D7.2 Analysis of obstacles to innovation for flexibility solutions

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Summary

Executive summary

This Deliverable presents the results of the analysis conducted in task 7.2 focused on obstacles to innovation for flexibility solutions. The goal of the analysis was to understand relevant barriers for the optimal deployment and operations of business models that exist for flexibility solutions at national and European level. The Technological Innovation System (TIS) theoretical framework has been deployed to structure the analysis and to identify obstacles related to *institutions, capabilities, coordination,* and *technology*. Because of the large influence of European and national regulation on the development of flexibility solutions, institutional obstacles such as regulatory and legal barriers have been specifically focused on. Critical obstacles related to social and behavioural aspects have not been part of the work in Work Package (WP) 7 but have been analysed in WP2 and presented in D2.2.

The Deliverable is structured as follows. First, key European policy and legislation is presented, especially the Clean Energy Package (CEP), which act, regulations and directives play key role in the EU's transition towards a climate neutral economy. The CEP is meant to support the EU's climate targets and focusses on renewable energy, energy efficiency and reform of the energy markets, among other subjects. The CEP promotes Demand-Side Flexibility (DSF) as a key aspect to stimulate the energy transition, and the directives put the customer at the core of the energy system. The CEP is an important driver to support the development of innovative flexibility solutions, but its implementation at the national level is still ongoing (and often lacking behind).

Second, the results of the comprehensive analysis of obstacles to innovation for flexibility solutions in Denmark, France, Italy, Spain, UK are presented. Obstacles are categorised into 4 main themes: “communication & data”, “energy flexibility assets”, “Demand Response (DR), aggregation, and flexible consumers” and “Distribution System Operators (DSOs) deploying flexibility”. The analysis shows that the largest differences in barriers among countries are related to DSF participation in electricity markets. There are large gaps between the European legislation and the national realities. For example, regulation related to independent aggregation and (small-scale) demand response needs to be further developed in most of the analysed countries. The possibilities of DSF to participate in the electricity markets is highest in France and the UK, followed by Denmark, and lacking most behind are Italy and Spain, but in both countries, legislation is changing rapidly. DSOs have more incentives and possibilities to deploy flexibility in the UK than in the other analysed countries.

Some obstacles are very similar in the analysed countries, namely the penetration and functionalities of smart meters, and the possibilities of deploying flexibility from electricity storage. Another similarity is the General Data Protection Regulation (GDPR) regulation that applies to all countries and needs to be considered in all data handling: access, storage, and exchange. Furthermore, not a barrier but an enabler: all analysed countries have the possibility for consumers and prosumers to subscribe to dynamic price tariffs.

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In summary (Table 1), at the level of Member States we found that Spain and Italy have the most obstacles for the ebalance-plus solutions. France has fewer obstacles, and the least obstacles are found in Denmark and the UK. Important to add is that the obstacles are very diverse and have a different impact, so from (use) case to (use) case should be considered which country has the least obstacles. Also the type of obstacles that are present in the countries, which have been identified with the TIS framework, should be considered.

Table 1. Overview of obstacles for key topics in the analysed countries (1= minimal/no obstacle, 2 = small obstacle, 3 = high obstacle)

Category	Obstacle	ES	IT	FR	DK	UK
Communication & data	Lack of internet access	2	2	2	1	1
	Smart readiness of buildings	3	2	2	1	2
	Smart meters	1	1	1	1	2
	Metering data access for third parties	3	3	2	2	2
Energy flexibility assets	Electricity storage	2	2	1	2	2
	V2G	2	3	3	1	2
DR, aggregation and flexible consumers	Demand response and aggregation	3	2	1	2	1
	Dynamic tariffs	2	2	2	2	2
	Flexible consumers (self-consumption)	2	2	2	2	2
DSOs deploying flexibility	DSOs incentives to use flexibility	3	2	1	2	1
	Local flexibility markets	2	3	2	2	1
TOTAL SCORE		**25**	**24**	**19**	**18**	**18**

The results of the analysis will be used for the further exploitation-related tasks in WP7, namely the market analysis, the development of business models for the demos and flexibility solution in general, and the exploitation plan.

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Abbreviations

ACER	Agency for the Cooperation of Energy Regulators
aFRR	Automatic Frequency Resotration Reserve
API	Application Programming Interface
AU	Acquirente Unico
BEMS	Building Energy Management System
BRP	Balance Responsible Party
BSP	Balance Service Provider
CAPEX	Capital Expenditures
CBA	Cost Benefit Analysis
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CEP	Clean Energy Package
CHP	Combined Heat and Power
CMU	Customer Management Unit
CNIL	Commission National de l'informatique et de libertés
CNMC	Comisión Nacional de los Mercados y la Competencia
CRE	Comission de Régulation d l'Energie
DC	Direct Current
DER	Distributed Energy Resource
DERMU	District Management Unit
DNO	Distribution Network Operator
DPIA	Data Protection Impact Assessment
DR	Demand Response
DSF	Demand Side Flexibility
DSO	Distribution System Operator
EC	European Commission
EDSO	European Distribution System Operators
EER	European Energy Retailers
EMS	Energy Management System
ESCO	Energy Service Company
ETIP SNET	European Technology & Innovation Platform Smart networks for energy transition
ETNSO-E	European Network of Transmission System Operators for Electricity
ETSI	European Telecommunications Standards Institute
EU	European Union
EV	Electric Vehicle
FCR	Frequency Containment Reserves
GDPR	General Data Protection Regulation
HBES	Home and Building Electronic System
HV	High Voltage
HVAC	Heating, Ventilation and Airconditioning
ICT	Information and Communication Technology
IEA	International Energy Agency
IEMD	Internal Energy Market Directive
IEEE	Institute of Electrical Electronics Engineers
IoT	Internet of Things

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IPR	Intellectual Property Rights
IRENA	International Renewable Energy Agency
ISGAN	International Smart Grid Action Network
ISO	International Organization for Standardization
JRC	Joint Research Centre
KER	Key Exploitable Result
LV	Low Voltage
mFRR	Manual Frequency Restoration Reserve
MV	Medium Voltage
NEBEF	Demand Response Block Exchange Notification
NECP	National Energy and Climate Plan
NIS Directive	Network and Information Security Directive
NRA	National Regulatory Authority
OPEX	Operating Expenditures
RED	Renewable Energy Directive
RES	Renewable Energy System
RR	Replacement Reserve
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SGAM	Smart Grid Architecture Model
SIPS	Supply Point Information System
SRI	Smart Readiness Indicator
TIS	Technological Innovation System
ToU	Time of Use
TOTEX	Total Expenditure
TSO	Transmission System Operator
UC	Use Case
USEF	Universal Smart Energy Framework
VPP	Virtual Power Plant
V2G	Vehicle to Grid
WP	Work Package

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1. Introduction

The ebalance-plus project is part of a larger transformation process towards decarbonisation of the electricity sector that is currently taking place: *the energy transition*. Such sustainability transitions are triggered by societal and environmental pressures. These pressures destabilise the dominant sectoral set-up or “socio-technical system”, and provide opportunities for innovations to develop into a fundamentally different socio-technical system, based on other technologies, consumption patterns, and market- and financial rules [1, 2].

The electricity sector is fundamentally changing because of the integration of ever larger shares of Distributed Energy Resources (DER) and the growing electricity demand due to increasing electrification of heat and transport. The total electricity demand in EU27+UK is expected to rise with ca. 1.8% per year by 2030 [3] .The existing electricity sector, characterised by the use of fossil fuels, large-scale centralised power plants and infrastructures is currently being replaced by another more sustainable version, based on decentralised technologies and renewable energies (Table 2). The changes needed to transform the electricity sector are multi-dimensional and relate not only to technologies and infrastructures, but also to *regulatory frameworks, business models, consumer behaviour, financial structures*, and *market reforms*.

In this deliverable, we analyse the regulatory aspects, policies, actors, and networks that the sector consists of, and that can enable as well as hinder innovation development.

Table 2. Comparison characteristics conventional- and new electricity sector (Inputs: [4, 5]).

Characteristic	Conventional electricity sector	Towards a new electricity sector
Main actors	Large energy producers, system operators, retailers, and consumers	New actors: prosumers, Energy Service Companies (ESCOs), aggregators
Technologies & infrastructures	Centralised; large-scale; Centralised controllable large power plants, electricity grid, infrastructures and grids, fossil fuels, little use of Information and Communication Technology (ICT)	Decentralised; small-scale; Increasing share of DER based on renewable energies, use of ICT to smarten the system
Market structures	Producers and consumers	Plurality of stakeholders entering the markets
Regulations & standards	Aligned with large-scale centralised technologies and infrastructures	Regulations and standards needed that enable the inclusion of DER and deal with growing flows of data
Financial structures (investment, tariffs)	Investments and tariffs based on large-scale power production and centralised infrastructure	Investments in renewables; new tariffs structures needed that
Consumption / users	Passive consumers	Prosumers are market players

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Knowledge base & (technical) skills	Based on current system	Increasingly ICT and communication skills required,
Culture	Trust in the large centralised system based on fossil fuels and large players	Sustainability and decarbonisation is important, small-scale customers can be active players in the electricity sector

A transition process is typically a contested, complex, and uncertain process which takes many years, because of the interconnected aspects that need to be transformed. Innovations that aim to fundamentally change a sector thus face a lot of obstacles such as *non-complying regulations*, *resistant users, lack of adequate standards*, *market conditions*, *lack of legitimation*, *absence of technological* capabilities, etc. In the electricity sector for example, the introduction of new technologies such as Vehicle to Grid (V2G) lack adequate regulations and standards. And for energy flexibility services based on small-scale generation and storage a fitting market is not existing in Europe (yet).

Ebalance-plus develops several innovations that can contribute to the transformation of the electricity sector (see Key Exploitable Results (KERs) in Table 3). The implementation of these innovations thus faces obstacles as outlined above. Especially the legal and regulatory frameworks at European and Member State level can enable or hinder the deployment of new technologies and business models around flexibility, as the electricity sector is highly regulated. Even though the European Union (EU) strives for similar electric regulation in all its Member States in the near future, at this point differences between each country still exist. These should be taken into account as much as possible in the ebalance-plus project to ensure compliance of the solutions to relevant legislation. In this report, the main obstacles for ebalance-plus flexibility solutions are identified and analysed at European and Member State Level.

Table 3. Ebalance-plus Key Exploitable Results (KERs)

Key Exploitable Result	Type
1.Comprehensive energy balancing platform	Knowledge, methodology
2. Energy mobile app	Software
3. Smart-storage solution to unlock and manage building flexibility	Software & hardware
4. Prediction models and balancing algorithms	Software, model, data, methodology
5.Cloud-based Microgrid Optimization Platform	Product (software), service
6.Integrated Smart Hub	Software & hardware
7.Grid control and automation units	Software & hardware
8.Control and optimization models for energy management systems	Software

Aims of the report

The goal of this Deliverable is to analyse the relevant obstacles for the projects flexibility solutions and specify differences between the analysed countries to understand the possibilities to implement ebalance-plus solutions in these countries.

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The analysed countries are the those where the demos are situated (France, Italy, Denmark, and Spain) and one high potential country (UK).

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2. Methodology

2.1 Theoretical Framework

Flexibility solutions such as developed in ebalance-plus are versatile and complex and might lead to transformation of many fundamental building blocks of the electricity sector. Thus, to understand the relevant obstacles to innovation for the flexibility solutions of ebalance-plus, a focus on market failures would be too narrow as it would not address the full range of obstacles that exist in the sector. A more inclusive approach is the *innovation system approach*, which is focused on *systemic failures* in addition to market failures [6, 7]. A specific form of innovation system focussed on the development and deployment of technological innovations is the *Technological Innovation System* (TIS) [7]. A TIS consists of actors, their networks, and institutions around a specific innovative technology (Figure 1). A TIS can be understood as: “a set of networks of actors and institutions that jointly interact in a specific technological field and contribute to the generation, diffusion and utilization of variants of a new technology and/or a new product” [8].

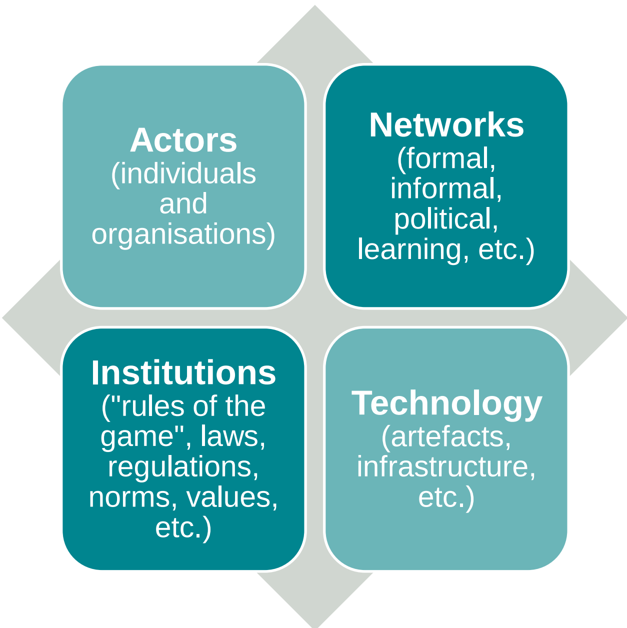

Figure 1. Structural elements comprising technological innovation systems.

When one or more of these system structures (actors, networks, or institutions) are absent or not functioning well, the innovation system does not function well, which will slow down or even hinder the development of the (technological) innovation in focus. These so-called “system failures” can be used to identify a broad and encompassing range of obstacles that innovations might face, see Table 4. These categories of obstacles to innovation will be used to structure the analysis and ensure a complete systemic analysis of obstacles for the flexibility solutions of the project.

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Table 4. Types of obstacles to innovation (inputs [6]).

Obstacle	Description
Infrastructural / technical obstacle	Absence or non-functioning physical infrastructure in relation to the innovation. E.g., communication and energy infrastructures such as high-speed ICT infrastructures, electricity grids, or smart meters.
Institutional obstacle	- **Hard institutional obstacle**: All written, formal mechanisms that may hinder innovation. E.g., technical standards, laws, rules, regulations, or the legal system related to Intellectual Property Rights (IPR). - **Soft institutional obstacle**: Wider context of political culture and social values, “the rules of the game” that may hinder the innovation. E.g., social norms and values, cultures, entrepreneurial spirit, or political culture.
Coordination obstacle	- **Strong coordination obstacle**: Too strong cooperation between actors going, consequently failing to supply each other with required knowledge, failure to exchange with actors who perform a bridging role, or failure to bridge to other industries. “Locked in” relationships with specific actors, e.g., due to monopolised markets. - **Weak coordination obstacle**: Poor connectivity between actors, missing out on interactive learning and innovation, lack of shared vision for future technology developments.
Capabilities obstacle	Companies and organisations might lack competencies, capacity, or resources, they are unable to make the leap from an old to a new technology or paradigm.

2.2 Data collection & analysis

The desk research consisted of a large variety of data sources: academic literature; official statistics (e.g. Eurostat); reports and websites from industry associations, research organisations, think-tanks, platforms, and networks[1]; documentation from the BRIDGE Horizon 2020 initiative; documentation and websites of related EU-funded projects; newspapers; government and company websites; documentation from standards bodies and regulators. Furthermore, data was collected through attending webinars of relevant platforms, networks, and think-tanks. The different data sources were triangulated to ensure validity of the results.

In addition to the desk research, a questionnaire was sent to all partners of the consortium to identify obstacles related to the use cases. Lastly, to gain an encompassing overview of the relevant obstacles, 2 expert interviews and an informal talk (Table 5) were conducted with representatives from different backgrounds. Experts were identified through the consortium’s network, and identification through webinars. All interviews were recorded and transcribed.

After finishing the list of potential obstacles, a country analysis was conducted. This was done based on literature and on the expertise of the partners in the different countries, which was collected through another questionnaire.

