Demonstration of **Inte**lligent grid technologies for renewables **Inte**gration and **Inte**ractive consumer participation enabling **Inte**roperable market solutions and **Inte**rconnected stakeholders

WP 7 – CBA, Regulatory Analysis and Business Models

Business Models to Support the Developed Concepts

D7.5

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Author(s)	Rafael Cossent, Leandro Lind, Lorenzo Simons, Pablo Frías, Carmen Valor, Mauricio Correa | Comillas
Reviewer 1	Hamid Aghaie, Bransilav Iglar | AIT
Reviewer 2	José Villar | INESC TEC
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Name	Partner
Boris Turha	Elektro Ljubljana
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Pedro Godinho Matos	EDPD
Ricardo Prata	EDPD
Ricardo Bessa	INESC TEC
Manuel Pio Silva	CNET
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Hossein Shahrokni	KTH
Olle Hansson	Ellevio
José Pablo Chaves	Comillas
Tomás Gómez	Comillas
Pablo Frías	Comillas
Timo Gerres	Comillas
Pedro Linares	Comillas

Executive Summary

The identification of disruptive business models relying on the solutions developed and demonstrated is one of the core objectives of InteGrid. The work presented in this report aims to contribute to achieving this goal and complement the work done by the demos and the exploitation WPs. First, it is relevant to note that the definition of business model adopted in this report is in the following:

> A business model ("BM") can be understood as a set of business strategies chosen by a certain agent (main actor) in order to generate economic benefit. These business strategies can combine multiple instruments, and the economic benefits can be generated by different sources of revenue streams and cost reductions.

This report starts by identifying a list of potential BMs that may derive from the Integrid concept. This list comprises five general BMs, although several of them are, at the same time, broken down into several sub-BMs. Overall, up to **10 BMs and sub-BMs have been identified**, each one of them characterized by the following parameters: main actor, benefits pursued, and strategies adopted to attain the previous benefits. These main actors comprise: **DSOs, data service providers, data/flexibility platform operators, end consumers, and flexibility operators**, i.e. VPPs and aggregators. A summary of these BMs is presented in the table below.

BM#	Related HLUCs	Main Actor	Benefit	BM summary
BM1	HLUC01; HLUC02	DSO	Investment deferral, RES curtailment cost reduction	The DSO uses flexibility from DER to manage the grid. As a result, investments may be deferred or RES curtailment costs reduced, reducing overall grid costs.
BM2	HLUC03; HLUC04	DSO	Reduced outages, lower maintenance costs, extended asset lifetime	On the one hand, the DSO may improve asset maintenance procedures by the adoption of predictive maintenance, as opposed to a conventional preventive (time-based) maintenance. On the other hand, fault locators and sensors may improve corrective maintenance procedures.
BM3.1	HLUC06	Data Service Provider	Revenue from data service provision	The new agent "data service provider" can exploit the opportunities created by the gm-hub, a platform that centralizes metering data, and acts as an interface for customers and third parties to trade data and flexibility services.
BM3.2	HLUC06	Gm-hub operator	Revenue from platform operation	The gm-hub operator itself may also profit from the operation of the platform. Different revenues models can be foreseen for this BM, both under regulated and competitive models.
BM4.1	HLUC08	Industrial Consumer	Reduced electricity bill	By improving electricity management, installing DG and possibly providing grid services, the industrial consumer can reduce its overall electricity cost.
BM4.2	HLUC09	Residential Consumer	Reduced electricity bill	Aided by new technologies such as the HEMS, residential consumers will be able to reduce their energy bill and enhance self-generation.

BM5.1	HLUC10	Retailer	Reduced imbalance costs and balancing service provision	The retailer uses the flexibility provided by commercial consumers to reduce imbalance costs (instead of adjusting its position in the intraday market). Additionally, the retailer may be able to aggregate the demand-response potential and offer it in the balancing markets.
BM5.2	HLUC11	Platform Owner/BDR (Behavioural Demand Response) Aggregator	Revenues from ads or subscription, provision of energy management services	The platform owner/BDR aggregator (through a webpage/app) provides energy feedback, tips, and other information to end consumers to modify their energy consumption. Revenues may come from subscriptions fees or ads, or from the provision of energy services to grid operators or other stakeholders.
BM5.3	HLUC12	Aggregator – cVPP (commercial Virtual Power Plant)	Revenue from ancillary services provision to TSO	The VPP operator provides ancillary services to the TSO (balancing services) using flexibility from DER.
BM5.4	HLUC12	Aggregator – tVPP (technical VPP)	Revenue from local services provision to DSO	The VPP operator provides local services to the DSO (e.g. congestion management) using flexibility from DER.

Each one of these BMs is then characterized in detail by the following parameters:

- **Business strategies**: going deeper into the different ways in which the main actor may exploit a BM, this report identified and discussed the different revenue streams the main actor could explore, what services could be provided and who the main potential users of these services are. In many cases, these business strategies may be complementary to each other.
- **Mapping of relevant stakeholders**: the implementation of the different strategies may require the participation, directly or indirectly, of different stakeholders. These key stakeholders were identified and mapped according to a "Power-Attention" matrix according to which, stakeholders are categorized into four groups: key players (high-power/high-attention), keep satisfied (high-power/low-attention), keep informed (low-power/high-attention), and minimum effort (low-power/low-attention).

However, some of the previous potential business strategies are subject to important uncertainties or open issues. In order to shed some light on these topics, this report **analyzes a set of real-life cases** of companies that have implemented similar or related BMs as the ones identified herein. The aim is to assess what conditions (regulatory, market, policy, economic, etc.) have enabled or promoted their development and identify **possible trends, or best practices**. The real cases analyzed focus on those BMs where the major uncertainties were found, i.e. in those new roles that are necessary as enablers of several BMs (the **flexibility/data management platforms and the flexibility operators**, as well as the role of **data service providers** relying on openly available distribution-related data).

Lastly, it is relevant to acknowledge that the development of these BMs strongly depends on i) appropriate regulatory conditions, ii) their economic feasibility, and iii) the direct or indirect participation of several stakeholders. Other activities within Integrid WP7 have analyzed each one of these topics by i) identifying regulatory barriers and providing recommendations to overcome them, ii) performing a CBA, and iii) carrying out a consultation among stakeholders. The key outcomes of these activities are summarized in this report and presented as a **list of barriers to the development of each BM**. These barriers are classified by their importance and their nature, i.e. **regulatory, economic or stakeholder-related**.

Overall, this report shows that Integrid has the **potential to foster innovative BMs for DSOs and distribution grid stakeholders** in a context with high penetration of DER and digitalized distribution grids. These BMs rely on the provision and procurement of DER flexibilities, and data-based services. They may be implemented both by existing agents who expand their business scope or improve the efficiency of their operations, as well as new agents entering the power sector, possibly in cooperation with existing actors.

Nonetheless, whilst the opportunities do exist, **the challenges are not negligible**. Several of the BMs require regulatory developments or amendments, and could face the opposition or indifference of stakeholders that are key to their success. Lastly, in addition to the previous barriers, some BMs still need to prove their economic viability and scalability potential. In this regard, the results indicate that fully exploiting economies of scale, in terms of portfolio size and geographical presence, and economies of scope, combining several revenue streams, increase the chances of success.

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Abbreviations and Acronyms

aFRR	Automatic Frequency Restoration Reserve
AMI	Advanced Metering Infrastructure
AS	Ancillary Services
B2B	Business to Business
B2C	Business to Customer
BDR	Behavioural Demand Response
BESS	Battery Energy Storage Systems
BM	Business Model
BMS	Building Management System
BRP	Balancing Responsibility Party
BSP	Balancing Service Provider
CAIDI	Customer Average Interruption Duration Index
CAISO	California Independent System Operator
CAPEX	Capital Expenditures
CBA	Cost-Benefit Analysis
CDS	Closed Distribution System
CEC	Citizen Energy Communities
CEP	Clean Energy Package
cVPP	Commercial Virtual Power Plant
DER	Distributed Energy Resource
DG	Distributed Generation
DNO	Distribution Network Operator
DoA	Description of Action
DR	Demand Response
DSO	Distribution System Operator
DSP	Data Service Provider
ENS	Energy Non-Served
EPEX	European Power Exchange
ERCOT	Electric Reliability Council of Texas
ESCO	Energy Services Company
FCR	Frequency Containment Reserve
GDPR	General Data Protection Regulation
Gm-hub	Grid-market hub
HEMS	Home Energy Management System
HLUC	High-Level Use Case
ISO	Independent System Operator
LV	Low Voltage

mFRR	Manual Frequency Restoration Reserves
MV	Medium Voltage
NEMO	Nominated Electricity Market Operators
NRA	National Regulatory Agency
P2X	Power to X
PPA	Power Purchase Agreement
RES	Renewable Energy Sources
RR	Replacement Reserve
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SaS	Software as a Service
SIDC	Single IntraDay Coupling
SRA	Scalability and Replicability Analysis
TLS	Traffic-Light System
ToU	Time-of-Use
TSO	Transmission System Operator
tVPP	Technical Virtual Power Plant
VPP	Virtual Power Plant
WP	Work Package

1. Introduction: goals and scope

1.1. The InteGrid project

The way electricity is produced and consumed is changing fast. Consumers are being empowered with more data, enabling better management of their own consumption, and more possibilities to participate in electricity markets. The concept of the producer is also changing. Now it includes not only the traditional large-scale power plants, but also the small generators connected to the distribution grid, storage, and Virtual Power Plants (VPP), through the aggregation of several users at the distribution level.

The creation of these new types of agents and the growing number of Distributed Energy Resources (DER) comes with the need for properly integrating them, both technically and from a regulatory perspective. They have the potential to contribute to the system with services that will enhance its performance and reliability, and potentially reduce operation costs.

A growing number of academic studies and research projects have been dedicated to the integration of a larger share of DER in power systems. Moreover, several pilot projects have been carried out by different DSOs in order to test the technical and economic viability of such integration. One challenge to be explored yet, however, is how the new agents and technologies can be integrated considering the roles of different stakeholders, and their expectation, while enabling new business models given the current and future regulatory environments.

InteGrid's vision is to bridge the gap between citizens and technology/solution providers such as utilities, aggregators, manufacturers and all other agents providing energy services, hence expanding from DSOs distribution and access services to active market facilitation and system optimization services, while ensuring sustainability, security and quality of supply. The main objectives of the project are:

1. To demonstrate how DSOs may enable the different stakeholders to participate in the energy market actively and to develop and implement new business models, making use of new data management and consumer involvement approaches.
2. To demonstrate scalable and replicable solutions in an integrated environment that enable DSOs to plan and operate the network with a high share of DER in a stable, secure and economic way, using flexibility inherently offered by specific technologies and by interaction with different stakeholders.

In order achieve the objectives mentioned above, the InteGrid project has carried out three different demonstrations in Europe (Portugal, Slovenia and Sweden) to enable the various stakeholders to develop new business models as well as to bring new technologies to the market.

Along with the physical demos, research will be conducted on the several topics surrounding the demonstrations and associated use cases. One of these topics is the analysis of the potential new business models that are enabled by the InteGrid solutions. This is the focus of this report, which identifies and characterizes the most relevant Business Models (BMs), assesses their current status under commercial operation, and discusses the most relevant barriers and drivers for their development.

1.2. Scope and objectives of this deliverable

The overall objectives of WP7 are to understand the potential business models enabled by the InteGrid solutions, carry a cost-benefit analysis of these solutions, and research the regulatory layer underlying their implementation in a set of focus countries.

Since the identification of disruptive business models is one of the core objectives of the InteGrid project, WP7 was structured having the BMs at the centre of the discussion as shown in Figure 1. The successful development and implementation of these business models strongly depend on i) appropriate regulatory conditions, ii) their economic feasibility, and iii) the direct or indirect involvement of several stakeholders. Therefore, the work in this WP includes: a characterization of the BMs (D7.5), a regulatory analysis and recommendations (D7.2), a cost-benefit analysis (CBA) (D7.4), and a consultation among key stakeholders about their views on the BMs proposed (D7.6).

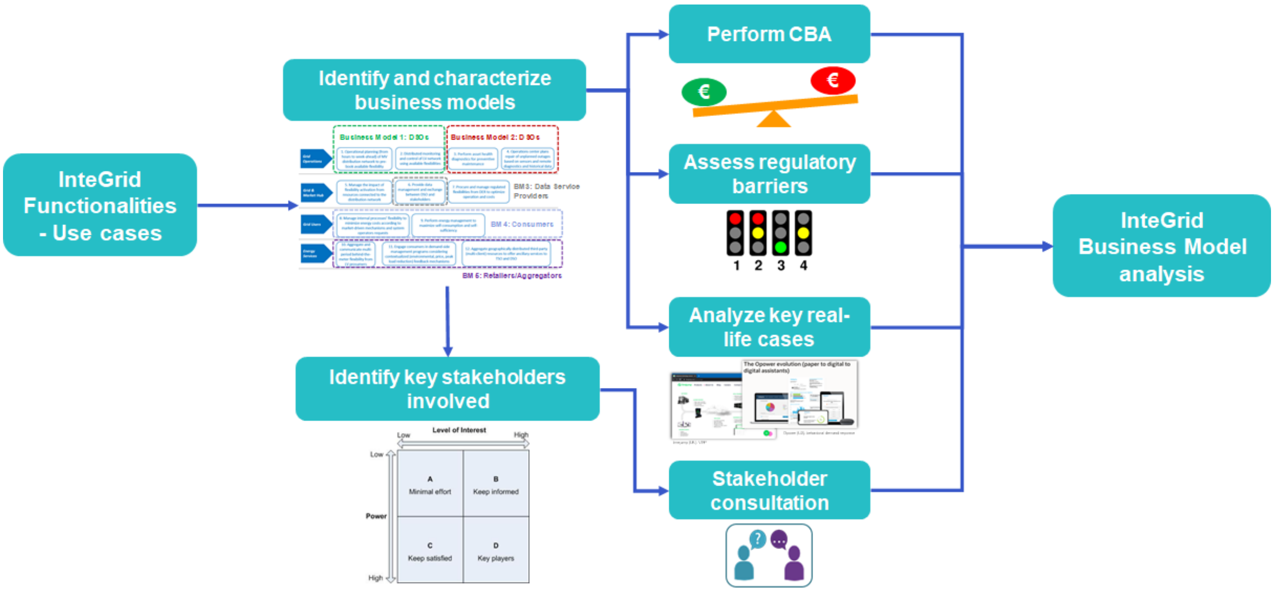

Figure 1: Flowchart of the business model analysis in Integrid

This deliverable aims at defining the BMs identified within the InteGrid project and incorporates some of the key lessons learnt in other task of the WP relevant to the development of these business models.

1.3. Document structure

The remainder of this report is organized as follows. After this introduction, section 2 presents the methodology followed to derive the BMs in InteGrid. Section 3 proceeds on presenting each individual BM, including their description and identification of the relevant stakeholders. Section 4 analyses some real-life experiences of companies that adopted similar or related business models in order to study what conditions (regulatory, market, policy, economic, etc.) have enabled or promoted their development. As mentioned above, other tasks in this WP address different topics that are relevant to the BMs, such as regulatory barriers, economic feasibility, or the perspectives of different stakeholders. The main outcomes of these tasks are summarized in section 5, which also discusses the implications these may have on the development of each BM. Lastly, section 6 presents some concluding remarks.

2. Business model identification and methodology

The aim of this section is to define what a business model is in the context of the InteGrid project, as well as to identify the business models in InteGrid based on the HLUCs defined in WP1. Hereafter we review the concept of business model and define what a business model means in the context of InteGrid.

Business models can generally be understood as a way in which agents generate, perceive and capture value from a product or service. In fact, the literature on business models, although vast, is not precise in defining the concept. (Zott et al., 2011) reviewed 103 business models publications and showed that more than one third do not define the concept of business model, "taking its meaning more or less for granted", around half of them define it or cite the main components, and only 19% refers to the definition of other authors.

In the context of the power sector, several research projects have used the business model framework to analyse the new business opportunities for utilities, distributed generation, and smart grid-related services, as shown in the introduction of this internal deliverable.

In InteGrid, we take the definition used in the Horizon 2020 IndustrE project (IndustRE H2020, 2016) as a starting point and expand it to fit to the several agents considered in the HLUCs of InteGrid. The IndustrE project had the industrial consumer as the only agent. In InteGrid we apply the same business model concept as in IndustrE, but we extend it to consider System Operators, residential consumers, retailers, aggregators and others.

For the purpose of InteGrid, a **business model** can be understood as a set of **business strategies** chosen by a certain agent in order to generate **economic benefit**. These business strategies can combine **multiple instruments,** and the economic benefits can be generated by different sources of **revenue streams** and **cost reductions**.

The instruments necessary to implement a business strategy vary and may include the provision of services, the selling of a product or the improvement of internal processes to enhance operational efficiency. These business strategies are then combined into an actionable framework, meaning that the main agent has a common final goal for all business strategies.

By following this definition, we aim to identify the different possible business strategies, and explore existing barriers under current regulation and what stakeholders think would be the most suitable or likely developments. Note that in this report, we do not intend to define or guide the exploitation of a specific product or service of any specific company. Thus, this report does not analyze in detail the profitability of a specific BM implementation, or explore the market conditions (e.g. market size, revenue volume, competitors, etc.). For these reasons, the BM canvas methodology was not deemed suitable for our purposes.

Once the above-mentioned definition is established, the first step to define the BMs consisted in evaluating InteGrid High-level Use Cases (HLUC) defined in Integrid D2.1. For each one of them, the main actor and its corresponding goals were identified. Those HLUCs who shared the main actor and had the same or similar goals were grouped together into a single BM. This resulted in the identification of five distinct BMs, as shown in Figure 2.

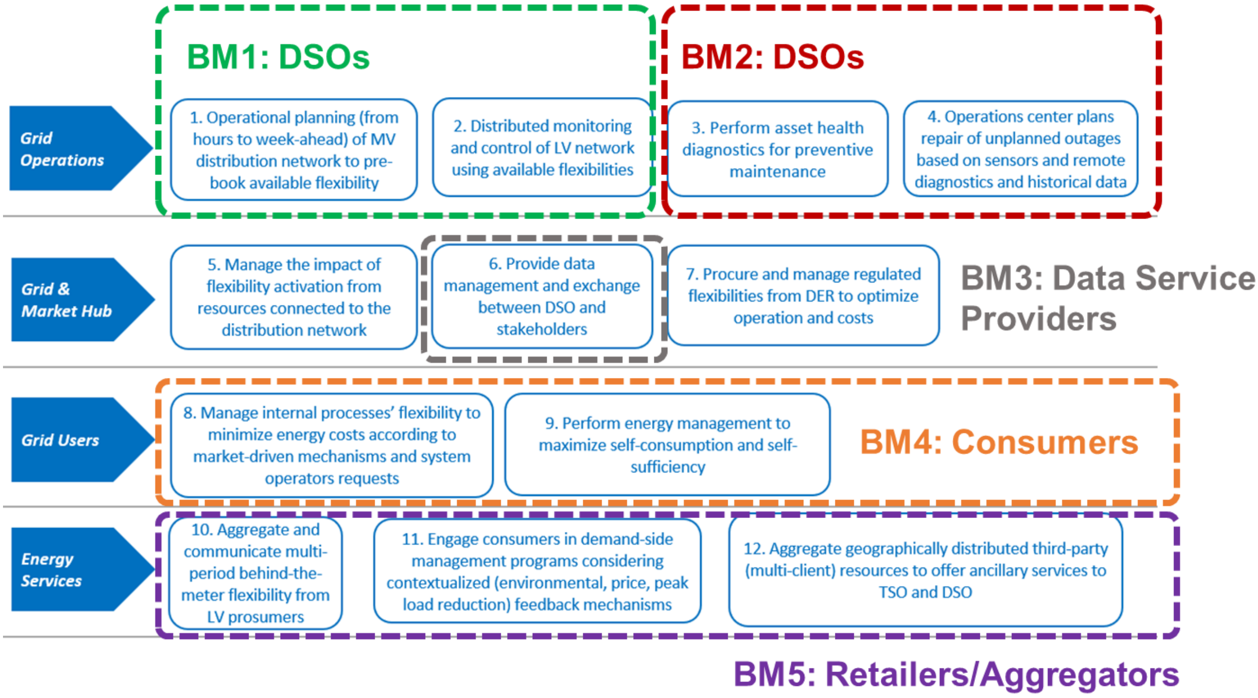

Figure 2: Business Models Mapping

Note, however, that HLUC05 and HLUC07 are not directly correlated to any BM. These HLUCs act as enablers for other solutions in InteGrid. HLUC05 mainly tests the concept of the Traffic Light System (TLS), which determines if the flexibility can participate in other markets due to congestion in the distribution network. In this sense, this HLUC describes a tool that will be used to enable other BMs, as it is the case of BM5 in which the VPP offers balancing services to a TSO. In the case of HLUC07, the procedure for the DSO to procure and activate the flexibility is described. It is a HLUC limited to an internal procedure of the DSO, which will enable BM1, in which the DSO uses the flexibility to manage the grid.

Additionally, some BMs were divided into several sub-business models (sub-BMs). This was deemed necessary when the main actor could be further categorized into different sub-categories with implications for the BM strategy (e.g. consumers were divided into residential and industrial as they face different regulatory or institutional conditions), or when the main actor could follow alternative or complementary business strategies which implied interacting with different types of stakeholders or face different regulatory barriers (e.g. the VPP operator could use the same flexibilities to provide services to the TSO - cVPP- or the DSO - tVPP). The complete list of BMs and sub-BMs resulting from this process is shown in Table 1.

Table 1: Characterization of InteGrid BMs and sub-BMs

BM#	Related HLUCs	Main Actor	Benefit	BM summary
BM1	HLUC01; HLUC02	DSO	Investment deferral, RES curtailment cost reduction	The DSO uses flexibility from DER to manage the grid. As a result, investments may be deferred or RES curtailment costs reduced, reducing overall grid costs.
BM2	HLUC03; HLUC04	DSO	Reduced outages, lower maintenance costs, extended asset lifetime	On the one hand, the DSO may improve asset maintenance procedures by the adoption of predictive maintenance, as opposed to a conventional preventive (time-based) maintenance. On the other hand, fault locators and sensors may improve corrective maintenance procedures.
BM3.1	HLUC06	Data Service Provider	Revenue from data service provision	The new agent "data service provider" can exploit the opportunities created by the gm-hub, a platform that centralizes metering data, and acts as an interface for customers and third parties to trade data and flexibility services.
BM3.2	HLUC06	Gm-hub operator	Revenue from platform operation	The gm-hub operator itself may also profit from the operation of this platform. Different revenues models can be foreseen for this BM, both under regulated and competitive models.
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BM4.2	HLUC09	Residential Consumer	Reduced electricity bill	Aided by new technologies such as the HEMS, residential consumers will be able to reduce their energy bill and enhance self-generation.
BM5.1	HLUC10	Retailer	Reduced imbalance costs and balancing service provision	The retailer uses the flexibility provided by commercial consumers to reduce imbalance costs (instead of adjusting its position in the intraday market). Additionally, the retailer may be able to aggregate the demand-response potential and offer it in the balancing markets.
BM5.2	HLUC11	Platform Owner/ Behavioural Demand Response (BDR) Aggregator	Revenues from ads or subscription, provision of energy management services	The platform owner/Behavioural Demand Response aggregator (through a webpage/app) provides energy feedback, tips, and other information to end consumers to modify their energy consumption. Revenues may come from subscriptions fees or ads, or from the provision of energy services to grid operators or other stakeholders.
BM5.3	HLUC12	Aggregator – Commercial VPP	Revenue from ancillary services provision to TSO	The Virtual Power Plant (VPP) operator provides ancillary services to the TSO (balancing services) using flexibility from DER.
BM5.4	HLUC12	Aggregator - Technical VPP	Revenue from local services provision to DSO	The VPP operator provides local services to the DSO (e.g. congestion management) using flexibility from DER.

On the ensuing, a **short description of each of the BMs** is provided:

BM1 - DSO procures flexibility: The DSO is the main agent. In this Business Model, the DSO generates economic benefit by procuring flexibility from resources connected at the distribution level. By doing so, costs for the DSO are expected to be reduced and investments for network reinforcement deferred. Several agents will be involved in this business model, namely DER owners and consumers connected at the distribution grid, or the aggregators operating this flexibility on their behalf.

BM2 – DSO improves quality of service. The DSO is the main agent. The economic benefit is generated for the DSO in the form of cost reduction by reducing interruptions through improved fault location and enhanced maintenance procedures through predictive maintenance. The increase in the quality of service may lead the DSO to higher incomes, depending on how regulation incentivizes it, and the improved asset management may reduce overall maintenance cost.

BM3 – Data Services: In this BM, the Data Service Provider (DSP) and the data platform owner are the main actors. This BM encompasses businesses enabled by the implementation of the grid and market hub (gm-hub). Firstly, DSPs will be able to exploit the data in gm-hub for the benefit of consumers, DSOs, TSOs, and aggregators. These agents may pay Data Service Providers for providing analyses that may decrease the energy bill (in the case of consumers), reduce costs (in case of system operators), or increase revenues (for aggregators) (BM3.1). On the other hand, the operator/owner of the gm-hub operator may benefit from providing access to this platform; several different revenue models may be found for these services (BM3.2).

BM4 – Consumer reduces electricity bill: The Consumer is the main agent of this BM. The economic benefit to be generated in this BM is the reduction of the electricity bill for the final consumers through load automation. Two sub-business models are identified, one for the industrial consumer (BM4.1) and another for the residential consumer (BM4.2). Other agents will also be impacted by this BM, such as system operators (DSO and TSO) that may profit from end-user flexibility, or the retailers who can offer new services/tariffs to its customers.

