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DR-BOB

DEMAND RESPONSE IN BLOCKS OF BUILDINGS
D2.1: MARKET AND STAKEHOLDERS ANALYSIS

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Deliverable Administration & Summary			
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Editor	Federico Noris (R2M)		
DoA	A market analysis will be conducted across the different countries and sectors touched by Demand response. This will focus both on the present and expected market trends. Additionally, an 'environment map' will be performed to clearly understand the context and conditions in which the developments should enter. As a result, the needs for the different stakeholders involved are categorized and mapped. Mature/favourable markets and lagging/less favourable markets will be identified as well as their size, features and the reasons. This information will be critical during exploitation planning (T2.5) since a clear picture of the market and stakeholder needs will be established. The stakeholder analysis/need will focus on: i) DSO/DNO, ii) utilities, iii) ESCo, iv) Owner/manager v) Equipment manufacturers vi) Occupants. Different customer profiles will be defined, what are their responsibilities/activity, expectations/desired benefits, and problems they would like to fix. Some of these could be explicit and well-known while others could be hidden (customers not knowing that they have an issue yet). These will be classified as 'essential' or 'nice to have' and should be addressed by the 'Value/benefits' of the developments. Preliminary condition variations that the occupants should accept and associated incentives will be defined. Potential development application/market analysis breakdown could be: • Legislative framework • Type of construction (e.g., new or renovation) • Climatic potential and energy context (sun availability and building heating/cooling dominated) • Building typology (e.g., residential small or large, industrial, commercial) • Potential of building elements/technologies (e.g., ventilation, Thermal mass, storage, CHP) This will support the understanding of which specific market and elements attention should be the focus. Specific technological drivers (e.g. added values regarding price, cost or equipment) will be mapped. The specific challenges that have limited/could limit the diffusion of DR will be discerned. The customer and stakeholder will be informed/educated and reassured about the positive aspects the new developments will bring. Potential competitors will be identified and characterized in terms of products /services offered, associated costs, market share, and strengths.		

	Stakeholders and market actors are further segmented according to priority of interest to partners, intended territorial cost and benefit distribution, and involvement required for deployment, as well as potential interest in the offered solutions (products and services), which will be investigated in terms of advantages and limitations. The analysis of the market and its needs will be periodically revisited to stay up to date regarding possible news affecting the sectors. This analysis will also support the definition of the communication and dissemination plan (D6.3) specific for each targeted stakeholder. The output of this work will be presented in D2.1.
	D2.1 – Market and stakeholders analysis (m3) A comprehensive market and stakeholder's analysis of Demand/Response in Block of Buildings for different energy and geographical contexts.
Contribution of partners	R2M was responsible for the overall structure of the document and of the individual chapters as well as of the following sections: introduction (ch.1); introduction for ch2.1; ch. 3.1 introduction; ch. 3.2 introduction; aggregator; conclusions and executive summary SERVELECT was responsible for section 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.2, and the following stakeholders: TSO/DSO, ESCo, policymakers, developer/builder. Siemens was responsible for section 2.3 and 3.2.1.3 as well as the review of the entire document. GRIDP was responsible for 2.1.3 and 3.2.2.1. TEES was responsible for 2.4 and 3.2.2.3 as well as the review of the entire document. DW was responsible for the following stakeholders: Building owner/manager and occupants as well as the review of the entire document.

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Date	Authors	Description
10/03/2016	Juan Manuel Espeche (R2M)	Table of contents circulated for partners' contribution.
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EXECUTIVE SUMMARY

Purpose: This report presents a market and stakeholder analysis for Demand Response (DR) in blocks of buildings (BoB). This encompasses the identification of market size and its trends, the key drivers and the regulations, incentives and legal aspects that set the context in which solutions and services for DR in BoB should enter, specifically in the target countries where will be demonstrated during the DR-BOB project. Additionally, it assesses the roles, expectations and benefits for different relevant stakeholders to understand how to leverage and engage them. The analysis of the current and expected markets and stakeholder requirements and benefits will help the consortium to make future decisions for business plans. This document provide critical information to be able to refine product development and define best exploitation strategies for each application and geographical contexts. Therefore, this report provides a first step in developing the business requirements and business models in the DR-BOB project. This market analysis, through a detailed analysis of the target countries, provides the foundations and constraints to define feasible business models (D2.4) for the different demonstration sites. The specific needs, requirements and local features of the specific demos (D2.2) uses this analysis to study the context in which they are situated. The market analysis and the demo sites report are the main inputs to identify the technological requirements (D2.3).

Methodology: The methodology employed is mainly based on desk research techniques via literature review, partner knowledge and targeted interviews/discussion with experts. Limitations include the new and rapidly evolving conditions and markets for DR, and especially relevant to BoB (such as if it is allowed to exchange energy from one prosumer to another), and the disaggregated and heterogeneous contexts and markets from technical (e.g., smart meter roll-outs) to legislative point of views.

Key Findings and Conclusions: The DR has been growing worldwide and its growth is expected to continue and accelerate. The USA is the most significant DR market. In the USA, more residential customers than commercial/industrial customers take part in the DR market. However, commercial/industrial consumers make up the largest market share in terms of DR flexibility. The EU DR market is underdeveloped in comparison to the USA market. In many parts of the EU smart meters are not well distributed (limiting therefore the bidirectional communication). However, pressure on the grids is increasing with the continuous growth of intermittent sources and the lack of peak capacity likely to increase in the future. The DR potential is about 52 GW and accounts to 9% of peak capacity, almost equally split between residential, tertiary and industrial sectors. The most active countries regarding explicit (i.e., incentive-based) are England and Switzerland, France and Finland are expanding, while Italy and Spain have closed markets for DR. However, implicit DR Europe has achieved a more mature situation in which variable prices are available in most of the countries (excluding Romania as of 2016) and consumer can use this information to decide when to use energy. Linked to the deployment of DR programmes is the rollout of smart meters, which vary country to country, however most share a common target of >80% deployed by 2020. Several market drivers should favour DR deployment, including:

1. fluctuation and level of electricity prices advising consumers to adjust their behaviours;
2. legislation approved at the EU level forcing member states to open conditions for DR, but the level of transposition differs across single states;
3. renewable energy technologies penetration causing stresses to grids and calling operators for solutions to manage imbalances;

4. increasing presence of smart building and Internet of Things (IoT) technologies providing the data and communication to enable DR programmes.

With respect to the target countries (where the DR-BOB project demonstration cases are) we found different conditions across these geographical and legislation contexts. France is the most forward thinking with variable retails price schemes available and opening of the market set for 2017 to also aggregators. The UK gas been opening its energy markets to balancing services and aggregators but some requirements are slowing the market deployment. Several aggregators and DR service companies are active. Italy is lagging behind due to incomplete transposition of EC directives with only pilot programs available. Upcoming regulations are expected to improve the scenario. Romania has also a closed market that does not even contemplate implicit DR since they have a flat tariff. Improvements are expected for the end of 2017 with liberalisation of the market and smart meter roll-out.

This context suggest different potential for explicit (e.g., incentive-based) and implicit (i.e., price-based) DR. Regarding **explicit DR**, France is the most evolved market with a high DR potential and the regulatory framework incentivising DR. UK situation is moving toward a competitive market, there are still minor decisions to be taken which will ensure fair and regulated competition between generation and DR resources. Italy is still in a primitive phase, load is not accepted in any market and therefore requirements, measurement and payments remain unfair and with no clear perspective as of 2015, however this should rapidly evolve due to EU recommendations. In Romania, the DR market is not yet developed and there are still missing clear guidelines for its deployment. **Implicit DR** is homogeneous in France, Italy and UK and self-consumption is permitted in all of them without any tax. Time of Use (ToU) tariffs are available in all these three countries with two or three price slots according to the time, day and month. Regarding smart meter deployment, Italy is the European leader with more than 30 million smart meters installed. The rest of the countries are following this trend with most aiming for a large (>80%) deployment by the year 2020.

The increased and gradually liberalised markets are opening opportunities for a range of companies offering services, hardware and software enabling DR. Many are active worldwide, while some are only present in some of the most active countries (France and UK). Their relevance for DR in BoB varies.

The analysis of the most common DR programmes reveals that Generic Variable Tariff (GVT), Direct Load Control (DLC) and Distributed Energy Resources (DER) have the greatest potential for application in BoB. The basics for implementing GVT and DLC DR programmes is already present since market conditions in most EU nations (currently excluding Romania) already support simple on-peak and off-peak tariff structures. In addition, distributed energy generation is also often present in large developments and therefore, a DER DR programme is favourable. The main reason for less favourable conditions for the Capacity Bidding DR Programme (CPB) and Fast Dispatch/Ancillary Services (FD/AS) DR programmes is the need for a controllable resource, which is large enough to be activated. These programmes and their application at the demonstration sites will be investigated in the later phases of the DR-BOB project. The table below summarises the technical and market requirements as well as applicability in the demonstration countries and BoB pilots.

DR Programme	DR Incentive and Impacts	Technical Requirements	Type of DR	Potential application in target countries	BoB Potential
Generic Variable Tariff (GVT)	Low to medium economic benefit to participant,	Schedulable / controllable devices or EV charge	Implicit	France, Italy, UK;	Very High

	continual peak-to-peak reduction	points, Optimizer, HMI, BMS or HAN		Romania expected in the next years	
Capacity Bidding DR Programme (CBP)	High economic benefit to participant, sporadic peak reduction	Sheddable load of 100 kW or more, HMI	Explicit	France, UK	Low
Direct Load Control (DLC)	Medium economic benefit to participant, sporadic peak and energy usage reduction	HVAC with appropriate control system or other suitable load, HMI, BMS or HAN	Explicit	France, UK	High
Fast Dispatch / Ancillary Services (FD/AS)	Potentially very high economic benefit to participant, sporadic peak reduction	Fast sheddable load of 100 kW or more, Plus high-speed and reliable telecontrol & telemetry interfaces OR frequency sensitive / frequency aware loads	Explicit	France, UK	Very Low
Distributed Energy Resources (DER)	Medium to high economic benefit to participant, continual peak-to-peak reduction	Dispatchable DER, Storage, Optimizer, HMI, BMS or HAN	Implicit/Explicit	France, Italy, UK, Romania	Medium

The conducted stakeholder analysis highlights the relevance, needs and benefits for a wide range of involved actors. Primary stakeholders (those with high influence and power with respect to DR) include TSO/DSO/Retailer, Aggregator, BMS & equipment manufacturer, Building owner/manager, and Policymakers. Secondary Stakeholders (those without high power/interest but still playing an important role) include ESCO, Building Designers, Builder/developer, Maintenance team, and Occupants. The findings for primary stakeholders are summarised in the Table below.

Actor	Relevance	Needs and challenges	Benefits
TSO/DSO/Retailer	Managers of energy fluxes and grid stability Flexibility buyers Retailers can become aggregators	ICT infrastructure and forecasting Incentives for energy efficiency solutions DR potential knowledge	Additional solutions to manage reliability and grid imbalances Greener and modern infrastructure Satisfied and loyal consumers
Aggregator	Flexibility aggregation to deliver value to buyers	Revision of market rules for balancing, reserves,	Revenues from commercial agreements

	Give market access to end consumers	capacity and wholesale market to include DR Fair competition between market players Allow aggregation Allow Flexibility Service Define the role and responsibilities	Revenues from consulting services to final-users Revenues from associated services
BMS & equipment manufacturer	Technology enabler DR automation and control Visibility and control of the buildings assets Relationship with 3rd parties	Knowledge of the state of energy demand and production Ability to accept and process DR signals Ensuring comfort of the occupants Interoperability	Increase revenues Sales of equipment and consultancy services
Building Owner/Manager	Implementation of DR systems Possess valuable information about building characteristics Decision Makers	Lack of interest Complexity of system Training needed for managers and staff Uncertainty on future energy prices and regulations	Cost and energy-savings Improved operation of equipment Green innovative image
Policymakers	Policy enablers Providing a favourable and stable DR environment	Having alignment between the National Energy Strategy and other policies Granting non-discriminatory access to the markets to all users Raising awareness on DR benefits Accelerating the energy market development	Have functional energy markets which will lead to growing economies Increase impact on network codes

Lessons Learned: In addition to the specific findings regarding the potential applicability of DR in BoB programmes in target countries and assessment of needs and benefits of relevant stakeholders, four key challenges for the implementation of DR, especially for BoB, are:

1. Ensure fair and transparent payments.
2. Involved key stakeholders and attempt to deliver them value by solving their issues/providing benefits.
3. Define fair measurement procedures avoiding contradictory requirements;
4. Products and services to fit with the capabilities of consumers, grids and relevant actors.

CONTENTS

ACRONYMS AND ABREVIATIONS

ACER	Agency for the Cooperation of the Energy Regulators
AMI	Advanced Metering Infrastructure
AS	Ancillary Services
BEMS	Building Energy Management Systems
BMS	Building Management System
BoB	Block of Buildings
CBP	Capacity Biding Pricing
CHP	combined Heat and Power
CPP	Critical Peak Pricing
DER	Distributed Energy Resources
DR	Demand Response
DRAS	Demand Response Automation Server
DLC	Direct Load Control
DSO	Distribution System Operator
EC	European Commission
EED	Energy Efficiency Directive
ENTSO	European Network of Transmission System Operators
EPC	Energy Performance Contacting
ESCO	Energy Service Companies
FD	Fast Dispatch
GVT	Generic Variable Tariff
HVAC	Heating, Ventilation and Air Conditioner
IEM	Internal Electricity Market
IoT	Internet of Things
LEM	Local Energy Manager
OEM	Original Equipment Manufacturer
PiP	Power information Pod
RES	Renewable Energy Systems
RTP	Real-Time Pricing
ToU	Time of Use tariff

TSO	Transmission System Operator
TTP	Two-Tier Pricing
V2G	Vehicle to Grid
VEP	Virtual Energy Plant
WRI	World Resource Institute

GLOSSARY

Advanced Metering Infrastructure (AMI) are systems that measure, collect, and analyze energy usage, and communicate with metering devices such as electricity meters, gas meters, heat meters, and water meters, either on request or on a schedule. These systems include hardware, software, communications, consumer energy displays and controllers, customer associated systems.

Ancillary Services (AS) are the specialty services and functions provided by the electric grid that facilitate and support the continuous flow of electricity so that supply will continually meet demand.

Building Management System (BMS) is a computer-based control system installed in buildings that controls and monitors the building's mechanical and electrical equipment such as ventilation, lighting, power systems, fire systems, and security systems.

Combined Heat and Power (CHP) is the use of a heat engine or power station to generate electricity and useful heat at the same time.

Critical Peak Pricing (CPP): when utilities observe or anticipate high wholesale market prices or power system emergency conditions, they may call critical events during a specified time period (e.g., 3 p.m.—6 p.m. on a hot summer weekday), the price for electricity during these time periods is substantially raised.

Distributed Energy Resources (DER) are smaller power sources that can be aggregated to provide power necessary to meet regular demand. As the electricity grid continues to modernize, DER such as storage and advanced renewable technologies can help facilitate the transition to a smarter grid.

Demand Response (DR) provides an opportunity for consumers to play a significant role in the operation of the energy grids by using energy management technologies to reduce or shift their energy usage during peak periods in response to time-based tariffs or other forms

Direct Load Control (DLC) is A DR activity in which the program sponsor remotely controls a participant's electrical equipment on short notice (normally several hours). Typically, this would involve temporarily reducing temperature, humidity or air pressure set points in home and building HVAC equipment to achieve a short-term reduction in electricity demand

Distribution System Operator (DSO) are responsible for the transport of electricity at a regional level and as such they transport electricity at gradually reducing voltages from national grid supply points to final customers, both residential and none residential. Throughout the EU, electricity distribution is a regulated monopoly business.

Energy Performance Contracting (EPC) is a contractual arrangement between the beneficiary and the provider of an energy efficiency improvement measure, verified and monitored during the whole term of the contract, where investments (work, supply or service) in that measure are paid for in relation to a contractually agreed level of energy performance criterion, such as financial savings.

Energy Service Companies (ESCO) is a company that offers energy services that may include implementing energy-efficiency projects (and other sustainable energy projects). The energy services supplied by ESCOs can include a wide range of activities such as energy analysis and audits, energy management, project design and implementation, maintenance and operation, monitoring and evaluation of savings, property/facility management, energy and/or equipment supply, provision of service (space heating/cooling, lighting, etc.) advice and training.

Generic Variable Tariff (GVT) or Generic Dynamic Tariff (GDT) provide variable pricing structures for electricity which are designed to reduce consumption during periods of high wholesale market price or during known periods of system contingency, and encourage consumption in times of low wholesale market price. In a GDT program, the program sponsor will advertise hourly or sub-hourly prices for electricity consumption (possibly having several tiered levels) to DR participants at least one hour in advance, typically one day in advance - and in some cases even months in advance.

Heating, Ventilation and Air Conditioner (HVAC) is the technology of indoor and vehicular environmental comfort. Its goal is to provide thermal comfort and acceptable indoor air quality. HVAC system design is a sub discipline of mechanical engineering, based on the principles of thermodynamics, fluid mechanics, and heat transfer.

Open Automated Demand Response (OpenADR) is a research and standards development effort for energy management led by North American research labs and companies. The typical use is to send information and signals to cause electrical power-using devices to be turned off during periods of high demand.

Renewable Energy Systems (RES) is defined as energy derived from resources that are regenerative or for all practical purposes cannot be depleted

Real-Time Pricing (RTP) rates generally apply to usage on an hourly basis.

Time of Use (ToU) tariff typically applies to usage over broad blocks of hours (e.g., on-peak=6 hours for summer weekday afternoon; off-peak = all other hours in the summer months) where the price for each period is predetermined and constant

Transmission System Operator (TSO) are responsible for the bulk transport of electricity by high voltage power lines from power stations to grid supply points. The transmission system is generally referred to as the national grid. Throughout the EU Transmission is a regulated monopoly business.

Vehicle to Grid (V2G) describes a system in which plug-in electric vehicles, such as electric cars and plug-in hybrids, communicate with the power grid to sell demand response services by either returning electricity to the grid or by throttling their charging rate.

Virtual Energy Plant (VEP) is a system that integrates several types of power sources, (such as microCHP, wind-turbines, small hydro, photovoltaics, back-up, batteries etc.) so as to give a reliable overall power supply. The sources are often a cluster of distributed generation systems, and are often orchestrated by a central authority.

1 INTRODUCTION

The rapid growth of Renewable Energy Sources (RES), which tend to have variable and less predictable production profiles, is putting increasing stress on the management of the energy grids. The energy production and distribution system is therefore moving from a highly centralised and controlled production infrastructure to decentralised, distributed and fluctuating production points. However, the grids are still expected to be able to accept the energy generated, even at times and locations that are not necessarily ideal, and meet the consumer expectations regarding energy supply.

Demand Response (DR) has the potential to be a valuable strategy to shift/shave some of the load peaks and better match the production and demand curves, with benefits for the customers, national energy networks, and to the environment. Demand Response offers several benefits including: increased efficiency of asset utilisation, support of penetration of RES, easing capacity issues on congested distribution network and reducing generator margin of traditional spinning reserve.

***Demand Response** provides an opportunity for consumers to play a significant role in the operation of the energy grids by using energy management technologies to reduce or shift their energy usage during peak periods in response to time-based tariffs or other forms of incentives.*

Demand Response in Blocks of Buildings (BoB) focuses additionally on the clustering and synergies, regarding energy production and consumption, available between different connected buildings. However, the specific value chain for DR provision in BoB is yet to be conclusively proven. The control technologies, the management systems, the energy tariff schemes and business models must still be defined and are influenced by the specific local and national conditions. In this context, the aim of the DR-BOB project is to demonstrate the economic and environmental benefits of DR in BoB for the different key actors required to bring it to market. These include, but are not restricted to, Energy Suppliers, Distribution System/Transmission Operators (DSO/TSO), Energy Service Companies (ESCO), IT providers and Building owners/managers.