[1] e.g., smartEN, Universal Smart Energy Framework (USEF), International Renewable Energy Agency (IRENA), International Energy Agency (IEA), European Smart Grid Task Force, International Smart Grid Action Network (ISGAN), European Technology & Innovation Platform Smart networks for energy transition (ETIP SNET).

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Table 5. List of interviewees

Nr.	Role	Type		Date
1	**Energy transition expert**	DSO	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 preliminary findings of the analysis were presented for the ebalance-plus consortium members on 12 November 2021. After the presentation, the results were discussed and refined. New (regulatory) developments have been included until the deadline.

2.3 Identifying relevant regulatory themes

The ebalance-plus consortium has identified 11 use cases, which are divided in three different clusters: The Architecture, Resilience and reliability, and Flexibility mechanisms (Table 6).

Table 6. Use cases ebalance-plus

Cluster		Use case
The architecture	1	Hierarchical energy communication platform
	2	Interoperability solutions to integrate existing Building Energy Management Systems (BEMS) within demand response markets
Resilience and reliability	3	Application of IEN 50160 for voltage quality
	4	Fault detection, isolation and restoration (FDIR) services
	5	Volt/Var optimisation with increasing RES generation
	6	Intentional islanding after cascading failures
	7	Secondary substation transformer monitoring (health and voltage quality)
Flexibility mechanisms	8	Flexibility measures I: Virtual Power Plant (VPP) services based on district solutions (variable Photovoltaic (PV) generation, storage and V2G)
	9	Flexibility measures II: VPP services based on building solutions (Internet of Things (IoT) devices, PV and storage)
	10	Flexibility measures II: Price/CO2 based optimisation (demand response)
	11	Ancillary services and market mechanisms based on residential power-to-heat-control

These three clusters of use cases help to determine the relevant (regulatory) themes for the obstacles to innovation analysis.

The first cluster of use cases is related to the architecture of the system. Use Case (UC) 1 deals with the infrastructure for data exchange which is the basis of the implementation of energy management algorithms. UC2 is about the interconnection between the ebalance-plus and other existing data infrastructures (in the project this

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is tested with BEMS). The key innovation in this cluster is the set-up and functioning of a hierarchical energy balancing platform. Thus, regulatory and standardisation themes that enable energy balancing platforms related to **communication and data** (chapter 4), such as interoperability, standardisation, connectivity of devices, metering *data access and exchange,* and *smart meters* will be important. These aspects might affect the possibilities and opportunities for innovative energy balancing platforms to provide services to different stakeholders in the electricity sector.

The second cluster of use cases is related to resilience and reliability of the distribution grid. The use cases focus on reliability and resilience services to DSOs related to voltage quality, fault detection, volt/VAR optimisation and intentional islanding. This UC cluster is related to **DSOs deploying flexibility** (chapter 7), especially to *incentives* that motivate, and regulations that might restrict what DSOs may and may not do in terms of using flexibility for voltage control or congestion management.

The third cluster of use cases is related to flexibility mechanisms, especially the use of DERs and end-users' flexibility in energy- and ancillary service markets. In UC9 and UC2, available flexibility at building level (batteries, thermal storage, IoT devices controlling Heating, Ventilation, Air Conditioning (HVAC) and smart appliances, smart storage, local Renewable Energy Systems (RES)) is managed by a Customer Management Unit (CMU) in different ways. In UC8, flexibility at district level from DER is managed using a District Management Unit (DERMU) (UC8). In all these use cases different **energy flexibility assets** (chapter 5) are deployed to enable flexibility mechanisms. Thus, regulation around the use of *energy storage, DER*, and *V2G* need to be considered to understand the (in)possibilities to deploy these assets (e.g. connection rules and taxes) in the different countries.
In this UC cluster, building assets and DER provide flexibility services to other stakeholders through intermediaries like aggregators (VPP). These use cases thus highly depend on the possibilities of **demand response, aggregation, and flexible customers** (chapter 6) in the market, and thus the market design (e.g. access conditions, products available, participation conditions) in the different countries. Furthermore, for UC11, in which ancillary services at residential level using a heat pump and thermal storage will be tested, the market design is the key. As in UC11, a marketplace proposal will be developed in which DSOs are using flexibility from consumers to deal with congestion, regulation related to *DSO remuneration* and *local flexibility markets* will be of critical importance for the implementation potential of this proposal.
Lastly, in UC10, customers' power consumption is controlled based on time-varying electricity or network tariffs. Essential is the availability of *dynamic electricity prices* in the countries and the availability of smart control system equipment, which together determine if there are enough incentives for customers to participate in flexibility services. Lastly, for the use cases in this cluster in which prosumers and consumers participate in flexibility mechanisms, the roll-out of *smart meters* with the right functionalities is a critical enabler, and thus needs to be analysed.

The four main regulatory themes identified: (1) Communication and data, (2) Energy flexibility assets, and (3) DR, aggregation, and flexible consumers, (4) DSOs deploying flexibility, all have a dedicated chapter in this Deliverable.

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3. European policy and legislation

The development of demand-side flexibility (technologies) in the Member States is strongly driven by EU-level legislation and policies. The objective of this chapter is to present the most important European directives, standards, network codes, and regulations that are key to consider for, or might hinder, the implementation of the ebalance-plus technological solutions. These policies are related to energy (section 3.1) and information and communication technologies (section 3.2).

3.1 Energy policy

Europe has ambitious climate targets: the "*Fit for 55*" plan includes the ambition to reduce greenhouse gas emissions with 55% by 2030 (compared to 1990) and net zero emissions should be achieved by 2050. The *European Green Deal* (2019-2024) is the roadmap to ensure that the EU will be the first climate-neutral continent by 2050.
The EU's **Clean Energy Package** (CEP) (submitted to the European Parliament in 2016, formally adopted and completed in 2019) plays a key role in the EU's transition towards a climate-neutral economy [9]. The CEP is meant to support the EU's climate targets and focusses on renewable energy, energy efficiency and reform of the energy markets, among other subjects. Relevant for ebalance-plus are five key principles included in the CEP (Figure 3). Those principles will foster the use of **demand side flexibility (DSF)** in European electricity markets. In short, the aim is to realise energy markets with active consumers as central players, and where new stakeholders (e.g., aggregators) have access to the market to enable DSF. Consumers should have a better choice of supply, access to reliable energy price comparison tools and the possibility to produce and sell their own electricity. The CEP is also an important step towards the creation of a single internal European energy market.

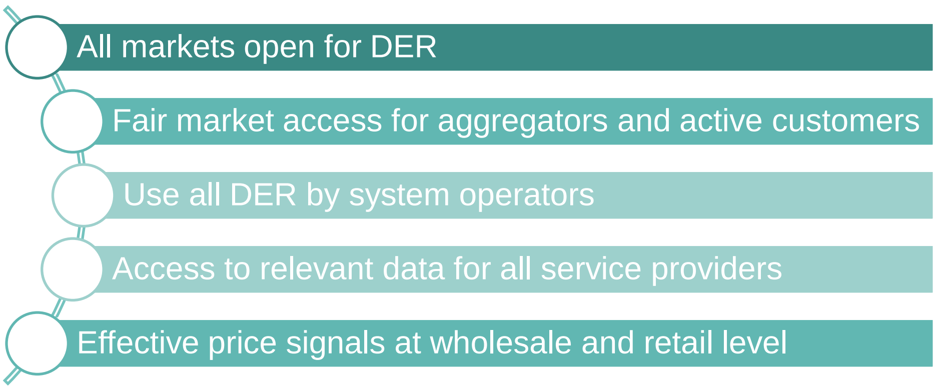

Figure 2. Five key enablers for DSF in the CEP (adopted from SmartEN)

The CEP consists of 8 legislative acts, four directives and four regulations [10]. The four directives of the CEP are:

1. **Energy Performance of Buildings Directive (2018/844)** [11]
   This directive encourages the deployment of automation and control systems in buildings for a more efficient operation as well as the rollout of charging points for Electric Vehicles (EVs).

2. **Renewable Energy Directive (2018/2001)** [12]

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This directive sets a binding renewable energy target in final energy consumption of at least 32% by 2030. Moreover, one of the key objectives is to put the customer at the centre, customers can produce their own renewable energy, and should have the right to consume, store or sell their generated energy.

3. **Directive on Energy Efficiency (2018/2002)** [13]
Sets a target of improving energy efficiency to 32.5% by 2030. Transparent information (metering & billing rules) should be provided to customers to achieve energy savings, especially for apartment blocks.

4. **Electricity directive (2019/944)** [14]
This very extensive directive lays-out several important radical changes for the electricity markets. The directive emphasises the focus on consumers and the importance of the internal market and its main principles. The directive lays down the general principle that Member States must ensure that the EU electricity market is competitive, consumer-centred, flexible, and non-discriminatory. Prices should be market-based, and consumers have the right to choose a supplier. Consumers are at the heart of the energy market; they should be empowered and better protected. There is a need for clear billing information and certified comparison tools.
Consumers shall be free to choose a supplier, aggregator and are entitled to a dynamic price contract. Consumers shall be able to engage in DR, self-generation, and consumption. This means that the wholesale and retail market should be better linked. Aggregators play an important role to support customers to participate in the market.
Consumers may request a smart meter, which should meet a minimum requirement on function, technology and interoperability and provide easy access to historical consumption data. Relevant data should be accessible for all service providers. The directive improves pre-existing rules on the consumers' possibility to share their data with suppliers and service providers. A common European data format shall be developed. Also, energy poverty shall be addressed by Member States.
The directive requires Member States to define frameworks for market participation of independent aggregators and for demand response. It defines a framework for local energy communities which may engage in local energy generation, distribution, aggregation, storage, supply or energy efficiency services [15].
All these changes lead to new tasks for DSOs, especially regarding procurement of ancillary services, flexibility, data management and the integration of EVs. The procurement of ancillary services should be market-based, transparent and non-discriminatory [9]. The directive indicates that DSOs should procure flexibility services where these are cheaper than grid expansion [16]. The regulatory framework in the Member States should allow and provide incentives to DSOs to procure flexibility services.

The four regulations of the CEP are:

5. **Regulation on the Governance of the Energy Union and Climate Action (EU 2018/1999)**
This regulation sets the requirement for EU countries to develop a 10-year national energy and climate plan (NECP) for 2021-2030.

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6. **Electricity regulation (2019/934)** [17]
   Provides general principles for the operation of the electricity market. It includes market-based prices, more use of flexibility, customer participation and cross-border electricity flows. This regulation does not need national implementation and has been in force in all Member States since 1 January 2020.

7. **Risk preparedness (2019/941)** [18]
   This regulation focuses on the need on collaboration and solidarity and includes a framework to manage energy among Member states.

8. **ACER (2019/942) [19]**
   This regulation includes a stronger role for the Agency for the Cooperation of Energy Regulators (ACER).

The CEP thus provides guidelines and regulation for radical changes of the European electricity market. These changes, when implemented, will provide a supportive ground for the implementation of the ebalance-plus solutions. However, the implementation of the proposals and directives at Member State level is lacking behind. The CEP should have been implemented by National Regulatory Authorities (NRA) before 31 December 2020, which has not been achieved, regulation and market structures have only been changing slowly [20].

Thus, there are still many obstacles in the electricity markets that might hinder the implementation of the ebalance-plus innovations. These will be analysed in the rest of this deliverable. When possible, we elaborate how individual countries (do not) comply with the European framework, or how certain barriers vary from (target) country to (target) country.

3.1.1 Network codes

Network codes are a set of rules drafted by the European Network of Transmission System Operators for Electricity (ENTSO-E) and the ACER to push for the harmonisation of the national electricity markets and regulations [21]. There have been 8 network codes in force since 2017 that address *market, system operation*, and *grid connection rules*[2]. We will not go into detail on these codes, they can be found on the ENTSO-E website (see footnote). Two new codes that are under development are worth mentioning:

Network codes under development (2020-2023): Cybersecurity and Demand Side Flexibility [22].

The CEP has brought significant changes for existing and future EU network codes. The "second generation" of new and revised network codes and guidelines will have to include rules on demand response, aggregation, energy storage, demand curtailment and non-frequency ancillary services [23]. The European Commission (EC)

[2] *Connection:* High Voltage Direct Current Connections, Demand Connection Code, Requirements for Generators. *Operation*: Operations, Emergency and Restoration. *Market:* Forward Capacity Allocation, Capacity Allocation & Congestion Management, Electricity Balancing (https://www.entsoe.eu/network_codes/)

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is currently working on a network code on demand-side flexibility to facilitate the access to the market for all types of flexibility providers [24]. This network will standardise the flexibility approaches around Europe for both Transmission System Operators (TSOs) and DSOs [25].

Additionally, the increasing use of IoT and ICT in traditional power systems and related cyber-security vulnerabilities will lead to a new *Network Code on cybersecurity.* The Smart Grid Task Force has developed recommendations for this new Network Code to address cybersecurity risks and support energy system operators to mitigate risks. The network code might address TSOs and DSOs, which should meet a baseline protection and implement minimum security requirements [26]. The new code for the electricity sector will build on the *Network and Information Security (NIS) Directive (2016/1148)*, which is the key legislation on cybersecurity for all sectors in the EU.

3.2 Information and communication policy

Digital Single Market

The EC launched in 2015 its *Digital Single Market* strategy which aims for [27]:

- A better access for consumers to digital goods and services across Europe.
- Creating the right conditions and a level playing field for digital networks and innovative services to flourish.
- Maximising the growth potential of the digital economy.

The Digital Single Market Strategy outlines the problems of collecting, pressing and protection of data. The lack of interoperability and absence of standards are seen as hurdles for the establishment of a Digital Single Market, and ICT standardization is deemed essential. ICT standards can steer new technologies like 5G wireless communications, cloud services, IoT or data-driven services.

The Digital Single Market Strategy identifies three interrelated areas where ICT is expected to impact the efficiency of energy systems [27]:

- ICT in buildings – building management systems and sensor networks.
- ICT in energy grids (smart grids) – to reduce peak demand and potentiate integration of renewable sources.
- ICT in households – smart meters and smart appliances make consumers aware of their energy consumption and potentiate behavioural change.

Action plan on the digitalisation of the energy sector

Specific for the energy sector, on 23 July 2021 the EC launched a roadmap which includes an *action plan on the digitalisation of the energy sector*. This plan will emerge from both the Green Deal and the plan to make Europe fit for the digital age [28].

General Data Protection Regulation (GDPR)

With the increasing digitalisation, data protection is an increasing issue. The GDPR was adopted by the Commission to protect personal data in April 2016 and came into effect in 2018. More on how this affects smart grid projects is explained in Section 4.2.

Cybersecurity

Furthermore, cybersecurity is an increasing topic of attention in policy making. The NIS

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Directive (2016) delivered a first piece of EU-wide legislation on cybersecurity, to achieve a high common level of cybersecurity across the Member States [29].

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4. Communication and data

This chapter presents the identified barriers for different ebalance-plus Use Cases (UCs) and Key Exploitable Results (KERs) related to communication and data. In each paragraph the related "ebalance-plus enabler" explains what the ideal situation for the implementation of ebalance-plus solutions would be, followed by the related UCs and KERs, and then explains the actual situation in Europe or the analysed countries.

4.1 Standardisation for interoperability

ebalance-plus enabler: *having a certain degree of standardisation in place that enables interoperability of devices, DERs, Energy Management Systems (EMS), etc.*
Related UCs: *At first all UCs, but especially UC2 (integration of existing BEMS in the ebalance-plus platform), UC9 (IoT solutions).*

A requirement for the use of DSF is that smart appliances, smart meters, EV charging stations, EMSs, etc. can communicate with each other, thus are interoperable. Interoperability is especially also important when the DSO infrastructure provides information (e.g., smart meter data) that is needed by DSF applications. And when aggregators need to communicate with devices and markets. Interoperability is stimulated when the communication is based on standard interfaces.

