opt for demand control contracts, when they have the necessary telemetering equipment. Furthermore, residential customers can sign contracts for lower tariffs in the night, or interruptible load contracts for “agricultural customers”, and thus participate in implicit DR [60].

Portugal

National Regulatory Authority	ERSE
Market operator	Mibel market operated by OMIP
TSO	Redes Energéticas Nacionais (REN)
Number of DSOs	13
DSOs concentration	High

Sources: [28]

Explicit DSF

Portugal shows emerging activity and industrial customers are already active in the Replacement Reserve (RR), which has also opened for consumption loads after a pilot project in 2018. The regulator works on opening this market further for aggregation and non-BRP stakeholders [17]. Markets are open to independent aggregation, RR is opening-up for aggregation and non-BRP stakeholders.

Implicit DSF

Portugal is advancing very well with its smart meter roll-out in urban areas and is progressing in the rural areas [59]Portugal has a very active customer participation in the retail electricity market: 21% of the Portuguese households switched their electricity supplier in 2016, which was the highest rate in Europe. Starting from this given, several Portuguese pilot projects trial DR programs, also because of the large-scale introduction of renewable energy in the country [115].

Poland

National Regulatory Authority	Urząd Regulacji Energetyki (URE)

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Market operator	TGE
TSO	Polski Sieci Elektroenergetycnza
Number of DSOs	184
DSO concentration	Medium

Sources: [28, 49]

The day-ahead market (DAM) in Poland is operating since 2000. It carries out the electricity energy transactions for the next day and the day after. Companies can purchase and sale energy every day between 8:00 and 14:30 [116]. The intraday markets (IDM) has been connected to the intraday markets within the EU since 2019. Trading is continuous, 24 hours a day [116].

Explicit DSF

Poland's balancing markets are not open to independent participants, DR is not allowed and aggregation is not permitted [12]. The market is only open for large industrial players. Poland still works with a central dispatch model: balancing is provided by centrally dispatched generation plants with capacities over 100MW [12]. The primary control reserve (FCR) is not a market, all large generators are obliged to maintain the ability to provide balancing services. The secondary control reserve (aFRR) is arranged by the TSO via bilateral contracts. The tertiary control reserve (mFRR) does not exist in Poland [12]

However, Polish TSO "Polski Sieci Elektroenergetycnza" has ambitious plans to allow DSF in ancillary services over 2022/2023. Furthermore, Poland has a high level of existing industrial assets and high renewable targets, which create large opportunities for a market for DSF [49].

Implicit DSF

There are several energy operators with slightly different prices. Most people use flat rate tariffs in Poland, but there is the possibility to choose a tariff with lower costs in off-peak hours.