BM5 – Creating of value through aggregation: In this BM, retailers and aggregators are the main agents. They will be able to create value for end-users by reducing their electricity bill through aggregation and fostering the use of demand flexibility. This BM is divided into four sub-business models. The first one (BM5.1), centered in the retailer (or the BRP) that uses commercial demand flexibility to reduce imbalance costs and/or provide balancing services. In the second business model (BM5.2), a platform/app will foster demand-side management by the residential consumers through tips and gamification (behavioural demand response). The third business model (BM5.3), in which the aggregator is the main actor, explores the idea of aggregation through the Commercial VPP concept (cVPP). In this BM5.3, the aggregator profits from providing ancillary services (AS), specifically mFRR, to the TSO. In the fourth business model (BM5.4), the aggregator explores the Technical VPP concept (tVPP), in which local services (e.g. congestion management) are provided to the DSO by the aggregated flexibility.

Subsequent sections of this report will present the next steps carried out in the BM analysis. Firstly, for each business model, a set of parameters is identified, namely main actor, involved stakeholders (partners, customers, enablers, etc.), economic benefits for the main actor (revenue, savings), and different strategies that could be followed to attain the previous benefits. This is presented in section 3. Moreover, this BM analysis was complemented with an assessment of some selected real-life cases of companies exploiting similar BMs (section 4), as well as the outcomes of other activities in the same WP such as the regulatory analysis, the CBA, and the stakeholder consultation (section 5).

2.1. Stakeholder classification

The identification of stakeholders for each BM has two objectives. The first one is to properly identify which agents will be impacted by each BM and how. This is important to understand where the value is created and to whom, as well as to identify which stakeholders are key to enabling the BM and which ones may pose barriers to the development of the BM.

The second objective of identifying stakeholders is to carry out a stakeholder consultation on the BM described hereafter. Due to the number and the diversity of InteGrid BMs, the number of stakeholders potentially involved or affected in any way is large. For this purpose, in addition to identifying the relevant stakeholders, information about their interest and power in the BM must be gathered. Therefore, this identification needs to be accompanied by an assessment of the relevance that each of them has for the BMs, so that key stakeholders may be prioritized

For these reasons, we identified and classified stakeholders according to the "power/attention" matrix methodology, detailed in InteGrid Deliverable 1.4. The following box presents a transcription of this tool.

Box 1: Stakeholder classification matrix (from Deliverable 1.4, page 26)

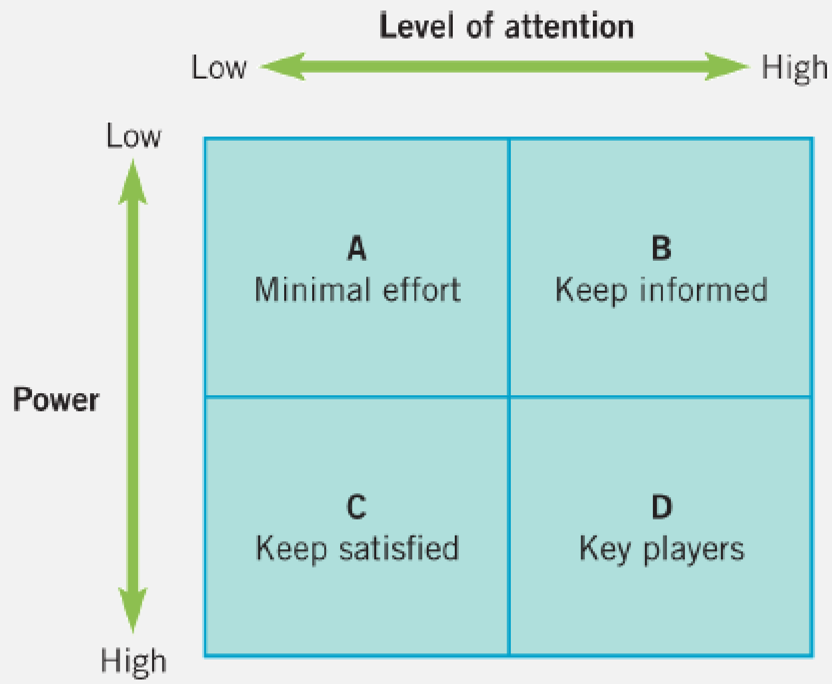

Figure 3: Stakeholder mapping: the power/attention matrix. Adapted from Newcombe (2003).

Figure 3 depicts the power-attention matrix, which visualises a categorisation of stakeholders according to their respective power and level of attention. Depending on the category, this model proposes different avenues to deal with these stakeholders. Stakeholders with little interest in energy activities and little power to influence strategies, policy or business models (Zone A) will require minimal effort on the consultation process.

Those stakeholders in Zone B with a high level of interest in the energy activities but little power to influence them will need to be kept fully informed of the potential actions, so good communication with this type of stakeholder is essential, although their participation in the consultation process prior to the implementation of the BM is not deemed key.

Stakeholders in the remaining two zones C and D represent different but equally important stakeholders. Clearly the acceptability of decisions by key players in Zone D is a major consideration when formulating a strategy, a policy or an action, but often it is the stakeholders in Zone C that are the most difficult to manage. Their level of interest in the actions will remain low as long as they feel satisfied with the policies adopted. However, if they become dissatisfied, they can easily increase their interest and, because of their powerful position, move to Zone D, thus becoming key players.

The stakeholders in Zones A and B need to be informed. Although lacking power (at least formally), they may have disproportionate influence on the more powerful stakeholders. Stakeholders such as media, users through social networks, or representatives of the community can exert this kind of indirect influence.

3. Characterization of InteGrid business models

In this section, the five business models are characterized in detail through a set of parameters: main actor, mapping of stakeholders involved, interactions among stakeholders, economic benefits and possible strategies to attain these benefits. In cases where one BM has been broken down into several sub-BMs, a separate characterization is provided for each one of them. In all cases, the BM description follows this structure:

1. **General BM description**: identification of the main actor, main objectives, and main strategies
2. Simplified diagram showing the **interactions among actors**
3. **Stakeholder mapping** using the power/attention matrix
4. **HLUC description box** with further information on the technical aspects underlying the BM

3.1. Business model 1: DSO procuring flexibility

This BM encompasses the business strategies deriving from HLUC01 and HLUC02. The main aim of this business model is to reduce DSO investment and/or operational costs by procuring, and activating when necessary, the flexibility provided by resources connected to the distribution grid to prevent or alleviate grid constraints. In the long-term, network investments are expected to be deferred or avoided, whereas, in the short-term, the operational costs derived from curtailment compensations or energy losses may be decreased. Since electricity distribution is a regulated activity, the business case for the main actor would depend mostly on the regulatory framework.

Within the project demonstrators, flexibilities were exchanged using the grid and market hub (gm-hub) as a platform to share the flexibility needs from the DSO and the flexibility availabilities from the corresponding providers. In practice, this would require properly defined and regulated procurement mechanisms, which allow for an efficient and transparent procurement and settlement processes. There are several different schemes which could allow DSOs to contract flexibility from DER[1]:

- Mandatory provision under pre-defined conditions: under certain conditions (e.g. network security threats) the DSO can activate (load or generation curtailment) the flexibility available, normally compensating DER accordingly. These mechanisms are usually considered as a last resource and these compensations are generally quite costly[2].

[1] For further discussions about the regulatory implications of the different schemes, the reader is referred to Integrid deliverable D7.2.

[2] Traditionally, network access has been provided on a firm basis, i.e. grid users had the right to use the full access capacity allocated at any moment. Thus, this type of curtailment is usually not seen as a flexibility service but as an emergency solution. This is the reason why it is defined as a mandatory requirement.

- Flexible access contracts: new network users may be offered the possibility to temporarily reduce their available network capacity granted in their access rights when requested by the DSO. This modification in the access rights may be triggered by specific events on defined by time periods. In exchange, these grid users may benefit from lower connection charges, possibly a faster grid connection (as less improvements in the network are needed), and/or direct economic compensations when activated.
- Administrative prices for local flexibility services: instead of creating a local market, the DSO, following the corresponding regulatory guidelines, can set prices administratively and activate flexibility according to their needs for those DER that had previously agreed to provide these services.
- Local flexibility markets: the DSO can create a local market in which flexibility can be procured to satisfy DSO requirements. This is the most advanced approach, which also requires some form of local market platform. The Integrid gm-hub could serve for this purpose, offering the bases for local flexibility markets to be established.

Apart from the options on **how** to procure the flexibility, DSOs may also decide **who** can provide flexibility. Different technical eligibility criteria such as size, location, technology, response times, aggregation and others may affect the profitability of the BM.

Figure 4Figure 1 displays a simplified diagram of the stakeholder interactions in this BM. Therein, it can be seen how the DSO exchanges information (flexibility needs, availabilities and activation set-points) and services (flexibility procurement/delivery and settlements) with the flexibility providers (DER, consumers), either directly (a) or through the intermediation of a flexibility operator (b). The latter may be the VPP operator or a retailer/aggregator. Additionally, the DSO receives information from a forecast provider, i.e. localized generation and consumption forecasts, in order to determine flexibility needs. This role can be internal to the DSO, be outsourced to a "data service provider" as discussed for BM3 (see section 3.3).

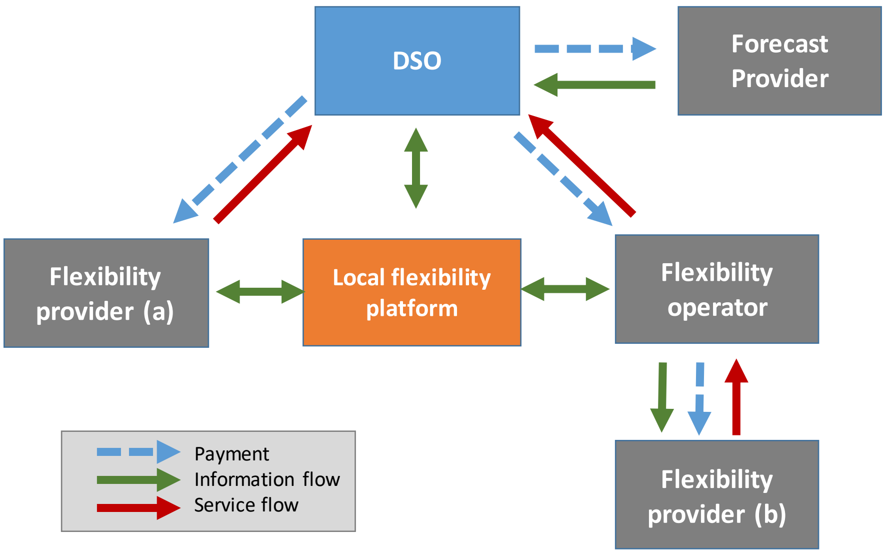

Figure 4: BM1 – The DSO procuring flexibility – BM Diagram with local flexibility platform

In Integrid, the gm-hub is used as a platform to manage information exchanges using standard formats; this is referred to as local flexibility platform in the diagram. Nevertheless, in some cases, especially when the flexibility mechanisms adopt simpler non-market-based approaches, the information and activation exchanges may happen directly between the DSO and the flexibility providers, as represented in Figure 5. What is more, some activation mechanisms that do not require pre-qualification and/or reservation, e.g. emergency curtailment, would not even require these information exchanges.

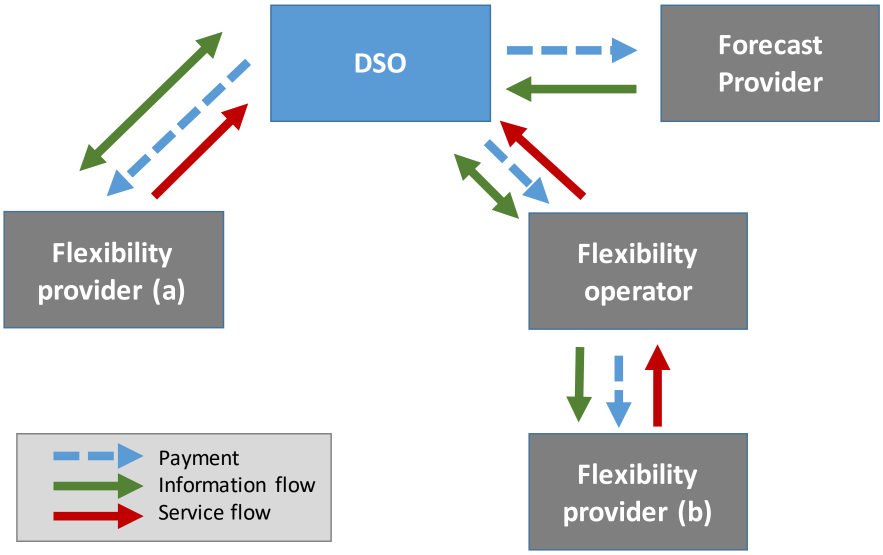

Figure 5: BM1 – The DSO procuring flexibility – BM Diagram without local flexibility platform

In addition to the actors/stakeholders depicted above, several others are involved or affected by this BM in one way or another. Firstly, the regulator or NRA is central to enable and promote this BM, as this entity is in charge of defining the DSO revenue regulation and the local flexibility mechanisms regulation. Likewise, policy-makers play a role in defining the high-level legislative dispositions affecting this BM; nonetheless, now that the Clean Energy package is approved, the detailed implementation is more closely related to the responsibilities or National Regulatory Authorities (NRAs). Lastly, the activation of flexibilities at distribution level, especially in the HV and MV grids, may be coordinated with the TSO. In Integrid, a traffic-light system has been developed and integrated in the gm-hub for these purposes. The full stakeholder mapping is depicted in Figure 6.

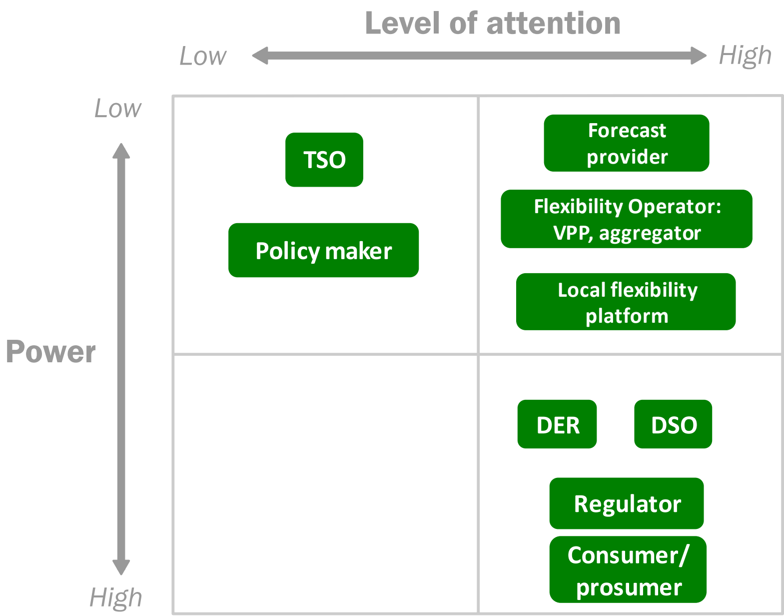

Figure 6: BM1 - Stakeholder Matrix

Box 2: HLUC01 and 02 descriptions

The scope of HLUC01 is the management of distributed energy resources (DER) connected to the distribution networks considering a multi-period and predictive approach. The DSO will compute for a predefined time horizon (e.g., between hours and week-ahead) a set of optimal automatic and manual control actions for DER (and DSO own resources) to minimize active power losses and solve potential technical problems. The input data are the active and reactive power forecasts for the net-load in each bus and for the renewable energy sources (RES) connected to the MV network, as well as operating points and available flexibilities. As the time goes by, more reliable forecasts along with the current state of the resources will be used to update the plan. The control set points computed for the resources not owned by the DSO will be considered as pre-booked (reserve) flexibility that can be later activated based on real-time information about technical constraints verification (automatic actions proposed by the developed tools can be performed on the DSO assets). The interaction with the LV network control capabilities is also included in the predictive management strategy, in articulation with HLUC02. The developed tools and load and renewable energy forecast algorithms will be integrated into the DSO DMS system to help the decision-making process and to enable real-time operation and supervision.

The scope of the HLUC02 is the operation of LV flexibilities (i.e., small-scale storage, HEMS, EV charging stations, PV voltage regulation) based on predictive management to solve technical problems and real-time monitoring of voltage profiles by exploring real-time smart metering information. In-line power regulators and secondary substation transformers tap changes capabilities for voltage control are also considered for this HLUC. A set of automatic and manual control actions for DER are determined to solve technical problems for a predefined time horizon (HLUC01). In real-time, the current state of the network is determined and compared with the scenarios used to build the preventive plan and deviations will trigger its update, and the control set points that were computed and only used to pre-book (or reserve) flexibility can be activated (partially or completely) based on real-time information about technical constraints verification. The developed tools should be integrated into the DSO DMS program to help the decision-making process and to enable real-time operation and supervision.

3.2. Business model 2: DSOs adopt new grid operation practices to improve quality of service

This BM is derived from HLUC03 and HLUC04, in which the DSO, which is the main agent, adopts innovative solutions for advanced fault location and predictive maintenance of transformers. These solutions are based on the deployment of new sensoring equipment in the field, as well as data analytics and software solutions in their operation systems. The main benefit from this BM consists in the improved quality of service, measured as reductions in indicators such as AIDI, SAIFI, CAIDI or ENS, or as a cost of the level of interruptions for consumers. Additionally, the DSO may benefit from lower maintenance and operational costs[3], as well as a longer lifetime of assets in the long-term.

[3] Predictive maintenance may allow reducing unnecessary maintenance actions, and advanced fault location may reduce the need for manual switching operations (labour costs).

This BM may be rather characterized as an improvement in the DSO internal operations. Thus, it is carried out with limited interaction of external stakeholders. For this reason, an interaction diagram is not presented for this BM, as done for all the BMs. Nevertheless, Figure 7 presents other relevant stakeholders identified for this BM. Besides the DSO, the regulator was identified as a high-power/low-attention stakeholder, as the benefits for the DSO of this BM depend strongly on the existence of incentives to improve continuity of supply or lengthen the lifetime of assets. Likewise, the companies subcontracted by the DSO to perform maintenance actions and fault location, if that is the case, may see their activities modified if these solutions are deployed.

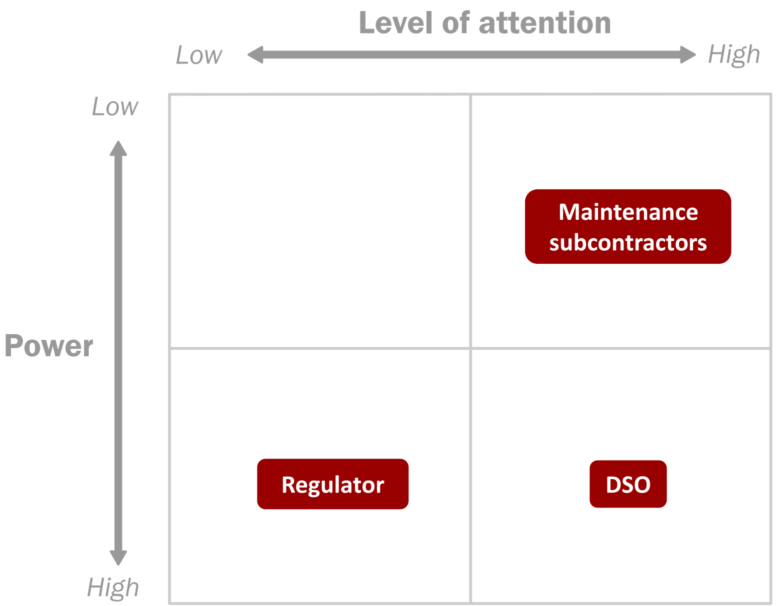

Figure 7: BM2 - Stakeholder Matrix

Box 3: HLUC03 and 04 descriptions

The goal of HLUC03 is to increase the distribution grid reliability, avoid fatal errors, reduce maintenance costs, and postpone unnecessary local maintenance tests by using big data analytics with event-driven maintenance for self-monitored equipment. At the core of the HLUC03 is the concept of predictive maintenance. Vital information for important network assets (e.g., the historical oil temperature of transformers, number of short-circuits sustained, number of changes in control) is collected by sensors and processed through tools that can diagnose and assess the current technical conditions and trigger probabilistic alarms to schedule maintenance actions. This could allow the DSO to reduce outage times, reduce maintenance costs and lengthen the lifetime of the transformers.

The main objective of HLUC04 is to improve fault location after unplanned outages based on pre-fault data collected from sensors, on remote equipment diagnostics, and on historical data collected from smart secondary substations. The expected result is a reduction in the outage time and, consequently, an improvement in the SAIDI, SAIFI and CAIDI indexes, and a reduction in the cost of ENS. Information collected from multiple sensors is used to schedule repair actions supported by intelligent tools and that aim at improving the relationship with consumers (e.g., power quality improvement).

3.3. Business model 3: Data services and platforms

BM3 is developed around the concept of the grid and market-hub (gm-hub). Besides being an important enabler for several other BM described in this report (e.g. BM1, in which the gm-hub may be the platform through which the DSO procures flexibility), new specific BMs may arise from the concept of the gm-hub itself. In this section we describe two sub-BMs derived from it. Firstly, BM3.1 describes the business opportunities for the so-called "data service provider", an agent that may use the data stored within the gm-hub to provide different data-based services. Secondly, BM3.2 explores the business case for the operator of the gm-hub itself as a platform operator.

3.3.1. Business model 3.1: Data services

This BM describes the opportunities for the "data service provider" (DSP), which is expected to use the data in the gm-hub in order to provide data-driven services to other agents. The latter may include retailers, DER owners, aggregators, consumers, etc. Thus, the gm-hub enables both business-to-business (B2B) and business-to-customers (B2C) services. The data supplied by the DSO accessible through the gm-hub are mainly metering data[4], although it may also include other relevant information supplied by the DSO such as tariff-related (e.g. hourly prices) or network hosting capacity information.

Several different data-based services can be envisioned. Hereafter some examples are listed:

- ***Forecast provision (B2B):*** load and generation forecast with different time and geographical granularity based on anonymized data stored in the gm-hub. The forecasts can be used by DSOs, TSOs, retailers, aggregators, etc.
- ***Portfolio management (B2B):*** analysis for aggregators on the best mix of resources to compose a portfolio of DER for aggregation. The analysis may consider historical load and generation data, complementarity between DER profiles, market data, locational specificities, and forecasts.
- ***Customer engagement strategies (B2B)***: retailers may be offered services based on anonymized data to improve their customer engagement strategies
- ***DER sizing (B2C):*** information for consumers/prosumers on the best size of storage and/or PV panels, as well as the adoption of new loads such as heat-pumps, water heaters or EVs, depending on tariff alternatives.
- ***Electricity usage intelligence (B2C):*** Information for end users on how and when to offer flexibility, or how to improve consumption patterns according to price and/or environmental signals. This includes advice on adjusting the contracted power or high consumption alarms.

It should also be noticed that the DSP can be an independent agent or it can also be a new role of an already existent business. For instance, ESCOs, retailers or even the DSO[5] can possibly offer one or more data

[4] In most countries, the DSO performs the metering activity and would thus supply information to the gm-hub. Nonetheless, in case of alternative organizations, it would be the metering operator supplying this data.

[5] In principle, this role could be performed by DSOs as a service only when no other enterprises are available or interested to do so. For a comprehensive discussion on this topic, we refer the reader to deliverable D7.2, more specifically on the section on "New Roles for DSOs".

services. In fact, in some countries, this is already happening. Nonetheless, the data management platform would facilitate data access to all stakeholders, reduce transactions costs, and promote innovation in data services. Figure 8 displays a diagram showing how the DSP exchanges information with the data platform to provider service to different stakeholders. Note that the DSP may have to pay the platform operator for accessing the data (any potential remuneration to end-users as data owners has not been depicted for the sake of simplicity).

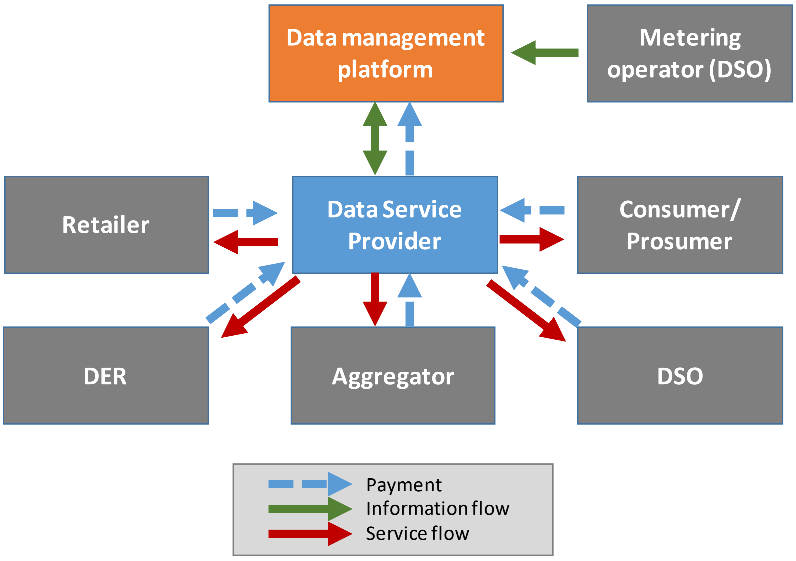

Figure 8: BM3.1 – Data Services – BM Diagram

Figure 9 shows the stakeholder mapping for this BM, which, in addition to the aforementioned stakeholders who supply and procure data-based services, shows how regulators and national data protection authorities have a central role in deploying and overseeing metering data collection and management, complying with data protection regulations.