Smart grids

The mandate (M/490) to develop European standardisation for smart grids lays with the European Standards Organisations.[3] They have developed several standardisations and guiding documents[4] such as use case and smart grid architecture model (SGAM) approach (IEC 62559-2:2015). The main *European standard CEI EN 50090* applies to Home and Building Electronic Systems (HBES) open communications. It covers any combination of electronic devices linked via a digital transmission network to provide automated decentralised and distributed process control for domestic, commercial, and building applications. The standard is focused on the needs of home and building applications and includes a specification for a communication network for example for the control of lighting, HVAC, and energy management [30].
However, too many standards on interoperability do not necessarily make the situation better in terms of innovation. Standardisation should only set minimum requirements to allow for innovation to develop [31].

Energy balancing / flexibility platforms

For energy balancing platforms the interoperability with existing systems (e.g. IoT, EMS, smart appliances, etc.) requires high-level coordination. Specifically for flexibility platforms, the British regulator proposes the following standardisation possibilities, that could be relevant for energy balancing platforms in general: (1) a common protocol for sharing data on flexibility platform transactions; (2) open data principles to drive innovation; development of standards to keep transaction costs low and ensure the

[3] The three European Standards Organizations (ESOs): the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC), European Telecommunications Standards Institute (ETSI).
[4] Reports on smart meters (M/441) and electric vehicles (M/468), among others.

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ability for platforms to cooperate; (3) universal definitions of asset and product characteristics to foster interoperability [32].

Smart homes

The smart home market is challenged by the large amount of different communication standards and protocols that are being used for devices to communicate among themselves [27]. To support the development of energy balancing platforms, standardised processes, data formats, data models and communication protocols help to ensure interoperability of, and exchange of data between new and existing infrastructures and devices [33]. Specifically, standards from the telecom industry, utility industry and home appliances industry are still fragmented, and need to become increasingly aligned. In 2019, various large corporations (e.g. Apple, Amazon, Google) and the Connectivity Standards Alliance have started to develop a shared royalty-free home automation connectivity standard, called: “Matter”. Updates for existing products and Matter-compatible products are expected in 2022.[5]

Table 7 summarises the key potential obstacles for ebalance-plus use-cases.

Table 7. Obstacles related to standardisation and interoperability in Europe.

Potential obstacles related standardisation and interoperability: • Lack of standards in force to date (e.g. for processes, data formats, data models and communication protocols) which complicates interoperability and thus the possibilities of energy balancing platforms	

ebalance-plus approach

Relevant protocols for ebalance-plus are those on IT communication between devices like heat pumps, EV charging stations, solar panels, and back-office systems. Many different protocols[6] are implemented in practice [34]. Ebalance-plus solution uses adapters that can interface with devices using Modbus, KNX, OCPP, Z-Wave, BACnet among others (Deliverable 5.1). This is how ebalance-plus deals with the interoperability challenge.

4.2 Data security and privacy

Related UCs: *All, but especially UC1 and UC2 that define the architecture of the ebalance-plus platform. Also, UC11, ancillary services and market mechanisms based on residential power-to-heat control is especially complex to implement with GDPR conform data management.*
Related KERs: *KER2, KER4, KER9*

The collection of personal data such as household consumption or usage data is one of the core business enablers for smart grid operators [35]. Data security and privacy

[5] https://buildwithmatter.com/
[6] For example: ECHONET Lite (2018), EEBus SPINE (2016), EFI (2017), KNX (2013), OCT (2019), OCPP (2018), SEP-IEEE (2013), OpenADR (2015), Modbus (2012), Z-Wave, BACne

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are a key crosscutting issue for energy balancing platforms. Cyber security is necessary to ensure confidentiality, integrity and authenticity of the data. Data protection is required to guarantee that the data is exchanged and accessed in compliance with the contractual agreements between the commercial actors and the GDPR, as far as it concerns citizen data [31].
The BRIDGE initiative identified two barriers based on GDPR for actors to exchange sensitive data in smart grids [31]:

(1) *purpose limitation principle*, personal data may not be used for new purposes; and
(2) *data minimalisation principle*, sensitive data shall be kept in a form which permits identification of data subjects for no longer than is necessary for the purposes for which the personal data are processed.

Two solutions for these problems are the *anonymisation* and *aggregation* of data.

Another barrier could be that end-users need to give their consent in line with the GDPR policy. There should be tools and mechanisms for users to ensure meeting these rights [31].

Smart grid operators such as DSOs, generators, suppliers, metering operators and energy service companies are addressed to do a Data Protection Impact Assessment (DPIA) to support them to operate GDPR compliance. A DPIA helps to evaluate risks to the rights and freedoms of individuals and ensuring the protection of personal data.

Still, because of GDPR, people can choose not to share data about their energy consumption, because of sensitivity of their personal data and privacy concerns. This might significantly reduce the effectiveness of certain smart energy solutions.

Table 8. Obstacles related to GDPR in Europe.

Potential obstacles related to GDPR:

- Data management needs to be done in accordance with GDPR
- Anyone can choose not to share his / her data because of GDPR.

ebalance-plus approach

In the ebalance-plus solution the data processing is realised on different layers of the energy grid. Some operations are already happening within the household of the users. Depending on the scenario the need to transfer the detailed data may be thus avoided and it may be sufficient to send only aggregated data to external parties. The ebalance-plus approach also enables the users to define the set of other stakeholders that are allowed to access their data.

4.2.1 DSOs & data

Related UCs: *UC5 & UC7*
Related KER: *KER1 The energy balancing platform*

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A first challenge regarding DSOs and data relates to the fact that DSOs are only allowed collecting data from smart meter infrastructure. Communication platforms like ebalance-plus provide additional information that should be regulated (clearly identified and projected). Another challenge is that the data that is generated, calculated and stored from grid assets needs to be regulated as well, especially the ownership of this data. This type of regulation is currently lacking.

Table 9. Obstacles related to DSOs and data in Europe.

Potential obstacles related to DSOs and data	
• Regulation about collecting data by DSOs, other than smart meter data, is lacking. • Regulation related to the ownership of data generated, calculated, and stored from grid assets is lacking.	

4.3 Internet access

ebalance-plus enabler: *having good coverage of access to internet is key for the ebalance-plus solutions to work.*
Related UCs: *All*

In the EU internet access is widespread, but not even among Member States. Not all European countries provide communication networks (broadband, cellular) that are for example required for optimal VPP operation. For example Germany and France lack good coverage, which is an issue for the operation of DER in less populated regions [36]. Table 10 shows the situation for the analysed countries.

Table 10. Internet access in the analysed countries.

Potential obstacle: Lack of internet access. X = **Minimal obstacle,** *household internet access higher than 90%* X X = **Low obstacle,** *household internet access between 80-90%* X X X = **High obstacle,** *household internet access lower than 80%*		
	X	Internet access of households in the analysed countries can be seen is as follows: **Italy** (81%) and **Spain** (83%) have lowest level of internet access of households. **Denmark** (95%) and the **UK** (94%) have the highest level of internet access [27].
	X X	
	X X	
	X X	
	X	

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4.4 Controlling of appliances, components, and devices

Ebalance-plus UC enabler: *presence of appliances, components and devices that are controllable.*
Related UCs: *UC1, UC2, UC9, UC10, UC11*
Related KERs: *KER2, KER3, KER6, KER7, KER8*

To realise the potential of DSF it is essential that appliances can automatically respond to external stimuli (e.g., price info, control signals, or local measurements) to change the appliance´s electricity consumption pattern. Appliances should have the capability to communicate both with the user, (other) platforms, and services. However, manufacturers of appliances are not building in connectivity as a standard as they are hesitant to allow access to their devices' communication protocols. This locks out many customers from the market [37]. The exception comes from EV charging stations which are mostly automatically suitable to be connected. Furthermore, consumers have been slow in up taking smart (home) technologies, mainly because of the price differences with non-connected appliances and because the lifetime of most appliances is long [27]. Aggregators that depend on the "smartness" of consumer´s assets have found a way to deal with this, as the CEO of a large European aggregator explains (interviewee 3):

> *"It will take years and years before all these appliances* [e.g., heat pumps] *become smart because you have to install to replace them, so this is not a short-term issue… in the meantime, devices* [e.g., from aggregators] *are becoming smarter and smarter. Our devices are already able to talk with so many interfaces."*

Another barrier related to controlling appliances but also other components (such as inverters) or devices, is that manufacturers do not let other parties access their Application Programming Interfaces (APIs). Sometimes trademarks limit the access to components, or additional APIs to control their systems need to be procured. This can also be the case for existing BEMS.

Table 11. Obstacles related to controlling of devices in Europe.

Potential obstacles related to controlling of devices:

- Build-in connectivity of devices (as a standard) is absent.
- Manufacturers of appliances, components, BEMS, and devices allow limited or no control of their products.

4.5 Smart readiness of buildings

ebalance-plus enabler: *buildings with a high smart readiness indicator can be easier*

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connected with the ebalance-plus platform.
Related UCs: *Especially UC1 and UC2*

The smart readiness indicator (SRI) was introduced in 2018 in the revision of the European Energy Performance of Buildings Directive. The smart readiness of a building depends on the assessment of smart ready services and their functionality present in a building. Energy flexibility, and the ability of a building to participate in demand response, is one of the key criteria of the SRI [36]. A good SRI can be a key enabler for the implementation of energy balancing platforms and their communication with the distribution grid. In the EU, the smart readiness of buildings and building´s contribution to energy flexibility remain low, as can be seen in Table 12 [36].

Table 12. The smart readiness of building in the analysed countries and Europe.

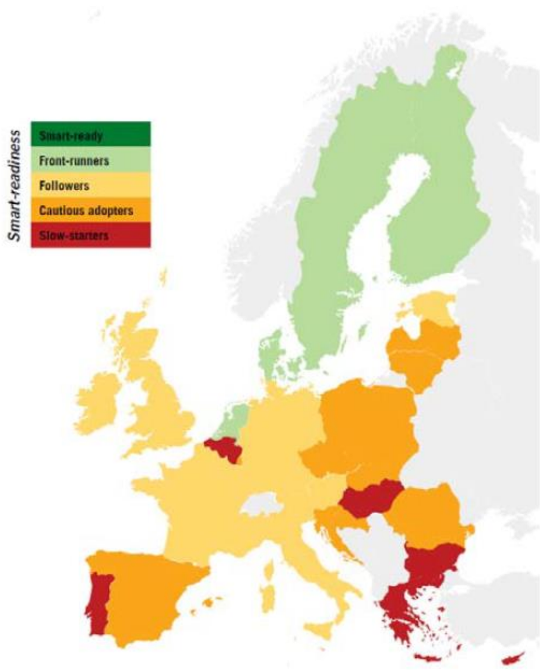
<table>
<tr><td colspan="3">Potential obstacle: The smart readiness of buildings is low.
X = Minimal obstacle, “front-runner” smart readiness of buildings
X X = Small obstacle, “follower” of smart readiness of buildings
X X X = Large obstacle, “cautious adopter” of smart readiness of buildings</td></tr>
<tr><td></td><td>X</td><td rowspan="5">In a holistic study of the smart readiness of buildings, several more indicators were taken into account (smart meter deployment, dynamic market, broadband access, DR availability or renewable energy access). Denmark is the furthest advanced, followed by France, UK and Italy, and after that Spain (Figure 4).


Figure 3. Smart readiness of EU Member States (BPIE in [27]).</td></tr>
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<tr><td></td><td>X X X</td></tr>
<tr><td></td><td>X X</td></tr>
</table>

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4.6 Smart meters

Ebalance-plus enabler: *high smart meter penetration and smart meters with the right functionalities.*
Related UCs: *UC1, UC2, UC9, UC10, UC11*

Smart meters are a key enabler of demand response services and functioning flexibility markets. The EC requires each Member State with a positive Cost Benefit Analysis (CBA) to provide smart meters to 80% of all network users in 2020[7] [38]. DSOs are responsible for the roll-out of smart meters in most countries [4].
The EU rules oblige accurate and frequent metering of consumer energy and access to relevant information under the Directive on Energy Efficiency (2018/844). The directive sets out that for all newly installed heating, cooling and domestic hot water meters and heat cost allocators will be devices that can be remotely read, the information being available to the respective users [39].
Furthermore, smart meters need to meet the requirements on measurement precision and delivery time. A set of common minimum functional requirements for smart meters in the EU has been set out by the EC in 2012. Registration of time-of-use (ToU) metering data every 15 minutes is a prerequisite for ToU tariffs and dynamic prices [40]. Not all smart meters do meet this requirement yet. Table 13 and Figure 5 provide more information about the situation in Europe.

Table 13 Smart metering in the analysed countries & Smart meters time measurements [40, 41]

<table>
<tr><th colspan="3">Potential obstacle: Smart meter penetration & smart-meter functionalities (e.g., frequency measurements in time and spatial resolutions, remote management) not sufficient.
✗ = No obstacle, smart meter roll-out finished or in far progress, new smart meters have right functionalities
✗✗ = Low obstacle, smart meter roll-out in progress
✗✗✗ = High obstacle, no smart meter roll-out planned, low smart meter penetration</th></tr>
<tr><td></td><td>✗</td><td>Denmark has no mandatory nationwide-roll-out. However, DSOs nevertheless went ahead with the smart meter installation based on individual targets. Denmark reached a 100% smart meter roll-out in 2020. Most meters meter with a 15 min frequency.</td></tr>
<tr><td></td><td>✗</td><td>France has adopted a framework for a country-wide roll-out but is still working on its execution and reached 90% by 2020, the full deployment is scheduled to be completed by the end of 2022 [20]. France is introducing its new meters called “Linky” [42]. The meters meter every 30 minutes and there is a protocol that allows energy management systems to get the needed data from the Linky meters [20].</td></tr>
<tr><td></td><td>✗</td><td>Italy was a pioneer in smart meter roll out and replaced all its conventional meters by 2011. Italy is now challenged by outdated infrastructure and is working on the roll-out of a second generation of smart meters, which should be completed in 2026 [20]. The meters meter every 15 minutes or the newest meters even close</td></tr>
</table>

[7] If 80% of EU citizens is to be equipped with smart meters, this corresponds to 200 million smart meters in total.

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		to real time. The 2G LV meters can supply data to Energy Management systems.
	X	**Spain** is also a pioneer if it comes to smart-meter roll-out and reached a national-wide roll-out already but is lacking the utilisation of this hardware. The smart meters are interoperable in terms of sharing data at a central system layer. Datadis is a national data hub platform that joins all national DSO Smart Meter information [20].
	X X	The **UK** will complete its smart-meter roll-out in 2024 [43], the meters measure every 10 minutes.

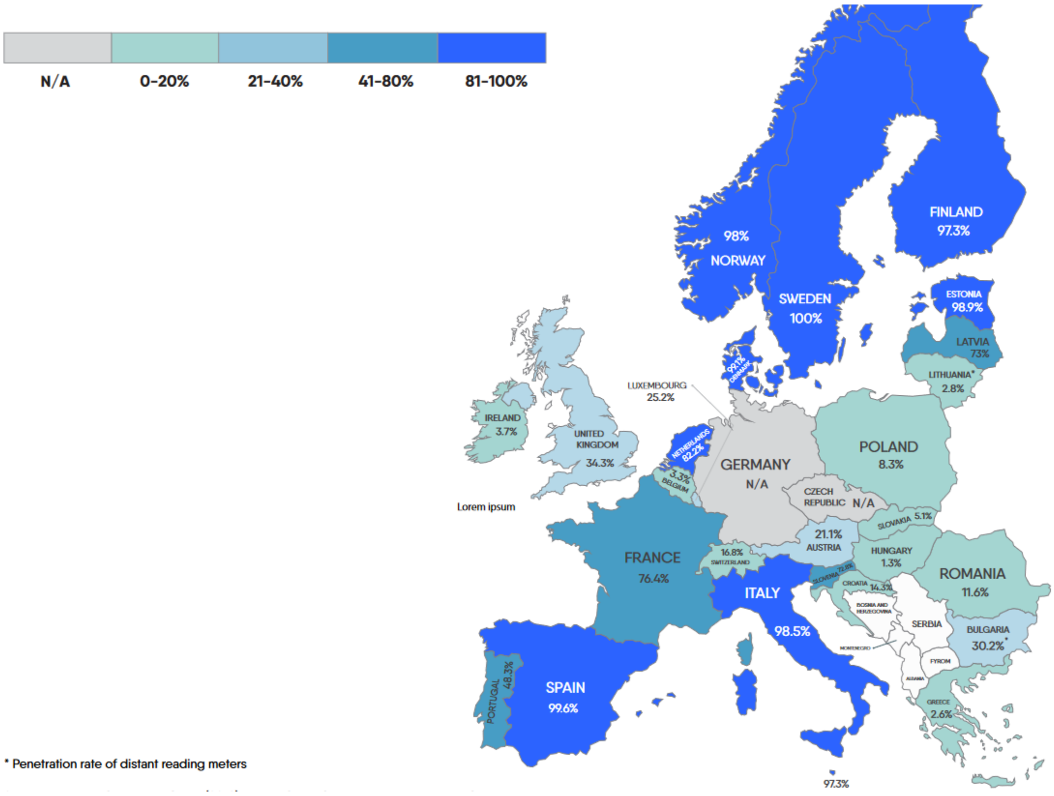

Figure 4. Smart meter penetration in Europe [44].