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References

1. Lynch, P., et al., *Business model strategies: Flexibility trade in low voltage distribution networks.* The International Journal Entrepreneurship and Sustainability Issues, 2017. **4**: p. 380-391.
2. Matusiak, B.E., *e-balance - Deliverable D2.3 - Definition of new Business Models*. 2015.
3. Prata, R., R. Cossent, and R. Bessa, *New business models for distribution grid stakeholders under high penetration of DER*, I.A. webinars, Editor. 2020. p. https://www.iea-isgan.org/our-work/annex-8/.
4. USEF, *USEF: The framework explained*. 2021.
5. EEA, *Share of renewable energy in gross final energy consumption in Europe*, E.E. Angency, Editor. 2019, European Environment Angency.
6. Delta-EE, *The state of the new energy market in 2020*. 2020.
7. Vitale, C. *Spain towards the famous demand aggregator*. 2020; Available from: https://www.magnuscmd.com/spain-towards-the-famous-demand-aggregator/.
8. smartEn, *The smartEn Map 2020 - PROSUMERS*. 2020.
9. Nordic Council of Ministers, N.E.R., *Demand side flexibility in the Nordic electricity market: From a Distribution System Operator Perspective*. 2017.
10. USEF, *White Paper. Flexibility Value Chain*. 2018.
11. Poplavskaya, K. and L. de Vries, *Aggregators today and tomorrow From intermediaries to local orchestrators?* Behind and Beyond the Meter: Digitalization, Aggregation, Optimization, Monetization, 2020: p. 105-135.
12. smartEn, *The smartEn Map. European Balancing Markets Edition*. 2018.
13. BestRES, *Review of future electricity market options*. 2017.
14. European-University-Institute, *The EU Electricity Network Codes*. 2019.
15. Valarezo, O., et al., *Analysis of New Flexibility Market Models in Europe.* Energies, 2021. **14**(12).
16. Lind, L., R. Cossent, and P. Frías, *New business models enabled by smart grid technology and their implications for DSOs*, in *25th International Conference on Electricity Distribution*. 2019, CIRED: Madrid.
17. smartEn, *EU Market Monitor for demand side flexibility*, D.E.E.L.a.s.S.E. Europe), Editor. 2019.
18. Delta-EE, *Whitepaper - Distribution networks and demand side flexibility*. 2021.
19. Brasington, L. *Smart Grid Flexibility Markets – Entering an Era of Localization*. 2020 [cited 2021 23 June]; Available from: https://www.cleantech.com/smart-grid-flexibility-markets-entering-an-era-of-localization/.
20. Schittekatte, T. and L. Meeus, *Flexibility markets: Q&A with project pioneers.* Utilities Policy, 2020. **63**: p. 101017.
21. Gómez, T., R. Cossent, and J.P. Chaves, *Flexible network access, local flexibility market mechanisms, and cot-reflective tariffs: three regulatory tools to foster decarbonized electricity networks.* Oxford Energy Forum, 2020.
22. Baes, K., Carlot, F., *Virtual Power Plants – At the heart of the energy transition*. 2018.
23. Deloitte, *Energy-as-a-Service The lights are on. Is anyone home?* 2019.
24. DeltaEE, S., *EU market monitor for Demand Side Flexibility*. 2020.
25. Brasington. *Energy Flexibility: Emerging Revenue Opportunities for the 2020s*. 2021; Available from: https://www.cleantech.com/energy-flexibility-emerging-revenue-opportunities-for-the-2020s/.
26. Delta-EE, *Flexibility Research Service Brochure and Research Highlights*. 2020.
27. Prettico, G., Marinopoulos, A. and Vitiello, S., *Distribution System Operator Observatory 2020*. 2020, EUR 30561 EN, Publications Office of the European Union, Luxembourg, 2021,.
28. Eurelectric, *Distribution Grids in Europe Facts and Figures 2020*. 2020.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°864283