To achieve these ambitious goals the DR-BOB project will:

- ✓ Integrate existing technologies
- ✓ Provide and validate a methodology of assessing 3 levels of technology readiness
- ✓ Identify revenue sources for different types of stakeholders
- ✓ Demonstrate the integrated solutions at 4 sites in different energy and geographical contexts
- ✓ Achieve savings in energy demand, electricity demand and reducing the difference between peak and minimum demand
- ✓ Engage companies involved in the supply chain of demand response.

The key functionalities of DR-BOB project solutions are based on real-time optimisation of the local energy production, consumption and storage. The energy management can adapt to fluctuations in energy demand/production and the system efficiencies to maximise profit and/or minimise CO_2 emissions. The scalable cloud based architecture will be based on three tools:

1. Virtual Energy Plant (VEP) provides a flexible platform for forecasting, scheduling and optimising demand response schemes for load shedding and shifting.

2. Local Energy Manager (LEM) develops and runs optimisation scenarios for production, storage and consumption at the building/building cluster level that integrate with the BMS taking weather and market prices into account
3. Consumer Portal represents an online guide and stimulation tool for engaging energy users based on gamification, challenges, visualisation of processed data and direct contact.

1.1 AIMS AND OBJECTIVES

This report presents a market and stakeholder analysis for DR in BoB. The main objective of the work presented is to identify the attractiveness and the dynamics of DR markets with a special focus on DR for BoB. By conducting this market analysis, we will be able to gather valuable data that will help to identify the market size and its trends, the key drivers and the regulations, incentives and legal aspects. Additionally, it will assess the roles, expectations and benefits for different relevant stakeholders to understand how to leverage and engage them. This market analysis involves determining the unique characteristics of a particular market and analysing this information will help the consortium to make future decisions for business plans. As such, it collects and aggregates market data and information related to aspects pertaining DR and its intended products / applications driving development and exploitation.

DEFINITION

*A **market analysis** is a study or section in a business plan that presents information about the commercial market in which the business operates, the purchasing habits of customers in that market, and information about competitors. Based on market research and intended to attract investors, a strong analysis will show why a new product, innovation or business is a strong addition to a given market*

The current document has therefore the **objectives** to provide critical information to the consortium partners to be able to refine product development and define best exploitation strategies for each application and geographical contexts. With this framework, we will be able to identify in which sectors, locations and at which price range there is potential to enter the market and to identify the associated competing products. Via the market analysis, critical aspects, opportunities, influencing factors, relevant actors are identified so to monitor them during the development. To do so, the following factors in relation to DR are considered:

- Market Size
- Market trends
- Key market and technological drivers
- Target countries analysis (France, Italy, UK, Romania)
- Regulations
- Applications and services

Alongside the market analysis, a stakeholder analysis is presented to identify the key actors for DR in BoB. Analysing the stakeholders is crucial to projects to understand needs, desires and potential barriers to a specific implementation. By assessing the needs of each category, proactive steps can be taken to ensure they would work synergistically with the goals of the project and do not undermine its success. The following areas are studied in this deliverable:

- Stakeholders' interests
- Relevance to DR
- Needs and challenges

- Benefits

1.2 RELATIONS TO OTHER ACTIVITIES IN THE PROJECT

DR-BOB project focuses on DR in BoB by integrating existing solutions with great potential for social and economic benefits. It will demonstrate its soundness in 4 demonstration cases each in a different country (Italy, France, Romania and UK) in a range of building typologies and geographical contexts. From a general point of view this analysis has a cross cutting impact through the entire project since it provides the basis of understanding the context and the possible extent of the results.

This report provides a first step in developing the business requirements and business models in the DR-BOB project. This market analysis, through a detailed analysis of the target countries, provides the foundations and constraints to define feasible business models (D2.4) for the different demonstration sites. The specific needs, requirements and local features of the specific demos (D2.2) use this analysis to study the context in which they are situated. The market analysis and the demonstration sites report are the main inputs to identify the technological requirements (D2.3). Therefore, by providing key data, knowledge and analysis related to market and stakeholders this reports contributes to the STOs associated to WP2 (‘Requirements, Business models and Exploitation’): ‘’The identification of the values propositions underpinning demand response in blocks of buildings for the energy services industries and their consumers in different EU market contexts’’ and ‘’Integrated innovation management and exploitation planning’’.

1.3 REPORT STRUCTURE

This deliverable is composed by 5 chapters. It begins with an introduction regarding the topics of interest regarding the market and the stakeholder analysis. It specifies the questions that are answered in the report and its motivation. The analysis is based on desk research via literature review and expert knowledge of the fields.

Chapter 2 focuses on the market analysis in which a top-down analysis is performed, starting with a global picture of DR, then the European perspective and finally a focus on the target countries (France, Italy, Romania and UK). An overview of key market drivers and relevant regulations is then presented. In the last section of the chapter, first the current DR services and technologies available in the market are illustrated and then a focus on DR in BoB applicable programmes with and relevant barriers.

Chapter 3 presents the stakeholder analysis, which is divided in primary and secondary stakeholders. Within this section, relevance, needs/challenges and benefits for each of the stakeholders identified are assessed. Chapter 4 contains the conclusions of the report with the implications for the rest of the activities in the DR-BOB project.

2 MARKET ASSESSMENT

There is growing consensus among policy makers and market participants alike, that demand-side flexibility, empowered through DR, is a critical resource for achieving a low carbon and efficient electricity system at a reasonable cost. Today, this understanding is reflected within the European Network Codes, the Energy Efficiency Directive (EED) and the European Commission (EC)'s Energy Union Communication. Within these, Demand Response is named as an important enabler of security of supply, renewables integration, improved market competition and consumer empowerment. It is now an integrated part of Europe's efforts to lower energy costs, support clean energy resources, and combat climate change. Additionally, the synergies present within building clusters concerning energy production, storage and consumption could help reduce production-consumption mismatch and lower system costs.

The strategies, tools and adoption speeds of the different countries and markets in implementing DR strategies vary. Some energy markets are more mature and ready in supporting DR than others, especially regarding variable and time of use (ToU) tariffs with incentives to reduce/shift consumption at certain times. In the context of this project, Demand Response is defined as:

'A programme established to incentivise changes in energy consumption patterns by end-use consumers in response to changes in the price of energy over time, or to incentive designs to induce lower energy use at times of high market prices or when grid reliability is jeopardised'

Therefore, this chapter assesses the current situation of DR market and technologies. Sections 2.1 and 2.2 include a top-down analysis of the market, starting from the assessment of global size and trends, then European perspectives and finally it takes a closer look to the target countries, corresponding to those where DR_BOB project demonstration sites are present, namely, France, Italy, UK and Romania. The following section presents DR products and applications divided by service, software and hardware. Finally, section 2.4 discusses the application of demand response programmes to the specific case of BoB.

2.1 MARKET ANALYSIS

The DR market size and its trends is where the consortium wants to start understanding and analysing the market and its business potential, both with the potential readers of a business plan and with ourselves. In this section the following questions are answered:

- How large is the potential market for DR?
- Where does this potential market stand?
- What are the main forces and trends driving consumers to purchase DR-BOB products and services?
- Who are the potential buyers/sellers?
- What forces are preventing DR from capturing its full potential?

This analysis is performed both globally and disaggregated by target countries. Finally, legal aspects enabling or challenging DR are assessed. Incentives, regulations and recommendations for each of the target countries are discussed to evaluate the economic feasibility of DR.

2.1.1 GLOBAL SIZE AND TRENDS

Market reports written in the past 5 years by most of the economic consulting firms, agree on the fact that the Demand Response market has consistently grown in this period and their prediction confirm that this trend will continue in the future. Some statements from these studies are:

- "the global DR market is expected to grow from $1.6 billion in 2014 to $9.7 billion in 2023 and the capacity of global DR is estimated to increase as well from 30.8GW of 2014 to 196.7GW in 2023." (Navigant research, 2015)
- "global demand response spending will grow from $183.8 million in 2014 to more than $1.3 billion in 2024" (Walton, 2015)
- "the global market of demand response enabling technologies is projected to reach US$ 475 million by 2020" (Global Industry Analyst , 2015)

Figure 1 illustrates the forecasted DR market for the period 2014-2023, with exponential predicted growth. At present, North America (especially the USA) forms the largest DR market in the world but the EU and Asian markets are expected to grow rapidly over the next 10 years.

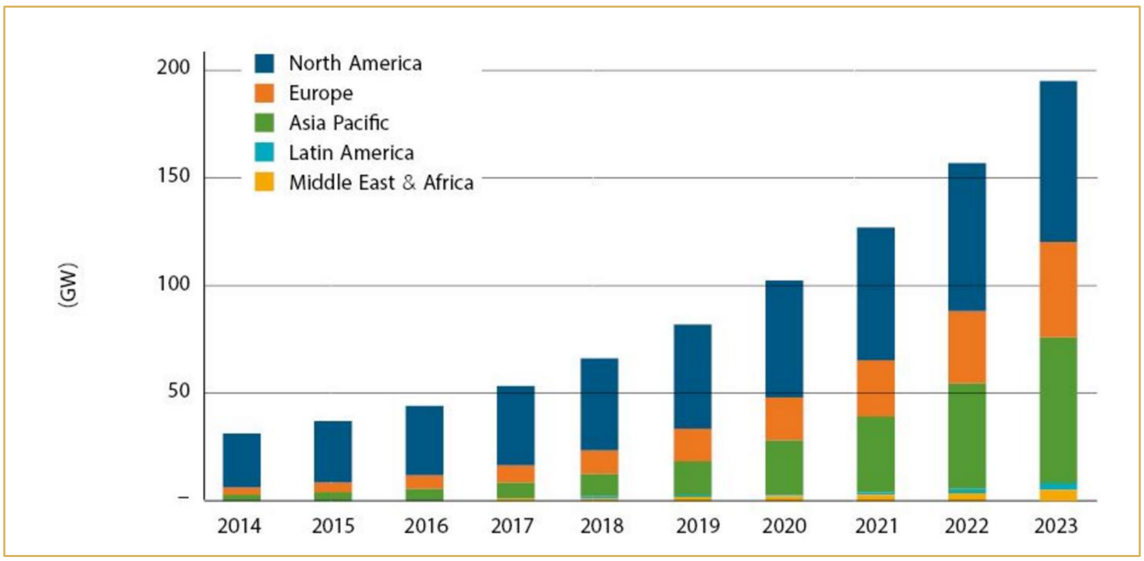

Figure 1. Global Demand Response Forecast (Source: Demand response enabling technologies, Navigant Research)

Since USA DR market is the most developed, it is used in this section as a case study to better understand the current trends. The USA launched DR for the stated aim of reducing instantaneous peaks. For example, in the summer time, power consumption hits the peak due to air-conditioning requirements and, in such a situation it is more effective and economically feasible to deal with such on-peak events through DR than increase generation. In the USA demand resources are actively traded and in 2014, the demand resource US trade market amounted to 27.3 GW.

Figure 2 summarises the composition of the DR sector based on data collected in EIA's annual survey of electric power sales, revenue, and energy efficiency. Approximately 9.3 million customers in the USA participated in Demand Response programmes in 2014. Most of these customers (93%) were in the residential sector, with the average residential customer saving/shifting about 100 kWh annually and receiving about $40. Commercial and industrial customers account for a small share of the demand-response customers (7% and <1%, respectively), but they delivered the majority of the actual peak demand savings from demand response in 2014. The average annual commercial customer incentive was almost $600, while the average industrial incentive was more than $9,000. The need to have fewer intermediary and large energy intensive users has directed the attention of DR program managers toward commercial and industrial customers. However, with the entry of aggregators capable of packaging the DR potential and flexibility of several smaller users this may change. California is the most active state in demand-response markets: the state has 12% of the nation's population but has 20% of the total demand-response customers and contributes 20% of the total peak demand savings. (Owen Comstock, 2016).

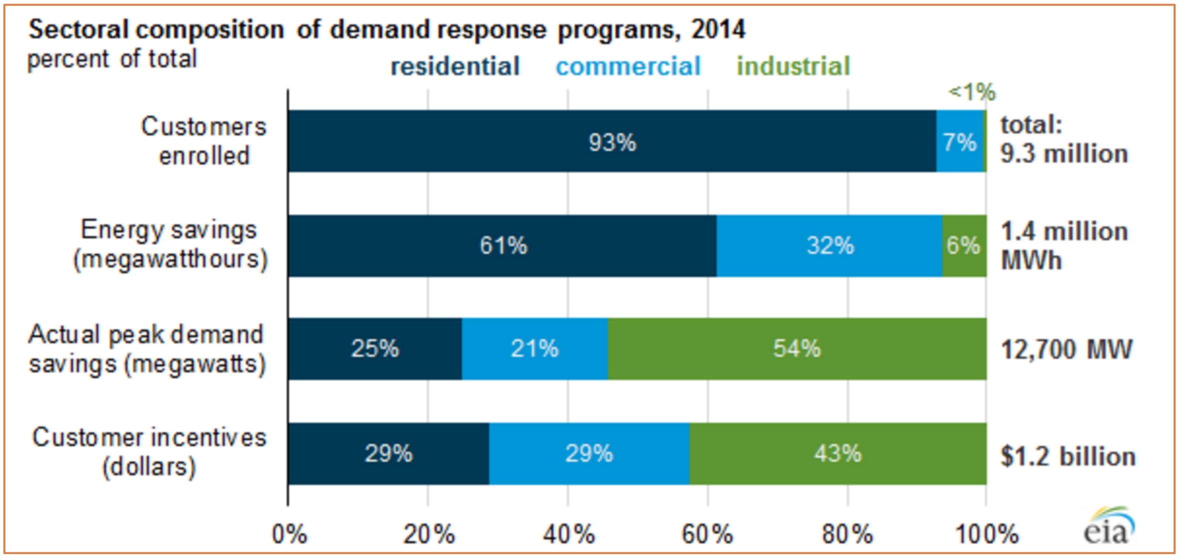

Figure 2. U.S. DR savings in 2014. (Source: U.S. Energy Information Administration, Electric power sales, revenue, and energy efficiency Form EIA-861)

The fact that the USA DR market is taken as an example allows the collection of guidelines about the synergies between the different flows, technologies and actors in the Demand Response value chain. The following section introduces the state of the art of DR in Europe. The EU DR market is underdeveloped and smart meters are not well distributed, so the market is lagging behind that of North America. However, recent interest has been sparked regarding the utilisation of DR to solve the instability of electricity network caused by the expansion of new RES. The EU aims to provide 20% of the total generation capacity by renewable energy by 2020, therefore the importance of DR is expected to grow (European Comission, 2010). The most active DR participants within the EU are England and Switzerland, with expanding DR markets in France and Finland. The total European DR resource in 2014 was just lower than 2 GW (Navigant Research, 2015).

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2.1.2 EUROPEAN PERSPECTIVE

According to the European Network of Transmission System Operators, Europe could lack up to 47 GW generation capacity by 2020 (ENTSO-E, 2014). This significant figure reflects the tough economic conditions faced by power plant operators. Market maker spreads on futures markets are often negative for baseload & mid-merit gas-fired generation units and this uncertainty leads to putting on hold investment decisions. The importance of intermittent renewable production in Europe is growing rapidly with wind and solar capacity that are expected to increase respectively from 117 GW and 80 GW in 2014 to about 193 GW and 114 GW in 2020. Facilitating the integration of these fluctuating energy sources and achieving the equilibrium between production and consumption will become increasingly challenging (ENTSO-E, 2014). The current lack of peak capacity, mainly caused by the decommissioning of old coal and gas-fired power plants, the non-integration of generation scarcity in market prices and a small but consistent growth of demand for electricity, is likely to subsist and even increase in the future (Bregt Vanderveken, 2015).

The European potential of DR in the industrial, tertiary and residential sectors is shown in Figure 3 (Sia partners, 2015). The total DR potential in Europe amounts to 52.35 GW representing 9.4% of the peak load estimated by ENTSO-E for its 34 represented countries, of which 42% comes from residential applications, 31% from industry and 27% from the tertiary sector.

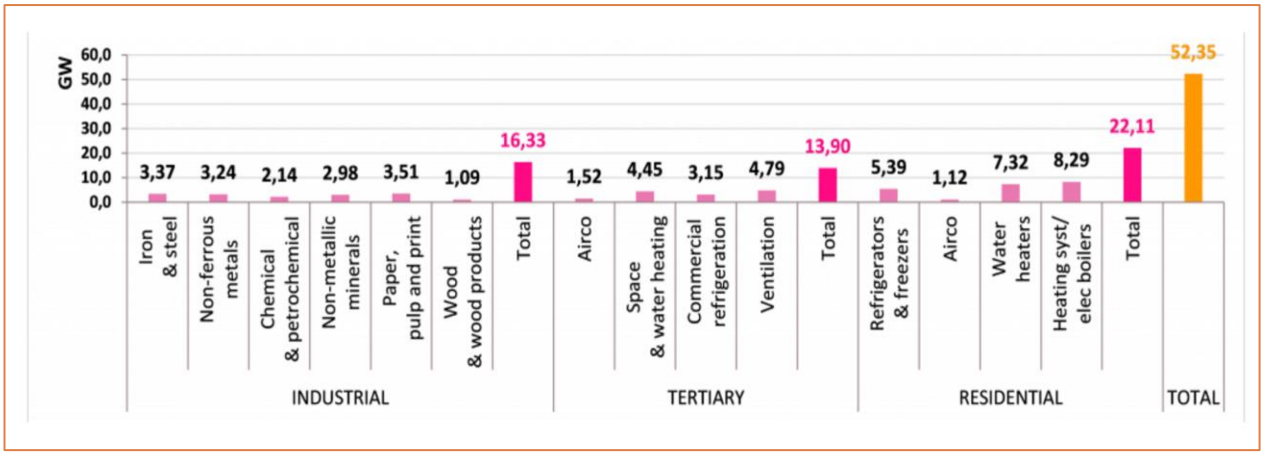

Figure 3. Total demand response potential in Europe. (Source: Demand Response: A study of its potential in Europe, Sia partners, 2015.)

The same study also assessed the potential per country from which it was possible to determine that the potentials differ notably in absolute terms, making evident the differences in energy consumption. Largest potentials are detected in the most populous countries: Germany (9.6 GW), France (8.1 GW), United Kingdom (5.8 GW), Italy (5.1 GW) and Spain (4.8 GW). In relative terms, in relation to the peak load, DR potential is around 7.5% for most countries. Figure 4 shows DR potential and peak load per country.