4.5 Metering data access and exchange

Ebalance-plus enabler: *access to data and exchanging data are key for the ebalance-plus platform to add value.*
Related UCs: *UC8, UC9, UC10*
Related KERs: *KER9*

Timely access to correct and historical interval data is crucial for the business model of market parties using energy balancing platforms such as independent aggregators [45]. Lack of access to customer data can form a market entry barrier for new service

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providers. The Electricity Directive (Directive (EU) 2019/944) prescribes the following criteria to regarding data management [41]:

- Availability of metering data and settlement at the same time resolution as the national imbalance settlement period.
- Access to (and exchange of) data for the customer and eligible third parties. For this purpose, data is understood to include metering and consumption data as well as data required for customer switching, demand response and other services.

The Electricity Directive indicates that data management parties (DSOs in most EU countries) should provide access to data upwards the value chain (to TSOs) and downwards (to consumers, suppliers, or other market participants) [46]. However, unclarities remain about specifies which data from smart meters may be accessed and used by whom under the new European privacy legalisation [45]. The use of energy balancing platforms complicates the matter even more, because these platforms might produce additional (consumer) data, and it is unclear if DSOs are allowed to handle this data, and how this should be protected.

The EC aims to reduce market entry barriers through stimulating the formation of centralised, regulated data management platforms or *data hubs.* Several countries are developing data hubs, mainly to facilitate well-functioning retail markets with data access for different market participants based on standard data formats. Data hubs are important for the ebalance-plus flexibility mechanisms use case cluster, especially for the establishment of VPPs by independent market players.

Table 14 summarises the situation in the analysed countries. In **Spain, Italy,** and **France**, DSOs are still highly involved in the management of smart meter data. This might have to do with the high market share of a single DSO in these countries; in Italy *E-Distribuzione* (7500 municipalities), in Spain *Iberdrola Distribución Eléctrica* (covers 10 autonomous communities and 25 provinces of Spain) and in France *Enedis* (95% of the electricity distribution network in continental France) [47].

Table 14. Consumer data management in the analysed countries [47, 48]

Potential obstacle: Third parties have no timely access to smart meter (consumer) data.

X **= No obstacle,** *central datahubs are fully functioning, all eligible third parties have real-time access to consumer data*
X X **= Small obstacle**, *data is accessible for eligible third-parties functioning, but third parties have no real-time access to consumer*
X X X **= Large obstacle,** *data access is decentralised (e.g., involvement DSOs), third parties only have non-timely access to consumer data*

	X X	In **Denmark**, a “datahub” owned and operated by TSO Energinet, is the central access point for suppliers to access all metering data of customers, which removes the need for suppliers to communicate with each DSO directly [49]. The data hub can be used for the procurement of DER for flexibility to improve collaboration between TSO and DSOs. The Danish data hub is fully implemented and handles all communication between suppliers and DSOs [50].

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<table>
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<td>
Suppliers are responsible for the customers data (e.g. registration of customer information). The DSOs are responsible for data on metering points (registering disruption of grid connection, new grid connection, etc.), but Energinet is responsible under the datahub for storing, metering, collecting and securing the validation of data. The datahub is a supplier centric model that strengthens the empowerment and creates incentives for suppliers and third parties to create new products and services [5]. Datahub can be accessed by customers to see their own data, and Energinet offers aggregated data to registered research institutions and the public for research and information purposes.
Eligible parties, such as aggregators, have access to metering data as long as they have permission form the property owners (agreement). Data is not available in real time. If there are no consents, usually only the utility provider has access to metering data which is available to them after 24 hours.

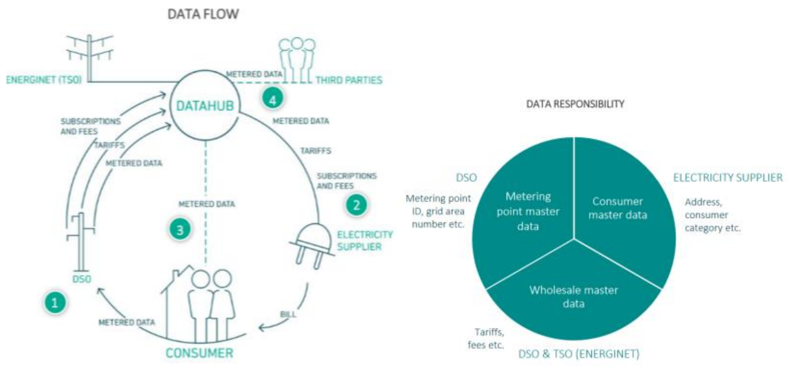

Figure 5. Data flow and responsibility in Denmark [51].
</td>
</tr>
<tr>
<td></td>
<td>✗✗</td>
<td>In France, DSOs implement smart meters (Enedis installs the Linky Meter), and own and read them. Eligible third parties have access to end-consumer data in a decentralised way and free of charge, through the DSOs. This access is only granted when customers authorise these third parties to obtain them. Eligible parties have no access to metering data in real time.</td>
</tr>
<tr>
<td></td>
<td>✗✗✗</td>
<td>In Italy, DSOs are responsible to provide suppliers with data. Currently, eligible parties can obtain metering data delayed by about a month by the DSO and TSO. If they need metering data in real time, eligible parties have to install their own metering system. Suppliers can access energy consumption data for billing and regulated purposes. A public entity, a third-party company called Acquirente Unico (AU), will increasingly manage data access on behalf of the National Regulatory Authority. AU will collect commercial and metering data from DSOs and will manage the exchange of this data with the TSO and retailers. It will host a complete database of customer's records and meter data and will be the central hub for cross-operator data communication, which decreases the responsibilities for DSOs. The data from the meter, as well as technical and commercial data will be held by the AU and the AU will make it available for suppliers. The DSO will only be responsible for meter readings, collecting and storing metering</td>
</tr>
</table>

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		data and validating them. The second generation of smart meters in Italy will also make data directly available in real time at home through users' in-home devices [5]. Italy has developed a datahub for the procurement of DER for flexibility, to stimulate the collaboration between TSO and DSOs [50].
	✗✗✗	In **Spain**, DSOs are in charge of metering data management. DSOs have a database with personal and consumption data of their network users, accessible for suppliers and the regulator (Supply Point Information System – SIPS) [52]. DSOs provide only limited access to the meter readings to third parties. A main problem for retailers with metering data in Spain is that they do not have real time data from smart meters managed by the DSO but can only access customers' consumption data on a daily basis with a delay of one day [53]. In the future, the aim is to have a single point of contact for all DSOs databases and a common data format, that guarantees neutrality non-discrimination and efficient process. This metering system that will be used is called SIMEL and is managed by the TSO. The TSO will measure and collect data of some network points and the rest of the network data will be measured and collected by the DSOs. In the future model, the Comisión Nacional de los Mercados y la Competencia (CNMC) collects the DSOs databases and standardises and formats them in a single contract point for suppliers to access them [5].
	✗✗	In the **UK** smart meter implementation, ownership and reading is done by energy retailers. Access for third parties is via these retailers or private companies [54].

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5. Energy flexibility assets

This chapter presents the identified barriers for different ebalance-plus UCs and KERs related to energy flexibility assets. Table 15 shows the energy flexibility assets that are deployed in the ebalance-plus demo-sides. Relevant regulatory issues for V2G and electricity storage are analysed in this chapter.

Table 15. Energy flexibility assets existing or deployed in ebalance-plus demo-sides.

Flexibility asset	Summer houses (Denmark)	Catholic Institute in Lille (France)	University of Calabria (Italy)	University of Malaga (Spain)
Energy storage				
Stand-alone batteries		x	x	x
DER - generation				
PV		x	x	x
Air handling units		x		x
Boilers	x	x		
Heat pumps	x		x	x
V2G				
EV charging stations		x		x (inc. V2G infrastructure)
Appliances				
Commercial and residential appliances			x	

5.1 Platform (ownership, investment, maintenance, terminology)

Ebalance-plus UC enabler: *clarity regarding ownership, investment, maintenance and terminology of energy balancing platforms.*
Related UCs: *all*

Innovative energy balancing platforms like the ebalance-plus platform, are a new type of infrastructure asset that leads several open questions, such as the unclarity about the ownership of these types of platforms. And thus, it is unclear who would invest in their installation, the management units, and the maintenance of hardware like servers or the cost of data storage.
There is a need for planning among all stakeholders, to make sure that future processes and systems enabled by energy balancing platform will be successful.
Furthermore, lack of shared terminology around energy balancing- or flexibility platforms causes a lot of unclarity. A good clear set of definitions could help to improve principles, standards, regulations and structures [32]. Table 16 summarises these obstacles.

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Table 16. Obstacles related to platform & management units in Europe.

Potential obstacles related to platform & management units:

- Unclear ownership, investment, and maintenance of innovative types of energy balancing platforms and related management units

5.2 Energy storage

Ebalance-plus UC enabler: *energy storage used at distribution level in a versatile way receiving reasonable compensation. Storage can participate in the electricity market, without barriers and under fair conditions.*
Related UCs: *UC8 & UC9*

Electricity storage is an essential complement to using renewable energy generation. At the distribution level storage can aid in power quality issues, increase the lifespan of the distribution system, and avoid building substations [55]. Its largest value lays in providing ancillary services, but several market and regulatory restrictions are still present [55]. The biggest barrier to energy storage in the EU legislative landscape is the lack of attention paid to storage itself, when the Electricity Directive (Directive 2009/72/EC) was published, energy storage was not included in the picture [56]. Storage is often considered a generation system, but this interpretation overlooks an entire set of services and properties of storage systems [56]. The lack of clarity concerning the definition of storage leads to taxation on storage systems for both generation and consumption and high grid charges. Double charges or fees for storage systems are still in place, despite Article 21.2 of the *Renewable Energy Directive (RED II)* that states that there should be no double charges [36].
Furthermore, electricity storage has still difficulty in lowering the cost of kWh below grid parity. To stimulate the inclusion of electricity storage in power systems, storage should be allowed participate in DR mechanisms in the electricity markets. Overall, storage will not necessarily receive compensation for all the services it can provide due to regulation restrictions [55]. Financial incentives should be put in place to help in the integration of distributed energy storage at buildings and districts.

Table 17. Regulatory aspects related to storage in the analysed countries [40]

Potential obstacles related to electricity storage:

- The legal status of storage is not cleared.
- Barriers for electricity storage to participate in the electricity market.
- Double grid fees/tariffs/taxes for energy storage.

X = **No obstacle**, *electricity storage used at distribution level in a versatile way receiving reasonable compensation (no double charges), can participate in the electricity market, without barriers and under fair conditions.*
XX = ***Low obstacle***, *electricity storage used at distribution level in a versatile way, there are double charges in place, and storage cannot participate in the electricity market without barriers and under fair conditions.*

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✕✕✕ = ***High obstacle**, electricity storage not used at distribution level in a versatile way, there are double charges in place, and storage cannot participate in the electricity market*		
	✕✕	In **Denmark**, a clear framework for storage to participate in the market is missing [57]. Storage is double taxed [40].
	✕	In **France**, a barrier is formed by the feed-in tariffs for electricity production, which favour the direct injection of electricity into the grid, rather than storage [58]. However, France has eliminated the double network charges for storage [20] and storage may participate in ancillary services [59].
	✕✕	A main barrier for the uptake of electricity storage in **Italy** are the high grid charges and the presence of net-metering [60]. On the positive side, double network charges for storage do not exist in Italy [20]. The legal status of storage is cleared based on CE 0-21 and CEI 0-16[8]; any storage system must be considered as a generator.[9] Storage may participate in ancillary services [59].
	✕✕	Legislation around storage in **Spain** is complex. Electricity storage is not separately regulated and counts as generation [60]. Storage is not allowed in ancillary services [59]. Spain has no double network charges for customers owning a storage facility, which is a positive factor towards storage uptake [20].
	✕✕	In **UK** storage is double charged [40]. Electricity storage cannot completely fairly alongside other energy technologies in the market [43]. But storage may participate in ancillary services [59].

5.3 V2G

Ebalance-plus UC enabler: *Use of V2G without double taxation, availability of smart charging stations with V2G capabilities.*
Related UC: *UC8*

Bi-directional smart charging, or vehicle-to-grid (V2G), allows EVs to provide services to the grid in the discharge mode. The impact of V2G technology in the distribution network has a significant effect on grid balancing and can help to suppress power peaks in the network. V2G can help solving local power issues, that might be caused by increased usage of EVs. Furthermore, customers at home level will obtain a product with two functionalities: transport and energy storage.

[8] https://www.ceinorme.it/it/norme-cei-0-16-e-0-21.html
[9] Italy is an exception if it comes to ownership of energy storage systems by system operators. The Italian government allows TSOs and DSOs to build and operate batteries under certain conditions. TSO Terna launched two grid-connected battery energy storage pilot projects [56].

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EVs and the charging infrastructure are defined in the *Deployment of Alternative Fuels Infrastructure Directive*, but this Directive does not explicitly describe smart charging or V2G and its electricity system integration. When EV users apply V2G or smart charging they are categorised as “renewables self-consumers” by *RED II, Article 2.14*, or “active customers” by *articles 2(8) and 16 of the Internal Energy Market Directive (IEMD)*. Thus, they are explicitly entitled to non-discrimination (= not subject to chargers or fees for self-consumed electricity or double charging), cost-reflective network charges, and to request a dynamic contract with a supplier, like all customers [36].

The roll-out of V2G is hindered by the difficulty to connect EV as a grid resource. Regulatory frameworks do often not recognize EVs as a DER. For example in Germany, anyone who wants to feed electricity from their EV battery into the grid is subject to numerous levies – both when storing and discharging [61].

The development of V2G services and a commercial model around V2G is, similar like battery storage, hindered by double taxation for charge and discharge in many countries [62]. The role and status of V2G as a form of participation in energy markets should be clarified in EU regulations, including a prohibition against discrimination regarding generation assets. Grid charges and taxation for grid feed-in must be established and EVs should be categorised as a generator to avoid double-charging [36].

Some of the present EV models and charging infrastructure are not designed for bi-directional charging. Generally, the roll-out of smart charging infrastructure has not been finished and charging infrastructure with V2G capabilities is very rare in most Member States. The presence of inadequate and expensive metering concepts for DER hinders the uptake of V2G [61].
Furthermore, the absence of dynamic pricing schemes, or time-of-use tariffs (ToU) and the electricity network tariff design that could stimulate EV users to change their charging patterns to different times of the day, are barriers for V2G to take off. Financial incentives should be sufficiently profitable to compensate for a potential loss of comfort [36, 61, 63].

Also, the lack of a globally valid standard interface in the global EV market and the lack of standard interoperability hinders the development of V2G. Real-time communication between grid operator, charging equipment and vehicle requires unified standards, and this is not always the case [61, 63]. There is also a serious need to go beyond technical approaches and consider the social engagement and willingness to participate among consumers (see Deliverable 2.1 and 2.2).