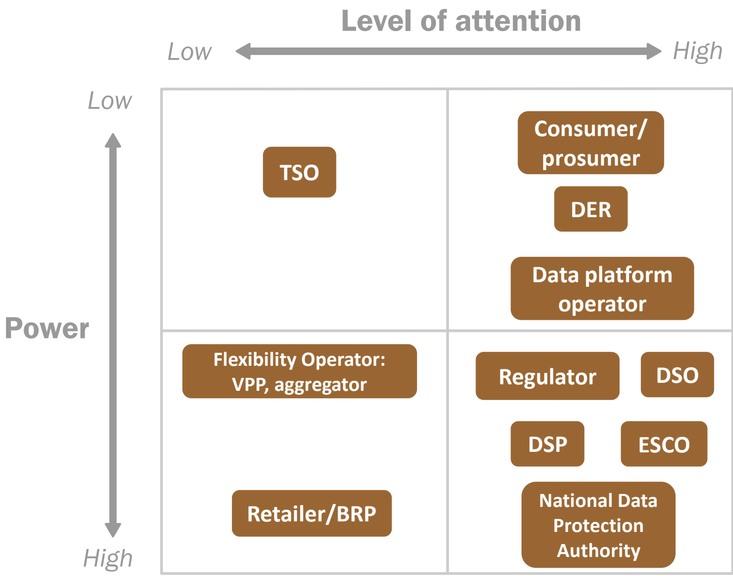

Figure 9: BM3.1 - Stakeholder Matrix

Box 4: HLUC06 description

The DSO provides anonymized and pre-processed metering data available to external stakeholders in order to promote new data-driven services provided by market entities with benefits for distribution grid users and market actors. These may include:

i. Provision of data regarding ToU / dynamic network tariffs to customers, suppliers, aggregators, inducing end use flexibility
ii. Provision of information to LV consumers about their peak demand in order to increase threshold if necessary (e.g. based on switch disconnections information or based on peak load before it happens) or the effective use of contracted power to incentivise them to reduce peak demand
iii. LV consumers will respond to prices and comfort. Therefore legislation, regulation and market roles must be appropriate for end users engagement (price) and HEMS should, in principle, be offer the possibility of pre-setting automatic parameters (comfort), facilitating the consumer's response to signals.
iv. Provision of basic efficiency tips based on customer consumption profiles (e.g. comparison to peers average)
v. Provision of data (e.g. load diagram) to customers or 3rd parties (e.g. suppliers, ESCOs) with explicit consent from customers (acting also as authorization manager)
vi. Information regarding new distributed resources connection may also be provided (e.g. inform new DER facilities in the moment of network connection request about the number of hours per year that may be curtailed).

3.3.2. Business model 3.2: Data management and local flexibility platforms

This business model focuses on the platforms enabling several of the other BMs, which corresponds to the roles the gm-hub plays within the Integrid concept. More precisely, the main actor is the gm-hub operator that, at the same time, can be broken down into two types of platforms: i) local flexibility platform, and ii) data management platform. In the InteGrid project, this platform, the gm-hub, is placed within the DSO domain. Nevertheless, alternative ownership/operation models can also be envisioned. Likewise, different revenue structures are possible, under both a regulated and a deregulated model.

In principle, this business model is defined by the gm-hub operator that receives a remuneration for operating and maintaining the platform. The gm-hub can be treated either as a regulated activity, or as a liberalized one. A regulated gm-hub would mean that the operator would receive the allowed revenues determined by the NRA, which would be recovered through the network or other regulated charges in the electricity bill. In this case, the gm-hub can be considered a tool to increase efficiency as whole, and therefore its cost socialized among all consumers/rate-payers.

Alternatively, the grid and market-hub can be treated as liberalized activity, and therefore the agents willing to use the gm-hub would pay to have access to the tool. Different revenue models can be envisioned, such as a subscription model (e.g. monthly payments for unlimited access), or some type of "pay-per-view" model, in which users pay for the functionality or data that they need. The data platform operator could also be responsible for the settlement of the data services traded in the gm-hub platform.

It is important to notice, however, that this BM proposes the use of consumer's data, and therefore data privacy requirements must be complied with. The General Data Protection Regulation (GDPR)[6] and the Clean Energy Package set the principles for which consumer's data must be treated. Metering data is a consumer's property, and only third parties authorized by the consumer can have access to it. Therefore, the challenge for this BM is on how to achieve a viable access to data while preserving all data privacy requirements. On one hand, some data services can be provided based on anonymized data. When that is the case, the authorization process could be simplified. On the other hand, when consumer's data is needed, the authorization process itself will play an important role in enabling the BM. A transparent and efficient process can be the key to make this BM viable[7].

In this case, the interactions with stakeholders and stakeholder mapping would depend on the BMs that use the gm-hub as enabler. Thus, the reader is particularly referred to Figure 4, Figure 8 and Figure 9 where the local flexibility platform and data management platforms are highlighted in orange.

3.4. Business model 4: Customers minimizing energy cost

In BM4, the consumer is the main agent. The core objective for the consumer, segmented into industrial and residential, is to reduce the electricity cost by managing internal processes, load automation and investments in DER. The provision of flexibility to SOs is also considered as a revenue stream for the end consumer, although it is not the main focus of the BM.

3.4.1. Business model 4.1: Industrial consumers minimizing energy Cost

As described in **Box 5**, this BM is based on HLUC08 in which the industrial consumer is the main actor. These industrial consumers would exploit their internal flexibilities in order to minimize electricity cost and provide flexibility services to TSOs and DSOs. In order to achieve these objectives, they may follow one or more of the following business strategies:

- **Energy Price response**: industrial consumers can adapt their consumption according to energy prices. Particularly for energy-intensive industries, where electricity costs account for a high share of the operating costs, such as metals (steel, aluminium), paper, chemicals or textile, it may make sense to adapt production processes and adapt shifts according to market prices.

[6] Regulation (EU) 2016/679

[7] Considering that data privacy is also an object of regulation, this topic is discussed in more details in the deliverable D7.2.

- **Network tariff response**: the same reasoning exposed above for the electricity price is also valid for the network charges, in case they are designed in a dynamic or time-dependent way (ToU network tariffs. The main difference as compared to energy prices (€/kWh) is that network charges for large industrial consumers will mostly correspond to demand or capacity charges (€/kW). Moreover, network charges, particularly when implemented as a ToU scheme, are more stable and predictable than energy prices. This can be a desirable feature for industrial consumers in order to avoid frequent changes in their production schedule.
- **Installation of DER and self-generation**: Industrial consumers can also own generators (directly connected to their facilities or not). If DER is installed on the industrial facility's premises, self-generation is also a possibility.
- **Sign renewable PPAs with 3rd parties**: industrial consumers may also sign PPA contracts with renewable producers as a means to reduce their energy costs or reduce price development risks. Depending on the characteristics of the contracts (physical or financial PPAs, linked to time-blocks or profile-based, risk sharing among parties, etc.), industrial users may need to modify consumption patterns to adapt to the RES production profile.
- Adopt innovative low-carbon energy solutions: deep industrial decarbonization may require these consumers to adopt more innovative alternatives such as the **production of hydrogen** thanks to low-cost electricity in time of high RES generation to store it and use it as a fuel in industrial processes (or even sell it to neighbouring industries).
- Participation in **closed distribution systems** (CDS). Regulation also foresees the possibility of industrial consumers being part of closed distribution systems (Article 38 of Directive (EU) 2019/944). These initiatives allow industrial consumers to operate a closed network jointly and possibly reduce network costs or share energy services (e.g. hydrogen, as mentioned above). One possibility could be balancing the consumption on the same grid node to reduce network charges.
- Provision of **balancing services to TSO**: industrial consumers, if allowed by regulation, can also provide flexibility to the TSO (mostly mFRR, but also aFRR or RR) as described in BM5.1 and BM5.3.
- Provision of **flexibility services to the DSO**: flexibility can also be offered to the DSO in local flexibility mechanisms. The viability of this option depends on how flexibility is offered and procured by the DSO. These options are listed in BM1 and discussed in BM5.4 too.
- **P2P trading**: industrial consumers may also be able to trade energy services among themselves through the use of peer-to-peer transactions, supported by new technologies such as blockchain.

Figure 10 illustrates how industrial consumers would interact with different stakeholders to reduce their electricity costs and provide flexibility services to TSOs and DSOs. It must be noted that this figure relfects some implicit assumptions. First, it is assumed that the industrial consumer would rely on a flexibility operator, not necessarily the same company as the retailer, to provide flexibility services. Nonetheless, industrial consumers may participate directly in these markets; particularly, large industrial groups may have the possibility to aggregate several diferent manufacturing plants in the same country. Similarly, the plot is implicitly assuming that the retailer is the only entity billing the industrial consumers, i.e. single billing. However, in some countries energy costs and network charges are billed separately by the retailer and the network operator respectively (dual billing). Additionally, some alternatives mentioned above, such as CDS or the use of hydrogen, are not reflected in the figure are they fall outside the scope of Integrid.

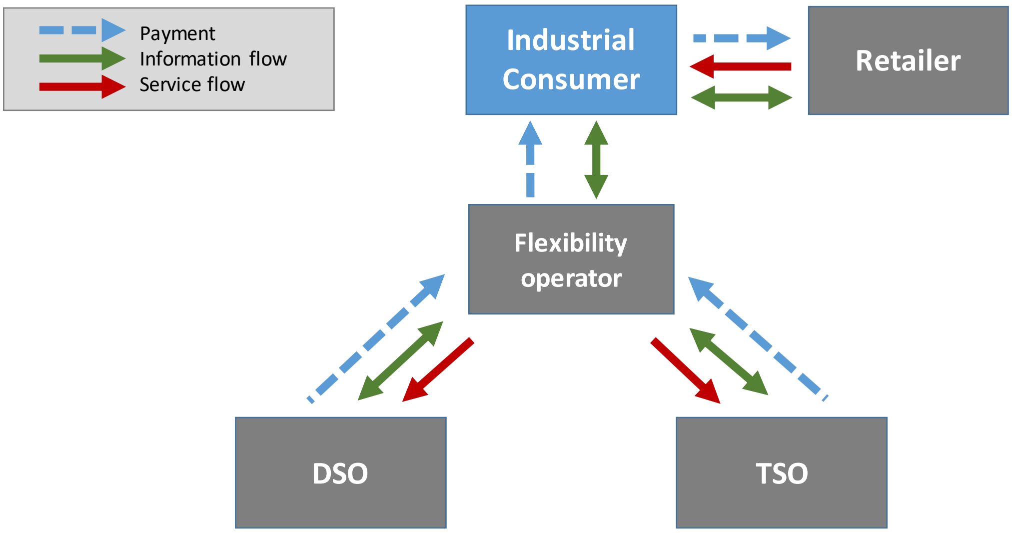

Figure 10: BM4.1 - Industrial consumers minimizing energy Cost – BM Diagram

The full stakeholder mapping for BM4.1 is shown in Figure 11. In addition to the aforementioned stakeholders, this figure includes:

- The DSP may provide B2C services to industrial consumers such as the ones mentioned for BM3.1.
- Regulators and policy-makers that should create the necessary conditions for the provision of flexibility services by demand.
- Industrial associations that could play a role in supporting their associates through the dissemination best practices and exchange or lessons learnt. This can be particularly relevant for medium and small industries that may not have the required expertise and resources to adopt some of the aforementioned energy solutions.

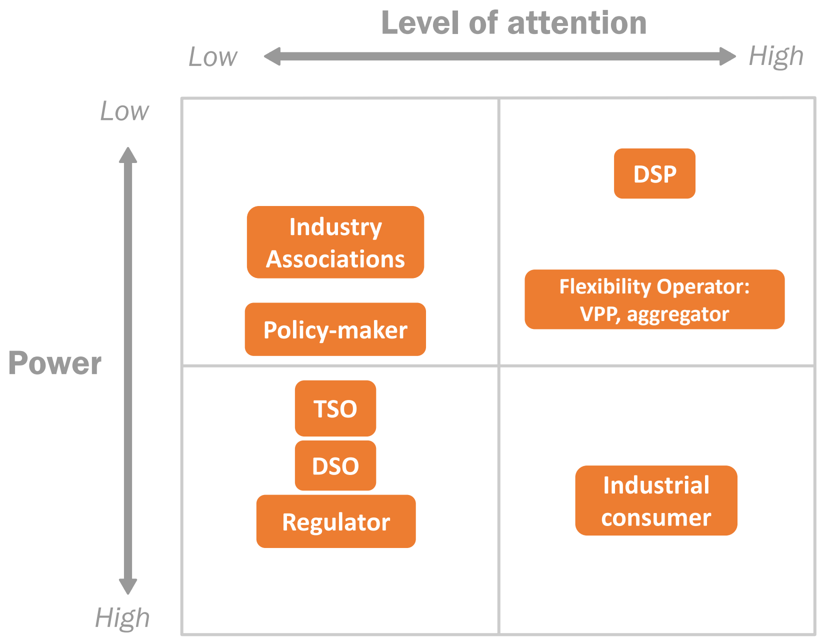

Figure 11: BM4.1 - Stakeholder Matrix

Box 5: HLUC08 description

This HLUC08 considers the case of an industrial consumer that explores flexibility in its internal processes with two goals:

i. Optimise energy consumption taking into account electricity purchasing costs, grid usage cost (specific timeframe) and self-consumption if local generation is available

ii. Offer flexibility to both DSO and TSO.

The goals of the HLUC will be achieved by using metering and sub-metering data from different types of sensors to determine the technical feasibility for changes in the industrial process to optimize energy consumption as well as by performing flexibility audits to characterize the degrees of freedom in energy consumption/production. From the flexibility characterization and activation, industrial processes are automatically adjusted to maximize overall profits taking into account energy purchasing costs and flexibility offer profits.

3.4.2. Business model 4.2: Residential consumers minimizing energy cost

This BM, which would correspond to HLUC09, is similar to BM4.1 but with a focus on residential consumers. As in the previous case, residential consumers can reduce electricity costs through energy consumption management, self-generation and the provision of flexibility services to DSOs. In this BM, load automation relying on a HEMS is a central element. The main strategies for residential consumers are therefore:

- **Energy Price response**: residential consumers can also react to electricity prices, which in their case would correspond to the volumetric component of the retail tariff (€/kWh). Whilst traditionally, this tariff was mostly flat, time-differentiated and dynamic prices (e.g. hourly pricing) are being increasingly common for residential consumers enabled by the deployment of smart meters. In fact, Directive 2019/944 gives consumers the right to have a dynamic price contract.

- **Network tariff response**: consumers can also react to time-varying network tariffs, particularly they are designed in a usage-reflective way. As mentioned above, these tariffs can be static ToU charges or dynamic network charges. Network charges are still mostly set as an energy payment (€/kWh), although fixed (€) and capacity-based (€/kW) charges may become more common in the future.

- **Energy Performance Contracts**: retailers or ESCOs may offer consumers to sign contracts based on demand-side management indicators (e.g. reducing consumption at peak hours).

- **Installation of DER and self-consumption**: residential consumers can also opt to install DER to self-generate locally produced electricity. The most common technologies for residential consumers would be solar PV and, particularly if costs decrease, battery storage systems (BESS).

- Advanced models for self-generation: since some residential consumers may be unwilling or unable to incur the full investments costs for these technologies, **third-party ownership models** such as leasing or financing models could be a facilitator for this option. Likewise, residential consumers who installed generation units in a second residence (e.g. a summer house with solar panels installed), may be allowed to **share the electricity surplus** produced when this residence is not being used with another supply point, with the same or a different contract-holder.

- **Participation in Citizen and/or Renewable Energy communities** (CEC, REC): energy communities are also a possibility for residential consumers, as laid out in Directives 2019/944 (Citizen Energy Communities) and 2018/2001 (Renewable Energy Communities). Although the scope of these communities is still not clear in the regulation, they are expected to allow consumers to jointly manage electricity generation/consumption and therefore reduce costs.
- **Provision of flexibility services to DSOs**: residential consumers can provide local flexibility services to DSOs. Providing balancing services to the TSO was considered outside the scope of this BM.

The interactions and exchanges between the residential consumers and other stakeholders are illustrated in Figure 12. In this case, the interaction between DSOs and residential consumers for the provision of flexibility will presumably require a flexibility operator in most cases. Nonetheless, this may be avoided, for instance, under mandatory curtailment programs or flexible access agreements.

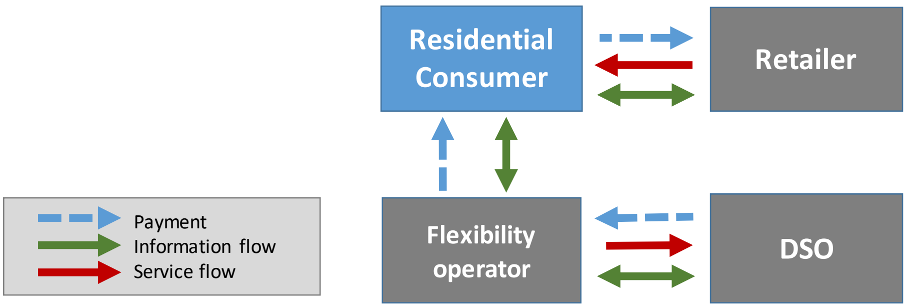

Figure 12: BM4.2 - Residential consumers minimizing energy cost – BM Diagram

Figure 13 displays the complete stakeholder mapping for BM4.2. In addition to the stakeholders mentioned above, this figure includes:

- The DSP and ESCOs that may provide B2C services to residential consumers such as the ones mentioned for BM3.1.
- Regulators and policy-makers that should create the necessary conditions for the provision of flexibility services by demand. Moreover, since residential consumers normally pay for most of the regulated costs (networks, RES support costs, others), the design of regulated charges by policy-makers and/or regulators is central to determine the benefits for residential consumers. Likewise, these authorities play a key role in defining the rules for self-generation and CECs.
- Consumer associations that may play a role in providing energy advice to residential consumers through reports, leaflets, comparison tools, etc. This can help overcome the information barrier faced by many residential consumers and enhance end-user awareness. Nevertheless, they are placed as low power/low attention considering that they do not participate actively in the BM.

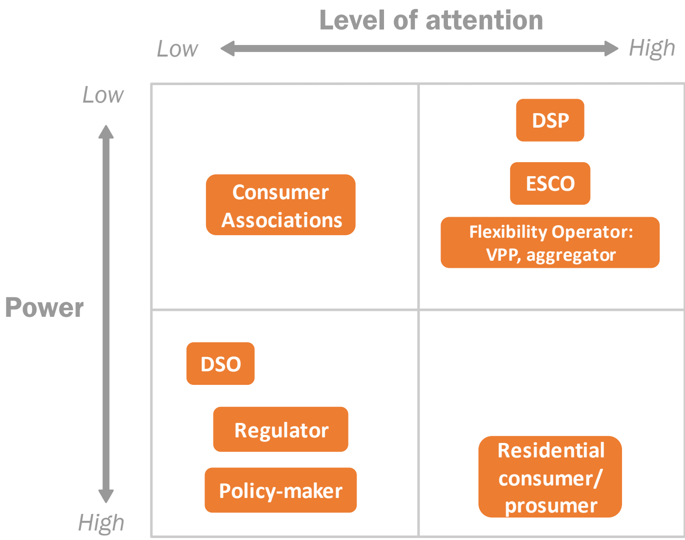

Figure 13: BM4.2 - Stakeholder Matrix

Box 6: HLUC09 description

The scope of this HLUC is the energy management at the residential consumer premises to maximize self-consumption and self-sufficiency. The possibility of performing load, PV and storage control to maximize internal goals like self-consumption and electricity cost minimization is considered as well as the possibility of making available information about the flexibility that can be transmitted to aggregators and/or DSO.

3.5. Business model 5: Retailers and aggregators

This Business Model combines strategies for retailers, aggregators and energy-information platform developers (se BM5.2 for further details) that aim to benefit from aggregating DER flexibility and using it to provide different flexibility services. Thus, in this case, the main actor is the flexibility operator and/or BRP.

3.5.1. Business model 5.1: Aggregation of commercial demand response

In this BM, the retailer in the role of Balance Responsible Party (BRP) is the main actor. The retailer would use the flexibility potential from commercial buildings, controlled through a Building Management System (BMS), to manage internal imbalances, reducing the corresponding costs, and provide balancing services to the TSO, opening a new revenue stream. Therefore, retailers are able to exploit demand-response flexibility in two different ways, either by reducing imbalance costs or by participating in the ancillary services markets.

The retailer may follow different strategies to achieve this:

- Flexibility for **internal portfolio balancing**: As of today, retailers have to manage imbalances by either trading in the intraday markets or face imbalance penalties. With the development of aggregation and the use of advanced technology such as the BMS, retailers will be able to use the flexibility from their clients to reduce imbalances and therefore reduce the associated costs. An issue to consider in this strategy is that, especially if market concentration is high, it may reduce liquidity in intra-day markets, as retailers will solve imbalances internally, without trading in this markets.

- Additionally, the retailer may use this flexibility to perform **arbitrage between day-ahead and intra-day energy markets**: under certain conditions, the price differential between day-ahead and intraday markets may increase or decrease and create opportunities for retailers to exploit flexibility to get a benefit from the price spread between market sessions. This could be particularly noticeable when day-ahead expected conditions deviate significantly from actual market conditions (large forecast errors, large generator failures). In this case, flexibility can be offered in the intraday to benefit from the high prices. Moreover, inefficiencies in intra-day markets (lack of liquidity, very discrete market sessions[8]) may also create conditions in which flexibility can be used. A situation of higher prices in the day-ahead markets in relation to the intraday market can also lead to benefits if the retailer is able to forecast this difference and act accordingly (e.g. buying less in the day-ahead and buy the remaining in the intraday), using flexibility to hedge the strategy.
- Flexibility aggregation to **provide balancing services to the TSO**: if allowed by regulation, retailers may aggregate the flexibility from several commercial buildings to provide balancing services to the TSO. Given the technical requirements, mFRR or RR seem better suited for these purposes, albeit the provision of other types of reserves, e.g. aFRR, could be explored.

When pursuing these strategies, the retailer would need to take into account the following considerations:

- Customer engagement strategies: retailers may carefully assess and select those customers with the highest flexibility potential and therefore maximize the effectiveness of the BM, as the deployment of the BMS and the required communication and information systems may be costly.
- How to remunerate flexibility providers: for the customers that agree on offering their flexibility to the retailer, a remuneration strategy will be necessary. It is important to notice that customers will also be able to offer their flexibility to other players, or refuse to take part if the benefit does not compensate the costs or complications perceived. Therefore, remuneration must be competitive. This can be based on direct compensations after successful activations, based on permanent discounts in the bill, etc.
- Metering data availability: this BM requires accurately forecasting expected deviations, and the consumption and flexibility capabilities of each commercial consumers, as control set-points have to be sent to each BMS individually. However, access to commercial consumers' metering data on a close to real-time basis is not common nowadays. This would probably require additional infrastructure of ad-hoc metering equipment[9].

[8] With the full implementation of the European intraday electricity market known as SIDC (Single Intraday Coupling), liquidity should be high in these markets.

[9] Additional regulatory definitions are also necessary for BMs, e.g. the definition of how the baseline for flexibility provision is calculated. Considering that these topics are defined in regulation, they are not discussed in this report. The interested reader is referred to deliverable D7.2, in which regulatory barriers for the different BMs are discussed in depth, and recommendations on how to overcome them are provided.

The main interactions between the retailer and the key stakeholders is shown in Figure 14. It essentially shows how the retailer uses the commercial demand flexibility activated through the BMS to modify its position in wholesale electricity markets and/or provide balancing services to the TSO.

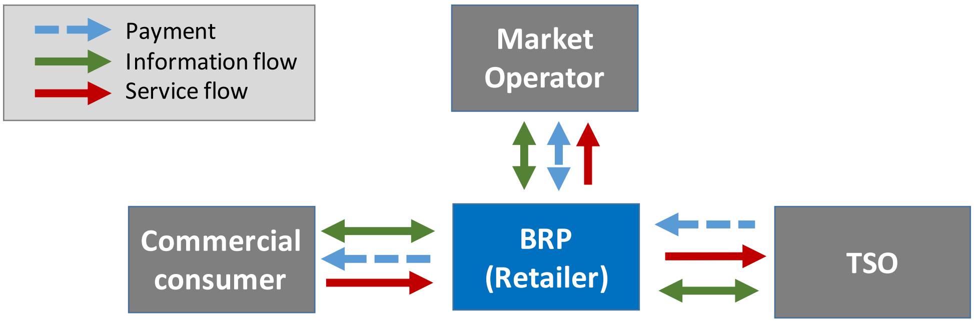

Figure 14: BM5.1 - Aggregation of commercial demand response – BM Diagram

Additionally, this BM may require the direct or indirect involvement of several stakeholders as shown in Figure 15. These include regulators and policy-makers that should create the necessary conditions for the provision of flexibility services by demand and have a role in the definition of the electricity tariffs paid by commercial consumers. Consumer associations or representatives (e.g. chamber of commerce) could play a role in supporting commercial consumers through the dissemination best practices and exchange or lessons learnt to reduce the information gap.