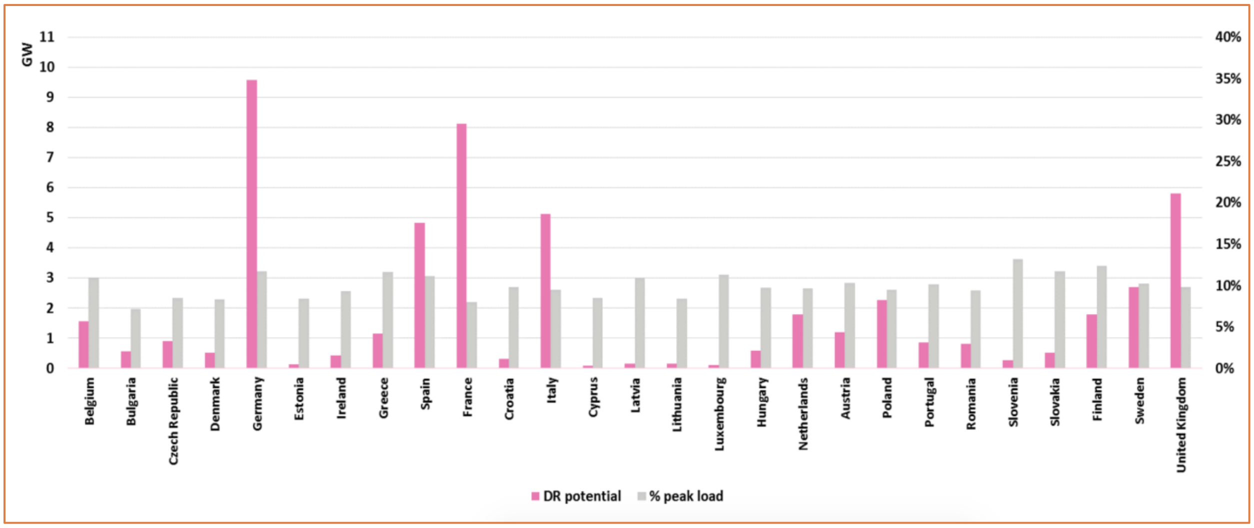

Figure 4. DR potential per country in absolute value on left axis and % of peak load on the right exis. (Source: Demand Response: A study of its potential in Europe, Sia partners.)

From a comprehensive market review on Demand Response (SEDC, 2015), under four criteria – enabling consumer participation and aggregation, appropriate programme requirements, fair and standardised measurement and verification requirements – some relevant findings were extracted and summarised into an overall score. Figure 5 presents the situation of the EU countries in 2015 with respect to explicit DR markets.

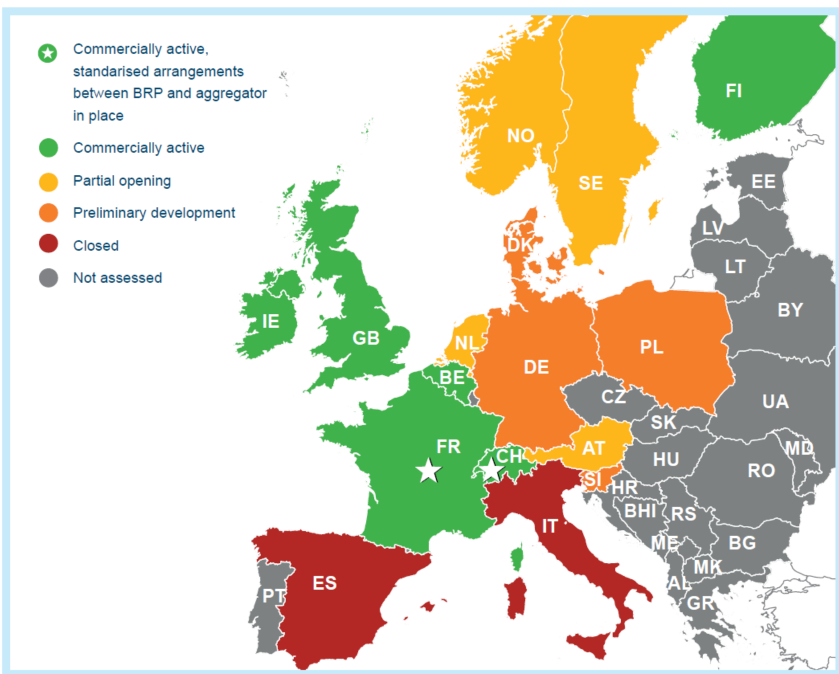

Figure 5. Demand Response scenario in Europe. (Source: Mapping Demand response in Europe today 2015, SEDC)

There is no data regarding DR programmes and implementation for Portugal or any of the Eastern European countries, starting from Greece going through Hungary, Romania, Czech Republic and up to the Baltic countries. The two south Europe Member States (i.e. Italy and Spain) have a closed market for explicit DR, while Germany and Poland are in preliminary development. Netherlands, Austria, Norway and Sweden have a partial open DR market, while Ireland, United Kingdom and Finland have commercially active DR services. Finally, France and Switzerland also have standardised arrangements. A more detailed analysis of the DR situation for the target countries is provided in Section 2.2

The above analysis considers mainly explicit DR which is sometimes called "incentive-based" where the aggregated demand side resources are traded in the wholesale, balancing, and capacity markets. On the other hand, implicit DR, sometimes called "price-based", refers to consumers choosing to be exposed to time-varying electricity prices or time-varying network grid tariffs that reflect the value and cost of electricity and/or transportation in different time periods (SEDC, 2015). Implicit DR seems to be closer to a common path in EU countries. Deployment status of smart meters, ToU tariffs, or dynamic pricing and self-consumption regulation are the key points to develop successful DR programmes. Smart metering deployments are currently successful in Europe, largely due to the legislation of many countries promoting, or even forcing, the replacement of old metering devices with smart meters. In fact, legislation for electricity smart meters is in place in the majority of the member states of the European Union, providing a legal framework for deployment and/or regulating specific matters such as a timeline of the rollout or setting technical specifications for the meters (European Commission, 2015). Member states have committed to deploy 200 million smart meters by 2020 (European Parliament, 2009). This implies that more than 70% of end-users will be covered by smart grid technology. Figure 6 shows the evolution of smart meters rollouts in European countries. ToU tariffs are already available in many EU countries and many pilot tests of dynamic pricing schemes are being developed, resulting in the identification of future types of electricity tariffs. These types of tariff are incentivising many R&D technologies that are been conceived as services, software and hardware. The state of the art of these technologies is discussed in section 2.3

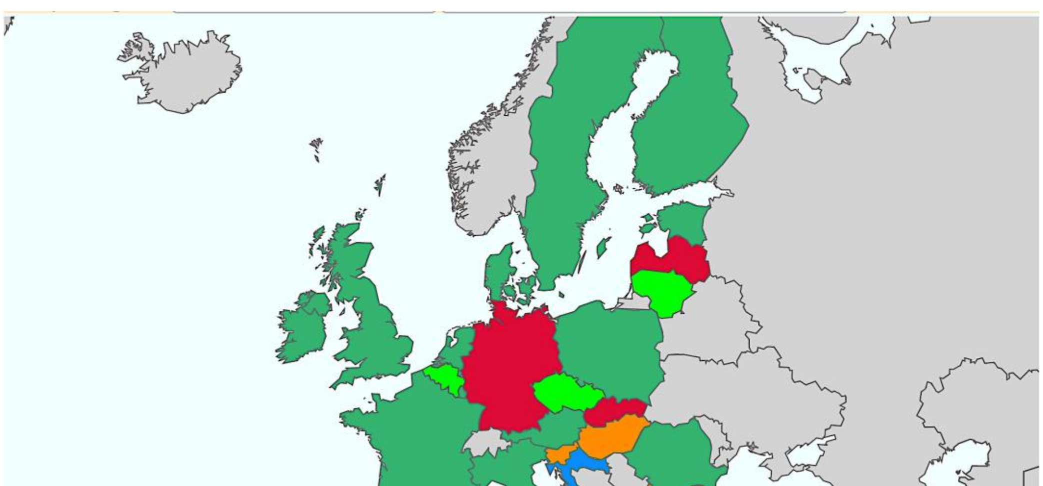

Figure 6. European Smart Meter Deployment for 2020 (Source: European Commission, 2014)

2.1.3 KEY MARKET DRIVERS

This section discusses the key drivers for DR in Europe and globally. Although each of them is assessed separately, it is clear that they are interdependent and must be considered together to present a complete picture.

2.1.3.1 Volatility & Levels of Electricity Prices

One market driver for DR is the volatility of wholesale electricity prices. When compared to other energy commodities, intra-day volatility in wholesale electricity markets is many times larger and varies across regions. As an example, Figure 7 shows the intraday power spot prices (European Power Exchange Spot) volatility on April 4-5, 2016.

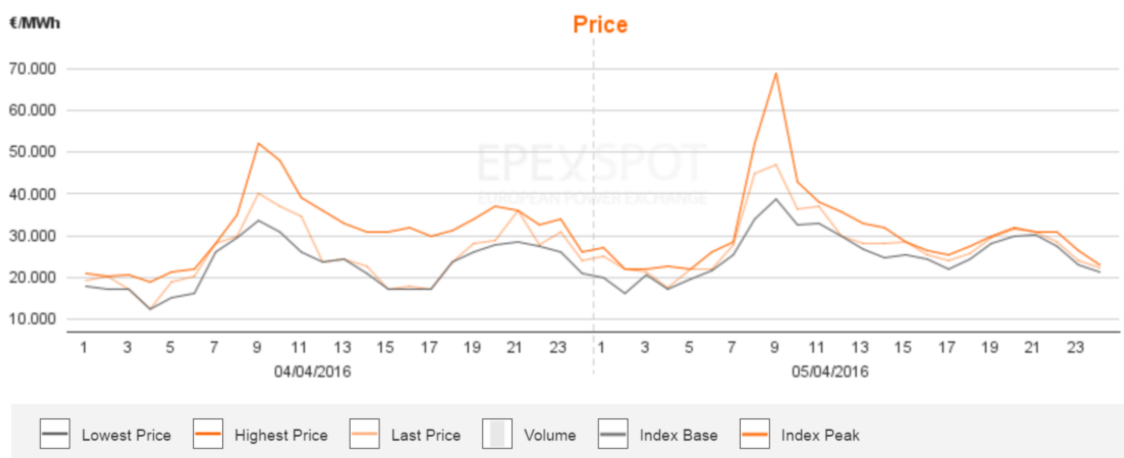

Figure 7. Intraday spot market prices on the EPEX Spot on April 4-5, 2016 (Source: https://www.epexspot.com)

Much of this variability is driven by the physical characteristics of electricity, notably the requirement to perfectly adjust supply to meet a demand that varies significantly throughout the day and across seasons, and the lack of cost-effective electricity storage mechanisms. By encouraging customers to either reduce or shift their electricity usage, DR programmes enable utilities and grid operators to avoid producing/purchasing expensive peak power. A further benefit of DR is the potential for wholesale price mitigation, which is the overall lowering of the marginal electricity price during DR events due to a downward shift in the demand curve

If electricity price volatility is key then the actual electricity price levels also impact on the absolute value of DR programmes. In the EU, the average household electricity prices have risen by 50% from 2005 to 2014 (Eurostat) and the average electricity price for industrial consumers has increased by 66%. However, prices vary significantly from country to country with differences that can rise to 3 times normal costs (e.g., Hungary: 10 cents/kWh in 2015 –Denmark: 30 cents/kWh in 2015). In the US electricity prices have historically been lower than in Europe but as can be seen in Figure 8, they are also increasing.

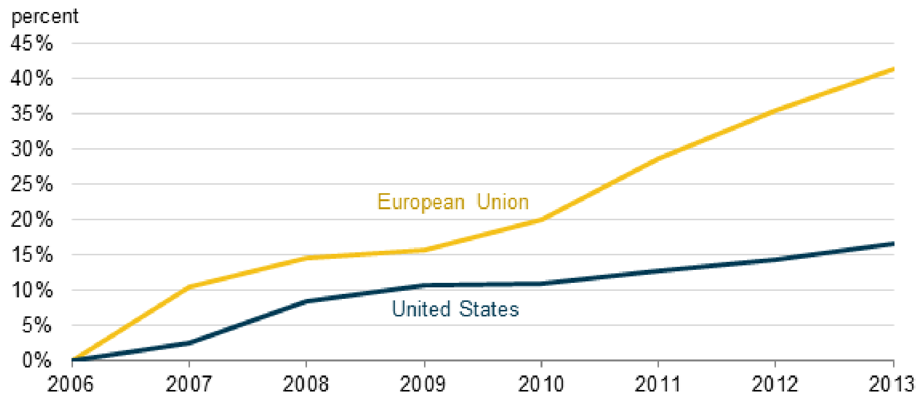

Figure 8. Changes in average residential electricity prices in Europe and the United States between 2006 and 2013 (Source: http://www.eia.gov)

High power rates, especially at peak power times, are a market driver for DR programmes through the creation of strong rewards and benefits for customers and operators that should incentivise the use of electricity at cheaper times and the self-utilisation of electricity generated on-site. Looking at the current trend and markets, we can see that if the strength of this driver is growing it is of unequal force across regions.

2.1.3.2 Legislation

Because clear regulatory frameworks are needed for the creation of market-based incentives that reward energy demand flexibility, legislation is a crucial market driver for DR. For DR programmes to flourish, electricity markets should be open; this includes equal access to the transmission grid, vertical separation of generation, transmission and supply and energy retail competition. Customer data privacy is also an important issue that can affect the development of DR. Lastly, legislation is an indirect market driver for DR with taxes and subsidies on certain energy sources and the enforcement of long-term governmental strategies.

The EC is clearly pushing for the creation of a single energy market where supply is more secure and climate friendly and demand is more responsive. Several legally binding directives are supporting these objectives. The energy efficiency directive (EED) 2012/27/EU sets several energy efficiency targets for 2020 and the electricity directive 2009/72/EC introduces common rules for the generation, transmission, distribution and supply of electricity; along with laying down universal service obligations, consumer rights and competition requirements. Both, are calling member states to remove incentives in transmission and distribution tariff that might hamper DR participation. Chapter 2.1.5 discusses about legislation and regulation in greater details.

2.1.3.3 Renewable energy integration

The rise of renewable energies means that growing fractions of electricity are provided by variable energy resources such as wind and solar. This trend is expected to continue and so it will be necessary to compensate for unexpected variations of the total system load on a short timescale (e.g., clouds covering solar panels or sudden drops in wind) or normal mismatch between production and consumption profiles. Because of the ability of DR to alleviate these short-term reliability concerns on the electric grid, the development of renewable energies is becoming an important market driver for DR programmes.

During the Paris COP21 climate conference, more than 150 countries set up ambitious clean energy actions plans. According to the World Resource Institute (WRI, 2015) these plans could help double the current renewable energy market in the next 15 years and renewable electricity generation will increase by nearly four times between 2012 and 2030 (Figure 9).

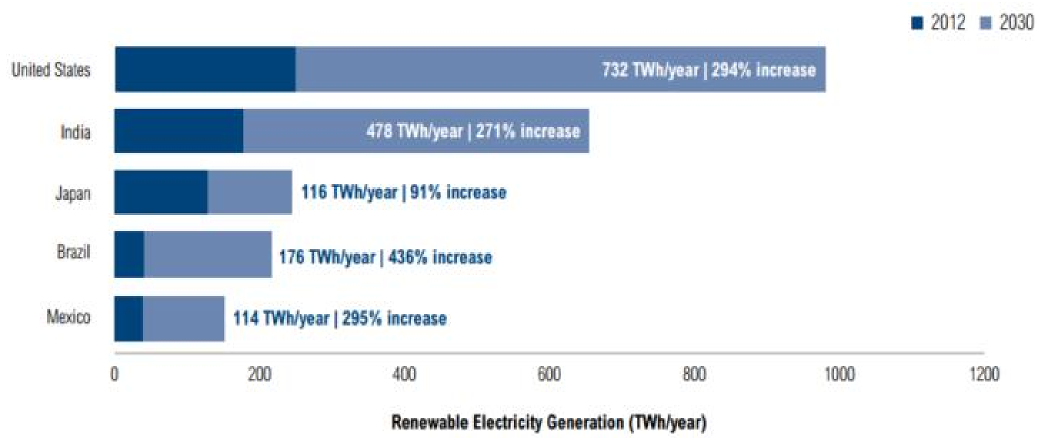

Figure 9. Expected growth in renewable electricity generation by 2030 if clean energy plans are met (Source: WRI – Assessing the Post-2020 Clean Energy Landscape)

In Europe, the EC have enacted a set of binding legislation (directive 2009/28/EC) aiming for certain climate and energy targets for the year 2020. One of these targets is to reach 20% of energy from renewables by 2020 (see Figure 10). In 2014, the European Commission progress report revealed that 25 EU countries were meeting their 2013/2014 interim renewable energy targets. As a result, the EU has three times more renewable power per capita than anywhere in the rest of the world.

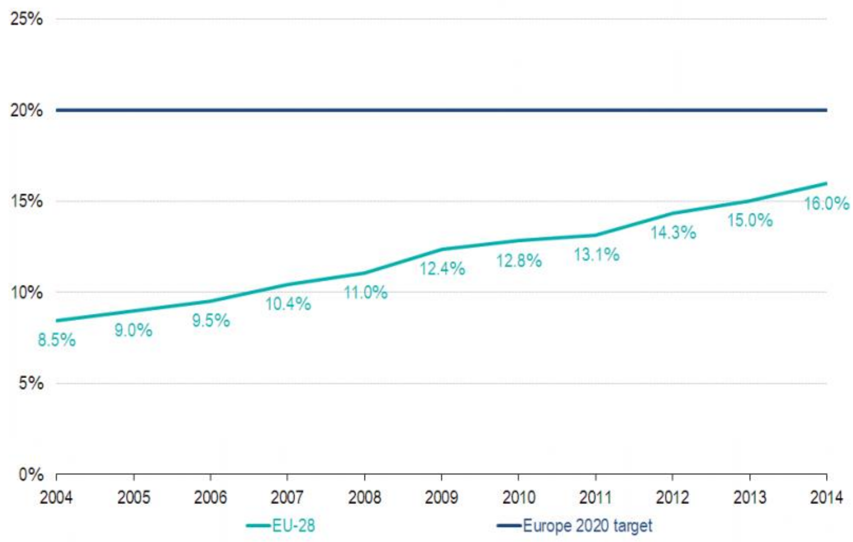

Figure 10. Increase in renewable energy capacity in Europe

2.1.3.4 Smart buildings & new electricity usage

The emerging smart building technologies and their associated systems and controls are also a key market driver for DR. Behind the vision of a smart building is the possibility to use information technology to connect a variety of subsystems and optimise the total building performance. This includes a connection to the smart grid and the development of interfaces that empower occupants and utilities with new levels of energy consumption monitoring and management.

Utilities are already deploying advanced metering systems that record the consumption of electric energy in intervals of an hour or less and communicates that information at least daily back to the utility for monitoring purposes. The EU has fixed a deployment objective for smart metering systems of 80% by 2020 and 100% by 2022 (Electricity directive 2009/72/EC). As a result, several European countries are conducting pilot projects. Italy for example is conducting the world's largest deployment of smart meters with more than 30 million Enel Spa customers. These smart meters are important building blocks for the future DR programmes.

New "grid friendly" electric appliances are also starting to appear on the consumer market. The most sophisticated of them can alter their operating profile based on DR policies. For example, Google Nest and its smart thermostat is partnering with utilities to provide a residential demand-response programme called 'Rush Hours'. Customers participating in this programme are compensated for allowing their thermostats to be adjusted during peak demand episodes.

Thanks to technological advances, the point at which sources of renewable energy – including solar which is particularly well-suited for buildings – cost the same as electricity derived from burning fossil fuels is quickly approaching. The future of a smart building being also an energy provider, with the use of alternative energy sources to supply electricity back to the grid is thus at hand. This should also be an important driver for the development of DR programmes.

Another potential booster for DR is the arrival of electric vehicles and the vehicle-to-grid systems (V2G). V2G describes a system in which plug-in electric vehicles communicate with the power grid to sell DR services by either retuning electricity to the grid or by throttling their charging rate. Since at any given time 95% of cars are parked, the batteries in electric vehicles could be used to let electricity flow from the car to the electric distribution network and back. Nissan Motor Corporation has begun testing these concepts with its latest Nissan Leaf electric car.