Table 18. V2G regulatory aspects the analysed countries [4, 40, 61, 64, 65]

Potential obstacles related to V2G:

- Connecting EVs as DER to the grid is not always recognized in regulation.
- Double taxation for bidirectional charging.
- Lack of global standard interface in EV market for real time communication.
- Lack of dynamic and ToU tariffs that reflect grid congestion.
- Lack of charging stations with V2G capabilities.

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X **= No obstacles,** *no double taxation on EV battery (re)charging, EVs may participate in ancillary services, V2G charging stations are being installed*
X X **= Low obstacles,** *no double taxation and smart-charging infrastructure roll-out*
X X X **= High obstacles,** *double taxation & no smart-charging infrastructure roll-out*

	X	**Denmark** is a forerunner country if it comes to V2G, as the country hosts several world leading V2G demonstration projects [62, 66]. DSO charges and double-charging have been removed for electromobility, and EVs already participate in ancillary services in Denmark (minimum requirement of 100 kW) [67]. However, charging stations with V2G technology are not public yet. Some projects work on commercial and technical solutions of V2G in Denmark. Active roll-out of smart-charging stations is ongoing.
	X X X	In **France**, EV batteries are double taxed. There is no smart-charging infrastructure roll-out, but any new infrastructure must be able to be remotely controlled and receive tariff signals through the meter [40]. The prices for EVs are considered to be (too) high in France, which slows-down their adoption.
	X X X	**Italy** is rolling out smart charging infrastructure. Like batteries, EVs are double taxed, which is a disincentive for the business case of V2G. Recently, Italy is opening up its balancing markets for the participation of aggregation of storage systems, including e-mobility charging stations [43]
	X X	In **Spain,** EV batteries are not double taxed. The participation of V2G services in electricity markets is not possible. Spain has some smart-charging stations available across the country, but generally the country has a lack of EV charging points infrastructure.
	X X	**UK** has double taxation on EV battery (re)charging and has reduced public smart charging presence. EVs may participate in the electricity markets.

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6. DR, aggregation, and flexible consumers

This chapter presents the identified barriers for different ebalance-plus UCs and KERs related to DR, aggregation, and flexible consumers.

6.1 Demand response and aggregation

Ebalance-plus UC enabler: *demand response (DR) aggregation is allowed to participate in the market, and independent aggregators do not face barriers to enter the market.*
Related UCs: *UC8, UC9, UC11*

Aggregators are key stakeholders in market-based flexibility mechanisms, and as prescribed in the CEP, they should be allowed in the electricity markets to enable small consumers to participate in DR and thereby extract the value of flexibility services on behalf of their customers [68, 69]. However, in most EU Member States it is difficult for (small) independent aggregators to access the market. When markets are open to load aggregation, they are still mostly focused on industrial or large energy consumers [70]. Market participants need to offer a certain size and meet a certain MW bid-size threshold, these and other specific market rules hinder participation of small players [45].

Another problem is that traditional energy companies are resisting independent aggregators as they are seen as a thread to their business model [71] (Interviewee 3). A related market entry barrier is formed by the prior consent that independent aggregators need to obtain from consumers´ retailer before they may engage with them. The only exceptions are France and Germany (only for the balancing market). Retailers can still discriminate against customers that engage with an aggregator in most countries, except France, Italy, Romania and soon Finland and the UK [67]. A last market barrier is the disproportionate compensation for energy imbalances that some independent aggregators might face when they activate flexibility from retailers´ customers [72].

Other markets than balancing markets in EU Member States still provide very few opportunities for DR. The CEO of a large European aggregator argues that the main market for DR should be the day-ahead wholesale market, as this is the core market for generation, and DR should be considered as a reliable means that can compete with generation (Interviewee 3).

In most markets where demand aggregation is allowed, there is a lack of regulation and an absence of a legal framework for independent aggregation [38, 70, 73]. Roles and responsibilities are unclear. This means in these contexts that only retailers are able to provide aggregation services to consumers [74]. The following issues need to be clarified to enable aggregators to participate in the market: (1) a clear allocation of energy volumes; (2) an appropriate methodology for baselining; (3) fair renumeration for DR, similar as for generation [45]. Additionally, the allocation of the balancing responsibility and relationship between retailers, Balance Responsible Parties (BRPs)

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and independent aggregators needs to be cleared. According to the European Smart Grid Task Force, balancing responsibilities for aggregators should be reduced/limited to lower market entry barriers. Moreover, aggregators should be allowed to provide flexibility without having to have a contract in parallel with the retailer of the BRP on the site. Lastly, penalisation for not dispatching the committed energy should be reduced to incentivise demand side participation [73].

All-in-all, despite all progress, a set of EU electricity market failures still prevent the scale-up of adding DSF into the system [75]. This also complicates certain UCs that can be enabled by the ebalance-plus solutions (see also Deliverable 1.1 for specific market requirements).

6.1.1 Denmark

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 [76]. Generally, the demand for flexibility from TSOs and DSOs is low.

Situation in the balancing market

Consumers and independent aggregators in Denmark are firstly allowed participating in the balancing markets (Table 19). But independent aggregators must register themselves as suppliers and a BRP, which in practice means that these aggregators need a cooperation with an energy provider and/or BRP, which is a barrier to market participation [57]. This reduces the available offers and most ancillary services are provided by retailers [76].

The primary control reserve (FCR) is based on daily tenders by Energinet in two areas: West and East Denmark. Entering the FCR is in principle allowed for small consumers and aggregated assets, but is not easy for small parties because in a bid generation and consumption may not be mixed, which is a barrier for storage, which can provide both [57]. The secondary control reserve (aFRR) is in practice not accessible for DSF, because Denmark has a bilateral contract with the Norwegian TSO Statnett with a duration of 5 years. The tertiary control reserve (mFRR) in Denmark is part of a common Nordic market for mFRR [77]. The mFRR is based on daily tenders. A entry barrier is formed by the need to have a control centre operating 24/7, which is costly and forms an entry barrier for new market entrants [57]. Overall, the primary and tertiary control are the most accessible programmes for DR participation. The Nordic TSOs are currently developing a new Nordic Balancing Model. The idea is to have a common Nordic capacity market for aFRRs and mFRRs and the implementation of a 15 minute imbalance settlement period [77].

All-in-all, the products in the balancing markets fit generators and focus on these actors, minimum bid sizes are high, and are not designed for DSF [78]. As a result, 5 BRPs participate (as aggregators) regularly in the Danish balancing markets, all larger than 50 MW [57].

Table 19. Explicit DSF products Denmark [57, 79]

Service	Product	Open to DSF
Wholesale	Day-ahead / Intra-day	Not open to DSF

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Balancing	FCR	Yes, also open to independent aggregation, but high entry barriers (e.g., long (4 hours) activation period)
	aFRR	Yes, in theory also open to independent aggregation. However bilateral contract with Norwegian TSO for 5 years
	mFRR	Yes, also open to independent aggregation, but high entry barriers (e.g., minimum bid 5 MW)

6.1.2 France

France is one of the leading countries in participation of the demand side in ancillary service markets. The independent aggregator framework is worked out in detail. This has been a key regulatory evolution implemented in 2014: the *Demand Response Block Exchange Notification* or "NEBEF[10]" mechanism [57]. It allows aggregators and consumers to provide flexibility without having to have a contract in parallel with the supplier of the BRP of the site, which significantly simplifies market entrance (exception is the mFRR market, where agreement with the BRP is needed). Both the balancing markets and the wholesale market are open to aggregation DR (Table 20).

<u>Situation in the wholesale market</u>

France is the only country in the EU that enables independent aggregation on wholesale markets using the NEBEF mechanism [80]. There is a transfer of energy mechanism active that ensures that suppliers are compensated by independent aggregators that source energy [81]. But, this conflict of interest between energy producers, aggregators, and distributors still hinders the business case for aggregators in France.

As the CEO of a large European aggregator explains (interviewee 3):
"And for the time being, like France, which is where the market is in principle open, but in fact it is not open because when you sell in the market, you have to reimburse EDF[11] basically all your revenues, that in fact means there is a radical economical barrier that makes the participation in the French market impossible. And this is why the European directive is so important and was supported by France, too."

<u>Situation in the balancing market</u>

As mentioned, France's balancing markets are almost fully open and allow participation of DR aggregation and DER aggregation [57] (Table 20):

- FCR is an auction held on D-2 basis and open to DR. Industrial consumers as well as aggregators pooling resources from the residential level up to the industry level participate. An entry barrier for aggregators comes from the fact that DR and generation cannot be mixed in the same pool [57].
- The aFRR market is open for DSF [59].
- mFRR is a yearly tender that guarantees a fixed annual amount of mFRR. The minimum bid size is 10MW and the activation time 15 minutes. This forms a barrier for small market participants. Additionally, DR and generation cannot be mixed in the same pool [57]

<u>Capacity mechanism</u>

[10] Notification d'Echanges de Blocs d'Effacement
[11] Large electricity supplier in France.

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Furthermore, France approved new capacity market mechanisms in 2018, and DR and DER are allowed to participate in capacity markets [50]. The capacity mechanisms are necessary to safeguard the security of supply during peak winter periods [81].

Table 20. Explicit DSF products in France [59, 81]

Service	Product	Open to DSF	Aggregation allowed	Require BRP	Renumeration type	Size
Wholesale	Day-ahead / Intra-day	Yes. Either in supplier/BRP portfolio or through NEBEF for aggregators.	Yes	N/A	Energy based	27 GWh activated through the NEBEF mechanism
Balancing	FCR	Yes, also open to independent aggregation	Yes	Yes	Capacity and energy based (spot price)	70MW (out of 570 MW in total) in 2018
	aFRR	Yes, aggregation is allowed in generation. Aggregated load, through a secondary market, is also allowed but never used in practice.	Yes	Yes	Capacity based (regulated price) and activation based	No DR participation
	mFRR	Yes. Either in BRP portfolio or through load aggregator	Yes	Yes	Availability and activation payment	More than a third of the reserves procured, come from demand side response providers. 727MW were offered on average, in 2018.
	RR	Yes	Yes	Yes	Availability and activation payment	N/A
Adequacy	Capacity Mechanism	Yes	N/A	N/A	Capacity based	1,7 GW

6.1.3 Italy

Italian legislation introduces the possibility of participation in the markets for both production and consumption units, without size limits but in aggregated form.

<u>Situation in the balancing market</u>

Since 2017, through pilot projects, the ancillary services market is open for aggregators. Aggregators are players seen as a Balance Service Provider (BSP). The BSP does not have to have a contract with the BRP and can provide services directly to the TSO [82]. They may aggregate small generation and / or consumption units and storage systems (including e-mobility charging stations). The pilot projects that have been running since 2017 are [43] (Table 21):

- **UVAP**: Virtually Aggregated Production Units – including production units and storage systems (2017-2018)
- **UVAC**: Virtually Aggregated Consumption Units – including only consumption units (2017-2018)

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- **UVAM**: Virtually Aggregated Mixed Units – including production units, storage systems, EVs in V2G mode, and consumption units (ongoing since 2018)
- **UPR** (relevant generation units) (ongoing since 2017)

These projects have been completely integrated and participate with more than 830 MW so far with the goal of 1000 MW by the end of 2019 [83]. There are 25 BSPs (aggregators) registered and assigned to a UVA so far [43]. Through these projects, distributed resources that do not meet minimum requirements defined by the Terna's Grid Code are enabled to provide ancillary services such as congestion management, balancing and tertiary control reserve services (mFRR). DSF is also allowed to participate in the secondary reserve (aFRR) since December 2021, but high metering and testing requirements still form a barrier to DSF participation [59]. The primary control reserve (FCR) products are not open to the market, as it is mandatory for generators and conventional power plants with an installed capacity of 10 MW to provide it. The tertiary control reserve (mFRR) is therefore the most accessible program for DR participation through the UVAM project. The minimum bid size is 1 MW for 1 hour of delivery, which might be achieved through aggregation of different units [57]. There is an ongoing discussion to reduce the minimum bid size to 0.2 MW A barrier for the business case based on the UVAM mechanism are the low price margins [76]

In January 2020, Edistribuzione (Italy´s main electricity utility) conducted its first DR pilot for aggregated residential storage assets in the UVAM managed by Terna [84]. According to TSO Terna, Italy has made most progress in Europe in the last years to enable DER on the dispatching services market [83].

Table 21. Explicit DSF products Italy [43, 57, 59]

Service	Product	Open to DSF	Aggregation allowed	Require BRP agreement
Wholesale	Day-ahead / Intra-day	No, also not to aggregation	No	N/A
Balancing	FCR	No, mandatory for conventional power plants	N/A	N/A
	aFRR	Yes	Yes	Yes
	mFRR (UVAM) – consumption points, non-relevant & relevant generation points, storage installations	Yes, minimal 1 MW power, increase or decrease generation of at least 1 MW within 15 min from Terna´s request	Yes	Yes
	mFRR (UVAC) – consumption points	Yes, minimal 1-10MW power, reduction of consumption on at least 1 MW within 15 min from Terna´s request	Yes	Yes
	mFRR (UVAP) - non-relevant generation points	Yes, minimal 1-5 MW power threshold, increase or decrease generation of at least 1 MW within 15 min from Terna´s request	Yes	Yes
	RR	Yes	Yes	Yes

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	Interruptible contract	Yes, but a minimal curtailment potential of 1 MW per site, response time is 200 ms. Participation requires a smart meter with remote control triggered by the TSO [82]	N/A	N/A

6.1.4 Spain

Spain does not yet accomplish the CEP, as independent aggregators are not active yet and aggregation is only allowed through retailers that aggregate resources in different markets. This is changing slowly (Table 22). Since January 2021, prosumers can provide balancing services to the market through aggregation offered by suppliers, and as of Q2 2022 this will also be possible via independent aggregators. In June 2020, the independent aggregator was recognised in a new Royal Decree-law (23/2020) following the implementation of the EMD. The actual implementation of the regulatory framework to allow independent aggregators in Spain is foreseen in October 2022 [20].

The Spanish TSO (REE) is responsible for the implementation of independent aggregators in the power system. The conditions for independent aggregators are not clear yet and might continue to be restrictive, for example as it will not be possible to aggregation generation loads or stack services [76]. Spain still needs to develop regulation to regulate the relationship between energy suppliers (BRPs) and independent aggregators (e.g. monetary compensation, balance responsibility, exchange of data, etc.) [20].

The only demand-side type of reserve in Spain is the Demand Interpretability Service run by REE, which is exclusively provided by large industrial consumers with more than 5 MW, as aggregation is not allowed. Moreover, this program acts as an last-resort mechanism, in case the system lacks generation and the balance resources are not enough, which is very seldom [57, 85].

Table 22. Explicit DSF Spain [57, 59]

Service	Product	Open to DSF	Aggregation allowed	Require BRP agreement
Wholesale	Day-ahead / Intra-day	No, not open to DSF.	N/A	N/A
Balancing	FCR	No	N/A	N/A
	aFRR	Yes, but the barriers for aFRR & mFRR are high, minimum size 200 MW for participation in aFRR.	No	Yes
	mFRR	Yes	Yes	Yes
	Interoperability services	Open for DSF, but no aggregation allowed, and minimum size is 5 MW. The market size for DSF was 2.6 GW of capacity in 2018.	No	N/A

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6.1.5 UK

Flexibility provision in the UK is complex. There are several different markets at regional and national level. Challenges are at national level that markets require scale and at regional level that the availability fluctuates.

Situation in the wholesale market

The wholesale market is open to aggregators. Price volatility is high, but not high enough for demand-side response providers. Recently, the dispute between suppliers that are exposed to delivery / imbalance risks due to the activity of independent aggregators, has been addressed by Ofgem. Ofgem suggests that the costs associated to balancing and delivery risks should be carried by the actors who produced them, thus aggregators [43].