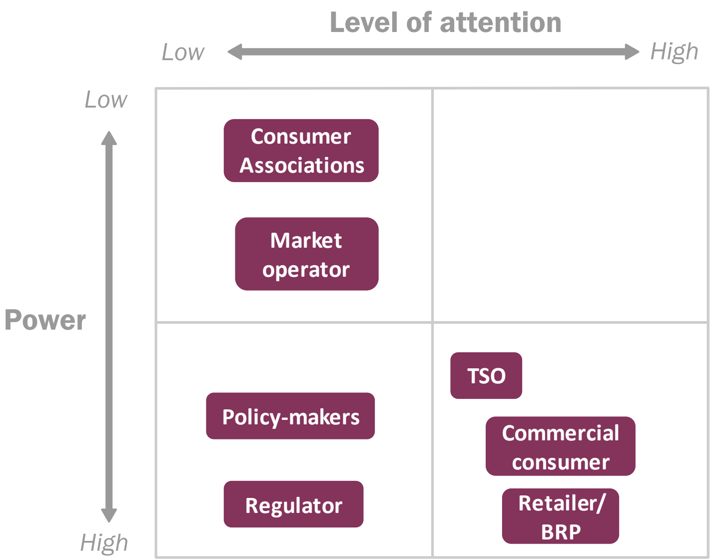

Figure 15: BM5.1 - Stakeholder Matrix

Box 7: HLUC10 description[10]

The goal of this HLUC is to aggregate and communicate behind the meter flexibility calculated in the HEMS (HLUC09) to the market hub. The aggregated flexibility from multiple LV prosumers will be used in the market by performing bidding optimization in day-ahead, intraday and ancillary services markets.

3.5.2. Business model 5.2: Aggregation through behavioural demand response

This BM is centred on the idea of the LocalLife platform, explored within HLUC11. This platform provides different types of signals (other than price signals) to end consumers to change or reduce their electricity consumption, i.e. behavioural demand response (BDR). In this BM, we explore the benefits that could be exploited from the BDR concept. Nevertheless, other functionalities could be added to this platform. In fact, some real-life experiences have already tried such combinations, as shown in Chapter 4.

Several demand response classifications can be found in the literature. Among those, SEDC (2016) proposes a classification consisting of two categories, described below.

1. Explicit Demand-Side Flexibility: DR is achieved by the active participation of consumers (directly or through a third party) in organized markets such as energy and service markets, or contracted or mandatory services. In the explicit demand-side flexibility, the DR unit is “activated”, or obliged to provide a flexibility following a commitment from a procurement mechanism. In order to participate in such organized markets, DR providers have to be usually prequalified, and the verification of flexibility provision in the real-time and ex-post is calculated based on a baseline methodology adopted for the specific market/product[11].
2. Implicit Demand-Side Flexibility: DR providers do not participate in organized procurement mechanisms and are not obliged to provide flexibility at any moment. Consumers are exposed to price signals (e.g. energy, network costs) and they may or may not react to these signals.

In this context of the concepts defined by SEDC (2016), behavioural demand response could be considered a third type demand-side flexibility, or at least a subcategory of implicit demand-side flexibility. Under BDR programs, consumers are also exposed to signals, but these are different from price signals. These may include environmental signals (e.g. effect of consumption on emissions), social signals (e.g. comparisons with neighbourhood/community consumption level), or gamification (e.g. system of points for achieving energy goals, rankings, and eventually prizes). Therefore, this business model leverages on the idea of behavioural demand response by the development and operation of a social platform that achieves DR flexibility provision.

The main value of this business model is the promotion of demand-side flexibility and efficiency. This value creation could be directed to the final consumers themselves, or to use the flexibility attained to participate in energy or flexibility markets. Depending on the selected strategy, several **different revenue models** could

[10] During the progres of the project, the focus on this HLUC was modified to focus on commercial consumers rather than residential consumers. Thus, this original description does not match the BM description. It is included here nonetheless for the sake of completeness.
[11] Additional information on prequalification and baseline methodology can be found in the deliverable D7.2.

be possible for this business model, as listed below. These may be classified into the revenues that could be obtained simply from acting as a platform, and those that would require becoming some sort of BDR aggregator. Note that several of these revenue streams could be explored simultaneously.

The possible revenue models under a **platform-only model** include:

- **Subscription fees**: in this revenue model, users of the platform have to pay a subscription fee to access the platform as a whole or to access some "premium" features. The challenge of this revenue model is in the fact that it may be difficult for users to perceive a value offered by the platform high enough in order to pay a subscription. Additionally, the subscription fee is expected to be low[12], and therefore the platform should have a big number of customers to be profitable.
- **Software as a service (SaS)**: the previous approach was based on a direct interaction between the platform operator and end consumers. Nonetheless, in order to reduce engagement costs, the platform could be offered to end consumers through existing companies, such as retailers or ESCOs, which may include this service in their commercial offers.
- **Advertising**: this model follows the usual revenue model of many online platforms, in which the user has free access to the platform, but is exposed to advertisements. The advertisers pay the platform owner. This revenue model may be only viable if the platform achieves a big user base.
- **Data model**: In this revenue model, users are free to use the platform. The platform owner would profit from selling aggregated data and its analysis from the platform to third parties. This revenue model, however, faces challenges related to data privacy compliance (GDPR).

On the other hand, the possible revenue models under a **BDR aggregator model** include:

- **Independent BDR aggregator**: the platform operator could become an independent aggregator and participate in organized markets and provide flexibility services. As discussed in section 4.2.2, some companies already tried this revenue model in parts of the US and Canada. However, for this revenue model to work in a European context, several aspects would have to be considered and researched. Firstly, companies would have to analyse the reliability of the flexibility that is offered. Secondly, the participation in energy markets usually requires providers to comply with several technical aspects (e.g. be prequalified, have communication systems) and economic aspects (e.g. large guarantees for participation in wholesale markets). Lastly, the market organization in the ISO regions, where the same operator handles energy and balancing markets, is quite different from the European structure where energy markets and balancing markets are distinctively operated by separate entities, i.e. market operator and TSO respectively. Further discussions about the feasibility of implementing a similar approach in Europe are presented in section 4.2.2 and 4.5.
- **Integration with an existing market agent**: this is similar to the software as a service discussed above, with the addition of the aggregation functionalities. This integration with an existing market agent may happen through a partnership or through an acquisition. This strategy could facilitate scaling-up the business and reduce transactions costs. On the other hand, the existing market agent would increase the efficiency in their operations and/or open new revenue streams. This could also be an alternative for the platform operator to start exploring the potential of BDR in unknown

[12] For a numerical analysis, the interested reader is referred to deliverable D7.4, in which a Cost Benefit Analysis is done for selected HLUCs, including HLUC11, linked with this BM.

territories, as this type of flexibility tends to vary considerably from place to place (e.g. consumers of one country may react a lot more to environmental signals than in other countries).

The revenue models described above can be considered general and possibly replicable across several European countries. Nevertheless, local contexts and regulatory frameworks may offer the opportunity for **region-specific revenue models**. These can be explored by the BDR aggregator as an additional revenue stream or as a way to kick-off the company whilst markets are fully open for demand. Below are a few examples:

- Provision of **energy management services**: in addition to the participation in organized markets and flexibility services, a BDR aggregator may provide energy management services to different stakeholders that have some relationship with the end consumers. These may include, among others, CECs or building managers. See, for instance the case of building managers in Sweden:
  - **Building managers in Sweden**: In Sweden, households that live in apartment buildings are responsible for the procurement of the energy (kWh), while the building managers are responsible to contract the grid capacity (kW) required by the whole building (later shared among all households). In this context, the platform could be sold as a service to building managers, in an effort to reduce the contracted capacity or network charges of the whole building. Households would be left with the shared cost of the platform subscription, but also with a considerably lower contracted capacity cost, resulting in an overall benefit for consumers.
- **Energy efficiency certificates**: provided the BDR aggregator is capable to certify the energy efficiency gains, this could allow obtaining tradeable energy efficiency certificates, also referred to as white certificates, and make a profit by selling them. This would only be possible in countries that have implemented and Energy Efficiency Obligation Scheme (EEOS) as a means to comply with the obligations under Directive (EU) 2018/2002.

As shown by the discussion above, this BM may be considered widely open, with many potential revenue streams. The reason is essentially its highly innovative nature. In order to reflect the different possibilities, the interactions of the platform operator with the other stakeholders mentioned above is shown separately in Figure 16, for the platform-only model, and in Figure 17, for the BDR aggregator model. In the latter case, the platform operator and the BDR aggregator may or may not be the same agent.

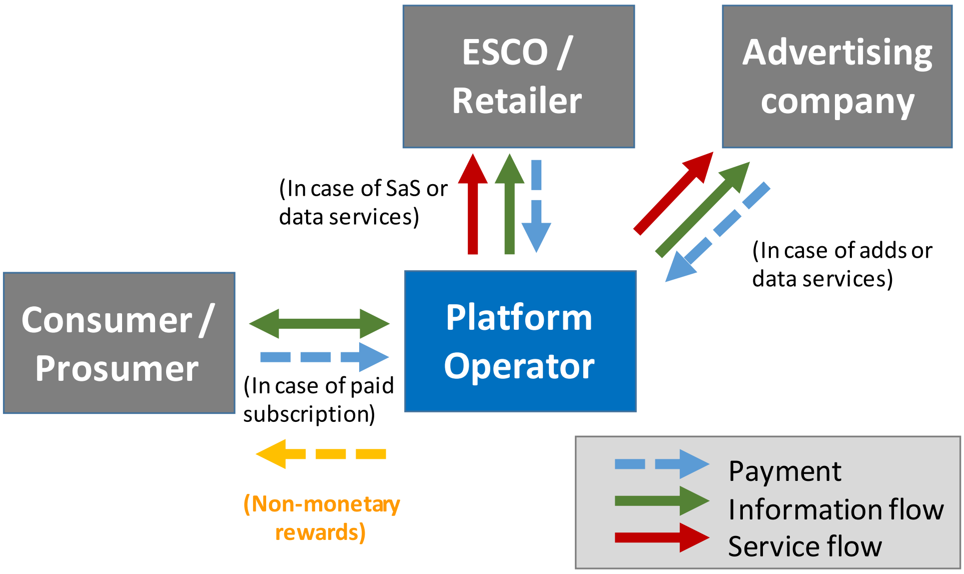

Figure 16: BM5.2 – Aggregation through behavioural demand response – BM Diagram for a platform-only model

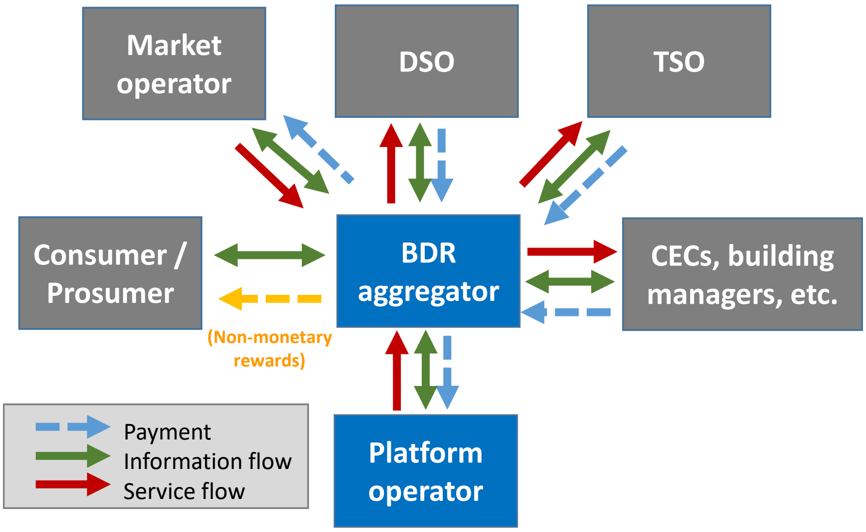

Figure 17: BM5.2 – Aggregation through behavioural demand response – BM Diagram for a BDR aggregator model

Figure 18 shows the complete stakeholder matrix for this BM. The reason why there are so many stakeholders depicted therein is that most of them could be involved in one of the several strategies, but not in all of them. The truly key stakeholders are the consumer and the platform operator/BDR aggregator. In addition to the stakeholders mentioned above, this figure depicts the institutions in charge of defining and overseeing legislation and regulation.

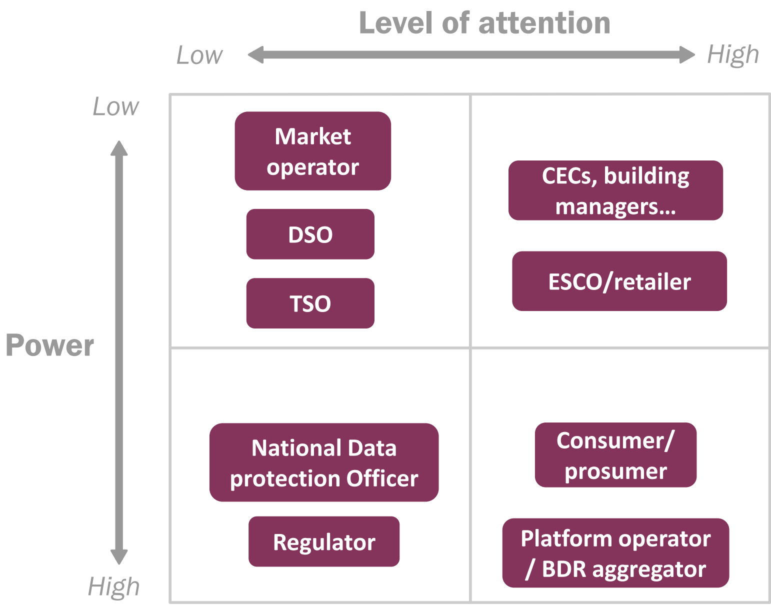

Figure 18: BM5.2 - Stakeholder Matrix

Box 8: HLUC11 description

This HLUC is centred on providing anonymized and processed data to consumers to promote energy efficiency. The actions are i) day-ahead hourly dynamic electricity prices targeting demand flexibility and peak load reduction, and ii) direct feedback on electricity consumption targeting demand flexibility and peak load reduction. The information is transmitted using secure local social networks on a community level, including non-economic information such as environmental signal's feedback.

3.5.3. Business model 5.3: Provide flexibility services through a commercial VPP

The main actor of this BM if the VPP operator who acts as flexibility operator to supply balancing services to the TSO by aggregating the flexibility from DER owners or consumers. The balancing services the cVPP may provide include the mFRR, which is where Integrid focuses on, but it could potentially provide other balancing services such as aFRR or even some other ancillary services procured by the TSO such as voltage control or congestion management.

Managing its flexibility portfolio is one of the key aspects in the BM of the VPP. Flexibility providers may comprise distributed generation, energy storage, industrial demand consumption or charging stations for electric vehicles; therefore, the flexibility of each one of them may present important differences regarding factors such as: upwards and downwards availability, ramping capabilities, speed of response, different availabilities over time (daily, weekly, seasonal), etc.

Furthermore, the location of the flexibility providers engaged can be relevant to provide certain types of ancillary services, such as voltage control or congestion management. Likewise, location is a key aspect to consider when the VPP also provides services to the DSO (see section 3.5.4) or when constraints in the distribution grid prevent the cVPP from activating the flexibility of DER. In this BM, it is assumed that some form of TSO-DSO coordination scheme, such as the Integrid traffic-light system (TLS), is in place.

Another key issue is how flexibility providers are remunerated. This remuneration, which would account for a certain share of the VPP revenues, should be enough for a successful engagement whilst ensuring the financial viability of the VPP.

The VPP operator may follow different strategies, listed below, to implement this BM and participate in ancillary services markets. These are very similar to the options discussed above for the BDR aggregator (see section 3.5.2).

- **Independent aggregator**: the cVPP could become an independent aggregator and participate directly in balancing markets according to the national rules for independent aggregation which, as of today, is still scarcely developed in many European countries.
- **Integration with an existing retailer/aggregator**: under this model, the VPP would activate the flexibility resources resulting from the needs of a market agent. This can take place through a partnership or through an acquisition. This strategy could facilitate scaling-up the business and reduce transactions costs. On the other hand, the existing market agent would increase the efficiency in their operations and/or open new revenue streams, benefiting also from a higher financial capability (e.g. to comply with the need for guarantee requirements in certain organized markets).

In addition to the strategy of acting directly as a market agent, the VPP operator may wish to explore some other alternatives in contexts where balancing markets are not open for demand-side participation or simply to obtain additional revenue streams. These are the following:

- **Software as a Service (SaS):** a first alternative would be to offer the software developed, i.e. the VPP platform, to BRPs, retailers or aggregators in order to perform their operations more efficiently or open new revenue streams. In this commercial arrangement, all necessary software to run the VPP is sold, and the client is responsible for the commercial and technical operation of the VPP. The software could contain forecasting modules, communication capabilities with DER, real-time monitoring among other functionalities.
- Provide **services to end-users**: additionally, the VPP could use its control software to provide services directly to end-users such as reducing capacity-based network charges, or reduce connection costs.

The interactions of the cVPP operator with other stakeholders is represented in Figure 19. Note that this figure includes some information exchanges between the DSO, the VPP operator and the TSO. This aims to reflect the need for a TSO-DSO coordination scheme to prevent constraints in the distribution grid.

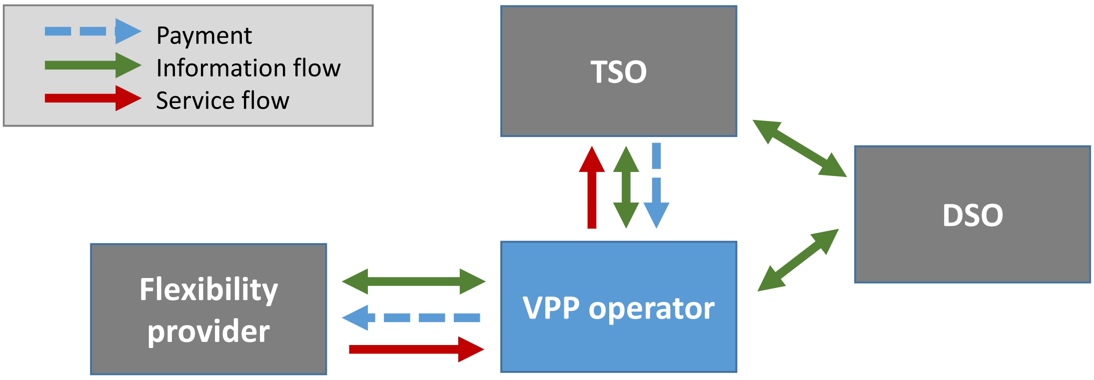

Figure 19: BM5.3 – Commercial VPP- BM Diagram

On the other hand, Figure 20 shows the full stakeholder mapping corresponding to this BM. In addition to the aforementioned stakeholders, the regulator is a central stakeholder as it is key to enable and determine the rules of aggregation and demand-side participation in balancing markets, according to the Clean Energy package dispositions. Moreover, since the entrance of the cVPP may change the market conditions (e.g. liquidity, prices, product definition, other market players can become a relevant stakeholder.

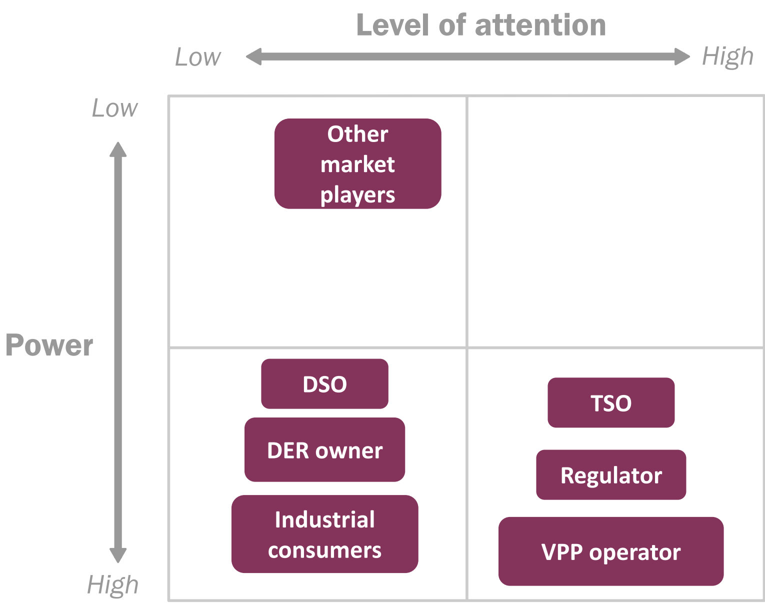

Figure 20: BM5.3 - Stakeholder Matrix

Box 9: HLUC12 description (i/ii)

Customers and distributed third-party energy resources that have the ability of changing their consumption or generation for short time could be aggregated, and their flexibility could be offered as ancillary service to TSO or to be used for DSO grid purposes.

In case of the commercial VPP, when the TSO triggers an activation of mFRR, the flexibility operator executes TSO's requested activation schedule by means of the VPP system. The VPP activates distributed flexibility resources like loads, renewables and storage for a predefined maximum period and controls the fulfilment of the activation schedule.

3.5.4. Business model 5.4: Provide flexibility services through a technical VPP

The main actor of this BM is again the VPP operator, but in this case it will be using the aggregated flexibilities to provide services to the DSO, i.e. a tVPP. The specific services provided would depend on the needs of the DSO[13], which can range from congestion management, voltage control, or long-term investment deferral. The same considerations described for BM5.3 about the VPP portfolio and the remuneration to flexibility providers are applicable here. The main difference being that the location of the flexibility providers is a central issue in this case since DSO needs will be strongly location-related.

Likewise, concerning business strategies, the tVPP would be similar to the cVPP. The only possible difference could be found in the models "SaS" and "energy management services". In these cases, one possibility is that the VPP software, instead of being operated by a third-party, could be embedded into the DSO systems who would directly activate the flexibilities previously contracted. Being this the case, these contracts should be made on a long-term basis.

Figure 21 shows the stakeholder interactions in this BM. The main difference with respect to BM5.3 is that the local flexibility platform, which is not necessarily operated by the DSO, is used for the flexibility information exchange, as it is done in Integrid through the gm-hub.

[13] Under the concept of the project, the tVPP is focused towards the DSO, and the cVPP towards the TSO (e.g. balancing services). Nevertheless, it is also possible to assume that the tVPP could provide services to TSOs in case of non-organized markets, and that a cVPP could participate in eventual local flexibility markets.

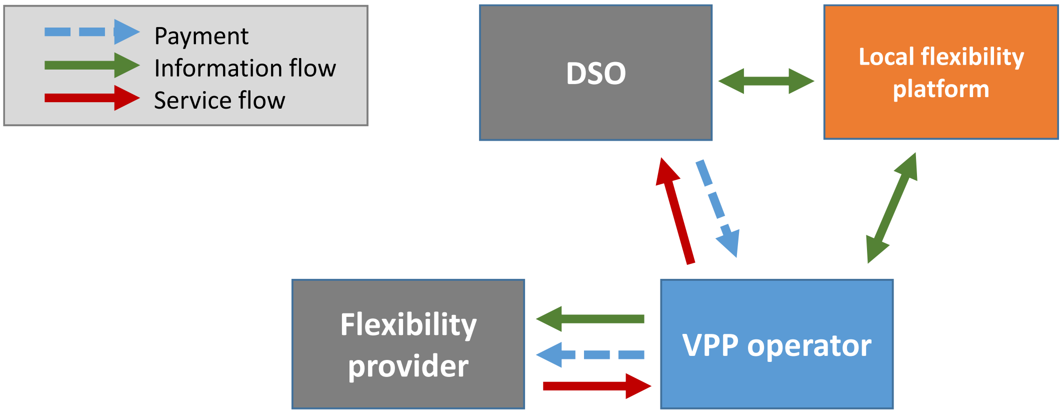

Figure 21: BM5.4 – Technical VPP - Diagram[14]

Lastly, Figure 22 displays the stakeholder mapping for this BM. Once again, the regulator is shown as a central stakeholder determining DSO revenue regulation, and incentives to use flexibility, as well as the regulation governing local flexibility mechanisms.

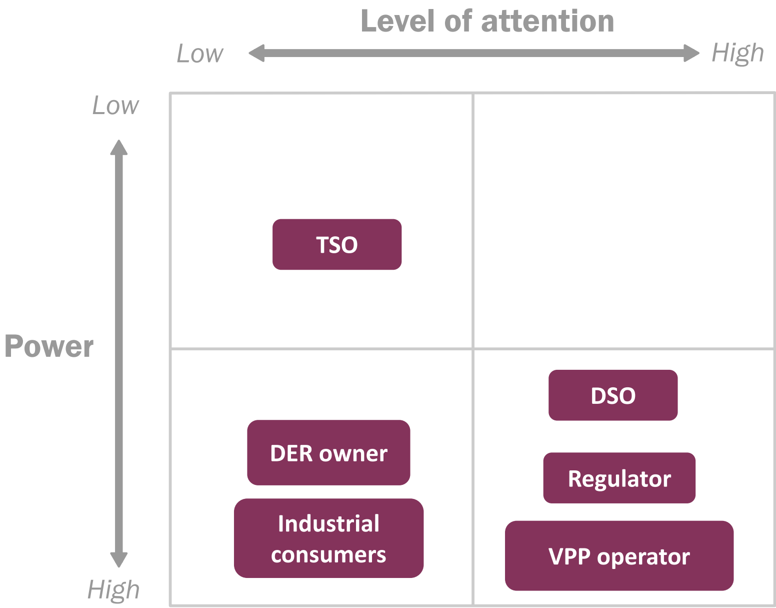

Figure 22: BM5.4 - Stakeholder Matrix

Box 10: HLUC12 description

Customers and distributed third-party energy resources that have the ability to change their consumption or generation in the short time could be aggregated, and their flexibility could be offered as ancillary service to TSO or to be used for DSO grid purposes.

In case of the technical VPP, whenever the DSO detects some congestions or voltage problems, he orders activation of distributed flexibility resources like loads, renewables and storage on MV/LV grid that are aggregated within the relevant grid sections by the flexibility operator.

[14] The local flexibility platform could be based on the gm-hub proposed in Integrid, for instance.

4. Real-life examples of innovative business models

The description of the BMs presented in section 3 clearly shows that the business strategies for the implementation of BMs are in several cases subject to significant uncertainties. This section intends to **shed light on some of the key uncertainties** identified by studying a set of **real-life case studies** of companies that have implemented similar or related BMs. The aim is to study what conditions (regulatory, market, policy, economic, etc.) have enabled or promoted their development. Note that this list does not intend to be exhaustive, but to identify existing trends, best practices, and possible no-go conditions.