2.1.3.5 Other market drivers

In addition to the market drivers presented above, the deployment of DR is influenced by many additional market and technological factors. These include the retirement of existing coal and nuclear power plants, the need to extend or replace the current energy networks (DR can allow investment to be deferred), the demand for grid resiliency towards natural phenomenon, deployment of micro-grids and insular electric system as well as the overall trend called “transactive energy”.

Lastly, at the BoB level, it is possible to scale up DR and generate significant financial and ecological benefits. Commercial buildings to start with, are responsible for roughly half of the peak demand for energy (Smith, 2010) and the key decision-makers are in control of large load reductions. Energy scale and centralised management of building clusters/neighbourhoods are thus two drivers for DR at the BoB level, also thanks to the economy of scale, negotiating power and synergies among systems.

2.1.4 NEEDS AND CHALLENGES OF DR

Worldwide, there is a large panel of businesses and institutions operating chains of buildings, from retailers with chains of supermarkets, stores, hotels within the same brand in a region, government institutions with central and local buildings, research & education institutions. Currently, the majority of these stakeholders do not have a significant role in the energy market, as the buildings are considered as individual energy users. Recently, more and more of the above mentioned actors in Eastern Europe started to purchase the needed energy for their whole pools of buildings, acting thus as stakeholders for blocks of buildings; other regions in Europe have been doing this for quite some time. This enables them to negotiate with the suppliers from a stronger position, where their requirements can be taken more seriously.

Most of the identified challenges and market barriers are general to all players, being related to the legislative requirements, the existing structure of the balancing markets, the already defined and permitted actors, lack of flexibility to new participants, and in relation to their actual impact on forming smart grids, as is the case of the BoB. Some of the barriers that have to be addressed and passed over by the stakeholders representing BoB are related to:

1. <u>Limited number of DR programmes available for consumer</u>: There is still a contrast between the requirements of the EED and the effective programmes available for users, especially for BoB willing to access the day-ahead, intraday, balancing or other markets. Today, few Demand Response service providers exist in Europe and thus in most EU Member States only the largest industrial consumers with their own bilateral power purchasing agreements can participate in Demand Response programmes. This is mostly due to an incomplete regulatory environment in the majority of Member States, and the lack of flexibility of the electricity suppliers.
2. <u>Consumer’s lack of information regarding grid issues and electricity cost</u>: Most European electricity consumers still pay tariffs that are based on average electricity costs and bear little relation to the stress on the electricity grids and the true generation costs of electricity as they vary over time (SEDC, 2015). The energy monitoring and smart metering systems

penetrating the market should enable a faster and more comprehensive communications with regard to energy consumption and pricing.

3. Demand Response may not be accepted in the legislations as a resource: many Member States have wholesale, balancing, or capacity markets where aggregated demand is not accepted as a resource.
4. Inadequate and/or non-standardised methodology to compare performance between before and after DR implementation: It is important that consumers' demand-side flexibility is accurately quantified through smart metering. Many Member States lack standardised measurement and baseline methodologies, or have methodologies which are designed for generators and therefore do not accurately measure consumption changes. This may entirely hinder a market, as consumers in buildings or industry will not receive payment for the services they deliver. The International Performance for Measurement and Verification Protocol (IPMVP) is not yet largely used for this application.
5. Technology biased programme requirements related to the historical data of energy use for consumers. The smart metering system and data should be made available to the users, not only to the DSOs of suppliers.
6. Aggregation services are not fully enabled: Prequalification, registration and measurement may still be conducted at the individual consumer level, or by the DSOs rather than on the pooled load collected by aggregators, thus blocking the participation by placing heavy administrative and legal burdens on the individual consumer, BoB or by the aggregators.
7. Lack of standardised processes between the Balancing Responsible Party (BRP) and Aggregators.

Some of the main **challenges** include:

1. The EU Demand Response market is still in the early development phase and fragmented because of Member States having widely varying regulations. Single Member States have between 4 to 9 separate electricity markets (forward, capacity, day-ahead, intraday, and a set of balancing markets) and each of these markets will have their own participation rules. Worse, in Member States with more than one TSO, each TSO may have different participation rules. Over and above this, even within this already severely fragmented market (28 countries, a maximum of 4 up to 9 electricity markets per country, individual rules per TSO), it is often impossible or often illegal to aggregate customers across balancing zones (SEDC, 2015), like the stakeholders owning chains of buildings (supermarkets, hotels, gas stations, public buildings, etc.). There is a critical need for standardised regulation at the European level, including clarified roles and responsibilities and a clear definition of the participants in the balancing market and the permission to enhance the BoB. The European Network Codes and the up-coming Market Design Initiative could unify and standardise the regulation across national markets.
2. There is need for inclusion of logical step-by-step strategies for market development of consumer demand-side services, measured and verified against well-defined key performance indicators. Only a planned and coordinated effort can help to overcome the systematic historical barriers to Demand Response. The European Commission's leadership in this process will be essential. The need for consumer empowerment and Demand Response is widely supported. Changing market processes will take time, work and a long-term commitment toward positive development (SEDC, 2015).

3. Demand Response was <u>included in the Network Code</u> to foster consumer participation. However, this initiative was achieved <u>without the engagement of aggregators</u> and actors involved in BoB

2.1.5 REGULATIONS, INCENTIVES AND LEGAL ASPECTS

European policymakers have demonstrated strong support for Demand Response. This is reflected in several important legislative texts:

- 2005 European Union Energy Policy
- 2007 The EU Treaty of Lisbon
- 2009 The 3rd Electricity Directive (ED)
- 2012 The Energy Efficiency Directive (EED)

The <u>Electricity Directive (ED)</u> of the Third Energy Package defines the concept of "energy efficiency/demand-side management", acknowledging the positive impact on environment, security of supply, of reducing primary energy consumption and peak loads. Art.25.7 requires network operators to consider Demand Response and energy efficiency measures when planning system upgrades. Art.3.2 also considers the implementation of long-term planning, and the access of third parties to the system. This language was strengthened further within the Energy Efficiency Directive (EED).

<u>The Energy Efficiency Directive (EED) (2012/27/EU)</u> constitutes a major step towards the development of Demand Response in Europe. According to Art.15.2, Member States are required to undertake an assessment of the energy efficiency potentials of their gas and electricity infrastructure, in particular regarding transmission, distribution, load management and interoperability, […] and identify concrete measures and investments for the introduction of cost-effective energy efficiency improvements in the network infrastructure, by 30 June 2015. Furthermore, Art. 15. 4 requires Member States to remove subsidies, price regulations and tariffs as they hamper the participation of Demand Response in the markets and to incentivise the improvement of systems and infrastructure efficiency within the framework of Directive 2009/72/EC (SEDC, 2015). Of outmost importance is Art.15.8 of the Directive, which establishes **consumer access to the energy markets, either individually or through aggregation** asks for:

- Encouraging demand side resources by the national regulatory authorities to participate in wholesale and retail markets.
- Ensuring that TSO and DSO are meeting the requirements for balancing and ancillary services to include in a non-discriminatory manner aggregators and demand response providers.
- Promoting access and participation of Demand Response in balancing, reserves and system services markets
- Requiring national regulatory authorities to define the technical modalities for participating in the above markets in cooperation with demand service providers and customers, including aggregators too.

Citing the EU regulatory framework makes DR possible, but its full potential will not be realised without further actions from national policy-makers, regulators and energy companies; additional efforts should aim at (Siano, 2016):

- Creating **market-based and transparent incentives** for DR that reward participation through dynamic prices without unnecessary constraints whilst respecting legal considerations on data **security and protection, privacy, intrusion**.
- **Opening up the market** to exploit the potential of DR, **treating demand side resources fairly** in relation to supply and elaborating clear and transparent market rules and technical requirements.
- Bringing the technology into the market through the **roll-out of smart metering** with the appropriate functionalities, creating the needed framework for smart appliances and energy management systems.

In slight contradiction, SEDC recommends for the legislative proposals affecting Demand Response and electricity markets to take into account (SEDC, 2016c):

- **Enforcing customer access for demand-side flexibility** to all energy markets in line with the Energy Efficiency Directive (2012/27/EU) Art.15.8.
- Creating a clear **regulatory framework** with roles and standardised processes for information flow and allowing third party aggregators participation in the market.
- Allowing a **non-discriminatory participation of all technologies** in the market including demand-side resources, distributed generation, self-generation and storage from the very definition of the technologies considered in the legislation.
- **Revising incentive structures** to allow the participation of these technologies in a non-discriminatory manner and removing "perverse" incentives focused solely on new generation capacities.
- Including **both capacity and flexibility in the supply safety management**, scenario calculations and infrastructure development.

In addition, in 2014 - 2015 a significant development of DR was within the European Network Codes, by the inclusion of Demand Response as a positive step towards the widespread consumer engagement in Europe. For the first time, there is thus a high-level structure enabling the participation of demand-side resources across markets and Member States. This success was achieved through productive stakeholder engagement between demand-side representatives, ENTSO-E, Agency for the Cooperation of the Energy Regulators (ACER) and the European Commission (SEDC, 2015).

2.2 TARGET COUNTRIES MARKET ANALYSIS

This section presents an overview on the situation in the 4 target counties (France, UK, Italy and Romania) with respect to DR. Subsequently, the potential market for implicit and explicit DR in these countries is assessed and discussed. The salient finding regarding implicit and explicit DR are summarised in Table 2.

<u>France</u>

France is becoming one of the most forward thinking and active energy markets in Europe. Current "energy transition" legislative efforts, could be another enhancer for the DR market.

DR on retail prices has been applied based on wholesale electricity market prices for more than 40 years. France has a history of retail DR programmes lead by EDF with programmes based on variable retail price schemes for both residential and industrial load management. The demand response products are allowed in the balancing market up to a limit of 1800 MW (in 2015), for the load participation. Starting from 2017 the market will be opened and start delivering to both generation and demand-side participation. Table 1 describes the programme requirements in the balancing products. Another attractive product for the DR operators is the 0.1 MW minimum size capacity to be controlled by a day ahead notification and a 2 way alternative: acting independently after the certification process of the loads, or contracting with their suppliers and consequently reducing their obligation through DR programmes.

The French regulator has consistently worked in the last years on opening up all ancillary service markets to DR and to third-party aggregators. In 2014, for the first time an industrial consumer provided its energy reduction as a FCR or Primary Reserve. This programme, together with Secondary Reserve (FRRa), is accessible to load participation since 1 July 2014. There were also revealed the first results of the experimental phase that allows curtailed load to bid as energy directly into the wholesale electricity market (SEDC, 2015).

Table 1 Accessible DR products and programme requirements in France (SEDC, 2015)

Product	Minimum size (MW)	Notification Time[80]	Activation	Triggered
Primary Control (FCR)	1 MW	<30 s	automatic	Triggered continuously
Secondary Control (FRRa)	1 MW	<15 min	automatic	Unlimited
Fast Reserves (FRRm)	10 MW	13 min	manual	Unlimited
Complementary Reserves (RR)	10 MW	30 min	manual	Unlimited
DR Call for tender (DSR – RR)	10 MW	2 h	manual (ongoing works on automation)	Up to 60 days/year

UK

The United Kingdom was one of the first countries that opened consumers' access to the energy markets, leading to an actual flexibility of all balancing markets to DR and load aggregation services. In the recent years the process between the stakeholders lead instead to a decline of the DR market due to inappropriate requirements regarding the measurement, baseline, bidding and to other reasons. There is also a disproportion between the generation and demand resources in the recent launched capacity market and a lack a clarity in the relation of the Aggregators and the BRPs.

The "Demand-Side Balancing Reserve" (DSBR), was introduced in winter 2015 with a contracted capacity of 318.7 MW and aggregated load accepted. DSBR targets large energy users who volunteer to reduce their demand during winter weekday evenings between 4 and 8 pm in return for a payment. The Supplemental Balancing Reserve (SBR) programme targets power stations that would otherwise close. One of the historical DR programme, the Short-Term Operating Reserve (STOR), has been updated to provide better opportunities for aggregation via the STOR Premium Flexible and STOR Runway programmes.

Several aggregators act in London and U.K. in the energy balancing market. The aggregator is not required to ask for permission or to inform the supplier prior to load curtailment and has direct access to consumers. They may aggregate load from all over the country. The consumer, however, is contractually obliged to inform the supplier about the intended participation. Five out of the six DNOs are currently running Demand Response trials (SEDC, 2015). Trials in the Thames River Valley and in Bristol involve a few dozen commercial buildings each, with a large scalability potential, but do not provide any payment to the end customer. Other trials involve the use of new commercial contracts for large customers (>100kVA) or seek avoidance of network reinforcements through smart voltage control in major substations.

Italy

In the recent years, the electricity market has been characterized by a rapid growth of renewable generation (mostly PV and wind) and by a decrease of electricity consumption. Italy relies mostly on hydro and gas for its flexibility needs, while the framework for consumer participation in the balancing market is not yet in place. The only exception is the interruptible contracts programme, which is a dedicated Demand Response programme separate from the balancing market. As Demand Response is not yet legal in the frequency reserves, here are overviewed only the rules of participation in the Interruptible Load Programme. The enrolment of interruptible loads is currently about 4 GW, with a minimum size of 1 MW to participate. Aggregation is not allowed. The payments are attractive and related mostly to availability payments rather than real utilisation. The programme has been called very few times during the last years, or never in some cases (SEDC, 2015).

A potential progress of the DR capacity market is expected if the strategic guidelines for the period 2015-2018, in which the Italian BRP (AEEG) included the evaluation of demand-side mechanisms, will be applied (SEDC, 2015). The main DSO, ENEL, launched a Pilot program called ''Enel Info+''. The participants received an energy monitoring kit including a specific device called "Smart Info" which enabled easy access to energy consumption data and, at a later stage, facilitates involvement into DR programmes (ENEL, 2015). At this moment to enter balancing market with demand-side resources would require a control centre operating 24/7, which is a market entry barrier. The rules regarding verification and definition of baseline are not clear yet.

Romania

For both electricity and gas markets, the regulator (ANRE – Romanian Authority for Energy Regulation) approves tariffs and limit prices for electricity and gas utilities. The tariffs methodology is designed to set pricing guidelines for existing consumers, while for new consumers the price is set based on the competitive market. ANRE set out a timetable regarding the introduction of a free-price of electricity acquisition component (percentage) for households and commercial customers alike. This component is to be applied in the current supply tariff calculation, on an increasing basis, according to a specific calendar that aims to achieve a completely liberalised market until end of 2017 for households and until end of 2016 for commercial customers (Kearney, 2013). Romania faces stability issues on the national power grid (especially at night) due to the lack of energy storage capacity, having only 230 MW of pumping hydroelectric capacities, at a total generation of about 7.5 GW (Vilt, 2013).

The Romanian BRP is called OPCOM, the commercial operator of the energy market. This entity is the only one to handle the energy market and relation between energy generation companies, energy suppliers, DSOs and other possible entities. Currently there are no DR active programmes. In the past, the energy tariffs were structured to have time based and energy and power based tariffs, but gradually the energy market quit these instruments in favour to a simple energy acquisition by the end user, independently from the time of rated power. Instead, the energy market has been harmonized toward the European energy market having different components such as: bilateral contracts, day ahead market, intraday based market, all in the frame of the OPCOM administration on a dedicated platform. There is no clear definition and clarification of any responsibilities with respect to the possible participation of aggregators into DR market. The current vision is that DR will become available after the introduction of smart meter and the liberalisation of energy market, after the 2017.

2.2.1 EXPLICIT AND IMPLICIT DR IN THE TARGET COUNTRIES

A detailed analysis of the current status of the **explicit DR** was performed by SEDC on a spectrum of the regulatory structures in 16 countries (Austria, Belgium, Denmark, Finland, France, Germany, United Kingdom, Ireland, Italy, Netherlands, Poland, Slovenia, Spain, Sweden, Norway, Switzerland), under the following criteria:

1. **Consumer access & aggregation**. It analyses the fundamental conditions for the existence of Demand Response including if DR and aggregation are allowed as well as the clarification of parties involved and responsibilities.
2. **Programme description & requirements** refers to the requirements of the different products/programmes assessing whether these enable demand-side resources to participate.
3. **Measurement & verification.** In close connection to the definition given in the International Performance Measurement and Verification Protocol (IPMVP) has a significant importance in establishing the baseline methodologies in a harmonised and fair manner for the events that should be measured.
4. **Finance & penalties** were examined under their flexibility and fairness, transparency and attractiveness on the one side, and on the other side under their healthy condition in penalising the non-delivery of DR resources.

As can be seen in Table 2, it is clear that the market situation for **explicit DR** is different for each country. The main reason for this diversity is the independent legislations in each country, which for the moment are driving the market in different directions and at different speeds. However, it is expected that in the mid-term legislation within EU countries will achieve a common framework to deal with DR. Results show that, currently:

- *France* is the most evolved market for explicit DR, it has a high DR potential to be exploited and the regulatory framework is incentivising DR.
- The *UK* situation is moving toward a competitive market, there are still missing minor steps (e.g. fairness of involved actors including supplier/BRP, place on equal footing DR resources and generation) to be taken which will ensure fair and regulated competition between generation and DR resources. The DR resource potential is 5.8 GW, making it an attractive market for investments.
- The case of *Italy*, with a potential of 5.1 GW, is still in a primitive phase, load is not accepted in any wholesale market and therefore requirements, measurement and payments remain unfair and with no clear perspective as of 2015. It is expected that this could rapidly evolve since recommendations from the EU are encouraging countries to implement DR as an active resource in the electricity grid.
- Finally, Romania is currently behind the other countries covered by the DR-BOB scope. DR markets have yet to be developed and there are still missing clear guidelines for its kick-off. The absolute DR potential is low, 0.8 GW, which in relative terms is lower than the 7.5% European average with respect to the total installed capacity (Sia partners, 2015).

From the perspective of the **implicit DR**, the authors performed an analysis of key enabler factors for each target country. The analysis is based on the following topics:

1. **Self-consumption regulation**: When allowed, it permits to shift loads into self-generation periods, therefore empowering consumer with a key implicit DR strategy.
2. **Revenues from self-consumption/load-shifting:** What, and by how much, are the financial benefits driving self-consumption/load-shifting?
3. **Smart meters deployment**: The extensive roll-out of smart meters is the main enabler for tariff schemes such as ToU and dynamic pricing. In addition, in the future it is expected that data from smart meters will be used for further developments in the grid and DR as, for example, price-based load automation.
4. **Type of tariffs available**: ToU or dynamic pricing consent the user to shift loads from high electricity price to lower price.

Implicit DR market is homogeneous in France, Italy and UK, self-consumption is permitted in all of these countries without any tax implications, and in the case of UK a generation tariff is offered to users making load shifting toward generation periods more attractive. ToU tariffs are available in all countries with two or three price slots according to the time, day and month. The details of the prices will be studied in D2.4 in order to estimate possible revenues by load shifting. Regarding smart meter deployment, Italy is the European leader with more than 30 million smart meter installed. The rest of the countries are following this trend and by the year 2020 all of them will have large (>80%) deployment. Finally, the issues of electricity exchange among different prosumers is becoming very relevant when discussing DR BoB and whether it should be allowed for one consumer producing excess energy (e.g., from RES or CHP) to sell to another entity without passing through the main grid. In Italy, for instance, this is highly restricted and granted only under special circumstances.