Balancing market

UK's balancing market is one of the most progressive in Europe. It was one of the first to allow DSF to participate in electricity markets (Table 23) [57]. Almost all ancillary services programmes are open to DR and aggregation. The competition is high, and this makes accessing this market difficult for new parties such as aggregators. The recent Wider Access balancing mechanisms allows independent aggregators to enter under the name of virtual lead parties (VLPs). This arrangement allows customers to offer generation and demand side response to a market which was originally the domain of large power stations. They can participate in this market independently of the customer's electricity supplier (BRP) [43]. The other way to participate in a balancing mechanism in the UK is through supplier volume allocation, consisting of around 20 different products [43], which do not all have requirements that fit small customers.

Capacity market

The capacity market mechanism in the UK is open for DSF, but presents various barriers to the participation of aggregators (e.g. long-term contracts) [43]. The capacity market was introduced to ensure continuous electricity supply in times of stress, while more unpredictable renewable energy plants were included in the grid. It operates in parallel with the energy market and is supported by the balancing market. Participants are paid per MW for the capacity they offer to the market [86]

Table 23. Explicit DSF products in UK [43, 59]

Service	Product	Open to DSF	Aggregation allowed	Require BRP agreement
Wholesale	DA	Yes, through suppliers	N/A	N/A
Balancing	FCR	Yes	Yes	No
	aFRR & mFRR	Yes, but minimum bid size of 25 MW	Yes	No
Adequacy	Capacity market	Yes	N/A	N/A

Country analysis summary

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Table 24 presents a summary of Section 6.1.

Table 24. Summary aggregation access to the market [57, 87]

Potential obstacles DR and aggregation:

- Small-scale (aggregated) assets as a resource are not accepted in all markets.
- Hurdles for small (independent) aggregators to access and compete in the market (e.g. prior consent to engage with the customer, registration as BRP/energy supplier needed, too big minimum sizes, to long minimum up/down times).

X = **No obstacles,** *all markets open for aggregated DR, fair competition for independent aggregators*

X X = **Low obstacles,** *some markets open for aggregated DR, entry barriers still exist*

X X X = **High obstacles,** *no market access for aggregated DR*

	X X	Aggregated assets have access to the market, but entry barriers because independent aggregators must register as supplier and BRP, no clear baseline methodology [88].
	X	Aggregated assets have access to all markets, independent aggregators do not have to have a contract with supplier or BRP and can operate in parallel.
	X X	Aggregated assets have access in the UVA pilots in the balancing market.
	X X X	DR only possible for large energy consumers, independent aggregators are expected in 2022.
	X	Aggregated assets allowed on all markets.

6.2 Dynamic tariffs

Ebalance-plus UC enabler: *prosumers are offered diverse dynamic electricity pricing schemes to stimulate implicit DR.*
Relation UCs: *especially UC 10 – customer power consumption control based on ToU electricity and network tariffs.*

To incentivise consumers to participate in implicit DR, suppliers should offer consumers prices that vary hourly or even in shorter time intervals to reflect the market conditions (e.g. power system balance or short-term wholesale market price signals). This is anchored in *Article 11* of the *IEMD*, which says that the national framework should enables suppliers to offer dynamic price contracts, and says that customers can request a dynamic contract with at least one supplier [36].

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Without dynamic or Time-of-Use (ToU) tariffs, aggregators are hindered in their work on price-based-DR and it is not possible to benefit from maximum flexibility of end-users. To benefit from dynamic tariffs, automation is key, and ESCOs or aggregators play a key role to valorise dynamic tariffs for customers (Interviewee 3).

Different forms of ToU tariffs are:

- **Static ToU prices (static):** vary during the day in a fixed way (e.g. peak prices on certain hours or days).
- **Real-time pricing (dynamic):** prices are based on close to real-time consumption and on wholesale electricity prices. Metering is at least hourly or even in shorter time intervals.
- **Variable peak pricing (both static and dynamic):** different periods for pricing are defined in advance, but the exact price depends on market conditions.
- **Critical peak pricing (both static and dynamic):** prices increase significantly for a few days per year, when wholesale prices are the highest.

The differences between the countries are presented in Table 25.

Table 25. Tariffs & prices in the analysed countries (Inputs [89]).

Potential obstacle: Lack of dynamic electricity pricing schemes available and used. X = **No obstacle**, *different dynamic electricity tariffs available and adopted on large scale* X X = **Low obstacle**, *electricity tariffs with dynamic components available* X X X = **High obstacle**, *no basic ToU tariffs available*		
	X	No ToU electricity tariffs, but dynamic real time prices: pricing based on spot market-based pricing through the monthly average wholesale price [50].
	X	ToU energy pricing and critical peak pricing are available [81]. Regulated tariffs are the most common choice and have three options: based, peak/off-peak and dynamic. “Tempo” is the most dynamic of regulated tariffs, with six different tariffs depending on the day, and peak and off-peak hours. “Tarif Bleu” (peak/off-peak) is the most popular among residential customers [90]. Dynamic pricing sometimes possible: evolution to tariffs based on spot and intraday prices, compliant legislation has been adopted and will apply no later than 1st January 2023 [20]. So far, dynamic supply tariffs are more common among large industrial customers [90].
	X	ToU tariffs available. All low-voltage consumers are mandatory exposed to ToU pricing if they do not choose a supplier in the liberalized market [91]. Also dynamic real-time prices available: contracts linked to wholesale and spot market prices are offered [20].

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	✗	Spain has regulated and free retail markets. Spain has basic ToU electricity prices in the regulated tariff (PVPC) linked to wholesale and spot market prices. A voluntary dynamic price for consumers in the regulated market also exists [20].
	✗	Critical peak pricing [91] and dynamic real-time pricing linked to wholesale and spot market prices (for customers with a smart meter). These ToU prices are available for small and large consumers, but not all suppliers offer them [43]. Residential customers need to have half-hourly meters to choose a ToU tariffs, but these contracts are not common. Only one retail tariff offers a dynamic setting for residential customers [90].

6.3 Flexible consumers: self-consumption & net-metering

Ebalance-plus UC enabler: *conditions that encourage consumers to contribute to implicit DSF and self-consumption*
Relation to UC: *UC10*

Local use of electricity reduces grid congestion. For consumers it reduces the purchase from other producers and avoid wholesale electricity market prices, fees, and taxes. The CEP supports the idea of self-consumption. *Article 2.14 of RED II* says that self-consumers must not be subject to charges or fees for self-consumed electricity, and *Article 21.2* ensures there will be no double charges for self-consumer electricity [36]. The CEP further states that Member States should ensure that renewable self-consumers (individually or through aggregators) should be allowed to sell their excess production of electricity for a price reflecting the market value without being subject to disproportionate procedures and charges that are not cost-reflective. They should not be considered suppliers if their volumes are less than 10 MWh four households and 500 MWH for legal persons and keep their rights as consumers. Self-consumption is not just attractive for prosumers, it can also lower the costs for the energy system and reduce the pressure on the distribution grid. For the grid and their own efficiency, balancing self-consumption is relevant for prosumers, especially for those providing active DR [92].

Net metering and feed-in-tariffs have been essential for the development of the renewables industry but are not conducive to the use of flexibility services in the energy system. Feed-in-tariffs isolate the producer of electricity from market prices and thus removes the incentives for flexibility [93]. Net-metering leads to customers that do not face the real-time value of electricity and thus the value of flexibility is not revealed to them, such as differences in value of electricity over time (e.g., feeding in during low-demand period and taking out during peak demand period). The grid is artificially used as storage for the prosumer and the value of electricity will be the same independently if it is consumer or produced. Net metering Is prohibited in *Article 15.4* of the *IEMD*. The Electricity Market Directive prescribes that net metering will be phased out in European Member States by 2024 [40].

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In countries that were open to aggregated flexible load and hat strong price signals, implicit demand side flexibility has been popular [94]. There is a need to move beyond "subsidized" business models for prosumers [95]. This is still a challenge, because revenues from implicit demand side flexibility for prosumers are low. Generally, the interaction of prosumers with the energy system in energy markets in Europe is very limited. The countries with the highest activity of prosumers in terms of volume and participants are **France**, **Germany** and **UK** [76]. Table 26 outlines the differences between countries.

Table 26. Self-consumption characteristics in the analysed countries [40, 96, 97].

Potential obstacle: Full net-metering regulation discourages contribution to implicit distributed flexibility services (self-balancing) by prosumers ✗ = **No obstacle**, self-consumption regulation stimulates self-balancing by prosumers ✗✗ = **Low obstacle**, regulation does not explicitly stimulate contribution to flexibility services (self-balancing) by prosumers, but does also not discourage it ✗✗✗ = **High obstacle**, net-metering regulation discourages contribution to flexibility services (self-balancing) by prosumers		
	✗✗	Denmark has no net-metering programme anymore, it only has the remains of two old programmes until 2032. The feed-in tariff for renewables 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 [76]. 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 [76]. 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 [76].
	✗✗	In **France**, self-consumption is regulated in national frameworks since 2015/16. And since 2019, there is an exemption from electricity taxes (RES levy) for self-consumed electricity, for generation less than 1MW, benefitting individual self-consumption. Producers under 3kW may feed their surplus of self-generated energy into the grid, this is not remunerated. There is a rooftop PV support scheme in form of a special grid tariff for self-consumption (feed-in-tariff) for installations below 100 kWp.[12] France has no net-metering in self-consumption projects.
	✗✗	**Italy** allows to self-generate and self-consume energy. Every Italian may produce energy to meet part of its needs and can also sell the surplus energy. This can be done through a bilateral energy purchasing contract or selling electricity directly on the market (IPEX – Italian Power Exchange). Self-consumers may also store electricity, but the relevant regulatory frameworks are only technical up until now [97]. The net metering scheme in Italy is called "Scambio Sul Posto" [98]. It

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		can be used for plants with a capacity between 20 kW and 200 kW [97].
	✗✗	In **Spain**, the "sun tax" was lifted in 2018, and a new Decree that was approved in 2019 is favourable for prosumers. It introduced self-consumption without charges and a surplus simplified compensation [98], to allow for feeding into the grid for privately owned systems, including residential, industrial up to 100 kW. There are different compensation models in case of discharge of surpluses. The benefit from surplus electricity is relatively low, because the price of fed electricity is lower than the retail price for the electricity consumer from the grid [98]. Surpluses may also be shared with other consumers (collective self-consumption). The shared-self consumption regulation in Spain allows energy sharing within a 500 meter radius [99].
	✗✗	Self-consumption is allowed and encouraged for small systems (<30 kW) through a generation and an export tariff, applicable to the electricity fed into the grid. The UK has a feed-in-tariff and is a net metering PV market [100].

6.4 Consumer involvement

Ebalance-plus enabler: *customers that are interested and willing to participate in energy efficiency and flexibility related services*.
Relation to UCs: *All UCs, but especially UC8, UC9, UC10, UC11*

The involvement of customers in flexibility solutions is key to their success. Extensive social research has been conducted in WP2. In the associated deliverables, several obstacles for flexibility solutions an already be found. We briefly summarise the major obstacles here.

Most people are not aware and have no knowledge about energy flexibility and related services. And as mentioned in section 4.2, GDPR regulations are in place and allow people to disagree with sharing their personal information about energy consumption, which may significantly reduce the effectiveness of flexibility solutions. There might be personal reasons not to share one´s data, but these can also be influenced by culture. Data on electricity consumption can provide very detailed knowledge about consumers, such as how many appliances they own or that they turn on lights in their house at unusual time. Privacy concerns are a key reason for people not to engage in flexibility solutions.
Furthermore, people might not understand energy flexibility and data-related concepts. The interaction with the electric markets must be user-friendly, which is currently standing in its infancy in most countries.

It is worth noting that from the user's perspective currently it is very easy to use electricity, just by switching on the appliance. Only some countries have different tariffs which differentiate prices. The new paradigm, using the concept of flexibility, means that electricity consumers will in some cases have to decide to give up some of their agency to automatic systems (e.g., dynamically changing the room temperature within

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a certain range). In some cases, they may also be asked to make their flexibility available (e.g., to charge their car battery more slowly, or to allow the system to use the energy in the car battery – V2G charging). In such cases, the use of electricity means a greater cognitive load, as the user constantly has to consider whether it is a rational decision (whether it is attractive, whether it is cost-effective). It may lead users to be reluctant to use the new paradigm, preferring existing solutions that are more cognitively accessible.

Another barrier is formed by people that is sceptic and has negative attitude towards changes in energy use. Some are changing their behaviour and participate in energy transformation efforts. Others might be reluctant to change their habits and learn about new technologies and concepts or might just not be comfortable using new technologies.

One out of many possible strategies (identified in WP2) to involve consumers in flexibility solutions is financial motivation. From an interview with the manager of a large European aggregator, we learned that they overcome the barrier of consumer engagement in their aggregation scheme, by simplifying their offering and providing their service for free:

> *"In our experience consumers are very happy to participate. (…) There are several reasons. The first one is (…) money. We provide our solution for free for consumers. That is absolutely key. Plus, they save energy, so they reduce their electricity bill (…) in terms of tens of euros per year. (…).*
> (Interviewee 3).

However, there where DR mechanisms are possible, revenues from DR for consumers are still relatively low. This is for example the result of the lack of volatility in prices and the level of prices in general. Also, for other actors that participate in DR mechanisms, the Capital Expenditures (CAPEX) should exceed the Operational Expenditures (OPEX) to be viable, this is not always the case yet. Furthermore, investment costs (for equipment, etc.) should also be (partially) returned by DR revenues, which is currently not the case.

Interviewee 3 argues that the benefits of flexibility in the system should come back to the customer (not just a benefit for the system):

> *"There is a systemised value of having flexibility in the systems, which provides reliability, avoid peaks and ensure that renewables are better used, less grid investments required. (…) the customer should be rewarded for bringing this benefit for everyone."* (Interviewee 3).

So far, the potential of finding viable business cases in which the consumer is paid sufficiently to motivate them to provide their flexibility is very low. This means that potential new solutions should actively incorporate also non-financial motivations - e.g., pro-environmental or pro-social (wise and efficient use of scarce resources).

Table 27 provides a summary of barriers. The topic of consumer engagement has been discussed in more detail in D2.1 (Energy end-user behaviour characterisation) and D2.2 (Methodology for user engagement in energy literacy and flexibility).

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Table 27. Summary potential obstacles related to consumer involvement in Europe.

Potential obstacles related to consumer involvement:

- Lack of awareness and knowledge about flexibility services
- People do not realise the challenges facing the energy system. From their point of view, the energy system is currently working well and there is no reason to change it
- People do not want to share their energy data: personal reasons and privacy concerns
- Lack of understanding of energy flexibility and related concepts
- Sceptical attitudes towards changes in energy use or might be reluctant to change their habits and learn about new technologies and concepts
- People might not be comfortable using new technologies
- Revenues from DR are too low to be motivating
- Incentive mechanisms for DR not sufficient to cover investment costs

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7. DSOs deploying flexibility

DSOs are the incumbents in the energy transition, who sometimes resist change in the sector. They are however important enablers of structural transformation. DSOs traditionally deal with issues like congestions, voltage control, and service restoration actions. The transformation of power systems brings new congestion and voltage issues. As DSOs deal with local problems in the majority of cases, solutions must also be found in their geographical service areas. DER flexibility can increasingly be exploited as an alternative to the installation of additional equipment or grid reinforcement to overcome shortcomings of conversional tools and services. There are different ways DSOs could access flexibility: mandatory provision, ToU tariffs, variable connection agreements and local markets. The advantage of flexibility to improve distribution network efficiency, reliability and resilience is widely recognised by DSOs. However, barriers remain, such as: 1) regulatory, 2) network observability, 3) deployment of DER control and management systems [101].

Directive 2019/944 of the CEP provides specific propositions regarding the role of DSOs: ensuring secure, reliable and efficient electricity distribution system and act as neutral market facilitators. The Directive incentivises DSOs to procure flexibility services. At national regulatory level, however, DSOs are often not yet considered as active users of balancing services (only in case of contingencies). And national regulations often restrict the offering of certain services or the participation of flexibility providers in the electricity markets.