In order to identify the business cases or strategies that deserve further analysis, the key question is whether it is clear **who will play certain roles or what the main benefits will be** (even if the specific strategy to rip these benefits is not entirely clear). To answer this question, the main actors, and the most relevant stakeholders with whom they interact have been broadly classified into three main groups:

i. **Purchaser:** Existing actors of the power system that procure flexibility or data-based services. In this group, one may find grid operators (TSOs, DSOs) and end-users (different types of consumers, DER).

ii. **Enabler:** New activities not necessarily performed by new actors, which act as enablers for the provision of flexibility and/or data services. These roles essentially comprise the metering data platform manager, the local flexibility platform operator, and the flexibility operators (VPPs, aggregators).

iii. **Provider:** Existing actors that adopt new activities providing flexibility, sometimes through a flexibility operator, or data services.

Based on this classification and the questions posed above, the most relevant uncertainties from the BM perspective were found in those new roles that need to be developed in order to enable some of the BM, i.e. **flexibility and data platform operators, and flexibility operators**. Therefore, the focus of this study was placed on the strategies or regulatory models of companies performing these roles. Additionally, despite the fact that the role of DSPs already exists, the possibility for these **DSPs to** rely on openly available distribution-related data is quite new. Therefore, this section will also address the services and models potentially adopted by this DSP.

4.1. Local flexibility/market platforms

The concept of flexibility platform is very broad and can encompass many different types of systems. Therefore, before describing the real-life cases analyzed in further detail below, it is relevant to provide some explanations on where the focus is placed herein. For instance, (USEF, 2018) enumerates up to eight distinct types of flexibility platforms, with different levels of maturity. These include the following (roughly ordered by their current level of maturity/development):

- Conventional **wholesale market platforms** and power exchanges

- **TSO platforms** to procure ancillary services and congestion management
- Those used by one agent to provide **services to their customers or manage their own portfolio** (VPP, microgrid controller, BRP/supplier trading platform, or energy management systems such as HEMS or BMS)
- **Data exchange** platforms (data hubs)
- **Local energy trading** platforms (P2P trading, CECs, shared self-generation)
- **DSO platforms** to procure services to support grid operation
- **TSO-DSO coordination** platforms, meaning the strategies and technological means implemented to carry out this coordination

Another concept that is closely intertwined with flexibility platforms is local **markets**. The term local market may refer to the local energy trading platforms mentioned above or to local flexibility markets where DSOs procure services from DER to prevent or alleviate grid constraints (Schittekatte & Meeus, 2019). The latter will be supported by the DSO platforms from the list above.

Within the realm of flexibility platforms, this report focuses specifically on the platforms that enable the DSO to procure local flexibility services, especially when the aim is to reduce the need for grid investments. This is because that is the function that Integrid gm-hub plays in BM1 (DSO procuring flexibility), and it is one of the strategies discussed for BM3.2 (Data management and local flexibility platforms). The data exchange platforms, another possible function of the gm-hub, and also part of BM3.2, are addressed in section 4.3.

Even though local flexibility platforms are still at an early stage of development, there are several examples that are already under large-scale or commercial operation. It is noteworthy that, contrary to conventional ancillary services platforms, all of these are operated by a third-party different from the DSO. On the ensuing, these cases are analysed to inform the discussions about BM1 and BM3.2. This discussion is strongly based on (Schittekatte & Meeus, 2019) and (SmartEn, 2019). Additionally, the corresponding web sites of the platforms and corresponding projects have been consulted for further details.

Piclo Flex (UK)[15]:

Piclo Flex is an independent market platform active in the UK, where DNOs[16] can procure flexibility services to solve constraints, manage outages or defer grid investments in the MV and LV distribution grids. The platform is owned and operated by Piclo, which is a private company and carries out a non-regulated activity. Its revenues come from the users of the platform.

The flexibility procurement is based on long-term auctions. The platform allows DNOs to design different auctions according to their needs and pre-qualified flexibility providers are entitled to bid, provided their resources are located within the area specified by the DNO. The type of parameters the DNO needs to set include the amount and type of flexibility needed (upwards or downwards), the remuneration option (activation only, or availability and activation), timeline for qualification and bidding, and the expected time, number and duration of activations. Figure 23 shows an example of one auction run on Piclo Flex. For each auction, several flexibility providers may partially fulfil the DNO needs and aggregation is permitted. This

[15] https://picloflex.com/
[16] Note that the terms DNOs (Distribution Network Operators) is most commonly used in the UK instead of DSOs.

platform is focused on the use of flexibility to support distribution grid operation and has no link to the wholesale markets or TSO-DSO cooperation scheme.

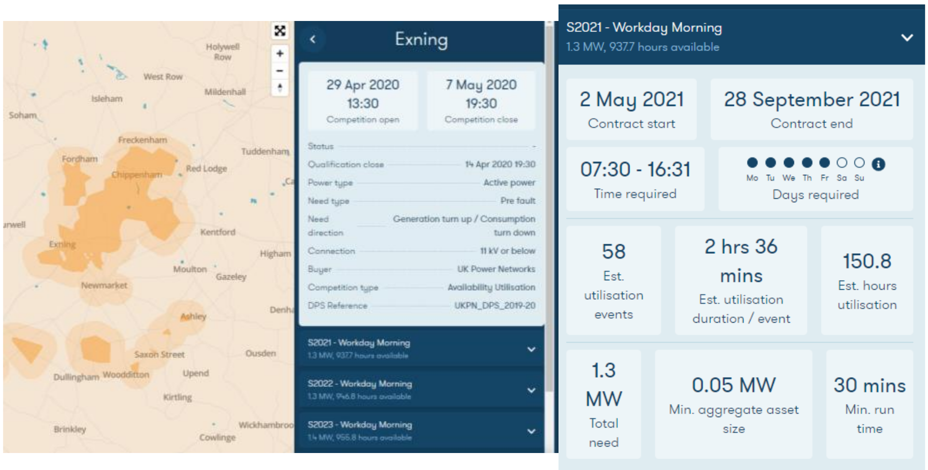

Figure 23: Example of a flexibility tender held on the Piclo Flex platform. Source: Piclo Flex®

At each price review, UK DNOs must show in their business plans that they have actively considered the use of DER flexibility as a means to deliver a reliable electricity supply in an efficient manner. Thus, the long-term procurement of flexibility through this platform can be used by DNOs to comply with this regulatory obligation.

Enera (Germany):

Enera is a local flexibility market operating under a regulatory sandbox funded by the German Federal Ministry for Economic Affairs and Energy (BMWi). The partners of Enera include EPEX SPOT, an independent power exchange and one of the NEMOs in central and northern Europe, one German TSO TenneT DE, and two DSOs Avacon Netz and EWE NETZ; these two DSOs are connected one downstream of the other. Whilst this started as a pilot project, the revenues from its commercial operation could come from a fee per volume of energy traded, similarly to other power exchanges.

This platform is operating in a region located in the Northwest of Germany. It allows for localized intraday trading, i.e. a few hours before delivery and remuneration only for service delivery and enables both the DSOs and the TSOs to procure flexibility for the distribution or transmission grids to alleviate congestion and minimize wind power curtailment. To do this, potential flexibility providers submit their bids, including locational information, and the platform coordinates the DSO and TSO needs based on these bids. Thus, this is a joint TSO-DSO congestion management platform, but it operates exogenously to the wholesale energy markets.

GOPACS (Netherlands)[17]:

GOPACS (Grid Operators Platform for Congestion Solutions) is a local flexibility platform owned and operated by a group of Dutch grid operators, including the TSO (Tennet) and four DSOs (Stedin, Liander, Enexis Groep and Westland Infra), that aims to alleviate grid congestions through short-term trading.

In order to do so, grid operators state how much increase/decrease of demand/generation is required in a given area and potential providers, already pre-qualified, would receive a call for bids. A particular

[17] https://gopacs.eu/

characteristic of this platform is that, in order to prevent creating a system imbalance, an opposite increase/decrease is activated outside the congested area. At the same time, the platform checks that this second activation does not lead, in turn, to another network constraint. This includes a TSO-DSO coordination scheme. The grid operator that procured the flexibility service would pay the difference between both the previous bids, i.e. one constrained-on and another constrained-off. These activations are made through the existing intraday wholesale market platform (ETPA), thus GOPACS would in fact act as an interface between flexibility providers, grid operators and wholesale markets (where bids may be submitted with a locational tag).

NODES (Norway, Germany, UK)[18]:

NODES is a joint venture between the Norwegian utility Agder Energi and the power exchange Nord Pool (acting as NEMO in several central and northern European countries) that acts as independent local market operator. NODES has six active or completed pilots relying on the market platform developed by NODES in different pilot sites in Norway, Germany, and the UK. The aims and scope of the pilots is different among them, although the platform allows for TSO-DSO coordination and integration with wholesale market processes, as well as different flexibility product definitions. A short summary of some of the most representative pilots is provided below:

- Mitnetz pilot (Germany): short-term intraday market-based congestion management in the HV distribution network operated by the DSO Mitnetz in order to reduce RES curtailment (and the corresponding cost for grid operators). In this pilot, one aggregator was providing demand flexibility.
- Engene (Norway): the DSO uses DER flexibilities to defer or avoid reinforcements in a HV/MV distribution substation through peak shaving services provided by demand response and batteries. The approach followed in this case is based on a predictive management of the MV grid, like HLUC01 in Integrid.
- Flexlab (Norway): one DSO is using the NODES platform to test how the long-term agreements that DSOs may have signed with grid users (e.g. non-firm access contracts) may be coordinated with short-term flexibility procurement to alleviate grid congestions in a more efficient and integrated manner.
- Intraflex (UK): this pilot is based on a local flexibility market where the DSO can procure flexibility in the day-ahead and intraday horizons. The differential characteristic is that this pilot aim to include mechanisms to prevent creating imbalances when activating distribution flexibilities.

4.2. Flexibility operators: aggregators and VPPs

The large number and diversity of DER that may potentially provide flexibility, together with their usually relatively small individual size, requires the intermediation of a specialized flexibility operator since this agent may benefit from economies of scale and reduce transaction costs. These flexibility operators are usually known as aggregators or VPPs.

[18] https://nodesmarket.com/

In this report, the terms aggregator and VPP operator are used essentially indistinctively as, from a business perspective, the goal is in all cases to trade/operate a large number of small producers and/or consumers as one for the participation in different markets and service provision. In practice, it is common to use the term aggregator to refer to the company or agent that performs these activities, and the term VPP to refer to the software platform that acts as an interface between the providers (DER) and the market or service platforms. The VPP platform would normally feature capabilities regarding forecasting, optimization, monitoring and control.

In the context of Integrid, flexibility operators have a key role in BM1 providing flexibility to the DSO, are presumably one of the key users of the platforms discussed in BM3 and are actually the main actor in BM5[19]. This section will analyse actual examples of aggregators and VPPs, which have been divided into two groups. First, what may be referred to as "conventional" VPPs/aggregators, who rely on price signals and usually automatic control to manage their portfolio, and, secondly, the aggregators that exploit behavioural demand response (BDR) instead of conventional price signals. In the latter case, automation or other DR enabling technologies may or may not be used.

4.2.1. Conventional VPPs and aggregators

This section focuses on those companies who use the flexibility of a portfolio of users to aggregate them and participate in different electricity markets, normally relying on a software platform for portfolio management. Within the BMs discussed in section 3, the companies discussed in this section would have a direct participation in BM1 as a provider of flexibility services to the DSO through the local platforms discussed in BM3.2, and as the main actor in BM5.1, BM5.3 and BM5.4.

To analyse the state of development of this BM and draw some lessons learnt, a list of around 40 companies acting as VPP/aggregators was elaborated and analysed[20]. The most relevant sources used to obtain this list and corresponding information are Navigant Research (2019), IRENA (2019), Arthur D. Little (2018), and Poplavskaya & de Vries (2020); as well as the web sites of the companies listed.

Note that the aim of this list is to be illustrative of the type of companies, mostly start-ups and new agents, engaged in this BM and the strategies they adopt. It does not intend to be exhaustive. In fact, many established stakeholders in electricity markets may be considered as some type of aggregator, such as conventional retailers or generation companies that perform portfolio bidding (when allowed by regulation). The full detailed analysis of these companies is provided in Annex I[21].

Company information

Most companies analyzed started as software development companies providing VPP platforms to different potential users, as discussed in section 5.4. Nonetheless, as these firms develop and improve their solutions,

[19] The main actor in BM5.1 is stated to be the retailer as BRP. However, when the commercial demand response is used to provide balancing services, the BRP would be acting as an aggregator.

[20] It was not possible to find information in English for some of the companies identified. These were excluded from the analysis. The sample of cases finally analyzed amount to 34.

[21] Note that the information provided is based on publicly available information at the time of writing this report. However, this does not necessarily represent the latest status. The situation and data of some companies is likely to change rapidly due to the evolving nature of this sector.

they have oftentimes attracted the interest of large investors who acquired these companies. These are mostly utilities and private equity firms, but also oil companies who wish to take positions in the power sector[22]. Examples include the acquisition of EnerNOC by Enel or REstore by Centrica. Alternatively, some established VPP operators reach alternative form of strategic partnership with retailers, e.g. through a memorandum of understanding or as a minority shareholder. Lastly, some of the VPP companies are owned by one utility but provide their software services to several different retailers (e.g. NRG, or PowerSecure).

These forms of cooperation allow retailers to improve their operations, whereas the aggregators benefit from the market access offered by retailers with low transactions costs, as well as access to a large customer portfolio. Within the sample analyzed, more than 50% of the VPP companies are independent from retailers and utilities (see Figure 24). These firms may offer only software services to BRPs, generators, large consumers, etc. (SaS) or even act as independent aggregators in the different markets open for demand-side bidding and portfolio bidding (concerning portfolio bidding, it is also relevant if VPPs are allowed to aggregate both generation and demand resources together in the same bid).

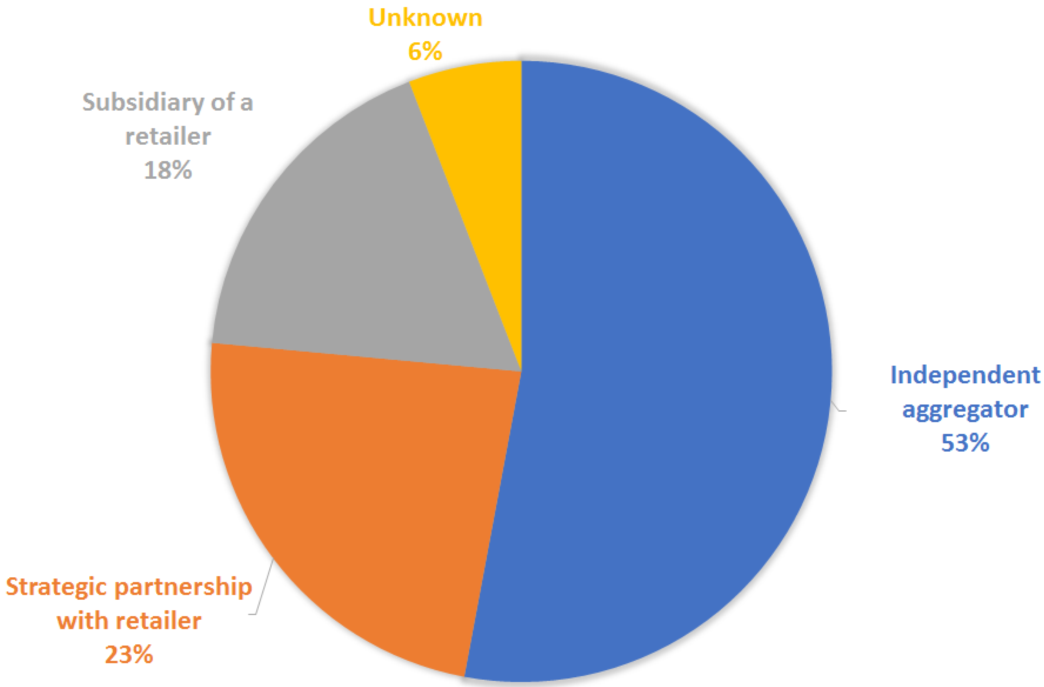

Figure 24: VPPs information - Integration with retailers (n=34)

From a maturity point of view, both technically and commercially, below (Arthur D. Little, 2018) classifies aggregators/VPPs into three categories as shown in Table 2. The level of maturity is determined by portfolio characteristics, geographical expansion, and services provided.

[22] Similar operations through which investor-owned oil companies acquire shares of companies related to other energy sectors can be found in the energy retail business or the EV charging management sector.

Table 2: VPPs according to stage of development. Source: Arthur D. Little, (2018)

Start-up	Active and developed	Self-sufficient
- Typically focus on either aggregated generation or load control. - Flexibility resources are a limited number of assets and geographic expansion is opportunistic - Partnership with retailers is key for their development	- Capacity to generate profit in a short time - Geographically expanded activities - Usually targets for acquisition by large-scale energy companies	- Considerable capacity under management - Presence around the world and developed flexibility portfolios composed of broad varieties of buyers and assets - Ability to supply all types of flexibility needs

Resources aggregated

As mentioned above, one of the key characteristics defining the VPP solution is the type of flexibility resources managed under the portfolio. In principle, when several types of resources can be aggregated together, the flexibility operator can improve its competitiveness thanks to the potential synergies between the flexibility potential of different types of DER. Accordingly, these companies can be classified into purely DR aggregators, purely generation based VPPs, and those which manage both types of resources. As shown in Figure 25, more than 70% of the companies analysed, aggregate both generation and demand-side resources, 15% are pure DR aggregators and 6% of them only aggregate generation resources. It is relevant to note that this is oftentimes not just a commercial decision from the aggregator, but a consequence of regulatory conditions.

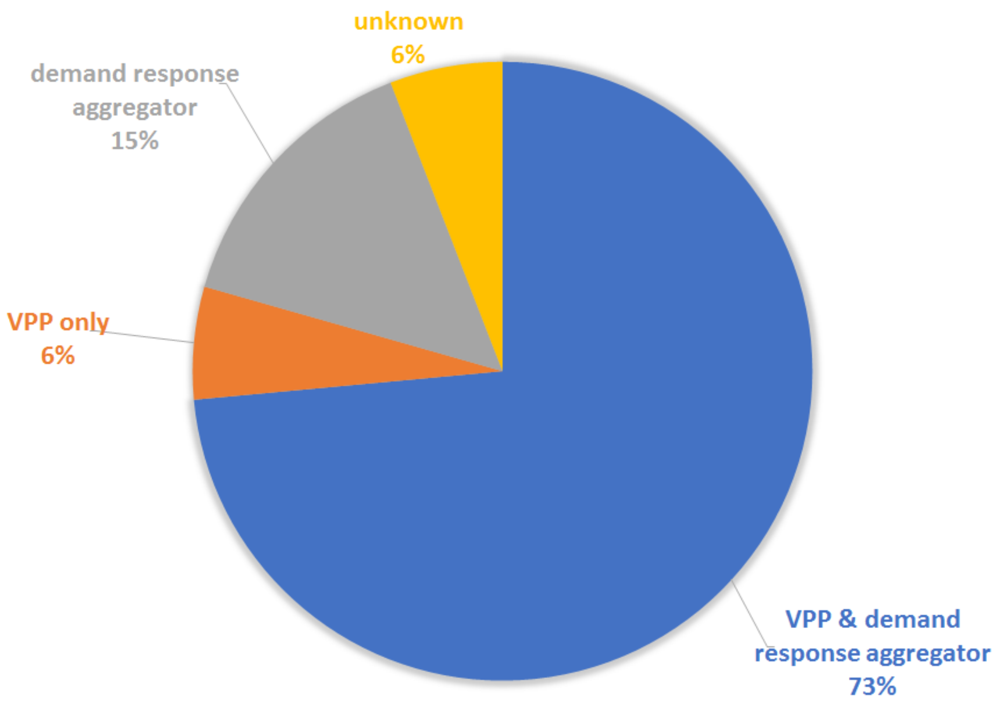

Figure 25: VPPs information - Resources under control (n=34)

Breaking down the previous information by the type of demand that is controlled (see Figure 26), it can be seen that BESS is the most commonly mentioned resource. This usually corresponds to companies active in the USA, Australia, in continental Europe or in the UK. The next most common type of aggregation is that of industrial demand, followed by commercial demand, i.e. the types of consumers who tend to show the highest individual flexibility as this reduces costs (e.g. RTUs) for the same portfolio size. In term of specific loads, HVAC and EVs are the most frequently mentioned ones, presumably owing to their storage and controllability capabilities.

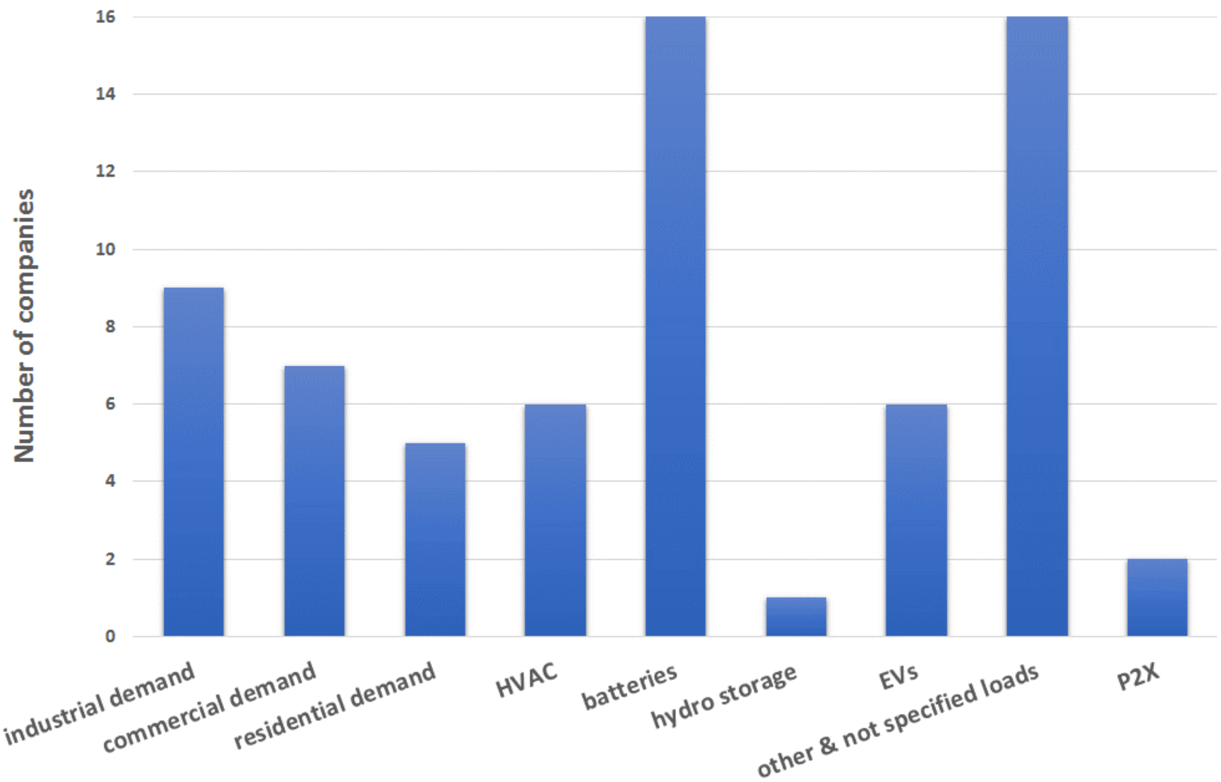

Figure 26: VPPs information – Types of demand-side (including storage) resources operated (n=29)[23]

By doing the same exercise for generation sources (see Figure 27), the picture is a bit more diffuse. In most cases, the type of generation is not specified; this can be because the same platform is capable to manage virtually any kind of generator. Nonetheless, when specified this corresponds mostly to RES installations, which is the type of generation source with a more varied ownership structure (i.e. other than incumbent utilities) and which are not as affected by economies of scale (therefore having many more smaller units).