Table 2. Key factors of implicit and explicit demand response

Country	DR potential (GW)	Explicit Demand Response				Implicit Demand Response			
		Consumer access & aggregation	Programme description & requirements	Measurement & verification	Finance & Payment	Right to Self-consume	Revenues from self-consumption/load-shifting	Smart meters deployment	Type of tariffs enabling DR
France	8	Aggregated load is accepted in a range of markets, standardised arrangements between involved parties	Minor barriers to demand-side participation in market remain, however participation is still possible	Requirements are well defined, standardised, proportionate to customer capabilities, and dealt with at the aggregated level	Payment is fair and penalties are reasonable	YES	Savings on the electricity bill	Second phase of installation (3 million installed in 2014)	Time of Use Pilots on dynamic pricing
U.K.	5.8	Aggregated load is accepted only in limited number of markets, lack of standardised arrangements between involved parties	Minor barriers to demand-side participation in market remain, however participation is still possible	Requirements are under development, but do not act as a significant barrier	Payment is adequate, but unequal per MW between supply and demand;	YES	Savings on the electricity bill + Generation Tariff	Day+night time meter since 1970 20 million between 2016-2018	Time of Use
Italy	5.1	Load is not accepted as a resource in any market	Significant barriers remain, creating major competition issues for demand-side resource participation	Requirements act as a significant barrier to consumer participation	Payment structures inadequate, unequal pay per MW between supply and demand, penalty for non-delivering or for reducing DR load	YES	Savings on the electricity bill	100%	Time of Use
Romania	0.8	Negative load (or peak-shaving) is not accepted as a resource in any market	Demand-side resource participation in the market is not possible	Requirements act as a significant barrier to consumer participation	No payment structure for DR	YES	Savings on the electricity bill + green certificates + cogeneration tariff	0% Planned to roll out 80% in 2020	None, only Flat Tariff

2.3 DR PRODUCTS AND APPLICATIONS

As a result of the uptake of the renewable resource market, the increased number of prosumers and relevance of the interaction between consumers and grids, private entities like Restore, KiWi Power and Lichtblik started providing Demand Response services in the UK, German, French and Belgian markets (St John, J. 2013). These services are mainly focused on industrial consumers, however the back-end IT systems are scalable and would allow the integration of smaller consumers, especially if already aggregated. Figure 11**Error! Reference source not found.** illustrates a map with the current players in urope as for 2015.

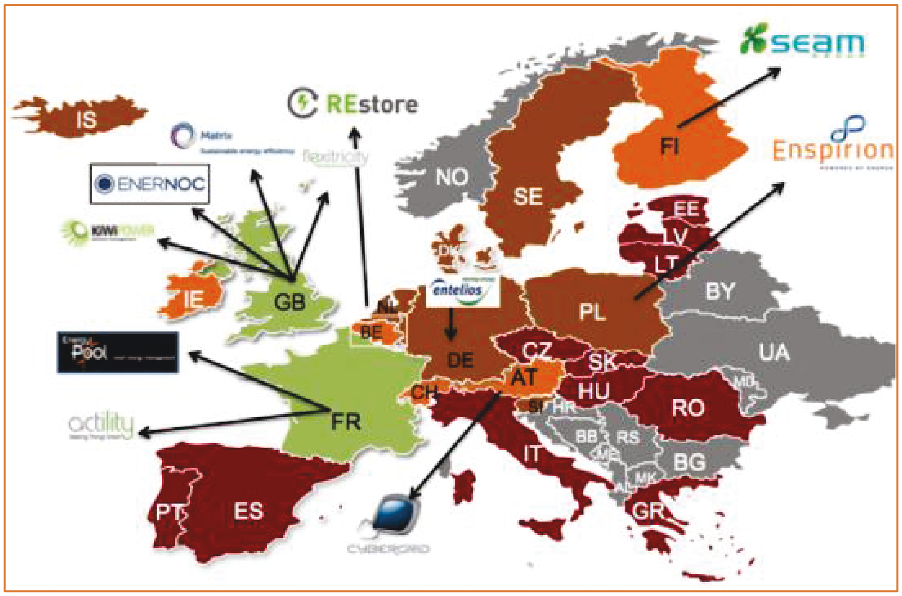

Figure 11. DR current players in Europe. (Source: Mapping Demand response in Europe today 2015, SEDC)

A number of different products and solutions that enable Demand Response are available on the global market. These solutions can be categorised into three offerings: services, hardware and software.

2.3.1 SERVICES

There are several service providers who offer help to organisations that are looking to participate in demand response. Some, such as REstore are 'virtual' services that are supported via an IT platform, whereas others such as EnerNOC offer traditional consultancy services in the form of technical advice and business modelling etc. **Error! Reference source not found.** summarises the services available for R. These are categorised by region and relevance to DR BOB.

Table 3. DR available services

Provider	Service	Region	Description	Relevance to DR BOB
REstore	Flexpond™ Cloud Based Platform	Europe	Flexpond™ is a cloud-based platform that allows Commercial & Industrial consumers to participate in Demand Response programmes. (Demand Response programmes for industries in Europe, 2016)	High
National Grid	Service provider	UK	National Grid is the TSO for England and Wales and offers a number of demand response markets that organisations (including BOB owners) can participate in such as STOR and frequency response. They also provide an advice service to help organisations access these markets. (Demand Side Response | National Grid, 2016)	High (UK only)
EnerNOC	Implementation of DR programmes	Global	EnerNOC provide a range of consultancy services to support the design and deployment of DR solutions. (Energy Management - Control, Submetering & Monitoring., 2016)	Medium
Kiwi Power	Implementation of DR programmes	UK	Frequency Response Program, Capacity Reserves program, Network constrain management (Kiwi Power, 2016)	Medium
Energy Pool	Service Porvider and Implementation of DR programmes	France, Belgium, UK	DR potential assessment and implementation of DR programs. (Energy Pool, 2016)	High

2.3.2 SOFTWARE

There is a plethora of software packages on the market which exist to facilitate various forms of demand response activity for organisations. These vary significantly in cost, scope and sophistication and so careful research must be undertaken by prospective clients to ensure that the tool they purchase is appropriate for their needs.

Table 4. DR available software

Provider	Product	Region	Description	Relevance to DR BOB
AutoGrid	Demand Response Optimisation and Management System	North America	Cloud-based Demand Response Management System platform that is scalable to millions of endpoints, secure, and can be easily integrated into any third party system through web-services APIs. Includes real-time forecasting and event modelling. (Auto-Grid, 2016)	Medium
EnerNOC	EnerNOC Site Server (ESS)	Global	ESS can be connected to existing meters and is equipped to read and record consumption or generation data. These data are then communicated back to a central location (Energy Management - Control, Submetering & Monitoring., 2016)	Medium
	Advanced Energy Intelligence Software		Cloud-based software which enables scheduling, monitoring and analysis of DR capacity. (Energy Management - Control, Submetering & Monitoring., 2016)	Medium
Elster	Enacto™ Collect	Europe & Asia-Pac	Cloud-based energy management software with three core modules: 'Collect', 'Insight' and 'Analytics'. It provides a foundation for DR by enabling an organisation to understand its consumption profile in detail, and understand where there are opportunities for participating in DR. (Elster, 2016)	Medium
GE	PowerOn™ Precision Solution	North America	PowerOn™ Precision Solution is a Demand Response Management System. It allows organisations to manage DR programmes, field assets and operational activities and includes a range of features such as load forecasting, load shaping, dispatch and ROI projection. (General Electric, 2016)	High
Honeywell	Demand Response Automation Server (DRAS)	Global	Provides a method of managing DR programmes, resources and events. It enables a wide range of DR programme types with advanced aggregation of assets as well as forecasting, analysis and scheduling. (Honeywell, 2016)	Medium
BuildingIQ	Predictive Energy Optimisation™ software	Global	The software works with a building's BMS and monitors a number of inputs such as weather, occupancy and energy prices etc. Using these inputs, the software will produce the most efficient HVAC operating strategy for the next 24 hours. (BuildingIQ Solutions, 2016)	Low

GridPoint	GridPoint Energy Manager	North America	Energy Management software that enables users to have a single point of control to monitor and manage energy consuming assets, across numerous sites, ensuring operational consistency and predictable spend. (Comverge - IntelliSOURCE, 2016)	Medium
Comverge	IntelliSOURCE	Global	Cloud-based software that gives utilities a single operational view into all of their demand response and energy efficiency programmes, as well as automating every phase of mass-market demand management programmes. It includes a Demand Response Management System that enables event control, pricing including cycling, temperature setback, critical-peak pricing etc. It also provides curtailment reporting and optimised dispatch. The IntelliSOURCE platform also uses open API standards, which allows for connection to third party devices. (Comverge - IntelliSOURCE, 2016)	High
Siemens	SureGrid	Global	Siemens offers a fully automated cloud-based Intelligent Load Management solution. SureGrid can monitor and control major energy consuming devices, such as HVAC, lighting, refrigeration etc, SureGrid technology enables each building to dynamically interact with the electricity grid based on local business rules and real-time asset and environmental conditions. (Smart Consumption for Commercial Building Operators - SureGrid , 2016)	Medium
Siemens	Demand Response Management System (DRMS)	Global	Software platform that allows organisations to manage all aspects of their DR programmes through a single, open-standards-based system. DRMS ensures that DR activity is scaled in a cost effective manner; automating manual processes that are typically used to execute DR events and settlement. It can be fully integrated with both field and back office utility systems. DRMS is able to target "surgical" planned load curtailments at localised grid environments where localised grid stress is present. The software is aimed predominantly at utilities and large aggregators. (Demand Response Management System (DRMS) - Smart Grid Solutions , 2016)	High

Silver Spring Networks	UtilityIQ®	Global	Demand Response Management solution that optimises load management across disparate DR programmes and systems, offers real-time optimisation and forecast analytics, dispatch of load control events as well as a notification system for informing consumers of upcoming events. (Silver Spring Networks Unveils New High-Precision UtilityIQ® Demand Optimizer; Oklahoma Gas & Electric to Leverage for Pioneering SmartHours DR Programme , 2016)	Low (unless aggregating multiple sites in which case this is high)
Kiwi Power	Kiwi Power Client App	UK	Kiwi Power is a UK based aggregator who offers demand response services. Their system is based on the use of Kiwi Power's own smart meter known as 'PiP'. Installation of a PiP gives the user access to the 'Client App' web portal which enables users to monitor consumption, track DR events and calculate revenues generated. (Energy Intelligence and Smart Metering., 2016)	Low
Alstom	e-terraDRBizNet	Global	Demand Response Management System that provides command and control capabilities over a utility's entire portfolio of DR programmes, locations, and end devices for residential, commercial, and industrial customers. Incorporates dynamic resource modelling, optimised dispatch, real-time resource tracking, and state-of-the-art performance evaluation techniques. (Alistom Products and Services, 2016)	Low (unless aggregating multiple sites in which case this is high)

2.3.3 HARDWARE

Demand response requires basic electrical components such as meters as well more advanced equipment such as communications infrastructure. Depending on its procurement policies and technical competence an organisation could purchase these from a single supplier or each device could be sourced separately. **Error! Reference source not found.** summarises the available hardware

Table 5. DR available hardware

Provider	Service	Region	Description	Relevance to DR BOB
Kiwi Power	Power information Pod (PiP) smart meter	UK	The Power information Pod (PiP) is a smart meter approved by system operators such as National Grid UK and is designed specifically for demand response. It is cloud-enabled and has a powerful, embedded Linux platform which allows for real-time power measurement, monitoring, logging and control. (Energy Intelligence and Smart Metering., 2016)	High (UK only)
GridPoint	Controllers, Sub-meters,	North America	The controllers, sub-meters, thermostats and sensors work together to set desired equipment	Medium

	Thermostats and Sensors		schedules and temperature set-points, as well as gathering circuit-level power usage and building environment data. In addition to standard functionality for scheduling it can also dynamically adjust building operations to changing site conditions and so optimise energy consumption (Energy Management - Control, Submetering & Monitoring., 2016)	
Comverge (Comverge-Hardware Solutions, 2016)	IntelliTEMP (Smart Thermostats)	Global	Offers multiple configurations to support varying levels of control—from one-way communications to two-way communications for HVAC systems.	Low
	IntelliPEAK (Control Switches)	Global	This switch includes a paging, Wi-Fi or cellular radio. For flexibility, it is designed for one- or two-way communications with a dynamic pricing and/or advanced load control programmes. It uses existing cellular networks or the consumer's broadband network, removing the need for an expensive and complex gateway. As a result, the implementation of a demand response programmes—with two-way communications—is significantly more cost-effective. IP-based communication enables remote programming, status reporting, near real-time presence, and telemetry collection.	Medium
Siemens	SICAM SGU	Global	Siemens SICAM Smart Grid Unit (SGU) is a field device that can be used for smart grid purposes such as demand response, DER controller for virtual power plants, renewable integration in microgrids, or small RTU installations. The SICAM SGU can be used with an integrated GPRS modem to connect remote distributed energy resources and it provides a cost-efficient alternative to expensive wired installations and separate configuration of an external cellular modem. (SICAM SGU - Digital Grid - Siemens., 2016)	Medium
Ecobee	ecobeeDR	Global	A range of Wi-Fi connected thermostats that help consumers understand how their home or business uses energy and find ways to save you money with minimal effort and without compromise. (EcoBee Solutions, 2016)	Medium
Encycle	Swarm Energy Management	Global	Solution for demand management and demand response using a wireless swarm logic approach to controlling loads which is billed as 'affordable, easy to use, and maintains occupant comfort'. (Encycle Technologies, 2016)	Medium
EnerNOC	S2	Global	Collects meter data from end users and streams it in real time back to EnerNOC's Network Operations Center (NOC). As an OpenADR-compliant communications gateway, the EnerNOC Site Server interfaces with buildings' existing control equipment flexibly, reliably, and	Low

			accurately to support real-time energy management in commercial and industrial applications. (Demand Response for Utilities, 2016)	
MelRok	Touch	Global	Touch communicates universally with all energy devices, sensors, sub-meters, renewable systems, and Smart Meters through their native protocols, and instantly forms a fully compatible IoT network for interoperability, simultaneous data integration, and control between any energy device or system and the Cloud. (MelRok Energy IoT, 2016)	Medium

2.4 DR IN BLOCK OF BUILDINGS

The OpenADR Alliance (a consortia consisting of leading DR providers, utilities, developers and end users) recently carried out an analysis of DR use cases and deployment scenarios. According to the findings, although DR programmes are to a certain extent unique – having to fit specific geographic and regulatory requirements as described above – common elements and characteristics have been identified among the large number of worldwide deployments. This has lead the OpenADR Alliance to produce a "DR Programme Implementation Guide" which has several stated goals, one of which is to present a number of common DR programme types (or use cases) which are known to be repeatedly used in practice and can now be considered as 'commonplace' DR scenarios (OpenADR Alliance, 2016). Seven main programme types have been identified, and the implementation guide goes on to provide detailed models, templates and guidelines for how these DR programmes may be implemented within the OpenADR protocol framework. Although it is not yet clear that OpenADR will be employed in the DR-BOB project, the identified commonly used DR programme types and their suitability for use within a BoB have merits and will be discussed. Although seven DR programmes are discussed in the guide, only five are reported below; the reason for this is as follows. As recently shown by Ogwumike et al. (2016), the salient features of cost and pricing signals for typical DR programmes involving dynamic tariffs – such as traditional Critical Peak Pricing (CPP), Real-Time Pricing (RTP), Time of Use Pricing (TOUP), Two-Tier Pricing (2TP) and various combinations thereof – can all be represented using simple generic cost functions. Therefore, to simplify the analysis that follows, several similar DR programmes involving these pricing signals have been merged into a single 'Generic Dynamic Tariff' DR programme.

Generic Variable Tariff (GVT) DR programme: GVT DR programmes provide variable pricing structures for electricity which are designed to reduce consumption during periods of high wholesale market price or during known periods of system contingency, and encourage consumption in times of low wholesale market price. In a GVT programme, hourly or sub-hourly prices for electricity consumption (possibly having several tiered levels) will be advertised to DR participants by the programme sponsor at least one hour in advance, typically one day in advance – and in some cases even months in advance. Although prices are variable and reflect market conditions, maximum prices may be negotiated in advance. Typically, they would be linked to day-ahead market conditions and seasonal market changes. Such DR programmes are especially useful for planning and scheduling controllable resources such as smart appliances and the charging times of electric vehicles. There are no minimum load restrictions and the target participants may be residential, commercial or industry.

Capacity Bidding DR Programme (CBP): A DR programme which allows a load resource and its owner to identify how much load it is willing to curtail for a specific price to the DR programme sponsor requiring the demand reduction. Although CPB contracts may be negotiated by the resource owner and the sponsor well in advance, real-time negotiation may also be performed e.g. based upon balancing (real-time) market conditions to help cover unplanned contingencies such as loss of expected renewable availability due to inaccurate weather forecasts. Notice periods for activating negotiated CBP contracts are typically one-hour minimum and are mostly one day-ahead. Such DR programmes are especially useful for deferring planned operation of large/medium sized industrial loads, where enforced loss or change of production is recouped through pre-commitment contracts and subsequent activation payments. There are minimum load restrictions (typically 100 kW) and the targeted participants may be load aggregators, commercial or industry.

Direct Load Control (DLC) DR Programme: A DR activity in which the programme sponsor remotely controls a participant’s electrical equipment on short notice (normally several hours). Typically, this would involve temporarily reducing temperature, humidity or air pressure set points in home and building HVAC equipment to achieve a short-term reduction in electricity demand. Once the DR event has passed, conditions are automatically returned to nominal levels. Financial incentives are paid for enrolling in the DR programme and may also include bonuses when DR events occur. It is possible for a participant to opt-out of a given DR event for a financial penalty. There are no minimum load restrictions and the targeted participants may be residential or (small) commercial.

Fast Dispatch / Ancillary Services (FD/AS) DR Programme: A DR programme which provides incentive payments to participants for fast load reductions (or increases in some cases) during emergency conditions on the grid that require immediate action to prevent loss of transmission lines, distribution equipment and/or generator tripping which could negatively impact the reliability of the wider system. Contracts are negotiated in advance and often activated without prior warning, as load needs to be shed (or increased) at very short notice ($\approx$ 2 seconds for frequency regulation). Such DR programmes are especially useful for large/medium sized industrial loads where enforced loss or change of production is recouped through pre-commitment contracts and subsequent activation payments. There are minimum load restrictions (typically 100 kW) and the targeted participants may be load aggregators, commercial or industry. This DR programme is very similar to the CBP DR programme, but timescales for real-time response and reliability of load change are much more stringent (and participation incentives much larger).

Distributed Energy Resources (DER) DR Programme: These are DR activities which are utilised to smooth integration issues for Distributed Energy Resources (DER) into the wider electricity grid, e.g. to help curtail over or undersupply issues. For most implementations of this DR programme, some form of storage and/or a dispatchable DER are required. The DR participant responds to day-ahead pricing signal incentives from the sponsor to either increase or decrease its nominal load at requested times during the day, using batteries, flywheels or other forms of energy storage or by dispatching a DER for a particular time period when it would not normally do so. This allows the DR participant to modify its nominal load profile in accordance with the sponsors’ incentives (which are often linked to intermittent availability of renewable energy elsewhere in the grid). There are no minimum load restrictions and the targeted participants may be residential, commercial or industrial.

2.4.1 POTENTIAL OF GENERIC DR PROGRAMMES FOR BLOCKS OF BUILDINGS

As mentioned earlier, each individual DR programme is unique in the sense that it must align with the market context and be well-suited to the interconnected equipment and compatible with specific geographic and regulatory requirements. From the above list of common DR programmes, one may observe that although all are suited to DR in BoB, some may be expected to be more easily deployable in a wider variety of situations than others due to significantly variations in technical and market requirements. Although specific decisions cannot yet be made regarding the selection of DR programmes to be employed in the DR-BOB demonstration sites, the basic participant incentive, sponsor impact and technical requirements features of each DR programme are stated in the context of BoB below. Based on the current legislation and tariff schemes available, we also listed in which target country the specific implicit or explicit DR program could be applied. An initial qualitative assessment of use in BoB is also stated. This assessment must be taken as very preliminary at this stage, and is based upon an initial estimation of the level of effort required and technical considerations to implement each DR programmes. Note that since each DR programme requires an existing Advanced Metering Infrastructure (AMI) and DR ICT infrastructure, this is not stated as an explicit technical requirement but it is a pre-condition. It must also be remembered that the market conditions and capabilities must also suit the specific DR programme.