7.1 Lack of incentives for DSOs

Ebalance-plus UC enabler: *DSOs are considered, incentivised, and renumerated to use flexibility*
Related UCs: *UC5, UC6, UC8, UC9, UC11*

The current typical DSOs rationale stimulates investments in assets, grid expansion (CAPEX). Thus, DSOs are not incentivised to increase operational measures, such as buying flexibility services (OPEX) [50, 102]. This CAPEX over OPEX bias has traditionally been there to prevent insufficient network investment which could cause security of supply problems [38, 70].
To solve this problem an incentive structure based on both capital and operational expenditures, the total expenditures (TOTEX), should be implemented as prescribed by to the European Electricity Directive in the CEP. However, no Member State has adopted a framework to adequately renumerate DSOs for the procurement of flexibility services (TOTEX) yet [54] and the CAPEX approach is still dominant.

Furthermore, managing local flexibilities (which is a system priority) comes at a cost, and DSOs need to invest to increase their monitoring and control capabilities, and acquire forecasting tools.

National regulatory authorities should set up network tariffs that encourage DSOs to appropriately manage the flexibility sources in their grids and to stimulate DSO-led innovation [46]. Fixed network tariffs do not stimulate DSO to innovate. Three-quarter of large European DSOs are still renumerated by fixed network tariffs [46].

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Network tariffs should reflect the value of flexibility. It is important that capacity (€/kW) and energy (€/kWh) are differentiated [103]. Innovative tariff structures can provide incentives to customers to deliver flexibility to the system and ensures that prosumers participate in a fair manner to network expansion and management costs. In many countries, capacity-based tariffs will or have been introduced, because capacity encourages time-shifting and reduces peak demand. Furthermore, ToU tariffs can be used to set predefined capacity network tariffs for predefined time schedules [103]. Sector organisation Eurelectric believes in the use of static ToU network tariffs in combination with flexibility markets to manage congestion and optimise network expansion. They however believe that dynamic ToU tariffs are excessively complex for DSOs, retailers and customers [104]. Table 28 summarises all obstacles related to incentives for DSOs.

Table 28. Obstacles related to incentives for DSOs (Inputs [89] [40]).

Potential obstacles regarding incentives for DSOs to use flexibility:

- DSOs have no incentives to purchase flexibility from organised markets (and set-up flexibility markets) nor to buy flexibility via bilateral agreements
- Lack of renumeration mechanisms for DSOs to develop flexibility capabilities (e.g. TOTEX)
- Fixed network tariffs

X = **No obstacle,** *implemented TOTEX approach for DSOs and dynamic network tariffs*

X X = **Low obstacle,** *pilots of TOTEX approach and some dynamic or ToU components network tariffs*

X X X = **High obstacle,** *no pilot projects to test TOTEX approach no dynamic components network tariffs*

	X X	In **Denmark**, DSOs are allowed to buy flexibility from market mechanisms or via bilateral contracts without limitations [88]. However, based on existing regulations, agreement with aggregators for procuring flexibility has not been defined as a role for DSOs in Denmark. Tariffs for capacity (based on size of the connection rather than measurements) and tariffs for energy (predominant) are available. ToU tariff is mostly volumetric, but different for each of the 44 DSOs in Denmark. There is no dynamic component in the network tariff.
	X	In **France** as an exception in the EU, DSOs are incentivised to increase their efficiency, support investments in digitalisation and flexibility services. DSOs are also incentivised to procure flexibility services [20]. Enedis wishes to implement flexibility in the medium and low voltage grid into its business as usual. The DSO wants to use flexibility as an alternative to resupply resources before or following accidents; to support planned maintenance; and to defer investments. Enedis uses flexibility wherever it is economically optimal at MV level, and pilots are being implement at LV level. The DSO is testing a TOTEX approach [67]. The network tariff is balanced for capacity and energy. At DSO level there are day and night tariffs and additionally 4 different time periods combining seasonal and peak and off-peak

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		components [105]. There is no dynamic component in the network tariff. The network tariffs make it possible for DSOs to propose innovative approaches based on regulatory sandbox concept [20].
	✗✗	In **Italy**, there is a continuous evolution regarding DSOs roles and responsibilities, and the DSO is seen as a possible actor for the balancing. Pilot projects to test TOTEX approach are there [67]. There is a tariff for capacity (which depends on the measurements) and a tariff for energy (predominant). There are no ToU or dynamic components in the network tariff. Volumetric terms dominant, reducing incentives for customers to maximise their smart meters and take an active role in their consumption.
	✗✗✗	In **Spain**, DSOs are not considered as user of balancing services in upcoming regulation. DSOs are not incentivised to procure flexibility, in the last revision of the DSO renumeration mechanism, flexibility was not mentioned [20]. DSOs can use DER for local congestion management and voltage control through the TSO [106]. In Spain there are no incentives and adequately renumeration for DSOs, still CAPEX based [67]. ToU network tariffs are there [67], as a balanced mix of capacity and volumetric components. From 1 June 2021 a new network tariff (2.0TD) came into force that offers customers different periods of hours during the day when charges are lower. There is no dynamic tariff.
	✗	In the **UK**, DSOs proactively seek flexibility to solve specific issues and flexibility is used wherever it is economically optimal at MV level, and tendering capacity has started for the LV levels. Flexibility is used in a TOTEX way for both grid planning (investment deferral) and grid operations (demand congestion and outage management). Long-term markets for planning related flexibility as well as capacity reservation are existing [25]. Furthermore, there is a special mechanism for Distribution Network Operators (DNOs) to manage constraints, the: "Distribution Use of System Charge Avoidance" tariff. DNOs may create their own mechanism to encourage customers to consume during low demand periods and avoid peak hours, and so prevent congestions in distribution grids. The customers who participate in these mechanisms are not explicitly paid by the DNOs, but they receive a discount on their energy bill [43].

7.1.1 Inertia

DSOs conservatism / inertia to keep conventional practices delay the deployment of flexibility to balance the distribution grid. Many DSOs deem flexibility services as unreliable as compared to grid reinforcements [70]. Planning methodologies follow a business-as-usual model, focussed on conventional network reinforcement investments [101]. Using flexibility causes also large organizational / cultural changes for the personal of DSOs, as the CEO of a large European aggregator explains (Interviewee 3):

> *"…They* [DSOs] *manage contracts with suppliers of wires and hardware. So, this is all a culture. While negotiating with us* [aggregators]*, people are not trained to do."*

The contracting, administration and settlement of flexibility services requires new organisational structures and capabilities for DSOs [72]. Furthermore, the DSO

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organisation *E-DSO* recognizes that regulatory frameworks should be designed towards stimulating innovations in DSO business models to adopt new technologies. The passive relationship that DSOs have with network customers should be replaced for one with greater interaction [107].
All-in-all, implementing market-based mechanisms using flexibility in their operations might be a costly solution to implement for some DSOs in the next 5 years [101], see summary Table 29.

Table 29. Summary potential inertia at DSOs

Potential inertia related obstacles: • DSO conservatism / inertia to keep conventional daily practices • Planning methodologies still focused on conventional network reinforcement investments • DSOs lack of organisational structures and capabilities to contract, administer and settle flexibility services	

7.2 Local flexibility markets

Ebalance-plus UC enabler: *Presence of local flexibility markets.*
Related UC: *UC11 includes the development of a concept for a local marketplace where ancillary services from the demand side can be traded to DSOs. For this use case it is key that DSOs will be allowed to contract and use flexibility offered by other market players, via market-based mechanisms. Requirements for local flexibility markets have been outlined in D1.1.*

Potential obstacles

Local flexibility markets allow network operators to procure flexibility services from grid users (flexibility providers), connected to the distribution network. The CEP is a driver of market-based approaches for DSOs aiming to procure flexibility (Article 32 of the Electricity Directive 2019/944). DSOs shall procure services in a market-base manner from DER, demand response and storage, when these are cheaper than grid expansion [108]. However, no Member State has fully implemented this Article yet. Differences between countries are outlined in Table 30. DSOs are mostly not allowed to create flexibility markets due to regulatory regimes. In most EU Member States there is a strict segregation of power production and distribution, which hinders a more active grid management substituting capital investment [109]. As a result, there are no market-based mechanisms to provide flexibility at the local or regional level yet [110]. Power system balancing is still mostly managed at the TSO level, not at the DSO level.

There are few initiatives to set up local flexibility market, but these are all relatively recent, not standardised and still very complex. Several barriers for DSOs to set-up flexibility markets remain present in the EU. Products for congestion management and non-frequency ancillary services at distribution level still need to be defined. The place of this local flexibility market among existing central flexibility markets (ancillary markets in TSO level), the relation between local and central flexibility markets, and solutions for conflicts between the operation of these flexibility markets should also be addressed. European regulation prescribes that products should be used under

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market-based rules by DSOs on a daily basis similar as TSO do already. This is a challenge as the European market design is organized in bidding zones per country and local congestions are so far not captured by market prices [72]. Furthermore, the application of market-based mechanisms to solve congestions might not be feasible in all distribution networks because of the scarcity of flexibility resources [72].
Roles and responsibilities in such flexibility markets are still unclear. When distribution level flexibility will be increasingly used to support distribution and transmission network operation, this needs to be coordinated between TSO and DSO [33].

Table 30. Potential obstacles related to local flexibility markets.

Potential obstacles related to local flexibility markets:

- National regulation restricts flexibility services
- Absence local flex markets by DSOs to purchase flexibility

X **= No obstacle,** *flexibility markets are (partly) implemented and are in use*
XX **= Low obstacle,** *flexibility markets are piloted and there are plans for further implementation*
XXX **= High obstacle,** *no implementation plans for flexibility markets, only fragmented pilots*

	XX	Local flexibility markets are underdeveloped in **Denmark**. DSOs in Denmark may buy flexibility from market mechanisms or via bilateral contracts with aggregators without limitations [88]. However, based on existing regulations, agreement with aggregators for procuring flexibility has not been defined as a role for DSOs in Denmark. Buying flexibility by DSOs is not renumerated sufficiently, the increasing costs for purchasing flexibility do not correspond with an increasing income [88]. And due to sufficient capacity in Denmark, at the moment, there is no significant demand for flexibility from TSOs or DSOs. So, the DSOs are not incentivised to participate in flexibility programs. In Denmark, DSOs may charge a connection fee or investment contribution from new connections [88], which discourages a focus on flexibility instead of grid investments.
	XX	In **France,** Enedis has implemented a local flexibility market for distributed flexibility. This market is open for aggregation and provides essential information to flexibility providers, such as location information and metering eligibility tool. The objective is to organise calls for tenders to procure its own needs of flexibility services on a market-based approach [104].
	XXX	Local flexibility markets with products to solve local congestion management are not existing **Italy**. The local flexibility market mechanism is not defined, regulation including rules on renumeration fees need to be updated. Some pilot projects are or have been run by different DSOs. The main disagreement is the cooperation scheme between TSOs and DSOs, which slows down the evolution of local flexibility markets in Italy [43].

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	✗✗	In **Spain**, there is no urgent need for medium and low voltage constraint management. Still, market operator OMIE is experimenting with local flexibility markets in a pilot project called IREMEL for market-based redispatch [111]. The project was launched to facilitate and promote the implementation of DER in the distribution local areas. The main aim is to test a market model for efficient integration of DER and their participation in solving local congestion and DSOs needs [16]. DSOs may only buy flexibility from market mechanisms in pilots. The last revision of the distribution renumeration mechanism did not mention any flex mechanism [54].
	✗	In the **UK** regulation allows DNOs to create flexibility markets [112]. Small-scale assets can participate in DSO services. There is an active local flexibility space with all six DNO procuring flexibility. There are also several market place platforms that enable the participation of local flexibility and reduce complexity and streamline procurement [59]. For example, Pico Flex helps DSOs to obtain DSF to lower network congestion. All assets that can provide DSF are allowed on the platform. The six main DNOs participated in the trial with 175 flexibility providers, resulting in a total capacity of 4 GW. This experience is extended in terms of covered network areas and provider´s capacity by DNOs across the country [43]. Another platform is “Flexible Power”, operated by five UK DNOs, in the last procurement cycle 440 MW of flexibility was contracted through this platform. Flexibility service providers can obtain information about flexibility locations, requirement data, procurement notices and documentation published by the 5 DNOs on a joint website [43, 104]. Still, the liquidity of flexibility products for DNOs is insufficient. Ofgem wants to overcome this situation by reviewing network charging and access, to include clear price signals towards the providers of services to DNOs [43].

7.3 Barriers for distribution grid management

7.3.1 Technical challenges

Related UCs: *UC5 & UC7*

Using market-based flexibility services changes control and monitoring strategies of DSOs towards a more predictive approach, forecasting technical restrictions to define the optimal operation of network assets and flexibility resources. This is especially a challenge for Low Voltage networks, due to their low observability and monitoring capabilities, as well as the high error of LV load forecasts [101].

DSOs have to work with DER which other stakeholders connect to the network, as they are not allowed to operate electricity generation and storage themselves, due to unbundling requirements. IoT can help DSOs to improve the remote management of substations and to manage DER, to ensure their quality of services. DSOs will (have to) increasingly make use of real-time data. Remote control of substations is quite a common practice at High Voltage (HV) & Medium Voltage (MV) levels, but not very

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common at LV level. This might form a barrier for the deployment of DER connected at MV and LV level [46]. However, only 36% of DSOs surveyed by Joint Research Centre (JRC) can perform remote load control of end-users [46]. Deploying flexibility from DER is difficult for DSOs because of the lack of transparency of loads connected to the distribution network, assets types and the types of responses they can provide, and the monitoring of assets providing the response [112]. There is a need for better observability through digitalisation of networks, and tools for LV networks to increasingly remotely control flexible resources.

Table 31. Potential technical challenges for DSOs in Europe.

Potential technical challenges deploying flexibility of DER by DSOs:

- Need for better network observability (digitalisation)
- Increase the remote-control of flexibility resources (DER)
- DSOs might lack the knowledge related to the use of DER flexibility to balance the grid, or do not know their flexibility needs

7.3.2 Islanding

Related UC: UC6

Flexibility provided by DER can enable islanded operation (creating a small microgrid), which is an increasingly interesting possibility with the growing integration of RES and increasing need to tackle grid resilience. Islanding is one of the actions that DSOs can use to support planned and unplanned maintenance actions, instead of disconnecting consumers or power cutting during maintenance. Also, islanding is a key strategy in the case of extreme events (e.g., natural disasters or whether events). This can reduce the System Average Interruption Duration Index (SAIDI) index and improve the DSOs performance reliability and continuity of supply in case of unavailability of the main grid [101].

However, island operations are regulated and not allowed in most countries. But the most important barrier might be that islanding has technical complexities and costs can be larger than grid planning, however, in areas where building new lines is challenging, islanding could be relevant. DSOs might therefore not consider islanding services [101]

Table 32. Obstacles related to islanding in Europe.

Potential obstacle:

- Island operations are regulated and not allowed

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8. Conclusions

8.1 Main obstacles in countries

The largest differences regarding obstacles between countries are related to DR and aggregation participation in electricity markets. Generally, the implementation of the CEP is lacking behind and there are large gaps between the European framework and the national realities. Regulation related to independent aggregation and (small-scale) demand response needs to be further developed in most of the analysed countries. The possibilities of DSF to participate in the electricity markets is highest in France and the UK, followed by Denmark, and lacking most behind are Italy and Spain, but in both countries, legislation is changing rapidly. DSOs have more incentives and possibilities to deploy flexibility in the UK than in the other countries.

Some obstacles are very similar in the analysed countries: namely the penetration and functionalities of smart meters, and the possibilities of deploying flexibility from electricity storage. GDPR regulation applies to all countries and needs to be taken into account in all data handling: access, storage, exchange. Furthermore, not a barrier but an enabler: all countries have the possibility for consumers and prosumers to subscribe to dynamic tariffs.

In sum (Table 33), at the level of Member States, Spain and Italy have the most obstacles for the ebalance-plus flexibility solutions. France has fewer obstacles, and the least obstacles are found in Denmark and the UK. However, important to note is that not all obstacles have the same weight. Furthermore, it is important to add that the obstacles are very diverse and not all of them are related to all KERs and use cases, so from (use) case to (use) case should be considered which country has the least obstacles. For the implementation of uses cases and KERs should be carefully assessed which obstacles are most relevant and what the situation in the countries is.