[23] The number of companies considered to obtain this table is 29 as shown in the figure caption. The total number of individual resources aggregated is because several aggregators manage more than one type of demand-side resources

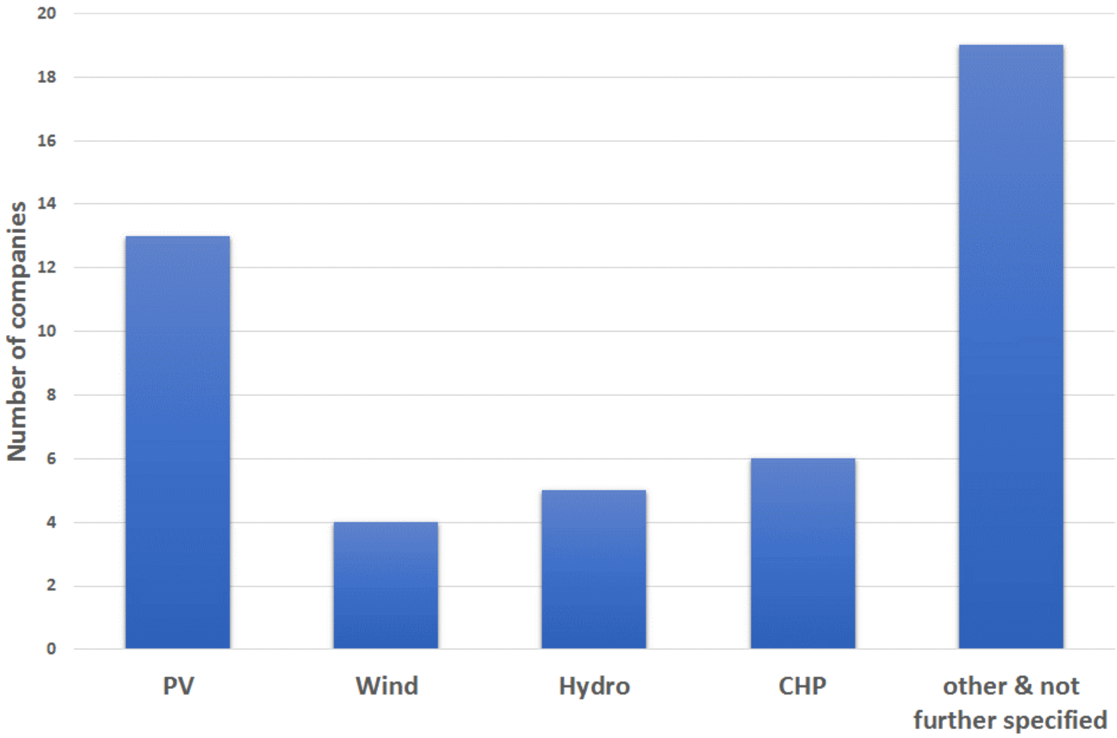

Figure 27: VPPs information - Generation sources operated (n=27)[24]

Services provided and revenue models

The companies that manage flexibilities through a VPP platform normally do not stick to a single revenue stream of a business model. Among the services these companies can provide we may find:

- Services to RES producers: Forecasting, trading, and/or curtailment of renewable energies (to prevent imbalance penalties or producing in hours with negative prices). RES generation companies who would benefit from lower imbalance penalties, higher market revenues (if there are controllable resources in the portfolio), or avoid producing in hours of negative prices (when the market price floor is lower than zero).
- Services to consumers: Energy management services to reduce electricity costs, both energy procurement and demand charges.
- Services to grid operators and utilities: Peak shaving and congestion management to prevent or alleviate grid constraints or, in the case of vertically integrated utilities, reduce energy procurement costs.

Nonetheless, the interest of this companies regarding BM5.1 and BM5.3 lies in the provision of balancing services to system operators. As illustrated in Figure 28, most of the companies analyzed state that they provide, or can potentially provide, some form of balancing services. However, almost 50% of them do not specify what type of balancing service they can provide. The rest is quite dispersed across FCR, aFRR, and mFRR.

[24] See footnote 23.

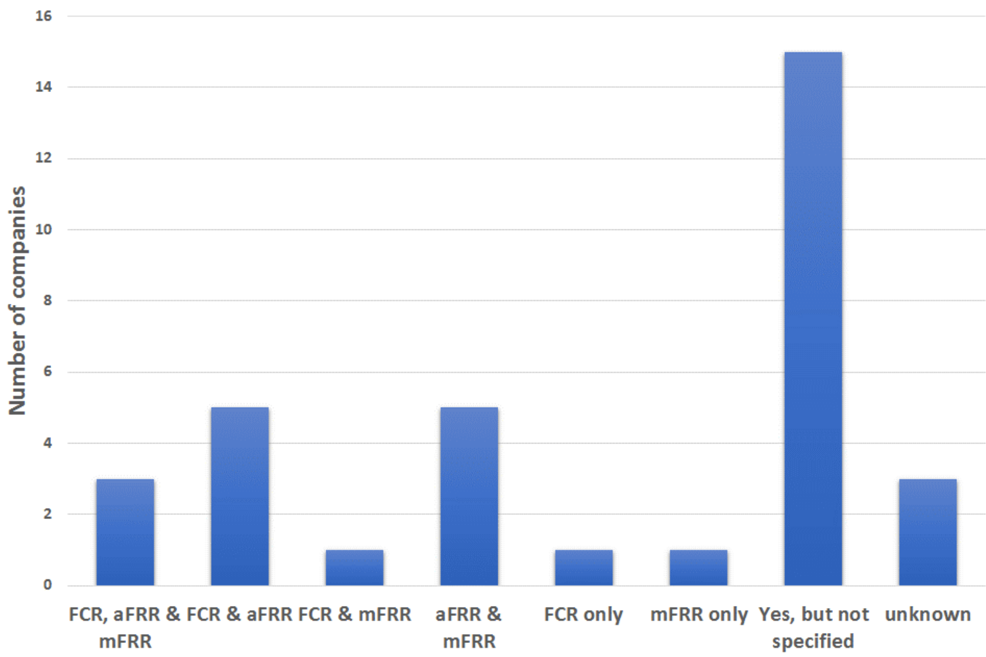

Figure 28: VPPs information - Balancing services provided by aggregators (n=34)

Geographical location:

A shown in Figure 29, the VPP operators and aggregators analyzed in this report are quite dispersed across several countries. Within Europe, the countries which tend to present the highest number of these companies are UK, France, Germany, Belgium and Austria. The main driver for the development of VPPs/aggregators seems to be the power system regulation, more specifically the opening of balancing markets to demand-side bidding, sometimes even creating ad-hoc services for demand, the re-definition of balancing/flexibility products in a technology-neutral manner, or developing specific regulation for aggregation, including about independent aggregators and their relation with BRPs.

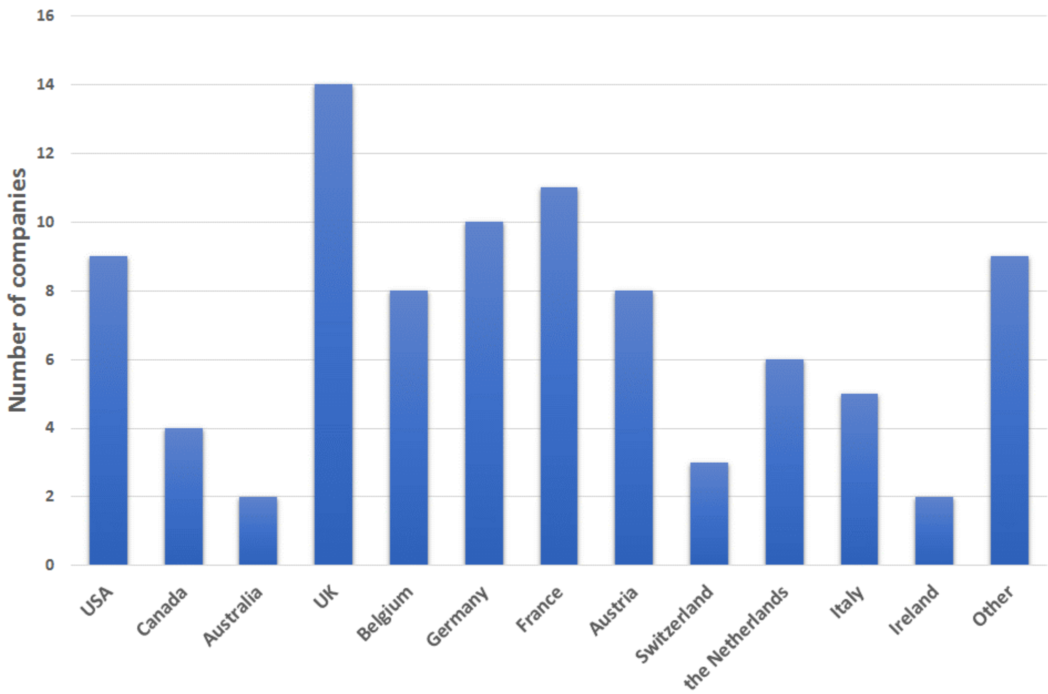

Figure 29: VPPs information - Geographical location (n=32)

The regulatory framework seems to be more relevant than the size of the market (e.g. Austria or Belgium are relatively small countries) or the electricity prices (e.g. France has a quite low average wholesale electricity price). In fact, this is more clearly illustrated by the map shown in Figure 30. It can be seen how the number of active VPPs/aggregators in Europe shown above is strongly correlated with the level of "regulatory market maturity" for demand side flexibility.

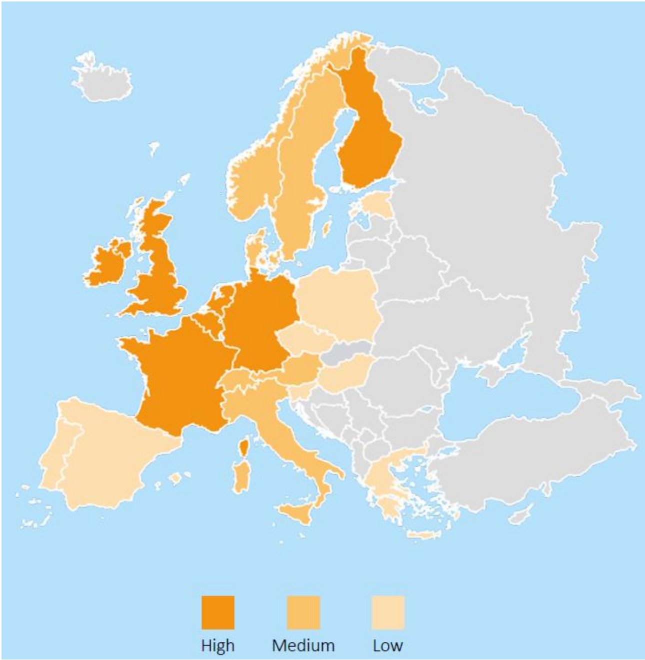

Figure 30: Market maturity for demand-side flexibility. Source: SmartEn, (2019)

4.2.2. Behavioural demand response and aggregation

In the cases described above, the management of the flexibilities in the portfolio of the aggregator are generally based on some sort of cost or revenue optimization and the subsequent submission of set points of instructions to the controllable resources within the portfolio. However, some companies are activating demand flexibilities based on different types of signals. These are known as Behavioural Demand Response (BDR) programs, and they can be used to provide energy efficiency services to end consumers (ESCO-like business model) and/or provide flexibility services (BDR aggregator business model).

The main difference of BDR with respect to conventional DR is that instead of price signals (or not primarily), consumers are encouraged to modify their consumption behaviour (load shifting, peak shaving) through other non-monetary signals such as environmental ones, implications of their behaviour for society, or gamification (community comparisons, target-setting).

The companies exploring this BM normally place a strong emphasis on customer experience and, compared to more traditional direct load control programs, present lower upfront costs as no specific hardware is necessary. Thus, BDR aggregators are software-based companies that base their activities on data analytics. Accordingly, instead of cost or revenue optimization as in the conventional VPP, data analytics is key in order to i) predict accurately, usually in a probabilistic manner, the response from the customer base that will be achieved at each moment, ii) submit market bids with a correct risk-hedging strategy, and iii) send the right activation signals to the customer base.

The companies discussed hereafter are directly related to BM3 as they could use the metering data (and other consumer-related data) accessible through the data platforms (BM3.2) to provide data-based services to end users and other stakeholders (BM3.1). Smart meter data can also be analysed to identify different patterns of usage among consumers and to target such customer segments more effectively. Moreover, the BDR aggregator is in fact the main actor of BM5.2.

The two most relevant examples of BDR that have been identified are described below. The main data sources have been the companies' web sites, terms of use of their products, media articles and, if available, information from the companies' registration (e.g. (SEC, 2014)).

Opower[25]:

Opower is a software company founded in California and active mostly across the US specialized in promoting energy savings and peak reductions through BDR. The BDR energy efficiency program includes both gas and electricity. Additionally, it now provides a wide array of data-based energy services to the customers of tens of utilities.

Originally, Opower started by promoting energy efficiency by simply redesigning conventional electricity bills, including peer comparisons and recommendations, in such a way that this prompted the reaction of consumers. This company was acquired by Oracle in 2016, turning into a software-oriented company combined with a strong focus on the user experience.

In practice, Opower's customers are the energy utilities with whom they have signed an agreement with a term of typically one to five years. Its revenues come mainly from the subscription fees paid by utilities for the use of the data analytics platform, generally based on the number of households/businesses served and the solutions selected. The prices charged per user vary across utilities. In exchange, utilities benefit from lower energy purchase costs, reduced investment needs thanks to peak reduction, data analytics services, and better customer engagement and satisfaction. The aforementioned data-based services include load disaggregation per use (e.g. thermal and baseline), automated energy audits, peak demand forecasting, or rate design support.

Opower BDR program focuses on the promotion of load reduction during peak demand events. Multiple channels are used to communicate these events to end users (email, SMS, App, voice messages) and advising them on how to save energy. After the events, end-users are informed about how well they did in terms of energy savings.

Opower states that, while their platform does not necessarily require smart meters to operate, the availability of this information is indeed key to provide several services to utility customers and unlock the full potential for utilities.

OhmConnect:

Another company exploiting BDR to sell DR flexibility in markets is OhmConnect. This company defines itself as a "software-based power plant" as its business model is based on using demand reductions to bid as a generator in electricity markets. Ohmconnect is mostly active in California, but also operates in Texas and parts of Canada.

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25 https://www.oracle.com/corporate/acquisitions/opower/.
https://ux.opower.com/#

The regions where this company can be active is limited due to two pre-requirements: i) electricity markets ought to be open to demand-side participation behaving as producers, and ii) Ohmconnect must be able to access the smart metering data of the corresponding users. The former naturally implies the size of electricity markets in the first place, which, in the US, would correspond to the ISO areas (including CAISO in California and ERCOT in Texas). The latter requires utilities[26] to have both, deployed smart metering systems and, a data management system is in place to grant access to third parties.

The general approach followed by this company to obtain load reductions is shown in Figure 31. First, critical system hours referred to as OhmHours, i.e. those with higher electricity prices, are identified through forecasting algorithms. A demand reduction bid is submitted for these hours based on the estimated available flexibility in its portfolio. Then, OhmConnect would send an activation request to its customers through email or SMS together with tips on how they can achieve their targeted reduction. It is important to note that whether each individual user is considered to have achieved the desired reduction or not is based on an individual forecast that can be consulted by end users. This enhanced energy feedback and visualization is an important part of the customer experience.

Figure 31: #OhmHour illustration and end-user notification. Source: OhmConnect

In order to attain load reductions, OhmConnect also sells energy management devices, such as smart thermostats or smart plugs, to the users. The market revenues obtained are shared with end-users following an allocation rule of 20% retained by OhmConnect and 80% delivered to end users who achieved the load reductions. Additionally, for each event that a user participates in, they earn Ohmconnect points, which can be cashed out in different forms as shown in Figure 32.

[26] US utilities are usually vertically integrated.

Figure 32: Market revenues and user rewards. Source: OhmConnect

4.3. Metering data platforms

DSOs have traditionally been the only operator for electricity metering. The wide-scale deployment of smart meters across Europe has drawn significant attention to the different activities around electricity metering and the actors that perform them. Across Europe, metering deployment and reading is still mostly an activity carried out by DSOs, with a few exceptions such as the UK, where this is the responsibility of energy suppliers, or Germany which also allows for third party independent metering operators (Tractebel, 2019). Likewise, metering equipment ownership, when not directly held by the end consumers, is generally within the DSO.

Nonetheless, the activity consisting in metering data management is experiencing more profound changes. Traditionally, since metering data was essentially used for billing, this activity did not attract much attention. However, with the liberalization of the retail segment and the European desire to place consumers at the centre of the energy transition, ensuring a transparent and non-discriminatory access to this information, whilst ensuring the necessary data privacy protection, is seen a central element.

Several data management model classifications may be found depending on who performs the data collection, data storage and data access management (CEER, 2014, 2012), (EG3, 2013). For this discussion, these models will be essentially classified into two:

i. Decentralised data exchange managed by the DSOs: third-party data access occurs on a bilateral basis. The DSO is responsible to store and manage data access by stakeholders, mostly retailers.

ii. Centralized data management platform (data hub or clearing house): this centralized system is usually a regulated activity whose aim is to promote well-functioning retail markets by facilitating data access to the different market participants based on standard data formats. Whilst the data access is centralized into the role of the platform manager, data storage may be either centralized or decentralized.

The gm-hub developed in Integrid is designed to act as a data exchange platform, and it is structured as a centralized hub with decentralized storage. Through this platform, consumers can request their meter data and authorize data sharing with third parties (e.g. DSPs), whereas these third parties can access consumer data, and manage the authorization requests and sign the required legal agreements. These data platforms are key for BM3.1 to grant DSPs with access to the data, and the main actor within BM3.2.

In the last few years, several countries have adopted relevant changes in the organization of this activity. For instance, UK, Belgium, Sweden, Norway, Italy, or Netherlands have relatively recently announced or implemented legal changes in their data management model. A general trend observed is that most countries have transitioned or are transitioning, towards more centralized systems (Corsini, 2019), (CEER, 2016). These are the data management platforms addressed in this section due to their similarities to the functioning of the gm-hub.

On the ensuing, some of the most recent developments regarding metering data platforms in Europe are discussed through a few examples. Sources include webpages from the platform operators, reports from NRAs and data management responsible parties, (CEER, 2016) and internet sources[27]. This analysis, which is summarized in Table 3, shows that the data platforms are normally a regulated or licensed activity. Further details on data management in different countries is provided in Annex II.

Table 3: Examples of data management platforms in Europe (*The Swedish datahub has not been set-up yet)

Country	Operator or platform name	Ownership	Regulated/non-regulated	Data management model
Belgium	Atrias	Several DSOs (outsourced operation)	Regulated	Centralized
Norway	Elhub	Stattnet (TSO)	Regulated	Centralized
UK	Smart DCC	Capita (Private)	Regulated (licensed activity)	Centralized
Italy	Acquirente Unico - AU	State-owned	Regulated (specific tariff)	Centralized
Denmark	DataHub	Energinet (TSO)	Regulated	Centralized
Netherlands	EDSN	Dutch DSOs and TSO	Regulated	Centralized
Sweden*	Elmarknadshubb	Svenska Kraftnät (TSO)	Regulated	Centralized

It can be seen that each country opting for this approach, has selected one company, generally different from the DSO, to carry out the duties of data management. However, there are important differences regarding the nature of these data platform operators.

- Several countries, particularly Nordic countries, have opted for allocating this role to the TSO (including the management of individual consumers' metering data).
- On the other hand, in Belgium or Netherlands, a new operator has been set up at the initiative of grid operators. DSOs (and TSOs if applicable) own the resulting data hub company and outsource the actual operation to a third party.

[27] E.g. https://energy.sia-partners.com/20160701/atrias-and-mig60-towards-new-energy-market-model-belgium

- In the case of Italy, the public entity *Acquirente Unico* is in charge of managing data access through the Integrated Information System (IIS). It collects commercial (e.g. tariff category or contracted capacity) and metering data from DSOs and manages the exchange of these data with the TSO (for balancing) and with retailers (for billing).
- The UK has opted for the creation of a new regulated activity (Smart Meter Communication Licence) that was granted to Smart DCC (Data Communications Company) fully owned by a private company (Capita).

Other countries that were analyzed follow alternative data management models, which do not fit with the potential role for the gm-hub. Some of these are the following:

- **Austria:** data exchange in Austria is based on a decentralized infrastructure known as EDA (Energy Data Exchange Austria). This was an initiative of the Association of Austrian Electricity Companies and includes DSOs, the TSO, retailers, and generators as members (Österreichs Energie). The goal was to base all data exchanges on standard and common formats, interfaces, and communication architecture to ensure an easy and unified data access, avoiding the cost of setting up a centralized infrastructure.
- **Germany**: the German data exchange is decentralized under the responsibility of DSOs who receive the data from the metering operators (in case of third-party metering operators). To grant data access, a standardized interface (EDIFACT) for data exchange between market parties and a smart meter gateway have been implemented.

4.4. Data Service Providers

The concept of data service providers (DSPs) refers to any type of company that is specialized in the use of analytical software tools to “transform data into information” in order to deliver data-based services. This is by no means a new business model; however, the accelerated deployment of smart metering systems throughout the world, together with the recent developments in data analytics algorithms and computational capabilities, has drawn the attention of DSPs to the data coming from electricity consumers and distribution grids. Within Integrid, the DSP is the main actor in BM3.1 accessing metering data through the data management platform in BM3.2 (as discussed in section 4.3)

The spectrum of companies that provide data services is very broad, and it includes companies that develop different activities, e.g. software development companies, smart meter manufacturers, BESS companies, consulting companies, new start-ups, ESCOs, etc. Moreover, this role of DSP may be in practice adopted jointly by more than one company through some form of collaboration or through acquisition in order to support the expansion of the scope of the services provided individually, geographical expansion, or product development. For instance, an existing retailer may reach a partnership with (or acquire) a software company to provide data services to the customers of the former. The retailer would benefit from a better customer experience and engagement, or an improved operational performance, whereas the latter would get the chance to develop new applications for its products by accessing a large pool of data. Likewise, a software company may acquire an ESCO specialized in customer engagement and end-user experience to maximize the adoption of its products.

Broadly speaking, the major companies acting as some form of DSP that have been identified could be classified into the following groups[28]:

- DSPs providing **services to end-users (B2C)**: the companies in this category mostly correspond to ESCOs, retailers, other forms of energy efficiency-oriented companies, or companies generally oriented to smart appliances and domotics. Some of the examples identified, focusing on specific types of applications, are EnergyCAP, Elighted Inc, BuildingIQ, Ecova, Bidgely's, Nest, or EnerNOC.

  The data-based services provided include, among other: energy management and optimization for end consumers, building energy management, EV charging management, energy efficiency, energy audits, load disaggregation, DER sizing, energy feedback and advice, etc.

- DSPs focused on **providing data services to utilities, grid operators or generators (B2B)**: this group mostly correspond to software providers (who provide many other services and products) or pure data companies. Some of the relevant examples in this category include the following. Siemens, GE, Oracle, IBM, Schneider, Itron, SAS, Reuniwatt, Aleasoft, Meteológica, ENFOR, SAP, Matrica, etc.

  The data services provided are manifold. (Wang, Chen, Hong, & Kang, 2018) provides a classification of some of the key applications for utilities. When targeting DSOs, these include forecasting, predictive maintenance, state estimation, fraud detection, fault detection, connection management (e.g. changes in contracted capacity, disconnection in case of non-payments), or operations optimization. On the other hand, concerning services to retailers, these comprise improved billing, customer categorization/segmentation, DR/flexibility forecasting, load disaggregation, engagement strategy design, customer services, etc.

- Lastly, some of the companies analyzed **provide both B2C and B2B services** as part of their core activities. An example of this approach is that of Opower discussed in section 4.2, which engages end consumers in BDR programs, and other energy services, and provides services to the utilities they partner with based on data analysis.

4.5. Summary of lessons learnt from real-life case and implications for InteGrid BMs

In a context with high penetration of distributed energy resources, the smartening and digitalization of distribution grids enable unlocking the potential of distributed flexibilities. However, new business models as described in section 3 are necessary to make this a reality. In particular, the following aspects require additional research for these BMs to materialize:

- Technical: due to more uncertain and variable power flows, new technologies on the grid and consumers' sides, and the need of defining a new role for data and data management platforms.

[28] Once again, note that the list is not intended to be exhaustive; it is just used to provide some insights into the market trends that have been identified.

- Economic: due to new value/revenue streams, new innovative business models, participation of new types of stakeholders in the energy/electricity sector, more engaged and active end consumers, and the central role of electricity supply in social fairness and decarbonization.
- Institutional: due to new roles and responsibilities for several stakeholders, sometimes with inconsistencies between existing commercial/regulatory arrangements and grid operations, as compared to the needs posed by technological changes and future needs or expectations.

Even if the technical challenges are overcome, due to the uncertainties in the economic and institutional domains, it is not always clear how certain key roles within these BMs will play out. Attending to the classification of stakeholders and roles discussed at the beginning of this section, and shown in Figure 33: Classification of stakeholders according to their role in the flexibility and data services, these uncertainties are particularly high concerning the new roles that are necessary as enablers of several BMs (flexibility and data platforms, and the flexibility operators) as well as the DSPs.

This section has explored a set of real-life case studies of companies that have adopted BMs like the ones that may derive from the Integrid developments and functionalities in order to shed light on the aforementioned uncertainties. The figure also highlights those services that, based on current regulation and the cases analyzed above, are performed as a regulated activity and those that carried out in a competitive environment.

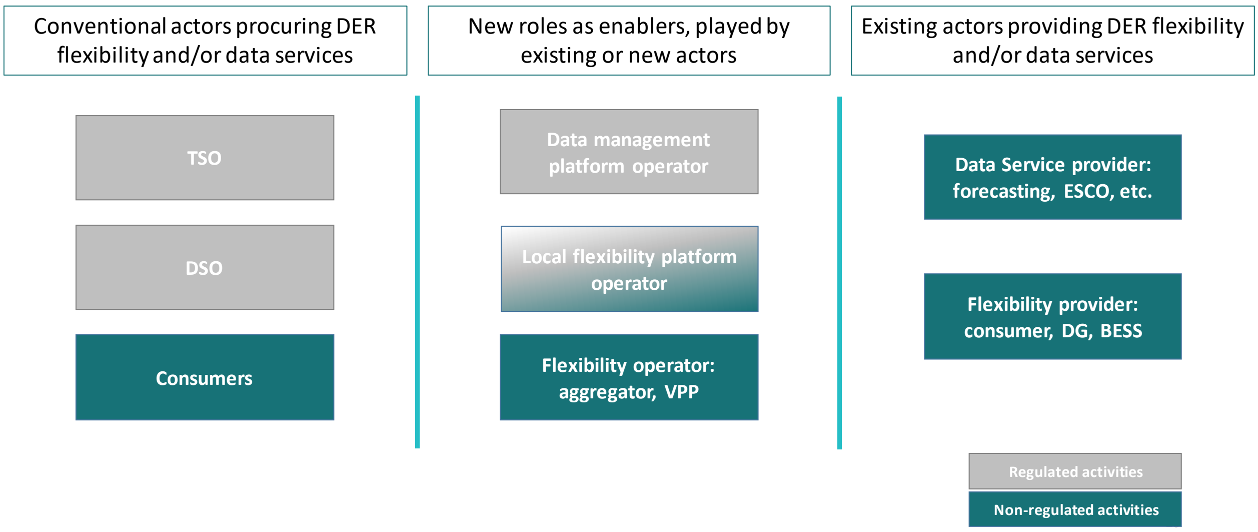

Figure 33: Classification of stakeholders according to their role in the flexibility and data services

Table 4: Mapping the roles for which real-life cases have been analysed to the Integrid BMs identifies the different roles that each one of the company categories assessed in this section 4 may play in each of the BMs characterized in section 3. Note that this table does not include BM2 and BM4, since the companies analysed do not have a direct role in these BMs. Nonetheless, for instance, DSPs may provide software solutions enabling enhanced fault location or preventive maintenance to DSOs in BM2. The key difference is that the data used for these purposes will presumably be internal to the DSO and accessed without relying on any data exchange platform. Likewise, DSPs may support the decisions made by consumers in BM4 regarding the adoption and sizing of DER or smart appliances, or the selection of the most suitable tariff scheme. In this case, these could be considered B2C data services as discussed in BM3.