Table 6. Summary of Technical and Market Requirements for DR Programmes, applicability in the target country and potential for BoB.

DR Programme	DR Incentive and Impacts	Technical Requirements	Type of DR	Potential application in target countries	BoB Potential
Generic Variable Tariff (GVT)	Low to medium economic benefit to participant, continual peak-to-peak reduction	Schedulable / controllable devices or EV charge points, Optimizer, HMI, BMS or HAN	Implicit	France, Italy, UK; Romania expected in the next years	Very High
Capacity Bidding DR Programme (CBP)	High economic benefit to participant, sporadic peak reduction	Sheddable load of 100 kW or more, HMI	Explicit	France, UK	Low
Direct Load Control (DLC)	Medium economic benefit to participant, sporadic peak and energy usage reduction	HVAC with appropriate control system or other suitable load, HMI, BMS or HAN	Explicit	France, UK	High
Fast Dispatch / Ancillary Services (FD/AS)	Potentially very high economic benefit to participant, sporadic peak reduction	Fast sheddable load of 100 kW or more, Plus high-speed and reliable telecontrol & telemetry interfaces OR frequency sensitive / frequency aware loads	Explicit	France, UK	Very Low
Distributed Energy Resources (DER)	Medium to high economic benefit to participant, continual peak-to-peak reduction	Dispatchable DER, Storage, Optimizer, HMI, BMS or HAN	Implicit /Explicit	France, Italy, UK, Romania	Medium

From the table, it can be observed that although all DR programmes have potential in BoB, the three most favourable DR programmes according to this initial evaluation would be GVT, DLC and DER, corresponding to two implicit and one explicit DR programme. This is principally because in most (not all) BoB, there are some controllable appliances (e.g. washing machines, EV chargers) and HVAC systems for climate control (temperature, humidity). Since market conditions in most EU nations already support simple on-peak and off-peak tariff structures – and are moving towards RTP pricing structures – the basics for implementing GVT and DLC DR programmes will be present (even if manual implementations are required). In addition, in many modern buildings, distributed energy generation is also present (typically in the form of PV panels and/or a CHP plant). Therefore, a DER DR programme also seems favourable, albeit slightly less so due to the additional need for storage and day-ahead signal from the DR sponsor.

The main reason for less favourable conditions for the CPB and FD/AS DR programme is the need for a controllable resource which is large enough to be activated (at very short notice in the FD/AS case). This is less likely to be available in a BoB. However, in many cases it is most likely that hybrid combinations of the above DR programmes could be considered for a particular area. For example, recent work by Zhou et al. (2015) has shown that by aggregation of multiple HVAC systems and the application of co-ordinated controls, it is possible to provide FD/AS-type DR programmes to provide frequency regulation services in the presence of fluctuating wind power. This is, in essence, a hybrid combination of DLC and FD/AS DR programmes that is enabled by adding an appropriate ICT infrastructure and control systems. This should be bore in mind when planning the technical aspects of the DR-BOB solution.

Another possible approach to providing fast ancillary and dispatch services for leveraging demand-side contributions to frequency regulation could also be emerging (Molina-García, 2011). In this decentralised approach, instead of having demands under tele-control by a DR sponsor, loads are equipped with (low-cost) instrumentation which is able to measure frequency directly at the point of supply. They are also equipped with controls which can quickly react to frequency deviations by modulating demand accordingly, without the need for any external signals. If properly implemented, a form of fast-acting demand-side primary droop control can be achieved by participating loads. Follow-up secondary frequency stabilisation using tele-control signals from the DR sponsor can also be used within such a framework ('traditional' DR). With respect to blocks of buildings, then HVAC systems seem to be the most appropriate for this kind of droop control by manipulating temperature and air-flow set-points to obtain fast, short-term reductions in demand (which are not likely to impact occupant comfort if only present for short time periods). This approach avoids the need for fast and reliable tele-control and telemetry interfaces and infrastructures, but requires the development of an appropriate set of technical standards and legislation. In addition, there do not seem to currently be financial incentives offered for providing such services within the EU; this is currently a barrier to an approach which appears to be emerging as one of the most technically feasible and potentially effective approaches for DR.

An example of how DR involving the control of local energy production are inhibited in some EU countries is the way in which the price paid to individuals and organisations that generate renewable energy is subsidised. Many EU countries have introduced Feed-in-Tariffs (FITs) that guarantee a price for the renewable electricity produced by distributed energy resources. Two types of tariff schemes are commonly applied: fixed-price FITs (FFITs) which guarantee a fixed price for every unit of produced electricity and premium based FITs (PFITs) which pay a premium on top of the variable market price (Crosbie 2016). *"FFITs do not provide any incentive to produce electricity when marginal production costs are high. Also, costs for balancing intermittent electricity production may be significantly lower with PFITs. Therefore, PFITs provide an incentive to match renewable power output better with marginal production costs in the system*" (Schmidt, 2013).

In the case of DER DR it must be highlighted that there are three key barriers to consider when thinking about the potential for the deployment of DER DR in blocks of buildings in some EU. Firstly renewable energy self-consumption and decentralised storage are not allowed in all EU countries (European Commission, 2016). Secondly complex and burdensome administrative and authorisation procedures still represent an important barrier for the competiveness of small-scale self-consumption projects in blocks of buildings where renewable energy self-consumption and decentralized storage are allowed (European Commission 2016b, 2016). Thirdly on-line information platforms and applications are so far used in only a few Member States (e.g. Portugal, Hungary, Italy and Sweden) (European Commission 2016b, 2016).Thus while several EU countries have introduced facilitated notification procedures for small renewable energy installations such as roof-top PV installations, additional national action is required (European Commission, 2016)

When considering the potential for DR in blocks of buildings the rise of the independent aggregator within European electricity markets is also crucial. As Demand Response in BoB will be difficult to capitalise on in those EU countries whose regulatory frameworks discourage or ban their growth. This is especially in the case of Explicit DR programs in which consumers receive direct payments to change their consumption (or generation) patterns upon request. This is because most blocks of buildings do not have the level of generation / demand reduction/ storage capacity to engage in many of the current DR products. Consumers, if they are to be engaged in DR need a clearly defined offer, which is clearly beneficial and simple to use. As such they "*require a party with expertise in selling and providing this offer through aggregation. Aggregation service providers (who may or may not be electricity suppliers) are therefore central players in creating vibrant demand-side participation and Explicit Demand Response*" (SEDC, 2015)An analysis of 16 member states in 2015 found that five EU markets were commercially active, four had Partial opening of markets and there was preliminary development of market in the case of two and two were closed (SEDC, 2015)

In summary, within a BoB scenario featuring large enough quantities of schedulable devices and controllable loads – along with DER/storage units (e.g. CHP with batteries / hot water tank) – modern optimisation and control techniques such as those described by Ogwumike et al. (2016), Short et al. (2016) and Zhou et al. (2015) allow for potentially large opportunities for DR. A key enabling factor, however, will be the provision of an appropriate AMI/DR ICT framework to assist with coordinated actions between buildings and BoB.

3 STAKEHOLDER ANALYIS

The building and energy sectors are complex industries with many involved stakeholders in several stages that are also evolving to meet the changing conditions and requests. These sectors are seeing the entry of new actors needed to provide requested services, as shown in Figure 12.

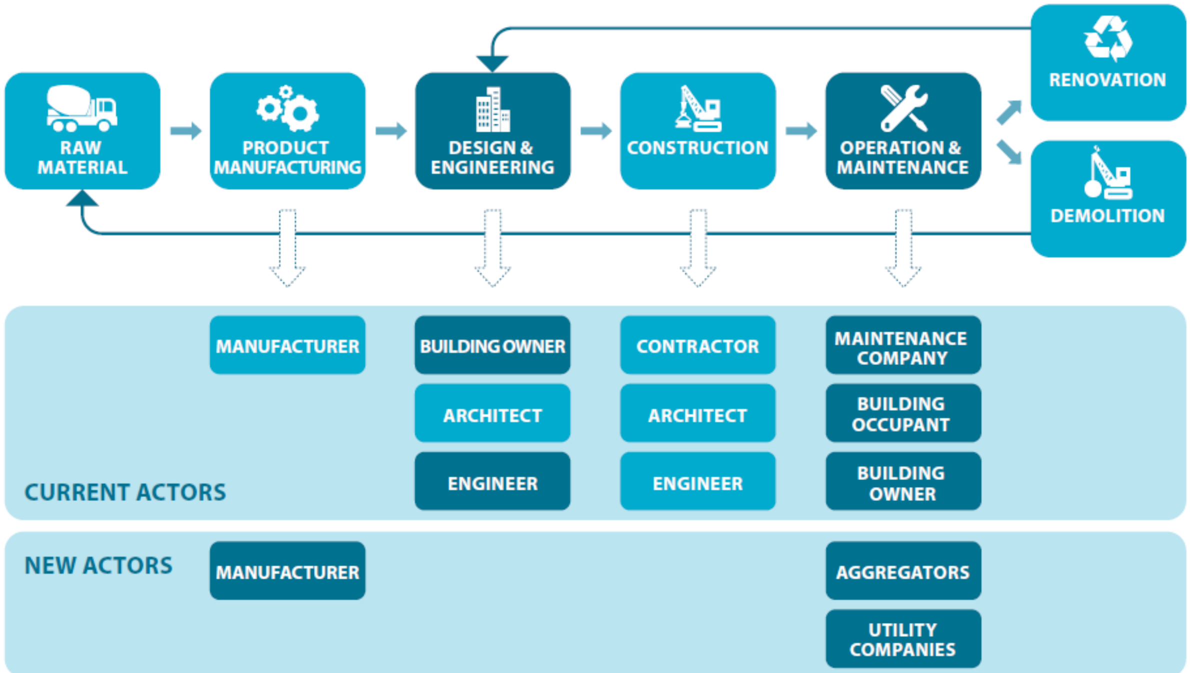

Figure 12. Simplified illustration of the main actors involved in the construction value chain (source: BPIE, 2016)

Analysing stakeholders is crucial for projects to understand relevant actors' needs, desires and potential barriers to a specific implementation, development or change. By assessing the needs of each category, proactive steps can be taken to ensure affected/affecting actors would work synergistically with the goals of the project and do not undermine its success. If we will be capable to identify and deliver benefits consequential to the engagement in DR for BoB for the most relevant stakeholders, the probabilities of success and large-scale deployments will exponentially increase.

This stakeholder analysis uses a common Power/Interest approach (Mendelow, 1991), which divides the stakeholders in 2 groups (primary and secondary stakeholder) as presented in

Table 7. The main difference between primary and secondary stakeholders is that DR success directly depends strictly on the involvement and cooperation of the first ones. Primary stakeholder may show more or less interest on DR but they have higher influence and power than the secondary stakeholders and their aversion could lead to project failure. However, although DR could be successful with low involvement of designers, builders, maintenance companies or occupants (secondary stakeholders), if they are involved in an early stage using the strategies listed in

Table 7 for group 3 and 4, the final solutions will be more complete and further business opportunities may arise. High power, high interest stakeholders are key players. Low power and low interest stakeholders are least important. Depending on the classification of the different stakeholders different engagement strategies should be implemented.

Table 7. Classification of different stakeholder types with associated strategies for engagement

Level of importance	Category & classification	Strategy to maximise their engagement
Primary stakeholders	1. **Key players:** High Influence & High Interest	• Key players focus effort on this group • Engage and consult regularly • Involve in governance
	2. **Meet their needs:** High Influence & Less Interest	• Engage and consult in their interest area • Try to increase level of interest • Aim to move into key players
Secondary Stakeholders	3. **Show consideration**: Less Influence & High Interest	• Make use of interest through involvement in low risk areas • Keep informed and consult on interest area • Potential supporter
	4. **Least important**: Low Influence & Low Interest	• Inform via general communications: Newsletter, website, etc. • Aim to move into group 3

Often the process of identifying stakeholders will result in a long list of individuals and groups. After identifying the long list of actors, these are condensed into the main relevant categories. Subsequently, each of them is assigned to a class, according to Figure .

Figure 13. Classification of different relevant stakeholders in the power vs. interest chart

The goal of the following sections is to highlight what are the needs, challenges, barriers and benefits of each listed stakeholder with respect to the successful diffusion of DR in BoB. Specific relevant questions/topics are:

- What financial or other benefits/impacts are likely to obtain from the implementation of DR?
- What is their relevance to the project?
- What are their needs with respect to DR?
- What is the primary motivation?
- What barriers they see in implementing DR?

3.1 PRIMARY STAKEHOLDERS

Primary stakeholders are those that have high influence and power with respect to DR. They include TSO/DSO/Retailer, Aggregator, BMS and equipment manufacturer, building owner/manager, and Policymaker. Table 8 summarises the relevance, needs and benefits for each primary stakeholder that is then discussed in further detail in the remaining of chapter 3.1.

Table 8. List of main stakeholders with associated relevance, needs and challenges, and benefits for them with respect to DR in BoB.

Actor	Relevance	Needs and challenges	Benefits
TSO/DSO/Retailer	Managers of energy fluxes and grid stability	ICT infrastructure and forecasting	Additional solutions to manage reliability and grid imbalances.

	Flexibility buyers Retailers can become aggregators	Incentives for energy efficiency solutions DR potential knowledge	Greener and modern infrastructure Satisfied and loyal consumer
Aggregator	Flexibility aggregation to deliver value to buyers Give market access to end consumers	Revision of market rules for balancing, reserves, capacity and wholesale market to include DR Fair competition between market players Allow aggregation Allow Flexibility Service Define the role and responsibilities	Revenues from commercial agreements Revenues from consulting services to final-users Revenues from associated services
BMS & equipment manufacturer	Technology enabler DR automation and control Visibility and control of the buildings assets Relationship with 3rd parties	Knowledge of the state of energy demand and production Ability to accept and process DR signals Ensuring comfort of the occupants Interoperability	Increase revenues Sales of equipment and consultancy services
Building Owner/Manager	Implementation of DR systems Possess valuable information about building characteristics Decision Makers	Lack of interest Complexity of system Training needed for managers and staff Uncertainty on future energy prices and regulations	Cost and energy-savings Improved operation of equipment Green innovative image
Policymakers	Policy enablers Providing a favourable and stable DR environment	Having alignment between the National Energy Strategy and other policies Granting non-discriminatory access to the markets to all users Raising awareness on DR benefits	Have functional energy markets which will lead to growing economies Increase impact on network codes

		Accelerating the energy market development	

3.1.1 TSO, DSO AND RETAILER

The Transmission System Operator (TSO) is responsible for the energy grid infrastructures, mainly the high-voltage grid. Due to the cost of establishing and maintaining an electricity transmission infrastructure, a TSO is usually a natural monopoly, and as such is often subjected to regulations. TSOs need to coordinate the supply and demand for energy, avoiding fluctuations in frequency and supply interruption.

The Distribution System Operator (DSO) is responsible for the final stage of the electric power delivery to the customer premises, i.e. the medium- and low-voltage grid, carrying electricity from the TSOs to the consumers.

Retailers are the first contact for the household customer regarding billing, house moves, retailer switching requests and energy supply. They are also the last value adding party before energy is delivered. Therefore, they have the direct contact with the consumer allowing them to engage, proposing and contract the DR programmes with them. Retailers could also aggregate some flexibility from multiple consumers or building groups participating in DR programmes to offer to DSO/TSO.

3.1.1.1 Relevance for DR

TSO, DSO and Retailer are one of the most important categories for DR since they control the distribution grids, the tariffs/programmes offered and need to ensure adequate balancing of the grid by matching the generation with the production. The penetration of RES and the policymakers push toward more sustainable energy systems have brought with them increasing pressure to modify their business-as-usual from highly controlled and centralised power generation and delivery to end-users, to a prosumer model that supports both consuming and generating energy via highly fluctuating renewable and sustainable sources. Incentives for the operation of expensive and polluting reserve generation systems are being removed and therefore the convenience in their use. These changes have coincided with an increased in pervasiveness of ICT and smart meters to provide additional functionalities to the grid and the TSO/DSO/Retailers.

Retailers can add DR to their energy service offerings since they are in a way already aggregating and delivering energy to a wide portfolio of consumers. They can therefore exploit the dynamicity of the market to offer new services/programmes attracting new customers, while at the same time still ensuring profits.

3.1.1.2 Needs and Challenges

TSO must ensure the safety and reliability of the transmission system. Generation/consumption imbalances are a major concern for reliability and grid stress at certain grid points and times. In the past, electricity generation was highly controlled and centralised to follow consumption load profiles. Now, electricity grids are being forced to accept, and give priority to, RES regardless of the existence of a consumer for that power. Therefore, the operators must transfer electricity from where it is produced to where it is needed, and to generate/acquire the electricity difference between what is produced by prosumers and the demand; similar phenomenon could actually occur with District Heating/Cooling systems and infrastructure accepting excess heat generated from processes or RES (i.e., solar thermal systems). This distributed system is clearly more complex, unstable and variable than a central power plant. At times there may be low demand and high production and the TSO/DSO may not need to acquire electricity. At other times, they must run generation to compensate for the lack of generation from RES.

In order to propose DR events, accurate forecasts of production and consumption are needed. System operators have a clear need to get high resolution and disaggregated data from smart meters and ICT devices with communication capabilities. In addition, one of the main challenges faced by TSO/DSO is the limited knowledge of the available building flexibility; this could either be through active storage systems or via the built-in flexibility that buildings can provide by modifying their load consumption profiles via for example, thermal mass, different ventilation strategies, and utilisation of equipment at other times. To support this a solid regulatory framework is needed which incentivises operators to work with consumers to promote DR rather than the Generators/TSO/DSO operating expensive and inefficient centralised generator systems or investing in grid reinforcements.

3.1.1.3 Benefits

In optimal situations TSO, DSO and Retailers would have great benefits from DR programmes. Specifically, they would have:

- Additional solutions to manage reliability and grid imbalances. With the entry of distributed RES, TSOs/DSOs are facing major challenges that DR could help reduce with limited infrastructural investment from their part. Instead of investing in traditional generation systems and in grid reinforcement at critical points to cover limited number of peak events, they would be provided with cheaper solutions in line with global trends toward sustainability. These solutions would allow the management of imbalances by the modification of certain profiles to the advantages of the stability and elimination of critical issues. Therefore, consumers would not be only passive users of the grid but active contributors.
- Happy policymakers that have shared goals across Europe for updating the energy sector habits compared to the previous structure. Being a service with great social implications and impacts (like public transportation or delivery of drinking water), there is a strong interconnection between the energy services and political pressures/desires. The energy sector is highly regulated and incentivized in several ways. Therefore, through satisfactory cooperation with policymakers can ensure a favourable environment to continue doing business.
- Greener and modern infrastructure and services delivering to TSO/DSO/Retailer an attractive and positive image. As mentioned before, big energy actors have public roles and impacts; the image that citizens have with respect to the environmental impact and business issues would have effects on the surrounding context. DR would help them to have a better image related to environmental issues (alleviating the pressure from environmentalist), business offers (proposing forward-thinking models), political regulations (jointly sharing regulations in their favour versus responding to impositions from politicians).
- Satisfied and loyal consumer. In addition to the indirect influence (via environmental and political pressure) that citizens have, they would be more satisfied and loyal to their provider, therefore, ensuring stable revenues as well as also be potentially interested in additional services (e.g., internet/TV, home upgrade, recycling services, vehicle charging)

3.1.2 AGGREGATOR

The role of an aggregator adds value to the DR market by continuously optimising the DR flexibility and its interaction with the grids. The aggregator creates scale, manages risk, and reduces complexity for the end customer. The aggregator is accountable for purchasing flexibility from prosumers, aggregating it into a portfolio, designing services that rely on the accumulated flexibility, and proposing these flexibility services to different markets, and assisting several market players. Figure illustrates the central role of aggregators with respect to DR in BoB. They trade flexibility provided by their clients with added value by the aggregation. Individual consumers may have low value for a TSO/DSO/Retailer needing for DR flexibility and definitely little negotiating power. By aggregating the flexibility the aggregator creates interesting products for potential buyers and interesting economic for building owners/managers. In a way, the aggregator already works with building groups/blocks although they may not be necessary physically connected.