29. Andreadou, N. and M. Flammini, Flammini, S. *Business Models for Electricity Distribution in Europe: Evidence from the JRC DSO Observatory 2018*. in *Cired. 5 th International Conference on Electricity Distribution*. 2019.
30. E.DSO, *The Thin Veil of R enewal: Building the Next Generation Grid*. 2021.
31. Hamwi, M. and I. Lizarralde, *A Review of Business Models towards Service-Oriented Electricity Systems.* Procedia CIRP, 2017. **64**: p. 109-114.
32. Delta-EE. *Demand-side flexibility for DSOs. Current market status, challenges and lessons learnt*. 2019; Available from: https://www.delta-ee.com/downloads/2400-delta-ee-webinar-demand-side-flexibility-for-dsos-everything-you-need-to-know.html#form-content.
33. Chasin, F., et al., *Smart energy driven business model innovation: An analysis of existing business models and implications for business model change in the energy sector.* Journal of Cleaner Production, 2020. **269**: p. 122083.
34. Karami, M. and R. Madlener, *Business model innovation for the energy market: Joint value creation for electricity retailers and their customers.* Energy Research & Social Science, 2021. **73**: p. 101878.
35. Specht, J.M. and R. Madlener, *Energy Supplier 2.0: A conceptual business model for energy suppliers aggregating flexible distributed assets and policy issues raised.* Energy Policy, 2019. **135**: p. 110911.
36. Lu, X., et al., *Fundamentals and business model for resource aggregator of demand response in electricity markets.* Energy, 2020. **204**: p. 117885.
37. ArthurLittle, *Distributed flexibility: The next pool of value*. 2020.
38. CEER, *Performance of European Retail Markets in 2017 - CEER Monitoring Report*. 2018.
39. Bertoldi, P., P. Zancanella, and B. Boza-Kiss, *Demand Response status in EU Member States*, in *JRC Science for Policy Report*, E. Commission, Editor. 2016.
40. project, A., *D1.2 Overview of actors, roles and business models related to Enhanced EPC and Building Demand Response Services*. 2020.
41. Boza-Kiss, B., A. Toleikyté, and P. Bertoldi, *JRC Science for policy report. Energy Service Market in the EU. Satus review and recommendations 2019*. 2019.
42. Metzger, A.S., et al., *Digitalization & Facility Management: Energy Flexibility of Existing Buildings.* Journal for Facility Management, 2019. **17**: p. 61-83.
43. Mlecnik, E., Li, R., Pernetti, R., Vigna, I., Ma, T.,, A. Knotzer, Petersen, S., Elbæk Hedegaard, R., Heidmann Pedersen, T.,, and M. Jessen Schultz, & Korsgaard, J., *Stakeholders' perspectives on Energy Flexible Buildings: Energy in Buildings and Communities Programme Annex 67 Energy Flexible Buildings*, Z. Ma, B. Nørregaard Jørgensen, and J. Parker, Editors. 2019, International Energy Agency.
44. smartEn, *Smart Energy Prosumers. Eight ways in which people and companies are leading us to a smart and decarbonised energy system*. 2020.
45. Bryson, J.M., *Strategic planning for public and non-profit organizations: A guide to strengthening and sustaining organizational achievement,*. 1995, San Francisco, CA: Jossey-Bass.
46. IRENA, *Demand-side flexibility for power sector transformation. Analytical brief*. 2019.
47. IES. *Demand Response. Tracking report - June 2020*. 2020; Available from: https://www.iea.org/reports/demand-response.
48. Hancock, E. *Flexibility demand to 'gather pace' as grid decarbonises*. 2020; Available from: https://www.current-news.co.uk/news/flexibility-demand-to-gather-pace-as-grid-decarbonises.
49. SmartEn, D.-E., *European Market Monitor for Demand Side Flexibility 2021*. 2022.
50. Delta-EE, *Residential demand response: Pilot to profitability*. 2020.
51. Baes, K., A. Krug, and F. Carlot, *Distributed flexibility: The next pool of value*. 2020.
52. van Gerwen, R., et al., *Flexibiliteit in de gebouwde omgeving: wegwijzer voor ondernemers*, in *TKI Urban Energy*. 2021.
53. Tennet, *Flexibility Roadmap NL*. 2018.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°864283