Table 33. Summary of obstacles in countries (1= minimal/no obstacle, 2 = small obstacle, 3 = high obstacle).

Category	Obstacle	ES	IT	FR	DK	UK
Communication & data	Lack of internet access	2	2	2	1	1
	Smart readiness of buildings	3	2	2	1	2
	Smart meters	1	1	1	1	2
	Metering data access for third parties	3	3	2	2	2
Energy flexibility assets	Electricity storage	2	2	1	2	2
	V2G	2	3	3	1	2
DR, aggregation and flexible consumers	Demand response and aggregation	3	2	1	2	1
	Dynamic tariffs	2	2	2	2	2
	Flexible consumers (self-consumption)	2	2	2	2	2
DSOs deploying flexibility	DSOs incentives to use flexibility	3	2	1	2	1
	Local flexibility markets	2	3	2	2	1
TOTAL SCORE		**25**	**24**	**19**	**18**	**18**

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8.2 Main obstacles for Key Exploitable Results (KERs)

All KERs will be affected by a variety of obstacles to a various degree (Table 34). KER 1 is affected by almost all potential obstacles because of its encompassing character, including different functionalities and modules. Also, KER 8 faces several obstacles, as the energy optimising models are facilitating the increasing use of energy flexibility, which still faces many obstacles in the EU.

Table 34. Links between obstacles and KERs (empty = no relation, 1 = indirect (implementation-dependent) relation, 2 = direct relation).

Category	Obstacle	KER 1	KER 2	KER 3	KER 4	KER 5	KER 6	KER 7	KER 8
Comm. & data	Standardisation and interoperability	2							
	Data security and privacy	1	2		2				2
	Lack of internet access	2	2	1	1	1	1		
	Controlling of appliances, components, and devices	2	2	1			2	2	2
	Smart readiness of buildings								
	Smart meters	1	2		2		2		2
	Metering data access for third parties	1	1		2				2
Energy flexibility assets	Platform (ownership, investment, maintenance)	2	2		1		2		1
	Energy storage			2			2		
	V2G						2		
DR, aggregation, and flexible consumers	DR and aggregation	1	1	1	1				2
	Dynamic tariffs	1	1						2
	Flexible consumers: self-consumption & net-metering								
	Consumer involvement	2	2	1			1		1
DSOs deploying flexibility	Lack of incentives for DSOs	1				2		2	1
	Local flexibility markets	1							1
	Barriers for distribution grid management	2				2		2	1

8.3 Obstacles links to use cases

The architecture use cases (UC1, UC2) are mostly hindered by obstacles related to communication and data (Table 35). In general, a data security, lack of data access, exchange and data management following GDPR rules makes it complex to deploy energy balancing platforms.

The resilience and reliability use cases (UC3-UC7) are mostly hindered by a lack of incentives for DSOs to deploy flexibility and by regulatory and technical barriers for distribution grid management.

The flexibility use cases (UC8-UC11) are hindered by the obstacles to deploy DR and aggregation in the EU´s electricity markets, the lack of dynamic tariffs and the complexities of consumer involvement. Related to DR and aggregation in electricity markets, especially lack of market access, are of major hindrance for the flexibility mechanism use cases.

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Table 35. Links between obstacles and use cases (empty = no relation, 1 = indirect (implementation-dependent) relation, 2 = direct relation).

Category	Obstacle theme	1	2	3	4	5	6	7	8	9	10	11
Comm. & data	Standardisation and interoperability	1	2	1	1	1	1	1	1	2	1	1
	Data security and privacy	2	2	1	1	1	1	1	1	1	1	2
	Lack of internet access	1	2	1	1	1	1	1	1	1	1	1
	Controlling of appliances, components, and devices	1	2							1	1	1
	Smart readiness of buildings	2	2									
	Smart meters	2	2							1	1	1
	Metering data access and exchange								2	2	2	
Energy flexibility assets	Platform (ownership, investment, maintenance)	2	1									
	Energy storage								2	2		
	V2G								2			
DR, aggregation, and flexible consumers	DR and aggregation								2	2		2
	Dynamic tariffs										1	
	Flexible consumers: self-consumption & net-metering										1	
	Consumer involvement	1	1	1	1	1	1	1	2	2	2	2
DSOs deploying flexibility	Lack of incentives for DSOs					1	1		1	1		1
	Local flexibility markets											2
	Barriers for distribution grid management					2	2	2				

8.4 Types of obstacles

The obstacles that have been identified and analysed can be categorised based on the TIS framework (Table 36). The identified barriers are diverse and relate to all categories: actors & coordination, capabilities and infrastructures. However, the most significant obstacles for ebalance-plus solutions in many member states are institutional (regulatory) barriers, as can be seen in the Table 36. Institutional obstacles hinder market formation, slowdown changes at DSOs and complicate user participation in electricity markets and other flexibility mechanisms.

Table 36. Types of obstacles

Category	Obstacle theme	Specific obstacle	Type of obstacle
Comm. & data	Standardisation and interoperability	Lack of general standardisation (e.g. for processes, data formats, data models and communication protocols) and interoperability	Institutional & Coordination
	Data security and privacy	Data management needs to be done in accordance with GDPR	Institutional
		Anyone can choose not to share his / her data because of GDPR	Institutional
	Lack of internet access	Lack of internet access	Infrastructural / technological
	Controlling of appliances, components, and devices	Build-in connectivity of devices (as a standard) is absent	Infrastructural / technological
		Manufacturers of appliances, components, BEMS, and devices allow limited or no control of their products	Coordination
	Smart readiness of buildings	The smart readiness of buildings is low	Infrastructural / technological

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Category	Obstacle theme	Specific obstacle	Type of obstacle
	Smart meters	Smart meter penetration & smart-meter functionalities not sufficient	Infrastructural / technological
	Metering data access and exchange	Third parties have no timely access to smart meter (consumer) data	Coordination
Energy flexibility assets	Platform (ownership, investment, maintenance)	Unclear ownership, investment, and maintenance of innovative types of energy balancing platforms and related management units	Coordination
	Energy storage	The legal status of storage is not cleared	Institutional
		Barriers for electricity storage to participate in the electricity market	Institutional
		Double grid fees/tariffs/taxes for energy storage	Institutional
	V2G	Participation of V2G in electricity markets is not possible	Institutional
		Double taxation for bidirectional charging	Institutional
		Lack of charging stations with V2G capabilities	Infrastructural / technological
DR, aggregation, and flexible consumers	DR and aggregation	Small-scale (aggregated) assets as a resource are not accepted in all market	Institutional
		Hurdles for small aggregators to access and compete in the market	Institutional
	Dynamic tariffs	Lack of dynamic electricity pricing schemes available and used	Institutional
		Small-scale (aggregated) assets as a resource are not accepted in all market	Institutional
	Flexible consumers: self-consumption & net-metering	Full net-metering regulation discourages contribution to implicit distributed flexibility services (self-balancing) by prosumers	Institutional
	Consumer involvement	People might not be aware and have no knowledge about flexibility services & people do not understand energy flexibility and related concepts	Capabilities
		People do not want to share their energy data: personal reasons and privacy concerns	Institutional
		People might have sceptical attitudes towards changes in energy use or might be reluctant to change their habits and learn about new technologies and concepts	Institutional
		People might not be comfortable using new technologies	Institutional
		Revenues from DR are too low to be motivating & Incentive mechanisms for DR not sufficient to cover investment costs	Institutional
		People might not be aware and have no knowledge about flexibility services & people do not understand energy flexibility and related concepts	Capabilities
DSOs deploying flexibility	Lack of incentives for DSOs	DSOs have no incentives to purchase flexibility from organised markets (and set-up flexibility markets) nor to buy flexibility via bilateral agreements	Institutional
		Lack of renumeration mechanisms for DSOs to develop flexibility capabilities (e.g. TOTEX)	Institutional
		Fixed network tariffs	Institutional
		DSO conservatism / inertia to keep conventional daily practices	Capabilities
		Planning methodologies still focused on conventional network reinforcement investments	Capabilities
		DSOs lack of organisational structures and capabilities to contract, administer and settle flexibility services	Capabilities
	Local flexibility markets	National regulation restricts flexibility services	Institutional
		Absence local flex markets by DSOs to purchase flexibility	Institutional

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Category	Obstacle theme	Specific obstacle	Type of obstacle
	Barriers for distribution grid management	Need for better network observability (digitalisation)	Infrastructural / technological
		Increase the remote-control of flexibility resources (DER)	Infrastructural / technological
		DSOs might lack the knowledge related to the use of DER flexibility to balance the grid, or do not know their flexibility needs	Capabilities
		Island operations are regulated and not allowed	Institutional

Combining the insights from Table 33-36 using TIS, leads to the following overviews that show the strength of, and the types of, obstacles in the demo countries (Figure 6), for the KERs (Table 37), and the use cases (Table 38).

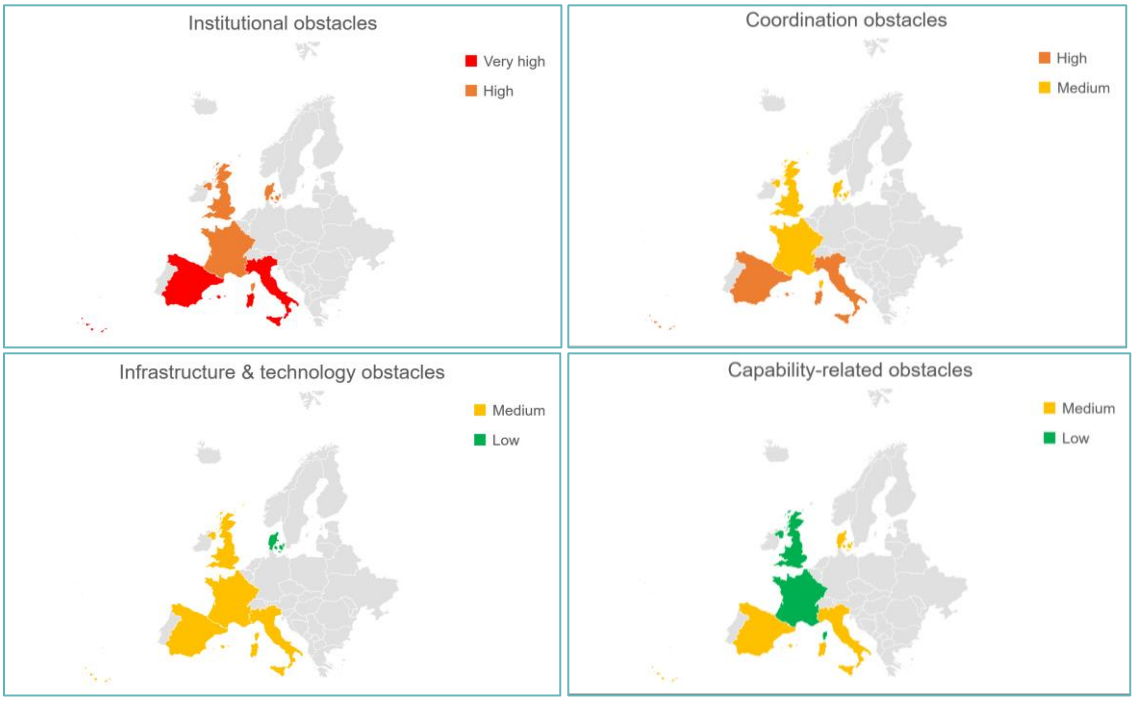

Figure 6. Types of obstacles in the demo countries and UK

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Table 377. Types of obstacles for the KERs

KER	Type of obstacle			
	Institutional	Coordination	Infrastructural / technological	Capabilities
1. Energy balancing platform	High	High	High	High
2. Mobile app	High	High	High	Low
3. Smart storage	Medium	Low	Low	Low
4. Prediction models	Medium	Medium	Medium	Low
5. Cloud-based microgrid optimization platform	Medium	Low	Medium	Medium
6. Integrated smart hub	High	High	High	Low
7. Grid control units	Medium	Low	Medium	Medium
8. Optimization models for energy management	High	High	High	Medium

Table 388. Types of obstacles for the use cases

Cluster	Use case	Type of obstacle			
		Institutional	Coordination	Infrastructural / technological	Capabilities
The architecture	1	Medium	Medium	High	Low
	2	High	Medium	High	Low
Resilience and reliability	3	Medium	Low	Low	Low
	4	Medium	Low	Low	Low
	5	High	Low	Low	Medium
	6	High	Low	Low	Medium
	7	Medium	Low	Low	Low
Flexibility mechanisms	8	Very high	Medium	Medium	Medium
	9	Very high	High	Medium	Medium
	10	High	Medium	Medium	Low
	11	Very high	Medium	Medium	Medium

8.5 Regulatory changes and enabling conditions

There are several regulatory barriers that can hardly be dealt with in innovative business models and ask for future regulatory adaptations, at national, as well as European level. Based on the analysis performed, the main regulatory improvements suggested are:

- General lack of consistent regulation is hindering the deployment of energy balancing platforms. National legislation is different in each country, and in many countries, there are even differences between regions. This should be streamlined.
- The implementation of the Clean Energy Package in the Member States will still take some more years but should accelerated as much as possible. Some key points that would help the implementation potential of ebalance-plus solutions:
    - Access to (metering) data for third parties and data exchange between market players.
    - DSOs should be allowed and motivated to buy flexibility and be renumerated for it. Generally, update of roles and responsibilities of DSOs to enable them to use flexibility.

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  - Development of local flexibility markets.
  - Participation of (small) resources, batteries and V2G in electricity markets.
  - Dynamic tariffs should be available in all countries.
  - Remove regulatory barriers for aggregators.
  - DR and aggregation allowed in the electricity markets.
- Regulation regarding DR and injection of energy from DER is in some countries very restrictive and should be reconsidered.

Other conditions that would enable the implementation of ebalance-plus solutions:

- Roll out of smart meters, availability of internet access, increasing smart readiness of buildings, increasing controllability of devices.
- Allowance of bidirectional communication with platforms like ebalance-plus and the DSO infrastructure.
- Recognition of non-wires alternatives for conventional grid expansion to incentivise DSOs.
- New models for the roll-out of energy balancing platforms (ownership, investment, maintenance) should be tested and shared.
- Increased standardisation (e.g., for interoperability and data).
- Safe data exchange between stakeholders in the whole value chain.
- Clarify benefits (other than financial) for users and come up with convincing arguments to ensure their engagement and behaviour change (in absence of financial gains on the short-term). Increase awareness and knowledge of consumers.

8.6 Opportunities for ebalance-plus solutions

Based on the work done for this task, some preliminary opportunities for ebalance-plus solutions can be identified. For EVs & V2G use cases, opportunities are the best in Denmark. Market access for aggregators, prosumers and demand respond mechanisms are the best in France and the UK. BMs based on dynamic tariffs (implicit DR) can be out rolled in all analysed countries. DSOs are significantly better enabled and more incentivised to use flexibility in the UK, compared to the other analysed countries. These opportunities, and opportunities for the KERs, will be elaborated in more detail and for more countries in *D7.3 Market analysis*. Lastly, Table 39 shows the flexibility services that can be used in the analysed countries.

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Table 39. Flexibility services opportunities in analysed countries.

	Flexibility services	Possible in…
Prosumer → DSO	Congestion management Voltage / reactive power control Grid capacity management Controlled islanding	**UK**
Prosumer → BRP (wholesale market)	Day-ahead portfolio optimization Intraday portfolio optimization Self-balancing portfolio optimization	**France & UK**
Prosumer → TSO (balancing market)	FCR, aFRR, mFRR, RR	**UK** **France** (FCR, mFRR), **Denmark** (entry barriers) **Italy** (UVAM)
ESCO → Prosumer (implicit)	ToU optimization Control of maximum load (load shifting) to minimise grid fees Self-balancing of own generated electricity	**Spain, UK, France, Denmark, Italy**
	Emergency power supply, using DF for islanding	**N/A** (depends on DSO)

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