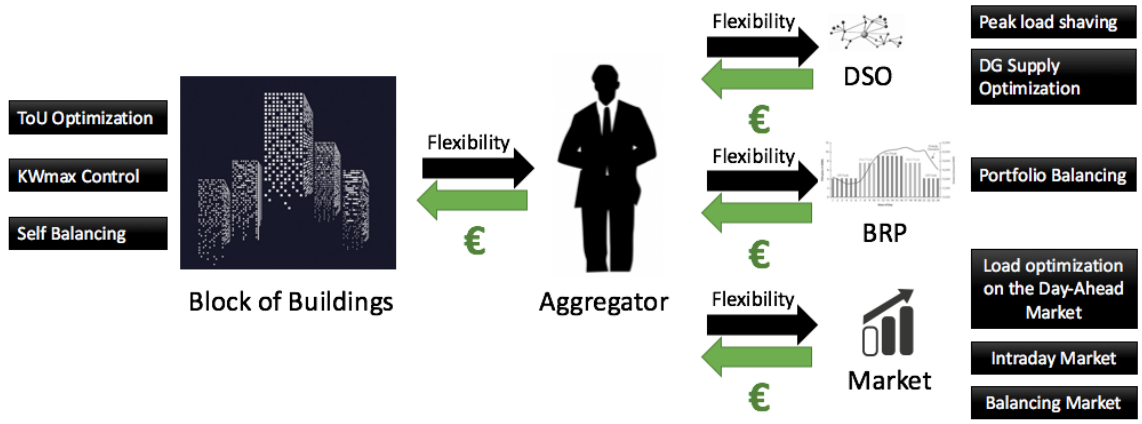

Figure 14. Schematic of the central role of aggregator in DR in BoB. On the far left are presented common DR programmes, while on the far right services offered to different actors after aggregation.

3.1.2.1 Relevance for DR

Aggregators have a central role in DR since they collect the flexibility they acquire from the DR resources owned by industrial, commercial and residential end users to develop the scale needed to make an impact. This pool of flexibility is then turned into products to serve the needs of the various stakeholders. One advantage of aggregation for the TSO/DSO/Retailer acquiring it is that these products provide reliable flexibility to the market by eliminating the risk of non-delivery inherent in depending on an individual prosumer. At the same time, aggregation prevents prosumer exposure to the risks associated with participating in the energy market and provides them with the expertise and bargaining power needed. Their role in some cases could be filled directly by the retailer but their presence would simplify the dynamics for the retailer since the flexibility would already be packaged. This would be critical because in this way, especially in the beginning phase of DR deployment, retailers could focus on their core business (i.e., distribution and supply of energy). Table 9 describes the services that could be/are provided by the aggregator in the demand response market to different stakeholders.

Table 9. Services offered by aggregators to different stakeholders.

Actor	Type of services	Description

DSO	Peak load shaving	Contribute to smoothing the aggregated load curve in some critical situations
	DG Supply Optimisation	Adapt the consumption curve in a given area to the production of distributed renewable and unpredicted generation sources
Retailer/BRP	Portfolio Balancing	Adapting actual consumption of its consumer to its day-ahead prediction on an hourly basis avoiding extra costs of purchasing additional electricity
Prosumer	ToU Optimisation	Reduce energy bill by load shifting from high-price intervals to low-price intervals or even complete load shedding during periods with high prices
	KW max Control	Reducing the maximum load that the Prosumer consumes within a predefined duration, either through load shifting or shedding.
	Self-Balancing	Value is created through the difference in the prices of buying, generating, and selling electricity (i.e., charge for using of the grid)
Trading Energy Market	Load optimisation on the Day-Ahead Market	Aggregator acts as a producer and/or consumer as long as it fulfils the size of the requirements to participate
	Intraday Market	Can participate as a pure market oriented towards profit maximisation
	Balancing Market	With some consideration it can participate in the Primary and Tertiary frequency control, capacity reserves

3.1.2.2 Needs and Challenges

New market players such as aggregators need access to the energy markets. They are significantly smaller than traditional players, and the number of parties active in the energy system will increase considerably. It is therefore essential to standardise market access, otherwise it will become impossible to serve them in a cost-effective way, and market conditions will become unmanageable. In addition to this, other needs and challenges are:

1. Definition of DR & flexibility service provider.
2. Review market rules for balancing, reserves, capacity and wholesale market to include DR.
3. Fair competition between market players (suppliers & independent aggregators).
4. Adapt standard products to DR Technical requirements – measurement & verification.
5. Allow aggregation: Cross suppliers portfolio aggregation.
6. Allow Flexibility Service Providers participation: Independently from supplier/BRP.
7. Open balancing, reserves, capacity & wholesale markets to DR.
8. Define the role and responsibilities of the flexibility service provider in the system independently from the role of supplier and balancing responsible party.

9. Ensure market price provides the right signal and enough visibility for consumer to invest in DR solutions.
10. Define temporary support scheme in case any failure in the market signal happen.
11. Appropriate understanding of the standard and shiftable loads offered by their clients.

3.1.2.3 Benefits

The aggregator's goal is to maximise the value of the flexibility provided by separate consumers by selling it in a package and therefore providing a service to both the Retailer/DSO and the building owners. The main benefits are therefore financial, due to:

- Revenues from commercial agreements with the actors that can exploit flexibility (TSO, DSO, Retailer).
- Revenues from final consumers that offer flexibility but do not have the expertise or negotiating power.
- Revenues from associated services available once the relationship has been established (e.g., energy trading, ESCo, facility management).

3.1.3 BMS AND EQUIPMENT MANUFACTURER

The Original Equipment Manufacturer(s) (OEM) of the Building Management System (BMS) and associated technologies represent an important stakeholder in the field of Demand Response. A BMS is an IT system installed in buildings that controls and monitors the building's mechanical and electrical equipment such as ventilation, lighting and power systems. A BMS often consists of software as well as hardware components such as meters and actuators. Complementary software platforms such as Building Energy Management Systems (BEMS) may integrate with the BMS also. BEMS tie into existing energy-related data streams of a building's infrastructure, such as its lighting, and provide visualisation and analysis of that data to enable better energy-related decision-making. Extending this concept, there are the hardware (e.g., smart meters) and software needed in for the data and signal communication among building owner, aggregators and DR exploiters. This connect to the management, decision-making process and actuation of the strategy. In a BoB scenario, a BEMS would oversee the data flow, the constraints, forecasts and the potential DR offer for the cluster, therefore servicing a physical or virtual aggregator with the tools to allow aggregation.

By providing the core infrastructure that enables organisations to participate in DR, the OEM represents a key stakeholder. But the OEM also plays an important 'soft' role in helping the customer (often a building or estate manager) to understand the requirements of the technology (in relation to configuration, protocols etc) and help identify interdependencies or synergies with other technologies, and how these can be leveraged. In essence, the OEM provide the technical expertise related to the controllability of equipment and the flexibility of assets available while at the same time providing the consumers with the communication and data needed.

3.1.3.1 Relevance for DR

The BMS and equipment manufacturer is relevant to DR for a number of reasons:

- Their technologies enable organisations to effectively monitor energy consumption, equipment operation, occupant comfort conditions and forecast future load profiles etc, which is fundamental to DR.
- The devices and software provides a means for remote automation and control, so participants in Demand Response can respond to events and triggers. This is true both for

final consumers offering flexibility and receiving signals as well as for TSO/DSO needed to potentially act automatically on certain equipment.
- BMS/BEMS play a key role in providing the overall visibility and control of the buildings assets to be able to effectively respond to signals and shift movable loads or increase generation.
- Finally, the OEM also has an ongoing relationship with 3rd parties such as aggregators, who take responsibility for much DR activity on behalf of the end customer.

Furthermore, as the DR market matures and changes the role of the OEM is expected to become even more relevant to the end customer. Traditionally, organisations have been persuaded to participate in demand response programmes by utilities and aggregators; Demand Response is complicated and so it requires support from a consultancy/technology business, which is what aggregators such as EnerNOC, KiwiPower and Flexitricity have provided. However, in the coming years, because of the reduced cost of technology and greater standardisation, it should be easier for organisations to participate in DR programmes directly. With more vendors entering the market, and with more products that support DR, it is expected that there will be more customers who will be proactively seek out revenue opportunities from DR without the support of 3rd parties. This will mean that OEM will build a closer relationship to the end customer, providing some of the technical knowledge/advising and consequently will play a greater role in specifying technology, recommending actions (such as which markets to participate in, which systems can provide flexibility, which actuators are suited) and in providing long-term operation and maintenance.

3.1.3.2 Needs and Challenges

To be able to participate in ancillary and other markets, BMS and BEMS need to possess knowledge of the state of energy demand and production at a building or BoB in such a way that excess or flexibility can be offered to these markets. This would ideally include the ability to provide forecasting energy demand, storage and generation to be able to ensure capacity at a future point in time, for example several hours to a day ahead. This is so that the BMS/BEMS can prepare the building for DR participation, for example increase energy storage if a DR is expected. In order to execute this efficiently, there should be a clear understanding of the flexibility potential of different building types and systems. This would include storage both as active and built-in (e.g., thermal mass), modification of operation of equipment (HVAC) still providing comfort conditions for occupants, or modification in operation of non-critical appliances.

In addition, these BMS systems and components have to provide the ability to accept and process DR signals from the market to participate. This would require integration to the external markets (e.g., via an interface) and have the programmability to process the request. The challenge comes in ensuring that normal operations, such as the comfort of the occupants or critical services are not adversely affected by these signals, and that conflict between the BMS/BEMS additional control systems, such as HVAC managers, is managed correctly. The above are features that most BMS and BEMS do not currently possess.

It should be noted that in many situations the building's manager, and in the case of BoB this could be several individuals, have, or want, to agree the participation before committing to it. This poses a challenge to automation that must be resolved. For this, a building block manager to deal with the flexibility offer and engagement in DR programme is needed. This role could also be served by an aggregator.

Interoperability is another key challenge. Currently there is a lack of a single common standard in Europe for DR integration with building management. In the US they have introduced OpenADR that provides a protocol specifically designed for different vendors to integrate their solutions including building management. The introduction of a standard such as OpenADR, or possibility the adaptation of an existing building management standard such as BacNet would give greater interoperability between Demand Response and building management.

3.1.3.3 Benefits

There are a number of benefits that BMS and equipment manufacturers can gain thanks to DR in BoB. Primarily, this will lead to increased revenues and sales of equipment and consultancy services. As mentioned above, some of the main logics to operate BMS and a building participate in DR programmes are not currently available. This would likely have to do with the assessment of the flexibility capacity of certain building components and equipment. A BMS capable, with limited manual intervention, of receiving external signals, understanding if it can accept the DR request and which subsystems can provide the flexibility without affecting operation would have a significant market advantage. The provider(s) capable of developing such a product will acquire important share of new expansive market and connected services.

3.1.4 BUILDING OWNER/MANAGER

In this section we discuss the roles of two types of stakeholders: the owner who owns one or more buildings that make up the BoB and the building managers who manage internal processes in the buildings.

It is likely that the owner of a (block of) building(s) will consist of multiple persons like a board of directors or some other organisational structure. The owner is the one that decides to invest or not in DR measures and does so on the basis of several considerations that may differ per situation (e.g. the state/quality of the building, costs, benefits, energy prices, policies). It is likely that building owners do not make investment decisions on their own but instead they will be advised by and discuss with building managers, consultants and other relevant stakeholders.

Building managers are responsible for the daily management of buildings and we can distinguish several types that are likely to be present in a (block of) building(s) for instance facility-, building-, energy -, and property managers. These different building managers may fulfil different roles and they may differ in terms of needs, responsibilities and mandates.

3.1.4.1 Relevance for DR

The successful implementation of DR systems requires a strong commitment of both owners and building managers. The first have to make investment decisions while the latter have to (learn how to) use the new systems and adapt their ways of doing to new situations as well as manage an additional layer of complexity. Both owners and building managers are furthermore relevant for DR because they may possess valuable information about building characteristics, energy systems, different usages and occupants of the buildings; and organisational information which is relevant if collaboration between different stakeholders is needed. This information can be helpful to design DR solutions that fit well in specific (blocks of) buildings. They will likely be both engaged by aggregators/retailer/ESCo providing the services to participants in DR programmes and they must understand the process, the benefits and the required commitment/investment while at the same time motivating users to actively participate.

3.1.4.2 Needs and Challenges

Building owners and the various building managers have different roles, have different needs and face different challenges. Some of the main needs and challenges are:

- Both owners and building managers may struggle with issues surrounding DR solutions such as a lack of interest and need to connect with core activities. A lack of interest is first of all caused by the fact that energy is almost invisible, that the perceived benefits of shifting or saving are agent regarded as not having a significant impact on the company finances. Hence, lowering or shifting energy consumption is usually not on top of the priority lists (except when required by regulations as for example for UK public institutions to achieve CO_2 reduction target). In case of university campuses or hospitals, very different priorities ask for the attention of the board of directors. Even though, for example, universities are keen about becoming more sustainable and saving money, the feeling that investments are jeopardising short-term investment in their primary processes (education and research) can undermine the decisions in favour of DR solutions. Hence, it is important to translate benefits of DR measures also in terms of other values and benefits that relate more directly to the core business of the organisation, healthier and comfortable work environments that will enhance productivity and top achievements in research and education. . Besides health and comfort improvements, non-energy related needs may consist of increased property values, increased productivity, costs savings, increased capacity and more efficient processes (Irrek et al., 2011). Thus, especially when targeting multiple buildings, it is essential to use a tailored approach to anticipate building and organisation specific core-activities and needs to ensure that the suggested DR solutions are not regarded as jeopardising these. Especially, when aiming at creating a new market beyond first movers it is important to learn what the potential clients' needs and goals are – including the non-energy related ones - and how DR solutions may help achieving them (Mourik et al., 2014).
- Complexity of system and expertise required of flexibility/DR potential. Different building types have different flexibility based on the structure and equipment they have, the occupant's profiles and the services offered. For example, hospitals need a healthy and stable indoor climate continuously while it is likely that a university only requires this during daytime since the buildings are barely used during nights and may also remain empty during certain periods of the year. It is key for the owners and, especially, managers to understand the specific needs of a building and usage profiles well in order to understand the extent of their participation and how this will affect their normal operation. Depending on the chosen DR solutions the energy system can become more complex since it makes use of a more diverse range of variables (e.g. dynamic prices and weather forecasts). However, this does not mean that building managers have to deal with this increased complexity directly since DR systems could act largely autonomously and when necessary they can provide simplified information or cues on which events the building managers have to act upon. However, fear for increased complexity and/or changing levels of controllability and automation may invoke resistance since it will cost time and effort to adapt working practices to the new situation.
- Training needed for managers and staff to operate buildings participating in DR programmes as well as consultancy beneficial to the acquisition of know-how related to DR programmes (technical, legal and financial). This largely depends on the types of DR solutions that are implemented.
- Uncertainty on future (dynamic) energy prices and regulations and thus also on pay-back periods of DR response makes it difficult to make well informed investment decisions (Hurley

et al., 2013). Another challenge entails the split-incentive problem: if those deciding to invest (or not) in DR solutions (e.g., the board of directors at a campus) are not the ones paying the energy bills (e.g., when at a campus the energy bill is being paid by a faculty), the former may feel little direct incentive to spend money on such interventions. Split-incentives may lead to conflicting perspectives between owners and building managers on the desirability of DR solutions which in turn may undermine investments. There is also the possibility that the promised benefits will not be realised because the DR systems do not work as good as predicted or are not used in the way as supposed to, or because of other unforeseen external circumstances that may affect the effectiveness of the DR systems.

Different types of building managers have different needs and challenges, which also depend on the type of DR solutions. In Table 10**Error! Reference source not found.**, we briefly discuss some needs and challenges that different types of building managers may face.

Table 10. Overview of roles, objectives, needs and challenges relevant for building owners and different types of building managers

Type	Role	Objectives	Needs related to DR	Challenges related to DR
Building owner	Make investment decisions	Maintaining or enhancing the value of the building while saving on operational energy cost	Clarity on how a DR solution affect the core-business and the value of the building(s)	Uncertain benefits understanding value propositions
Building managers	Supervise hard (e.g. fire alarm, lifts) and soft (e.g. cleaning, security) services	Maintain and develop the agreed services	Clarity on how a DR solution will affect the hard and soft services and satisfaction from occupants; notification prior to DR events	Clarity of risks involved
Facility managers	Coordinate space, infrastructure, people and organisation	Maintain and develop the agreed services which support the effectiveness of primary activities	Clarity on how a DR solution will improve the ability to ensure comfortable and healthy indoor climate; notification prior to DR events	Added complexity; lower controllability; informing occupants; clarity of risks involved
Energy managers	Manage the energy production and consumption systems	Cost savings, resource conservation, climate protection	Understanding the DR solutions (information and support/training); information to determine baselines and predict energy usage patterns ; clarity on reliability of DR systems; notification prior to DR events	Added complexity, lower controllability; low flexibility of energy usage
Property managers	Operation, control and oversight of real estate	Improving or maintaining the condition and value of real estate	Reliable information about increasing property values as a result of DR solutions; notification prior to DR events	Clarity of risks involved and maintenance tasks

				concerning DR systems

3.1.4.3 Benefits

Benefits for building owners and building mangers may consist of cost and energy-savings as well as in improved operation of equipment as a result of increased ability to locate problems and fluctuations in energy usage. This should lead to longer life, however as mentioned above, in many cases non-energy related benefits are considered more important since they have positive impacts on core-activities of the organisation. Another benefit is related to a green innovative image that could be marketed to consumers and other relevant actors due to participation in solutions that should favour the spreading of renewable systems and the dismissal of polluting power plants.

3.1.5 POLICYMAKERS

This section presents the impact of policymakers in the DR context. A policymaker is a person with power to influence or determine policies and practices at an international, national, regional, or local level. As it is discussed in the following parts, the differences between European politics and recommendation and the delay of the national regulations to follow that framework are delaying the DR deployment.

3.1.5.1 Relevance for DR

Developments in Demand Response vary substantially across Europe reflecting national conditions and triggered by different sets of policies, programmes and implementation schemes. National policymakers have a primary role in providing a favourable and stable environment for the different stakeholders involved. They would need to push TSO/DSO in proposing DR programme by removing some of the existing incentives of using inefficient and polluting old electricity producing systems (e.g., power plant) to cover peak loads.