Table 4: Mapping the roles for which real-life cases have been analysed to the Integrid BMs

	BM1	BM3.1	BM3.2	BM5.1	BM5.2	BM5.3	BM5.4
Local flexibility/market platforms	Key enabler	-	Main actor	-	-	-	-
VPPs and aggregators	Service provider	-	Platform user	Main actor	-	Main actor	Main actor
BDR aggregators	Service provider (potential)	Main actor (if DSP)	Platform user	-	Main actor	-	-
Metering data platforms	-	Key enabler	Main actor	-	-	-	-
Data service providers	-	Main actor	Platform user	-	-	-	-

The main takeaways and implications for Integrid BMs are summarized on the ensuing for each of the stakeholder/role types shown above. This summary discusses the types of companies adopting these BMs, the main business strategies and their evolution, and relevant regulatory conditions that make their business viable or easier to develop.

On local flexibility/market platforms:

The review made showed that, whilst this activity is still incipient, there are already some experiences of local platforms operating beyond the boundaries of grid operators open for flexibility bids. Therefore, there could be indeed some business opportunities for companies other than DSOs in operating these platforms.

In two cases, the platform is operated by software-oriented companies, in one case founded as a start-up, which reach agreements with grid operators, and the other as a joint venture between a utility and a power exchange. One potential advantage of these experiences is that they may be more easily replicable; in fact, one of the platform providers has already implemented its solution in three different countries for distinct purposes. On the other hand, these platforms may be harder to integrate seamlessly with existing market processes. Note that NODES allows for this market integration, but, so far, it has been deployed only in countries where EPEX Spot is active as NEMO.

In the other two cases, the local platforms have been an initiative of local grid operators, including both TSOs and DSOs. These cases incorporate, by design, advanced TSO-DSO coordination mechanisms and, when the local power exchange is involved, a market integrated design. A possible drawback is that they were mostly designed for the local context, without having replicability at the front.

Another relevant aspect to consider is that two of the platforms have been developed and implemented through the collaboration between a power exchange and a utility or a group of grid operators. The utility/grid operator may provide its know-how of the distribution network and end users, whereas the former contributes with its experience in market platform development and operation.

Lastly, three out of the four platforms rely on short-term flexibility trading, whereas only Piclo Flex allows for a long-term procurement (e.g. years ahead). This feature may be necessary to allow DSOs to rely on flexibility as a reliable alternative to grid reinforcements in long-term planning. Basing investment deferral purely on short-term procurement may be excessively risky for DSOs, particularly when short-term liquidity can be scarce. A possible future development in these platforms is how to coordinate the long-term procurement with the short-term activation in an efficient manner.

On VPPs/ aggregators:

The analysis presented above showed that aggregators and VPPs are already developing in Europe. Some of these companies, normally software-based start-ups in the beginning, are quite mature already and have attracted relevant investors. Nonetheless, their activities are concentrated in those countries with more favourable market and regulatory conditions; this is still one of the most relevant drivers for the development of VPPs and aggregators.

Software as a service still seems to be the most common business strategy followed by these companies. Nonetheless, several of them do perform aggregation activities over a given portfolio. These companies usually combine several revenue streams, such as the provision of services to end users, e.g. consumers or RES producers, and participation in balancing markets. In the latter case, a trend towards partnering with retailers has been observed. This may facilitate small VPPs/aggregators, specialized in software development, to access the markets and provide them with significant user engagement resources.

On BDR aggregators:

Only two companies acting as BDR aggregators have been found. Both of these cases discussed correspond to companies that began as independent start-ups, one of them, i.e. Opower, was recently acquired by the major software/data company Oracle.

Their business models are somehow complementary. On the one hand, Opower mainly provides services to the utilities they cooperate with. These include data-based services for their customers, enhancing customer satisfaction, and direct services for the utilities (peak load reduction, forecasting, load disaggregation, etc.). On the other hand, OhmConnect uses the demand flexibility to participate directly in wholesale markets.

In both cases, smart metering data is essential to carry out many of their activities (limited functionalities may be provided without smart metering data). The method followed by these companies to access the data is through one-on-one agreements with the utilities, i.e. not through a common data exchange platform. In fact, Ohmconnect only works with customers from utilities which can grant them access to smart metering data from consumers.

In principle, Opower's approach would be replicable in Europe. Nonetheless, several differences between the US and the European contexts hamper a straightforward replication. Firstly, the European GDPR may create barriers for enabling the utility to share metering data and other personal information with a third-party for the provision of data services. Additionally, many North American utilities are vertically integrated; therefore, they obtain several benefits from reducing peak loads including lower electricity procurement costs, lower grid investment needs, and avoided generation capacity increases. In the European context, these benefits would be split between the unbundled DSOs and retailers.

In the absence of an open data exchange platform, the BDR would need to reach an agreement with the DSO as metering operator to get access to the metering data. The problem is that the DSO would only benefit from localized peak reductions in congested areas, provided the users managed by the BDR aggregator are in those areas. A potential means of overcoming the lack of such data platforms is through the deployment of one's own metering devices, as mentioned by some stakeholders interviewed for

Integrid D7.6, although this would represent an added cost. Additionally, the BDR aggregator may have to reach agreements with several retailers, increasing transaction costs, and hedge the risk of consumers who agree to share their data but afterwards decide to switch to a different retailer with whom the BDR aggregator has not reached an agreement.

Concerning OhmConnect's approach, the first relevant difference is related to the organization of market and system operation. ISOs in the US act both as market and system operators and the economic dispatch is usually based on complex bids and a co-optimization of energy and reserves. Thus, with a single point of entry, this company may be able to participate in markets with different time horizons. On the contrary, in Europe, this BDR aggregator may have to access both market interfaces with the TSO and the power exchange (technical requirements, economic guarantees, etc.) or decide what revenue streams to seek. In some countries, where balancing markets are not open to demand-side bidding yet, this revenue stream would be blocked.

Moreover, the participation of this independent aggregator would require solving the problems related to the baseline definition, with respect to what benchmark are load reductions measured to, and the allocation of balancing responsibility[29], which is still open in most European countries. As a point of entrance, a BDR aggregator may offer its services to BRPs as a means to reduce its procurement costs under peak demand and/or high-price situations (shifting towards Opower's approach).

On metering data platforms:

The analyses presented in section 4.3 revealed a certain trend towards the creation of central metering data hubs in Europe. Other countries have instead opted for a decentralized data management model (e.g. Austria or Germany), whereas most of the remaining ones apparently have not made a clear decision on the future data management model, and remain with a DSO-oriented one.

The operators of these data platforms are, in all cases, a regulated company. Nonetheless, significant differences can be found across countries in terms of what stakeholder is assigned this responsibility. Whilst some countries have opted for the TSO as data hub operator (e.g. Norway or Denmark) or for an existing public entity (e.g. Italy), in other countries the creation of this platform has been mostly an initiative of the grid operators who have then created a separate company strictly for these purposes (e.g. Belgium or Netherlands). Lastly, the UK has opted for creating a new regulated activity supervised by the NRA. The corresponding license has been granted to a private company not previously active in the electricity supply chain.

Under these models, the developer and operator of the Integrid gm-hub could indeed have business opportunities, mostly as the operator designated by grid operators or the regulator. Nonetheless, a major difference between the observed real-life cases and the design of the Integrid gm-hub is that, whilst the gm-hub combines the functions of local flexibility and data exchange management in a single platform, in practice these tend to be separate platforms. Moreover, whilst local flexibility platforms, as discussed above, are non-regulated activities, metering data management is generally a regulated activity. Thus, a company wishing to exploit the gm-hub may face barriers to do so in an integrated manner (regulated and non-regulated activities generally require clear separation of accounts, resources, etc.).

[29] For a deeper discussion on the regulatory topics affecting the activities of independent aggregators, in particular the baseline definition or the allocation of balancing responsibility, the reader is referred to the Integrid deliverable D7.2.

On DSPs:

The review showed that there are many active players in the data services segment, even in the absence of open data exchange platforms. This is possible because DSPs may provide services that do not require individualized end-user metering data (e.g. forecasting), or because, at least in theory, consumers should be entitled to access their data and share it with third parties. Nonetheless, a certain specialization has been observed. On the one hand, some companies focus on providing services to end users (B2C). These companies are very diverse and do not necessarily have a strong emphasis on the electricity consumption, but they also offer services and products related to energy efficiency, domotics, or electric mobility.

On the other hand, the companies oriented towards B2B services usually correspond to well-established and mature software or data service providers whose customers are RES generation (mainly on forecasting), DSOs and utilities. With the deployment of smart metering systems, which some DSOs have deployed together with LV supervision, these companies are seeking to enlarge the data services they can provide to distribution grid stakeholders.

5. Barriers to the development of the BMs

The adoption of the business models described in this report will be subject to their economic feasibility, the existence of suitable regulatory conditions and the acceptance of relevant stakeholders. This section explores these three topics based on the results from other activities carried out within WP7 of the Integrid project (see Figure 1). The lessons learnt in this process are presented as a list of barriers to the development of each BM. These barriers are classified based on their type (regulatory, stakeholder, technical, and economic) and to their impact. This impact has been assessed by sorting each barrier into one of the following three groups:

- **Red light**: this category may include regulatory conditions that prohibit the implementation of the BM or limit significant aspects of it, as well as essential technical/technology solutions that effectively block the BM if not in place.
- **Entry barriers**: regulation, stakeholder attitudes or other economic conditions that, even if not explicitly prohibited, may de facto hamper the BM from developing.
- **Unfavourable conditions**: economic or market conditions that, even if the BM is not prohibited by regulation and there are no problems to enter the market, put a stop to the BM due to lack of economic feasibility.

The barrier types are defined according to what originated the barrier. This classification and identification combines the assessment of key challenges identified in this deliverable with the analyses from other tasks within WP7. The barrier types considered are divided into four groups:

- **Regulatory**: this type of barrier has its origin in the regulation, or more often, in the lack of regulatory definitions. This type of barrier is still present in all BMs, to a greater or lesser extent. For a detailed discussion on each of the regulatory barriers, the reader is referred to deliverable D7.2.
- **Stakeholder**: this type of barrier includes those related to behavioural or institutional aspects. These barriers became apparent during the stakeholder consultation on the different BMs. In this process, in which more than 30 interviews were conducted, barriers such corporate inertia and lack of willingness by consumers were mentioned by interviewees. These barriers classified hereafter as "stakeholder" type. For the detailed results on the stakeholder consultation, the reader is referred to de deliverable D7.6.
- **Technical**: The third type of barriers used in this classification incorporate technical aspects. The identification of this type of barrier is mainly contained in this deliverable.
- **Economic**: Finally, economic barriers are also identified. These barriers are mostly identified in the previous chapters and are eventually supported by the CBA analysis presented in deliverable D7.4. Additionally, the economic and regulatory Scalability and Replicability Analysis (SRA) was also used in the identification of these barriers. The economic and regulatory SRA is reported in the deliverable D8.2.

Most of barrier have a clear type associated to it. Nevertheless, some barriers are classified into two types. For example, several barriers have techno-economic origins, in which technical aspects and economics are interlinked and influence each other.

5.1. BM1: Challenges for the use of flexibility at distribution level

The main barriers identified for BM1 in the other activities of Integrid WP7 are summarized in Table 5. It can be seen that the "read-light" barriers correspond to regulatory aspects that effectively hamper the use of flexibility services as an alternative to grid reinforcements. Provided these barriers are removed, the BM may not work properly due to a combination of techno-economic, regulatory and stakeholder-related barriers. Lastly, the BMs may fail to work due to economic reasons derived from the needs of the DSO and the available flexibilities characteristics (i.e. where, when and how is needed or available).

Table 5: Key barriers identified for BM1

Barrier Importance	Barrier description	Barrier type
Red lights	Inappropriate DSO revenue regulation: bias in favour of CAPEX-based solutions	Regulatory
	DSOs not legally entitled to procure flexibility	Regulatory
Entry barriers	New users pay deep connection charges, so no constraints are caused	Regulatory
	High regulated costs and certain tariff designs do not incentivize (residential) consumers to adopt energy management solutions (e.g. HEMS), necessary for flexibility provision	Regulatory
	Lack of trust of DSOs on flexibility solutions (seen as unreliable)	Stakeholder
	Lack of efficiency or liquidity in local markets	Economic
	Flexibility providers not willing to provide local services (seen as too complex or low revenue expectations)	Stakeholder, Economic
	TSOs and DSOs not used/willing to implement coordination actions	Stakeholder
	Complex/costly communication and interoperability requirements	Techno-Economic
	Lack of market/products standardization across European countries limit scalability of flexibility providers solutions	Techno-Economic
Unfavourable conditions	Value of local flexibility not enough to compensate the costs	Economic
	Flexibility not located where it is needed by the DSO	Techno-Economic
	Distribution grids are not congested	Techno-Economic

5.2. BM2: Challenges for advanced fault location and predictive asset maintenance

This BM corresponds to an improvement in the operational practices of DSOs. As this activity is a regulated monopoly, the most relevant barriers are mostly related to the regulatory framework. Additionally, this BM may be hindered by the reluctance of regulators or DSO staff to adopt the new practices if they see them unreliable or complicated. Lastly, some countries already experience very high levels of reliability; therefore, many end users may not see much value in additional improvements. Detailed information is provided in Table 6.

Table 6: Key barriers identified for BM2

Barrier Importance	Barrier description	Barrier type
Red lights	Current regulation may require time-based maintenance actions even when not really needed	Regulatory
	DSO revenue regulation does not promote lengthening the lifetime of assets (asset write-off from RAB, OPEX increase seen as inefficient)	Regulatory
Entry barriers	Costly infrastructure for predictive maintenance, particularly for small transformers/low voltage	Techno-Economic
	Reluctance of regulators to shift away from time-based maintenance due to the concerns about quality deterioration	Stakeholder
	Some members of the DSO staff would rather use their own experience than data-driven solutions	Stakeholder
Unfavourable conditions	Weak regulatory incentives for improving continuity of supply (deadbands, tight cap/floor, low incentive rate, etc.)	Regulatory
	Already high levels of continuity of supply render. Incremental improvements have a low value for grid users	Techno-Economic

5.3. BM3: Challenges for local flexibility and data exchange platforms, and the provision of data services

Concerning BM3[30], the critical no-go barriers are again regulatory in nature. In this case, focusing on the hurdles imposed by data-privacy protection regulation and the lack of a clear data management model. If

[30] This BM comprises the provision of data services by DSPs, metering data exchange platforms and local flexibility platforms, as described in section 3.3. The barriers in Table 7 mostly apply to the first two elements, i.e. data exchange and data services. Regarding local flexibility platforms, since these are essentially an enabler for BM1, the barriers listed in Table 5 would be mostly applicable.

regulation fails to adapt in time or interoperability is not ensured, there is a risk that the market itself will seek its own alternatives to data platforms.

Nonetheless, even if all these issues are solved, the BM may not develop due to the resistance of several stakeholders such as consumers who may not be willing to share their data or DSOs/incumbent companies, who may not be interested in promoting or facilitating the change. Lastly, DSPs may not use these platforms due to their reluctance to rely on a third-party for some critical operations or because the data available in these platforms is insufficient for their needs. Full details are provided in Table 7.

Table 7: Key barriers identified for BM3[31]

Barrier Importance	Barrier description	Barrier type
Red lights	Data privacy regulation and/or security concerns hampers data access	Regulatory
	Regulation does not set a clear data management framework	Regulatory
Entry barriers	Data service providers not willing to rely on a third-party to provide information critical to their operation	Stakeholder
	Regulatory response falls behind technology and market initiatives. Alternative data sources are developed rendering data platforms useless	Regulatory
	Lack of interoperability between platforms (data, wholesale markets, local platforms, etc.)	Techno-Economic
	End users' reluctance to provide data in a data platform without a clear return	Stakeholder
	Reluctance from DSOs and incumbent companies in changing the status quo	Stakeholder
Unfavourable conditions	Limited value in the information exchanged or need for additional information on tariffs, network, higher disaggregation, etc.	Economic

5.4. BM4: Challenges for consumers minimizing their energy costs

As shown in

Table 8, the most relevant barriers for this BM[32] are either economic or related to the attitudes of the key stakeholders involve, i.e. end consumers or retailers. Note that even the barriers denoted as "regulatory" are mostly related to the tariff design, i.e. the economic signals to which end users respond.

[31] See footnote 30.

[32] This BM overlaps with BM5, since these consumers may also seek additional revenue streams through the provision of flexibility services to the DSO or the participation in balancing markets (mostly industrial consumers). In order to avoid repetitions in this section, this section focuses on the consumers using flexibility to reduce their energy costs. The barriers related to the participation in balancing markets will be discussion in section 0. Likewise, the barriers to the provision of flexibility services to the DSO are presented in 5.1.

Table 8: Key barriers identified for BM4[33]

Barrier Importance	Barrier description	Barrier type
Red lights	-	N/A
Entry barriers	Reluctance of some industry staff to adapt operations to exogenous signals (tariffs, system conditions)	Stakeholder
	Distrust of end users in energy companies, including new entrants	Stakeholder
	Impossibility of operational adaption in certain industries (flexibility activated on a short notice)	Stakeholder
	Difficulty understanding electricity markets and bills (residential)	Stakeholder
	Static/conservative retail market and reluctance of incumbents to change	Stakeholder
	Consumers' elasticity to price is very low. Consumers not interested in changing behaviour: lack of information, small benefit perceived (residential)	Stakeholder, Economic and Regulatory
Unfavourable conditions	High share of regulated costs in the electricity tariff. Limited impact of energy savings on the tariff	Regulatory and Economic
	High cost of automation devices and smart appliances (residential)	Techno-Economic
	Limited potential for residential self-generation: low benefits, high upfront costs, other complications (e.g. no available space, too complicated)	Economic
	Electricity tariffs have no or limited time discrimination	Regulatory
	Not allowed to introduce locational or dynamic network tariffs	Regulatory
	Limitations to test and implement innovative tariff designs: lack of power by NRAs, limited available data from smart meters	Regulatory and Technical

No critical "red-light" barriers may be highlighted. In fact, consumers already respond to electricity prices nowadays, even without automation technologies. The problem is that this response may not be dynamic enough to respond to the system needs or local network conditions. This would require deeper changes in end user behaviour, who may not be willing to do so, as well as new tariff designs, since existing ones may not be providing the right economic signals. Nonetheless, regulators also face limitations when trying to test and implement new tariff structures, such as the lack of legal powers to run such tests or redesign tariffs, or the lack of enough and reliable data of consumption to support the changes.

[33] See footnote 32.

5.5. BM5: challenges for retailers and aggregators using DER flexibilities

Table 9 presents a wide array of barriers for the development of this BM. Concerning red-lights, the key topics are related to enabling the access of DER, particularly DR, to flexibility and balancing services. These critical barriers will presumably be overcome in the short-term after the transposition of the CEP. However, even if nominally removed, significant barriers may remain. On the one hand, regulation will still need to evolve to ensuring balancing products are technology-neutral and aggregation faces no relevant barriers or uncertainties. On the other hand, the reluctance of grid and system operators to rely on new flexibility solutions or service providers ought to be overcome; running pilots under regulatory sandboxes may be a way forward to overcome this and assess the real capabilities of these flexibilities.

Lastly, even if all these problems are solved, new flexibility operators (VPPs and aggregators) can still have a hard time reaching economic profitability. Stakeholders consulted tend to agree that aggregation is generally a low margin activity. Moreover, individual flexibility potentials from DER are generally rather low. Thus, a large portfolio is required to break even or to be able to deliver the required services. This increases their costs, both in terms of equipment and customer recruitment. This, together with asymmetries in the design of electricity tariffs, can seriously jeopardize their competitiveness against centralized generation.

Table 9: Key barriers identified for BM5

Barrier Importance	Barrier description	Barrier type
Red lights	Demand-side resources not allowed to participate in balancing markets	Regulatory
	DSOs not allowed or not willing to procure flexibility services	Regulatory, Stakeholder
	Different types of DER cannot be aggregated, e.g. generation together with demand, to participate in balancing markets	Regulatory
Entry barriers	Resistance from TSOs to incorporate DR in sensitive and more complex services (aFRR, FCR)	Stakeholder
	TSOs' concerns about lack of observability by TSOs of DR as BSP	Technical, Stakeholder
	Balancing product design not suited for the characteristics of demand-side flexibility providers	Regulatory
	Undefined regulation on aggregation rules, especially for independent aggregators. Unclear roles of aggregators, BRP, and BSP	Regulatory
	Absence of TSO-DSO coordination schemes	Regulatory
	TSOs and DSOs not used to or not willing to implement coordination actions	Stakeholder
	Lack of built-in capacity (e.g. personnel) in industrial consumers	Stakeholder
	Industrial consumers reluctant to provide service due to uncertainty about expected revenues, low perceived benefits, or concerns about impact on industrial processes	Stakeholder
	Costly/complex communication and control needs for participation in fast balancing services or internal BRP balancing	Techno-Economic

	Need for real-time data, not available through data platforms, require deploying additional equipment	Techno-Economic
Unfavourable conditions	Lack of standardization in markets access interfaces and rules across Europe make it hard for aggregators to gain in scale	Regulatory
	Aggregators need a very large customer base to achieve adequate and reliable DR, due to a low individual flexibility potential and/or uncertain response (if override enabled or BDR)	Techno-Economic
	DR resources are not competitive against centralized generation	Economic
	Flexibility services not well coordinated with network tariffs, creating contradictory economic signals	Regulatory
	Flexibility providers within the VPP/aggregator portfolio are too dispersed to provide locational services according to the needs of grid operators	Techno-Economic

6. Conclusions

The identification of disruptive business models relying on the solutions developed and demonstrated is one of the core objectives of InteGrid. The work presented in this report aims to contribute to achieving this goal and complement the work done by the demos and the exploitation WPs. First, it is relevant to note that the definition of business model adopted in this report is the following:

> A business model can be understood as a set of business strategies chosen by a certain agent (main actor) in order to generate economic benefit. These business strategies can combine multiple instruments, and the economic benefits can be generated by different sources of revenue streams and cost reductions

This report started by identifying a list of potential BMs that may derive from the Integrid concept. This list comprises five general BMs, although several of them are, at the same time, broken down into several sub-BMs. Overall, up to **10 BMs and sub-BMs have been identified**, each one of them characterized by the following parameters: main actor, benefits pursued, and strategies adopted to attain the previous benefits. These main actors comprise: **DSOs, data service providers, data/flexibility platform operators, end consumers, and flexibility operators**, i.e. VPPs and aggregators.

Each one of these BMs was then characterized in detail by the following parameters:

- **Business strategies**: going deeper into the different ways in which the main actor may exploit a BM, this report identified and discussed the different revenue streams the main actor could explore, what services could be provided and who the main targets for these services would be. In many cases, these business strategies may be complementary to each other.
- **Mapping of relevant stakeholders**: the implementation of the different strategies may require the participation, directly or indirectly, of different stakeholders. These key stakeholders were identified and mapped according to a "Power-Attention" matrix according to which, stakeholders are categorized into four groups: key players (high-power/high-attention), keep satisfied (high-power/low-attention), keep informed (low-power/high-attention), and minimum effort (low-power/low-attention).

However, the previous exercises showed that some of the potential business strategies are subject to important uncertainties or open issues. In order to shed some light on these topics, this report **analyzed a set of real-life cases** of companies that have implemented similar or related BMs as the ones identified herein. The aim was to assess what conditions (regulatory, market, policy, economic, etc.) have enabled or promoted their development and identify **possible trends, or best practices**. The real cases analyzed focused on those BMs where the major uncertainties were found. These were deemed to be in those new roles that are necessary as enablers of several BMs, i.e. the **flexibility/data management platforms and the flexibility operators** (VPPs and aggregators), as well as the role of **data service providers** relying on openly available distribution-related data.

Lastly, it is relevant to acknowledge that the development of these BMs strongly depends on i) appropriate regulatory conditions, ii) their economic feasibility, and iii) the direct or indirect participation of several stakeholders. Other activities within Integrid WP7 have analyzed each one of these topics by i) identifying regulatory barriers and providing recommendations to overcome them, ii) performing a CBA, and iii) carrying out a consultation among stakeholders. The key outcomes of these activities were summarized in this report and presented as a **list of barriers to the development of each BM**. These barriers have been classified by their importance and their nature, i.e. **regulatory, technical, economic or stakeholder-related**.

Overall, this report shows that Integrid has the **potential to foster innovative BMs for DSOs and distribution grid stakeholders** in a context with high penetration of DER and digitalized distribution grids. These BMs rely on the provision and procurement of DER flexibilities, and data-based services. They may be implemented both by existing agents who expand their business scope or improve the efficiency of their operations, as well as new agents entering the power sector, possibly in cooperation with existing actors.