54. Hussain, A. and M.P. Torres. *Time to pick up pace of dynamic electricity pricing*. Unknown; Available from: http://www.frontier-economics.com/uk/en/news-and-articles/articles/article-i6106-time-to-pick-up-pace-of-dynamic-electricity-pricing/.
55. Schneider Electric, *Electric Vehicle Smart Charging in Buildings*. 2021.
56. Delta-EE, *EV charging business models whitepaper*. 2022.
57. Everzone&EVconsult, *V2G Global Roadtrip: Around the world in 50 projects*. 2018.
58. Research, N.E., *The regulation of independent aggregators. With a focus on compensation mechanisms*. 2022.
59. SmartEn, *The implementation of the Electricity Market Design to drive Demand-Side Flexibility 2022*. 2022.
60. Forouli, A., et al., *Assessment of Demand Side Flexibility in European Electricity Markets: A Country Level Review.* Energies, 2021. **14**(8).
61. Delta-EE. *Home Energy Management in Europe: A rapidly evolving market with a growing potential*. 2020; Available from: https://www.delta-ee.com/blog/home-energy-management-in-europe-a-rapidly-evolving-market-with-a-growing-potential/.
62. Allied Market Research, *Home Energy Management Market By Offering, Product Type and Technology: Global Opportunity Analysis and Industry Forecast, 2021–2030*. 2021.
63. Colthorpe, A. *Terawatt-hour of energy storage by 2030: BloombergNEF forecasts boom in installations*. 2021 [cited 2022 7 February]; Available from: https://www.energy-storage.news/terawatt-hour-of-energy-storage-by-2030-bloombergnef-forecasts-boom-in-installations/.
64. ENTEC, *Digitalisation of energy flexibility*. 2022.
65. IRENA, *Renewable Capacity Statistics 2019*. 2019.
66. BSE. *Substation and distribution automation a necessity for utilities*. 2017 [cited 2021 21 June]; Available from: https://solutions.borderstates.com/substation-and-distribution-automation/.
67. Smart Energy International. *Europe to spend $23.9 billion on substation automation*. 2019 [cited 2021 21 June]; Available from: https://www.smart-energy.com/industry-sectors/smart-grid/23-9-billion-anticipated-substations-automation/.
68. Navigant, *VPPs and DERMSs: Different Sides to the Same Coin. How Alectra Is Building the Business Case for Integration*. 2018.
69. Markets and markets. *Distribution Automation Market by Component*. 2020; Available from: https://www.marketsandmarkets.com/Market-Reports/distribution-automation-market-65029172.html.
70. Markets and markets. *Substation Automation Market*. 2020; Available from: https://www.marketsandmarkets.com/Market-Reports/electric-power-substation-automation-integration-market-208537744.html.
71. Shingetsu. *Global Distributed Energy Resource Management Market*. 2022; Available from: https://www.shingetsuresearch.com/distributed-energy-resource-management-market/#:~:text=The%20global%20distributed%20energy%20resource%20management%20system%20%28DERMS%29,of%2018.40%20%25%20during%20the%20forecast%20period%202021-2027.
72. Intelligence, M. *Substation Automation Market*. 2020 [cited 2021 21 June]; Available from: https://www.mordorintelligence.com/industry-reports/substation-automation-industry.
73. Spencer-Jones, J. *The future role of DSOs*. 2021 [cited 2021 21 June]; Available from: https://www.enlit-europe.com/news-grids/the-future-role-of-dsos.
74. TU Delft. *5,7 miljoen euro voor hybride energieopslagsystemen*. 2021; Available from: https://www.tudelft.nl/2021/ewi/57-miljoen-euro-voor-hybride-energieopslagsystemen.
75. Gordon, P. *The UK pilots smart EV charging hubs with V2G and storage*. 2019; Available from: https://www.smart-energy.com/industry-sectors/electric-vehicles/the-uk-pilots-smart-ev-charging-hubs-with-v2g-and-storage/.
76. EEA. *New registrations of electric vehicles in Europe*. 2021; Available from: https://www.eea.europa.eu/ims/new-registrations-of-electric-vehicles.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°864283