Nonetheless, whilst the opportunities do exist, **the challenges are not negligible**. Several of the BMs require supporting regulatory developments or amendments, and could face the opposition or indifference of stakeholders that are key to their success. Lastly, in addition to the previous barriers, some BMs still need to prove their economic viability and scalability potential. In this regard, results indicate that fully exploiting economies of scale, in terms of portfolio size and geographical presence, and economies of scope, combining several revenue streams, increase the chances of success.

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[DoA] InteGrid Description of the Action

[REF D1.2] Use Cases and Requirements

[REF D1.4] Consumers' engagement strategies

[REF D6.1] Concept of the Market Hub, Central Platform and Services

[REF D6.5] Prototype of the Market Hub, central platform and services

[REF D7.2] Regulatory barriers in target countries and recommendations to overcome them

[REF D7.4] Cost-benefit analysis: methodology and results

[REF D7.6] Stakeholder consultation

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Annex I – VPPs/Aggregators detailed analysis

Table 10: Analysis of existing VPPs-aggregators i/ii. Source: own elaboration using information from Navigant Research (2019), IRENA (2019), Arthur D. Little (2018), Poplavskaya & de Vries (2020), and the web sites of the companies listed

Company name	web page	Resources aggregated	Specific resources under control	Integration with BRP/retailer	Provides balancing services? Which ones?	Provides grid services to distribution/ transmission company?	Ownership	Geographical scope	Revenue model	Size of portfolio
AutoGrid	https://www.auto-grid.com/products/virtual-power-plant/	RES, demand and storage	Real Time Variable Loads, PV & other distributed generation, Residential Loads, Energy Storage, EV Charging	No, Only SaS provision	The software has the capabilities	Peak Savings programs	Several ones. Investment founds, Utilities, Energy traders, Energy produces and the Stanford	Global	SaS	2000 MW of flexible capacity, including distributed generation, storage and demand response, world-wide
Origamy Energy	https://www.origamienergy.com/	RES + demand	PV & other distributed generation, Residential Loads, Energy Storage, EV Charging	No, Only SaS provision	The software has the capabilities	No	Investment founds, a mobile power generator		SaS	
Stem	http://www.stem.com/	RES + storage + demand	storage, PV	directly or via 8 utility partners	FCR, aFRR	grid service dispatches	private, different investors	USA, Canda, Japan	SaS	400 MWh storage on 1000 sites
Sunverge Energy	http://www.sunverge.com/	RES + storage	PV, storage	No, Only SaS provision	FCR, aFRR	Peak reduction	private, different investors	USA, Australia, UK, two other not named countries	SaS	unknown
Enbala Power Networks	http://www.enbala.com/	RES + storage + demand	unknown	No, Only SaS provision	Yes, but not specified any further	Demand response (capacity), Regulation service, Energy dispatch, Peak demand management	private, different investors	Canada, USA	SaS	unknown
Leap	https://leap.ac/#team	RES + storage + demand	generation assets, batteries, EVs, HVAC systems	No, Only SaS provision	unknown	unknown	private, different investors	US West Coast	SaS	unknown
Geli	http://www.geli.net/	storage	PV and batteries	No, Only SaS provision	Yes, but not specified any further	yes, but not specified any further	private, different investors	USA, Australia	SaS	unknown
Next Kraftwerke	https://www.next-kraftwerke.com/	RES + demand + storage	PV, wind, hydro, biogas, biomass, CHP, demand, storage, P2G	SaS	FCR, aFRR, mFRR		private ownership with different shareholders, incl. Eneco	Germany, Austria, Belgium, France, the Netherlands, Italy, Switzerland, Poland		7560 MW connected capacity
KiwiPower	https://www.kiwipowered.com/	generation + demand + storage	commercial and industrial DR, battery storage, RES, EVs	yes, outside UK	yes but not specified	Constraint management for system operators, Peak shaving, Service provider for utilities	private, owned by a utility	UK, USA, Canada, Italy, Germany, Finland, The Netherlands, Belgium, France, Denmark, Czech Republic, Switzerland, Ireland	SaS	over 1 GW of connected DER in total; 70 MW of battery systems in the UK
Restore	www. restore.eu	demand + storage	Industrial DR (e.g., steel, paper, chemical industry)	yes, Centrica	FCR, aFRR	no	private, owned by Centrica	Belgium, Germany, UK, France, The Netherlands	SaS	2.3 GW of flexibility
VPS	https://www.vps.energy/kiplo-vpp	generation + demand + storage	unknown	No, Only SaS provision	Yes, but not specified any further	Optimisation software	private	UK	SaS	unknown
Energy Pool	https://www.energy-pool.eu/en/virtual-power-plant/	generation + demand + storage	commercial and industrial DR	No, Only SaS provision	FCR in France	Reduction of congestion in distribution grid by utilising flexibilities	private	France, Belgium, UK, Cameron, South Korea, Japan, Norway, Turkey	SaS	4GW of flexible load and 2GW of generation assets
Enernoc	https://www.enelx.com/n-a/en	demand + storage	not specified	The company was acquired by an energy retailer	aFRR in Alberta, CA and FCR, aFRR and mFRR in Ireland	yes, peak management	private, owned by Enel	USA, Canada, Ireland, UK, France, Spain, Portugal, Germany, Romania, Russia, Poland, Italy, Singapore, Korea, Japan, Colombia, Brazil, Peru, ROC, Argentina, Chile	SaS	6GW demand response capacity, 20MW of flexibility in Ireland for the operating reserve
open energi	https://www.openenergi.com/	RES + demand + storage	commercial and industrial DR	No, Only SaS provision	The software has the capabilities	Yes, peak management, constraint management	private	UK	SaS	3500 connected assets, 400 sites in the UK, 600 GWh of delivered flexible capacity
Flextricity	https://www.flexitricity.com/	generation + demand + storage	CHP, manufacturing loads, sewage and landfill gas, diesel, small hydro and storage, space cooling and cold storage	The company was acquired by an energy retailer	Yes for National grid, not further specified	Projects where it provides services for DSOs to refer infrastructure investments; Use of Footroom or Demand turn-up to avoid curtailment of wind farms by the TSO	private, owned by Alpiq	UK	SaS, Short-term market trading; Balancing market participation, including shortterm operating reserve and capacity market in the UK	300MW

Table 11: Analysis of existing VPPs-aggregators ii/ii. Source: own elaboration using information from Navigant Research (2019), IRENA (2019), Arthur D. Little (2018), Poplavskaya & de Vries (2020), and the web sites of the companies listed

Company name	web page	Resources aggregated	Specific resources under control	Integration with BRP/retailer	Provides balancing services? Which ones?	Provides grid services to distribution/ transmission company?	Ownership	Geographical scope	Revenue model	Size of portfolio
Sembcorp	https://www.sembcorp.co.uk/	generation + demand + storage	Biomass powerplant, waste incineration, gas-CHP	no	yes, not specififed	peak management	private, owned by Sembcorp Singapore	UK	Private high voltage grid operator, power plant management that provides also services to other commercial and industrial customers	937MW, 60MW of batteries
limejump	https://limejump.com/technology/	generation + demand + storage	batteries, chillers, CHP engines, LFG generators, AD generators	owns electricity supply license; the company was acquired by an energy retailer	yes, not specifed	peak management	private, owned by Shell	UK	SaS	185MW storage
npower	https://www.npower.com/	generation + demand + storage	unknown	owns electricity supply license	FCR, aFRR	peak management	private, owned by e.on	UK	SaS	unknown
yuso	https://yuso.be/	generation + storage	mainly PV	offers supply	yes, not specified	unknown	private	Belgium, The Netherlands	SaS, battery management	500 sites
Voltalis	https://www.voltalis.com/	demand + storage	residential and commercial DR	No, Only SaS provision	Yes, but not specified any further	Ancillary services for the TSO, IoT service provider for utilities and DSO	private	France	SaS	1000000 deviced connected
Tiko	https://tiko.energy/	generation + demand + storage	heating/cooling, water boilers, batteries, PV, EV chargers, heat pumps	provision of BRP services	Balancing service in Switzerland (FCR, aFRR), FCR provision in Germany and France via partnerships	unknown	private, owned by engie	Switzerland, France, Germany, Austria	SaS	over 100 MW
Smart Grid Energy	https://www.smartgridenergy.fr/	generation + demand	industrial and commercial load: paper, metal, chemical, cement industries, hospitals, logistics centers)	No	Yes, in France but not specified	No	private	France	SaS	600MW of flexible load
Teamwise	http://teamwise.be/	unknown	unknown	unknown	FCR, mFRR	unknown	owned by an investment holding which is public, owned by 41 municipalities	Belgium	SaS	unknown
Actility	https://www.actility.com/energy/	demand	unknown	no	Yes, but not specified any further	unknown	private	France, Belgium, UK, Germany, The Netherlands, Italy	SaS	unknown
PowerSecure	https://powersecure.com/	generation + storage	solar energy, fuel cells, energy storage and microgrid solutions	is a subsidiary of a utility but works for several utilities and their customers	unknown	unknown	private, owned by Southern Company	USA	integrated service provision for microgrids	2GW of distributed generation installed in the USA, 110MW of dispatchable load
nrg	https://www.nrg.com/home.html	generation	DR of industrial and commercial customers, natural gas, nuclear, RES, coal	the company is also a retailer and partners with different utilities	Yes, but not specified any further	unknown	private	USA	integrated service provision	23GW generation facilities
energy2market	https://www.e2m.energy/en/start-en.html	RES + demand + storage	3700 MW of traded generation capacity incl. PV, CHP, hydro and CCGT	The company was acquired by an energy retailer	FCR, aFRR, mFRR	no	EDF	Germany, Austria, Italy, Poland, UK, Benelux, Finland		4500 generators with 3700 MW generation capacity
Clean Energy Sourcing	https://www.baywa-re.de/en/energy-trading/direct-marketing/	RES + demand	3000 MW of installed generation worldwide		aFRR, mFRR	no	trading company	Germany, Spain, France, UK, Scandinavia		8300 MW of generation managed worldwide
CyberGrid	https://www.cyber-grid.com/	generation + demand + storage	unknown	No, Only SaS provision	aFRR, mFRR	unknown	private	Slovenia, Austria, Germany	SaS and consulting	unknown
Power2U	https://www.power2u.se/	generation + demand + storage	PV, heat pumps, batteries, EVs	cooperates with five Swedish utilities	unknown	unknown	private, co-owned by utilities	Sweden	SaS	unknown
A1 Energy Solutions	https://www.a1energysolutions.at	generation	Pool of CHP plants, small hydro, heat pumps, emergency power generators, wind, biogas, boilers, etc. Industrial DR, private households with adjustable loads (electric boilers, heat pumps as well as batteries or PV panels)	indenpendent aggregator	aFRR, mFRR	no	telecomunications company	Austria		
Verbund Energy Solutions	https://www.verbund.com	generation + demand + storage	hydro, PV, wind, loads of residential, commercial and industrial customers, batteries	yes - Verbund AG	aFRR, mFRR	no	Verbund AG	Austria		
GEN-I	https://gen-i.at			not in Austria	mFRR in Austria	no	different shareholders, incl. Elektro Ljubljana	Austria, Slovenia and different European countries		
Sonnen eservices GmbH	https://sonnengroup.com	RES, storage	PV, biogas, wind, batteries	yes, sonnenCommunity	FCR in Germany	Redispatch with TenneT	Shell	Germany, Austria, Switzerland		

Annex II – Data management platforms detailed analysis

Table 12: Analysis of some data management platforms

Platform/ operator's name	Webpage	Country	Data management Model	Description	Ownership	Revenue model	Services provided	Users	Further information
Elhub	https://elhub.no/	Norway	Centralized	Elhub is a neutral data hub that handles all measurement data and market processes in the Norwegian power market. Through standard messaging interfaces, all market participants relate to one party. Elhub receives and processes incoming messages, and then generates messages in return to the sender and relevant parties. According to a number of validation rules, market participants will therefore shortly receive information on, for example, completed supplier exchanges, changes in basic data and measured values for production and consumption in Norway.	Stattnet (TSO)	Regulated (TSO owned)	Elhub will also be responsible for reporting consumption and production to NECS, which is Statnett's register for electricity certificates and guarantees of origin. The DEP must report to the regulator on meter data quality, new meter points, supplier switches, transfers of meters (moving), generation, consumption and power exchange per metering grid area and per supplier	TSO, DSOs. Third actors can get acces to data via plug in	Elhub is a central data hub accountable for storing all meter data and supplying imbalance settlement data to the TSO. The DSOs remain in control of collecting meter data and sending it to the DEP. The DSO also owns and operates the meters.
EDSN	https://www.edsn.nl/	Netherlands	Centralized	EDSN is positioned as a shared service centre for delivering market facilitation services to all market parties on behalf of the system operators and is responsible for operating the central data hub systems. The responsibility for defining the right market facilitating services, supporting processes and implementing updates is allocated to an association (NEDU) in which all market players (suppliers, BRPs DSOs, TSOs, metering operators) participate.	DSOs and TSO	Regulated	Data accessible via the platform includes meter values, meter master data, contracts associated with a meter, including start and end dates, and customer master data. Data on grid tariffs is accessible and used by suppliers to invoice their customers. All generation units are registered, including their master data. Moreover, all market players – suppliers, DSOs, BRPs and so forth – must register their master data.	TSO, DSOs. Third actors can get acces to data via plug in	Customer processes (supplier switching, moving in/out) - Delivering of metering data (historical and smart meter data) to market parties, provided consumer consent is obtained - Settlement of grid charges from suppliers to DSOs - Allocation and reconciliation services, based on smart meter data
DataHub	https://energinet.dk/	Denmark	Centralized	DataHub contains three types of data necessary for settlement: -Wholesale master data (metering data collected by DSOs, tariffs, subscriptions and fees data). -Consumer master data (metering point ID, connection status, grid area, maximum power kW). -Metering point master data	Energinet (TSO)	Regulated (TSO owned)	DataHub handles metered values for all metering points as well as master data from the market participants	TSO, DSOs. Third actors can get acces to data via plug in	

Acquirente Unico - AU	http://www.acquirenteunico.it/	Italy	Centralized	The central database operated by Acquirente Unico Spa, called «Integrated Information System» (IIS), it collects commercial and metering data from all the DSOs and manages the exchange of these data with the TSO (for balancing) and with retailers (for invoicing purposes)	State-Owned	Regulated (Tarif)	Consumer portal: acces metering data and contractual information DSOs and suppliers: Facilitate supplier switching	Suppliers, DSOs, consumers	
Smart DCC	https://www.smartdcc.co.uk/	UK	Centralized	Smart DCC Ltd (DCC) operates under the Smart Meter Communication Licence which was granted by the Department of Business, Energy and Industrial Strategy (BEIS) and is regulated by Ofgem. The licence allows DCC to establish and manage the smart metering data and communications infrastructure. Under this licence, DCC must also be a Party to and comply with the Smart Energy Code (SEC) which suppliers, network operators, other Parties and DCC users also need to comply with	Owned by private company Capita	Regulated (charges paid by energy suppliers, network operators and other authorised users)	-Communications Hub -Service Request Variants -SRV Usage and Updating -Parse and Correlate -GFI -Testing & Test Assurance -Communication Services -Service Management -New Service Implementation -Elective Services	Energy suppliers, DSOs, TSOs, other authorized users	-DCC is regulated by Ofgem -The licence came into effect on 23 September 2013 -The licence term is 12 years (with a maximum further period of six years) -The licence imposes an ex-post Price Control regime to scrutinise DCC costs -The licence may be modified by BEIS (up to 31 October 2023) or Ofgem
Atrias	http://www.atrias.be/UK/Pages/Home.aspx	Belgium	Centralized	In Belgium, the five largest DSOs have grouped in the joint venture Atrias, which is to fulfil the role of a data hub. The project is called MIG TPDA (Message Implementation Guide Third Party Data Access).	DSOs	Regulated	Acts as a neutral, objective consultation platform for the energy network operators, suppliers and regional regulators	DSO, TSO also third parties	Atrias is a Clearing House and acts as an intermediary between the energy suppliers and the DSOs on the one hand and the DGs at TSO on the other hand. The state of the Belgian energy market has evolved from decentralised Clearing Houses to a central Clearing House. The DSO is the actor responsible for the metering process, including for the smart meter rollout
Data Hub - SVK (Elmarknadshubb)	https://www.svk.se/en/stakeholder-portal/Electricity-market/data-hub/	Sweden	Centralized (planned)	One of the main purposes of the data hub is to enable a supplier centric market model, meaning that electricity consumers will only need to have one electricity trading company that will invoice both distribution and consumption of electricity	Svenska kraftnät (TSO)	Regulated	Not available yet	Planned to be supplier-centric (retailers, ESCOs, etc.) Grid operators will access to obtain customer data	Its purpose is to enable new types of services related to energy efficiency by increased competition and transparency on the electricity market, as a result of improved access and exchange of information with the data hub

Annex III – High-Level Use Case Brief Descriptions

ID	*Primary actor (Role)*	*Name of use case (Goal to be achieved)*	*Brief description*
HLUC01	Distribution System Optimiser	*Operational planning (from hours to week-ahead) of MV distribution network to pre-book available flexibility*	The scope of this HLUC is the management of distributed energy resources (DER) connected to the distribution networks considering a multi-period and predictive approach. The DSO will compute for a predefined time horizon (e.g., between hours and week-ahead) a set of optimal automatic and manual control actions for DER (and DSO own resources) to minimize active power losses and solve potential technical problems. Network reconfiguration capabilities should also be considered. The input data are the active and reactive power forecasts for the net-load in each bus and for the renewable energy sources (RES) connected to the MV network, as well as operating points and available flexibilities. As the time goes by, more reliable forecasts along with the current state of the resources will be used to update the plan. The control set points computed for the resources not owned by the DSO will be considered as pre-booked (reserve) flexibility that can be later activated based on real-time information about technical constraints verification (automatic actions propose by the developed tools can be performed on the DSO assets). The interaction with the LV network control capabilities is also included in the predictive management strategy, in articulation with HLUC02. Is intended that the developed tools and load and renewable energy forecast algorithms are integrated into the DSO DMS system to help the decision-making process and to enable real-time operation and supervision.
HLUC02	Distribution System Optimiser	*Distributed monitoring and control of LV network using available flexibilities*	The scope of this HLUC is the operation of LV flexibilities (i.e., small-scale storage, HEMS, EV charging stations, PV voltage regulation) based on predictive management to solve technical problems and real-time monitoring of voltage profiles by exploring real-time smart metering information. In-line power regulators and secondary substation transformers tap changes capabilities for voltage control should also be considered for this HLUC. A set of automatic and manual control actions for DER were determined to solve technical problems for a predefined time horizon (HLUC1). In real-time, the current state of the network is determined and compared with the scenarios used to build the preventive plan and deviations will trigger its update (HLUC1). The control set points that were computed and only used to pre-book (or reserve) flexibility, can be now activated based on real-time information about technical constraints verification. The developed tools should be integrated into the DSO DMS program to help the decision-making process and to enable real-time operation and supervision.
HLUC03	Distribution System Optimiser	*Perform asset health diagnostics for preventive maintenance*	The goal of this HLUC is to increase the distribution grid reliability, avoid fatal errors, reduce maintenance costs, and postpone unnecessary local maintenance tests by using big data analytics with event-driven maintenance for self-monitored equipment. Vital information for important network assets (e.g., historical oil temperature of transformers, number of short-circuits sustained, number of changes in control) is collected using the advanced metering infrastructure and processed through tools that can diagnose and assess the current technical conditions and trigger probabilistic alarms to schedule maintenance actions.
HLUC04	Distribution System Optimiser	*Operations center plans repair of unplanned outages based on sensors and remote diagnostics and historical data*	The main objective of this HLUC is to schedule the repair actions of unplanned outages based on pre-fault data collected from sensors, on remote equipment diagnostics, and on historical data collected from smart secondary substations. The expected result is a reduction in the outage time and, consequently, an improvement in the SAIDI and CAIDI indexes.

			Information collected from multiple sensors is used to schedule repair actions supported by intelligent tools and that aim at improving the relationship with consumers (e.g., power quality improvement).
HLUC05	Contributor to Distribution System Security	*Manage the impact of flexibility activation from resources connected to the distribution network*	The objective of this HLUC is to conduct a technical validation of activation programs submitted by the market operator for distributed resources connected to the distribution network (generation, DR) at different timeframes (day-ahead and intraday). The DSO assesses in advance if the requested programs (e.g. flexibility activations) are technically viable or if they create local constraints in the distribution network (e.g. overcurrent, voltage limits). In the latter case DSO assesses if there are control actions in the resources of the DSO (e.g. transformer taps) that can solve the problems identified, and, if not, proposes modifications to the program. This validation service will be provided to the market or other relevant stakeholders (e.g. TSO) in the timeframe compatible with flexibility market.
HLUC06	Data Manager	*Provide data management and exchange between DSO and stakeholders*	The DSO provides anonymized and pre-processed metering data available to external stakeholders in order to promote new data-driven services provided by market entities with benefits for distribution grid users and market actors such as: i) provision of data regarding ToU / dynamic network tariffs to customers, suppliers, aggregators, inducing end use flexibility; ii) provision of information to LV consumers about their peak demand in order to increase threshold if necessary (e.g. based on switch disconnections information or based on peak load before it happen) or the effective use of contracted power to incentivise them to reduce peak demand iii) LV consumers will respond to prices and comfort. Therefore legislation, regulation and market roles must be appropriate for end users engagement (price) and HEMS will be automatized. iv) provision of basic efficiency tips based on customer consumption profiles (e.g. comparison to peers average); v) provision of data (e.g. load diagram) to customers or 3rd parties (e.g. suppliers, ESCOs) with explicit consent from customers (acting also as authorization manager); vi) Information regarding new distributed resources connection may also be provided (e.g. inform new DRES facilities in the moment of network connection request about the number of hours per year that may be curtailed)
HLUC07	Distribution System Optimizer	*Procure and manage regulated flexibilities from DER to optimize operation and costs*	This HLUC is divided into two parts for different time domains: i) pre-qualify flexibility operators based on technical parameters systems interoperability and activation cost; ii) enable the bidirectional exchange of flexibility data between DSO and external stakeholders (including activation acknowledgement) and manage non-firm connection contracts. The first part consists of defining the terms of new flexibility contracts. The goal is to produce updated information regarding the timeframes in which each flexibility supplier can operate the information regarding the non-functional requirements of ICT (interoperability) as well as the cost of flexibility activation (e.g. curtailment of DRES) It will also be pre-assessed the conditions of each network (e.g. set of networks without any constraint in the case of its resources activation or networks that constantly need it). The second part refers to the operational planning timeframe. The DSO will compute and publish the flexibility needs for the next hours/days in specific network MV and LV network areas and receive the stakeholder's information about their available flexibility for the desired timeframe in order to identify the most efficient decisions regarding the set of activated resources (merit- order). Near to real time and in the case of network eminent risk or network outage's restoration DSO may operate over LV smart meters to a temporary reduction of LV customer's available power (informing customers if

			possible). DSO must have updated information regarding all flexibilities (as client and as technical validator).
HLUC08	Industrial Consumer	*Manage internal processes' flexibility to minimize energy costs according to market-driven mechanisms and system operators' requests*	This HLUC considers the case of an industrial consumer that explores flexibility in its internal processes with two goals: i) to optimise energy consumption taking into account electricity purchasing costs, grid usage cost (specific timeframe) and self-consumption if local generation is available; ii) to offer flexibility to both DSO and TSO. The goals of the HLUC will be achieved by using metering and sub-metering data from different types of sensors to determine the technical feasibility for changes in the industrial process to optimize energy consumption as well as by performing flexibility audits to characterize the degrees of freedom in energy consumption/production. From the flexibility characterization and activation, industrial processes are automatically adjusted to maximize overall profits taking into account energy purchasing costs and flexibility offer profits.
HLUC09	Prosumer	*Perform energy management to maximize self-consumption and self-sufficiency*	The scope of this HLUC is the energy management at the residential consumer premises to maximize self-consumption and self-sufficiency. The possibility of performing load, PV and storage control to maximize internal goals like self-consumption and electricity cost minimization is considered as well as the possibility of making available information about flexibility that can be transmitted to aggregators and/or DSO within HLUC10.
HLUC10	Flexibility Operator	*Aggregate and communicate multi-period behind-the-meter flexibility from LV prosumers*	The goal of this HLUC is to aggregate and communicate behind the meter flexibility calculated in the HEMS (HLUC09) to the market hub. The aggregated flexibility from multiple LV prosumers will be segmented and used in the market by performing bidding optimization in day-ahead, intraday and ancillary services markets. There should be a reference to the possibility of technical validation on the flexibility mechanisms by the DSO before its activation. Segmentation should be done at least reflecting the most important parameters for the DSO activity, namely Contracted Power and Energy Consumption.
HLUC11	Energy Service Provider	*Engage consumers in demand-side management programs considering contextualized (environmental, price, peak load reduction) feedback mechanisms*	This HLUC is centred on providing anonymized and processed data to consumers to promote energy efficiency. The actions are: i) day-ahead hourly dynamic electricity prices targeting demand flexibility and peak load reduction; ii) direct feedback on electricity consumption targeting demand flexibility and peak load reduction. The information is transmitted using secure local social networks on a community level, including non-economic information such as environmental signal's feedback.
HLUC12	Flexibility Operator	*Aggregate geographically distributed third-party (multi-client) resources to offer ancillary services to TSO (frequency) and DSO (non-frequency)*	This HLUC materializes goal of the virtual power plant (VPP) which is to offer bids in flexibility markets by aggregating the flexibility from eligible consumers and distributed energy resources and exploit management functions to support their participation in energy and ancillary services (i.e., frequency services for TSO and non-frequency services for DSO).