77. Osório, G.J., et al., *Rooftop photovoltaic parking lots to support electric vehicles charging: A comprehensive survey.* International Journal of Electrical Power & Energy Systems, 2021. **133**: p. 107274.
78. Hilton, G. *Vehicle-to-grid outlook*. 2021; Available from: https://www.pv-magazine.com/2021/08/10/vehicle-to-grid-outlook/.
79. PR-electronics. *EV Fleet to Grid: why large fleets may be the first candidates for commercial V2X applications*. 2021; Available from: http://www.pr-electronics.nl/nl/nieuws/102/ev-fleet-to-grid-why-large-fleets-may-be-the-first-candidates-for-commercial-v2x-applications/.
80. Kester, J., et al., *Promoting Vehicle to Grid (V2G) in the Nordic region: Expert advice on policy mechanisms for accelerated diffusion.* Energy Policy, 2018. **116**: p. 422-432.
81. Parker, *The Parker Project - Final report - Appendices - Barriers within V2G Frequency regulation in Europe*, P. Project, Editor. 2019.
82. Delta-EE, *2020 was the year that European EV adoption exploded so which market do you enter next?* 2021.
83. BBC. *Solar-powered car parks for electric cars to go on trial*. 2019; Available from: https://www.bbc.com/news/uk-scotland-scotland-business-47654821.
84. Maisch, M. *The weekend read: V2G driving grid changes*. 2022; Available from: https://www.pv-magazine.com/2022/01/15/the-weekend-read/.
85. Dcbel, *Energy on your own terms*. 2022.
86. TurboPowerSystems. *Vehicle-to-Grid - Smart Hubs Demonstrator Project - TPS*. 2019; Available from: https://www.turbopowersystems.com/tps-v2g-smart-hubs-demonstrator/.
87. Evans, D.S., A. Hagiu, and R. Schmalensee, *Invisible Engines: How Software Platforms Drive Innovation and Transform Industries*. 2016.
88. Leutgöb, K., C. Amann, Tzovaras, D., and D. Ioammidis, *New business models enabling higher flexibility on energy markets*, in *ECEEE 2019*. 2019.
89. Emissions Euets. *Frequency Containment Reserve (FCR)*. 2019 [cited 2020 2 July]; Available from: https://www.emissions-euets.com/internal-electricity-market-glossary/793-frequency-containment-reserve.
90. ENTSO-E. *Frequency Containment Reserves (FCR)*. 2020 [cited 2020 2 July]; Available from: https://www.entsoe.eu/network_codes/eb/fcr/.
91. Flexigrid. *The key issues for the success of local energy and flexible markets*. 2021 [cited 2021 23 June]; Available from: https://flexigrid.org/the-key-issues-for-the-success-of-local-energy-and-flexible-markets/.
92. Prettico, G., et al., *Distribut ion System Operators observatory*. 2018.
93. Eurelectric, *Power Distribution in Europe Facts & Figures*, U.o.t.E.I.-. EURELECTRIC, Editor. 2020.
94. Katz, J., *Policy analysis of electricity demand flexibility*, in *DTU Management*. 2016.
95. Klinge Jacobsen, H. and N. Juul, *Demand side management - electricity savings in Danish households reduce load variation, capacity requirements and associated emission*. 2015, DTU.
96. IRENA, *Innovation landscape for a renewable-powered future: solutions to integrate variable renewables*. 2019.
97. Armentero, A.S., et al., *A state of the art review of demand side flexibility*. 2020, DNV-GL.
98. USEF, *Case Study. Practical deployment of electric vehicle flexibility*. 2020.
99. ETIP-SNET, *2nd ETIP SNET National Webinar: France. "Think SmartGrids R&D Roadmap.* 2018.
100. Vaasa ETT & Joule Assets Europe, *Demand Side Flexibility Through Smart Homes*. 2017.
101. SEDC, *Explicit Demand Response in Europe. Mapping the Markets 2017*, S.E.D.C. (SEDC), Editor. 2017, Smart Energy Demand Coalition (SEDC): Brussels.
102. Prettico, G., et al., *Distribution System Operators observatory 2018*. 2018.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°864283

103. Potau, X., S. Leistner, and G. Morrison, *Battery Promoting Policies in Selected Member States. Batstorm work package 5*. 2018.
104. Kolokathis, C. and M. Hogan, *Market reform options for a reliable, cost-efficient and decarbonised Italian power system*. 2019.
105. Ambience Project, *D1.1 Analysis of directives, policies, measures and regulation relevant for the Active Building EPC concept and business models*. 2020.
106. EUROSTAT. *Electricity price statistics*. 2019 [cited 2020 9 July]; Available from: https://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_price_statistics.
107. Bellini, E. *Spain's 'sun tax' set to be scrapped*. 2018; Available from: https://www.pv-magazine.com/2018/06/12/spain-set-to-cancel-solar-tax/.
108. Molina, P.S. *Spain's new rules for self-consumption come into force*. 2019; Available from: https://www.pv-magazine.com/2019/04/08/spains-new-rules-for-self-consumption-come-into-force/.
109. Rodilla, P. and C. Batlle, *Empirics of Intraday and Real-time Markets in Europe: Spain*. 2015, DIW - Deutsches Institut für Wirtschaftsforschung, Berlin.
110. IRENA, *Time-of-use tariffs. Innovation landscape brief*. 2019.
111. Endesa. *The 2 electricity markets: free and regulated*. 2022; Available from: https://www.endesa.com/en/advice/free-market-regulated-market-pvpc.
112. Epex spot, *Local Flexibility markets - a market - based solution to solve local grid congestions*. 2019.
113. smartEN, *SmartEn Position Paper. Design Principles for (Local) Markets for Electricity System Services*. 2019.
114. Largue, P. *HEDNO: The vision and future plans of Greece`s only DSO*. 2018 [cited 2022 3 March]; Available from: https://www.smart-energy.com/event-news/hedno-vision-future-plans-greeces-only-dso/.
115. Annala, S., et al. *Comparison of Opportunities and Challenges in Demand Response Pilots in Finland and Portugal*. in *2018 15th International Conference on the European Energy Market (EEM)*. 2018.
116. TGE. *About the market*. 2020; Available from: https://tge.pl/electricity-dam.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°864283