3.1.5.2 Needs and Challenges

European Parliament and Council Directives led to liberalisation in EU energy markets. The directives lay down the general conditions required for the creation of a single Internal Electricity Market in Europe, but avoided specifying a single market model. Instead, the EU gave its Member States the freedom to design their markets and regulatory frameworks to suit national conditions, so long as 4 broader objectives – such as open and fair third party access to national markets and introduction of competition – were adopted. One of the aims was to offer end-users choice between suppliers so that they can benefit from lower prices for energy and a better quality of service (Torriti et al., 2009). The main needs for the policy makers consist of:

- Full market liberalisation in some countries.
- Standardised guidelines for designing a functional market.
- For Eastern European countries having a review on regulations that prohibit third party access to the markets.
- Having alignment between the National Energy Strategy and other policies.

The challenges they face are related to:

- Implementing incentives that complies with the EED and does not cause significant imbalance in the market ranging from white or green certificate schemes to feed-in tariffs, high efficiency cogeneration or capacity remuneration schemes.

- Granting non-discriminatory access to the markets to all users by removing size, response time, availability or other limiting criteria that technically is not justified.
- Raising awareness on how DR would contribute both to the national and EU level goals and to a greater economic development.
- Accelerating the energy market development toward a green and sustainable economy.

3.1.5.3 *Benefits*

The inclusion of Demand Response in the Network Codes represents a positive step toward widespread consumer engagement in Europe. As SEDC also affirms, this success was achieved through productive stakeholder engagement between demand-side representatives, ENTSO-E, ACER and the European Commission (SEDC, 2015). The scope of existence of the policy makers is:

- Ensuring the proper functioning of the gas and electricity markets.
- Development of competition for the benefit of the customers.

The benefit for the policymakers, as legislative contributors in DR, will consist in functional energy markets which will lead to growing economies. Having an open market which includes DR in buildings as a resource would lead to a more balanced market, with less regulation need and reduced investments in new generating capacities.

The policymakers should have a significant impact on the European and national network codes regarding the assurance of a consistent level of rights for the consumers in the DR schemes. This will require a clear and consistent definition and implementation of responsibilities for all players and in particular the BRP, Aggregator and BoB as impact energy users and distributed generators. In some of the Eastern European countries the installation of household scale renewable energy generating or storing equipment are not subject to a permit and are governed by the provisions of the contract with the service provider. Policymakers can achieve their targets through the incentive programmes and a better overview of the market. To grant access for BoB in all EU countries will require the engagement of the EC not only on directives level, but possibly on a regulatory level.

3.2 SECONDARY STAKEHOLDERS

Secondary stakeholders are those who, although they do not have great power/interest in DR still play a role and influence the success of DR. Additionally, some secondary stakeholder could move toward becoming a primary stakeholder in future developments or in specific situations/contexts.

The first step in dealing with secondary stakeholders is identifying everyone who might fall into this group and afterwards, the subject of interest can start reaching out to them. This lets secondary stakeholders know that the project recognises they have a stake in it and cares about them. Projects that work with rather than against their secondary stakeholders tend to accumulate more good will and cooperation for expansion and other necessary business activities.

The following sections describe the relevance, needs and challenges and main benefits of the secondary stakeholders that were identified.

Actor	Relevance	Needs and challenges	Benefits

ESCO	Advising clients on solutions and Opportunities that are financially attractive Provide technical expertise Reduction of financial investment Reducing risk and provide consumer with the confidence needed	Build DR strategies easy and fair access to the energy market Clear rules and fair payments Develop partnerships with TSO/DSO/Retailers Certainty of regulations, tariffs and contracts	Increased revenues New contracts New partnerships Creation of new consulting opportunities
Designers	Influence on the initial building plan Reduce implementation costs Enhance flexibility potential	Knowledge on DR programmes Clear understanding on DR requirements Knowledge on DR technologies	Developing new expertise Increasing their design value proposition Increased legitimacy of their key role in the development of building projects
Builder/Developer	Enable the participation of buildings in DR programmes Influence Building Managers	Finding the value of demand response for their client Knowledge of features providing flexibility and potential for DR in BoB	Greater market value Possible expansion into aggregation field
Maintenance	Efficient and effective running of buildings and their energy systems Ensure reliability of the system	Skills /knowledge gap in relation to the maintenance Need for training and knowledge transfer	Financial benefits New services Financial incentives that indirectly can be captured by the maintenance company Companies with their own maintenance can reduce costs
Occupants	Impact on decision makers Susceptible of loss of comfort	Need for automated programmes High motivation for manual programmes	Bill reduction Social acceptance

3.2.1 ESCO

Energy Service Companies (ESCOs) offer a variety of services supporting property owners ranging from auditing, technical and economical assessment of solutions to financing them through Energy Performance Contracting. In some occasion, ESCO could also serve as aggregators and therefore be a primary stakeholder. In other instances the may be standard ESCO providing consultancy and economic support if needed. They typically use the following steps:

- Preliminary assessment of the energy efficiency and energy saving potential.
- Energy audits at different grade levels to identify, quantify and perform cost-benefit analysis of proposed solutions, both for energy efficiency and local energy generation.
- Engineering documentation for the proposed and agreed solutions to be implemented.
- Financial provision for the solutions then reimbursed via the generated savings.
- Overseeing of the solution implementation and monitoring of the energy performance through established key performance indicators.

3.2.1.1 Relevance for DR

A relevant description of the ESCOs role in enabling Demand Response resources and increasing the load participation can be found in (DRIP, 2015), as synthesised as follows.

ESCOs and associated consultants may play an important role in DR in BoB by advising clients on solutions and opportunities that are financially attractive. They support clients in defining which loads can be moved with maximum benefits and none/limited impacts while providing the financial instruments to allow investments. Energy services companies have a complex role in terms of reducing energy consumption and costs within companies. By relaying on the services of an ESCO the consumer obtains the deep expertise of organisation with financial shared interests in the implemented project with limited/no commitment of own financial resources; they also verify (e.g., through M&V procedures) the efficacy of the implemented solutions and the financial soundness that could be, if positive, replicated. In that way, ESCOs can be considered main enabler to overcome some of the common barriers to the implementation of DR solutions (e.g., technical expertise, reduction of financial investment).

The ESCOs generally appoints an Energy Manager that reports on the functionality of the DR concept, obtained benefits, adjustments and recommendations for improvement to name a few. Moreover, the Energy Manager's role can be expanded up to preparing the organisation for the ISO 50001 energy management standard implementations, where there is a clear procedure of how to exploit the DR concept.

In conclusion, the ESCO guarantees through energy performance contracts that the results quantified in the initial energy audit will actually be achieved, therefore reducing risk and provide consumer with the confidence needed. They will offer comprehensive packages and provide interface to the DR providers/regulators.

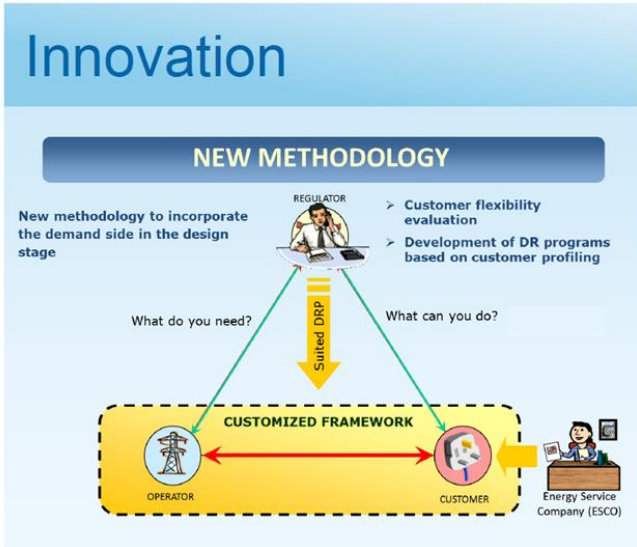

Figure 10. Illustration of role of ESCOs in supporting users navigate the DR process and relationship with regulator and other energy actors (DRIP, 2015)

3.2.1.2 Needs and Challenges

ESCO needs and challenges are related to some of those presented for the aggregators and retailers. The main need and challenges are:

- Build DR strategies by enabling different programmes to offer to clients. A solid strategy will ensure revenues for the end users by participating in DR programmes which signify revenues for the ESCOs responsible of the work.
- It is needed to have easy and fair access to the energy market. In this way, ESCOs can avoid unfair competition with existing actors.
- Clear rules and fair payments for the DR services provided to clients and network. These measures will encourage ESCOs to invest in demand side management infrastructure.
- Develop partnerships with transmission system operators, energy distributors, retailers and suppliers.
- Certainty of regulations, tariffs and contracts to ensure a controlled framework in which to work and offer to the clients to take part of it.

3.2.1.3 Benefits

The benefits for an ESCO are mainly increased revenue and contracts resulting from the DR in building groups. ESCOs with the needed technical, regulatory and financial expertise will be able to enter this emerging market and acquire important clients and contracts. Exploiting their original contacts and the evolving context they can offer investment in DR solutions in the form of new equipment, meters and software. They could also offer continuous consultancy to manage these solutions to ensure their expected benefits are real and to revisit the strategy in case of modification of regulation and/or update of the programmes available. Therefore, the main benefits for ESCOs are financial due to additional contracts and services.

3.2.2 DESIGNERS

All building projects require the services of building designers, typically a licensed architect or structural engineer. Smaller, less complicated projects often do not require a licensed professional, and the design of such projects is often undertaken by building designers, draftspersons, interior designers or contractors. Larger, more complex building projects require the services of many professionals trained in special disciplines, usually coordinated by an architect. Building designers can thus come from a number of design-related backgrounds and bring different focuses to the design process. For instance, engineers will more likely focus on operation and performance of the systems, while architect may be more interested in aesthetics and functionalities. The client/owner typically contracts the design team to define the guidelines for the project as well as its goals, setting therefore the tone for the ambitions.

3.2.2.1 Relevance for DR

Designers often have influence on the ambition level and define the specific building elements and building cluster features included. If the design team proposes DR features to the owner or if these are already included as specifications the buildings could have features that allow working synergistically to DR programmes. This is even more important for building clusters where the synergies among infrastructures and buildings specified during the design process are critical. To be functional to DR programmes buildings should be designed to have active (e.g., storage, multiple energy conversion systems) and built-in flexibility (e.g., thermal inertia) allowing them to modify their standard operation without jeopardising user comfort conditions. Furthermore, going down to the specific features of design such as storage capacity, storage efficiency, power density and control functionalities would determine the potential participation of buildings in such programmes and the extend of the resulting benefits.

3.2.2.2 Needs and Challenges

In order for the designer to execute a design that would be functional to DR for BoB he would need to have a clear idea of how DR programmes as the associated data needed to trigger events. Based on this, control capabilities would then be specified with the associated BMS or Automated DR (ADR) solution.

Clearly, the designer needs to understand the requirements from the client including ambitions, goals, comfort conditions, and profile expectations. These set the boundary conditions for the exploitation of the passive flexibility of the building. One of the key challenges/needs is the clear understanding of the technical solutions to provide flexibilities. For instance, for ventilation a designer, could specify Constant Air Volume, Variable Air Volume and Demand Control Ventilation with different level of flexibilities and controllability that would all meet requirements when occupants are present. The degree of monitoring and automation would be different; the knowledge of simple strategies to reduce peaks and the needed equipment, actuators and supervision system would be required. The standardisation of ADR would facilitate the specifications of hardware and software for enabling DR programme participation, although these would then be tailored to the specific systems present. The, even partial, automation of DR control would facilitate the engagement of owner/manager by designers. Simulation and decision-support tools can provide data to validate assumptions and projections. Based on the design requirements and specification, he would need to test and simulate DR events during the commissioning phase.

Depending on the specific roles of the designer, this can go down to specifying the single meters and actuators as well as the overall control system, therefore information on the resolution and actuation frequency needed to participate in these programmes is needed.

3.2.2.3 *Benefits*

Building designers can become important players in the deployment of DR at the building and BoB levels. For them, the expansion of Demand Response programmes means developing new expertise and increasing the value proposition they are bringing to their clients. The obvious benefit is an increased legitimacy of their key role in the development of building projects. In addition, many building design organisations (such as the US, Green Building Council) recognise the benefits of smart grid thinking and therefore encourage their members to adopt the demand response technologies.

3.2.3 DEVELOPER/BUILDERS

Developers and builders construct/retrofit buildings or BoB and have an important role as they often define the project goals, investment and targets. Therefore, in these cases they can influence the key features and components present, while on cases when they are simply executing the work following the specifications from the owner/designer.

3.2.3.1 *Relevance for DR*

By implementing the proper BMS equipment with flexibility and controllability features, metering and control systems, developers/builders enable the participation of buildings in DR programmes and give the owners/managers an additional capability. Where planning and developing BoB the synergies and infrastructure implemented are critical for the exploitation of energy fluxes. They can also play an important 'soft' role in helping customers (building managers) to understand their potential role and benefits from the DR market. They therefore have the potential to influence the owner direction by presenting the DR opportunities if aware. Developers/builders have the possibility, by choosing proper architectures of BEMS, to include DR features in the functionality of new buildings and become proactive players also on the real estate market. They could be helpful at the design stage of DR solutions for specific (blocks of) buildings, by sharing their practical experience with Designers.

3.2.3.2 *Needs and Challenges*

The main challenge for builders/developers comes in finding the value of demand response for their client. If BoB with greater flexibility (and therefore greater DR potential) are appreciated and valued by the market and clients are willing to pay a premium, then they will continue building such developments. If the clients and owners are not willing to pay such an incremental price, then additional flexibility features will not be incorporated if they are more expensive than traditional. The premium that owners may be willing to pay is influenced by the economic benefits offered by the DR providers and the stability of the DR regulations, therefore calling for favourable and predictable outlook.

Clearly, one of the main challenges would be the knowledge of features providing flexibility and potential for DR in BoB. Although, they would likely rely on the expertise of consultants and designers they must be open to modifying features compared to the standard practices. This involves the choices of different technologies (e.g., HVAC, energy generation) or management and control system (e.g., BEMS).

3.2.3.3 *Benefits*

Currently, most public and residential buildings across Europe have limited technology/infrastructure to maximise the DR potential, especially for BoB. The developers/builders that will integrate these features into their projects will likely have greater market value since they would have been built with specifications in line with the DR market needs. Also at this point developers/builders could also become aggregators as an active interface between end users and the DR market leveraging the fact that they build several developments and could at turnkey offer aggregation services to the clients.

3.2.4 MAINTENANCE

Building maintenance involves the upkeep of a building or group of buildings including their energy infrastructures and the surrounding area. Building maintenance services are offered by facilities management companies. Some ESCOs also offer building maintenance as part of integrated energy supply contracts (IEC) (Crosbie 2015). However, many organisations have their own building maintenance team within their wider in-house facilities management departments.

3.2.4.1 Relevance for DR

Building maintenance teams are responsible for the upkeep of the building fabric, and the fixtures and fittings and the energy infrastructures within buildings. They are essential to the efficient and effective running of buildings and their energy systems. As such they are essential to enabling DR by ensuring that the systems and controls are operating as intended.

3.2.4.2 Needs and Challenges

In many cases, the technology to enable the new approaches to energy management required for demand response will provide challenges for building maintenance. The most favourable programmes for DR in BoB (GVT, DLC and DER see section 2.4) require technologies such as controllable devices, schedulable EV charge points, energy management/optimisation tools and HMI, BMS or HAN: These types of technologies are becoming increasingly common but the level of control required for effective DR in BoB is only beginning to be realised. As such the barriers to effective control of energy systems in buildings include a skills/knowledge gap in relation to the maintenance and operation of building energy management systems and associated energy consuming/producing technologies. This demonstrates the need for training and knowledge transfer of best practice within the building maintenance sector.

3.2.4.3 Benefits

The benefits of DR for ESCOs supplying building maintenance through an IEC is that DR offers the opportunity to reduce building running costs making an IEC more competitive. In the case of facilities management, the source of the financial benefits of DR are also dependent upon the type of maintenance contract. However, if it involves some form of energy performance contacting (EPC) then again the opportunity to reduce building running costs provides some financial incentives that indirectly can be captured by the maintenance company. In the case of organisations with their own building maintenance departments the reduced costs to run buildings may also provide significant benefits. Therefore, maintenance teams with capabilities to maintain and optimise performance of equipment and components needed for DR would have professional advantage.

3.2.5 OCCUPANTS

Occupants are the main users of buildings. There are many different kinds of occupants and they can be very different for different (blocks of) buildings and also for different rooms. Table 11 shows a brief overview of different occupants that are relevant for some types of buildings, including DR BOB demos.

Table 11 Overview of different types of occupants in for DR-BOB project demonstration buildings

Building type	Occupants
Hospitals	Doctors and specialists, nurses, cleaning staff, service personnel, restaurant employees, etc.
University	Students, researchers, teachers, visitors, cleaning staff, service personnel, restaurant employees, etc.
Research Centre	Researchers, staff, laboratory technician, administrative personnel, visitors, cleaning staff, service personnel, restaurant employees,

Occupants are not just different for types of buildings, they also differ between different organisations in terms of organisational culture, i.e. the shared norms, values and practises that bind people together. Occupants also differ in terms of individual characteristics (e.g. attitudes, motivations, capabilities) and energy-use profiles (e.g. efficiency of appliances, presence patterns, flexibility, entropy and intensity) (Breukers & Mourik, 2013; Gulbinas et al., 2015). It is important to keep in mind that different occupants have different needs both to execute their tasks and for general satisfaction, therefore their requirements and demand for energy uses are more or less flexible.

3.2.5.1 Relevance for DR

The main function of a building is to facilitate its occupants' core activities. Which DR solutions fit best within a BoB strongly depends on these core activities and the buildings' energy use profile (PG&E, 2008). It is thus important that proposed DR solutions do not jeopardise core-activities and preferably they should be as little intrusive as possible. The impact on daily practices and activities of occupants in DR projects depend of course on the type of DR solution that is offered. These impacts can be high or low and positive or negative. If the impacts on occupants are significant and disruptive, it is likely that the latter will not engage in behaviours that are synergistic to the success of DR programmes. In addition, depending on occupants' needs, motivations and daily practices, DR solutions may engage or involve them in different ways. An example of a DR solution that requires involved occupants is when occupants are asked to turn off non-essential equipment during DR events, e.g. turn off cooking equipment and serve cold food instead (PG&E, 2008). In contrast, DR solutions can also be fully automated.

3.2.5.2 Needs and Challenges

Different levels of involvement and impacts may bring up different issues that are relevant for occupants. When the level of impacts of a DR solution is low, the effects will be mostly invisible for occupants and thus active involvement may not be necessary. However, when the DR solutions do have (negative) impacts on daily practices and activities of occupants, involving and informing them will become important. For example, in cases where DR solutions result in fully automated heating and lighting (low involvement), is it important that it contributes to a comfortable and healthy indoor climate for *all.* Moreover, care should be taken not to take away all (sense of) control from occupants. For instance, if lights, computers, machines turn off automatically while there are still people working, this will not be appreciated (and it can in worst-case scenarios result in sabotage or can health and safety issues). Another issue is how to set the 'right' temperature for all, knowing that for instance men and women differ in what they consider to be a comfortable indoor temperature. When occupants do get the opportunity to control their indoor climate (high involvement), it is useful to consider feedback mechanisms that support them to proper use and to encourage them to energy saving (or shifting) behaviour. Supportive and feedback devices such as smart meters, displays, using ICT can help occupants to change their behaviour. Other supportive measures could consist of e.g. providing lockers where staff can store additional clothing in case they feel chilly. Furthermore, notifications through a variety of channels (e.g. intranet, email, signs in buildings, overhead announcements) may give occupants an opportunity to prepare for DR events so that large intrusions can be prevented (Talbott, 2013; PG&E, 2008).

If occupants are to play an active role in the proposed DR solution it is important to remember that occupants come in all sorts and are not all motivated in the same way. Anticipating the needs of occupants by engaging them will help to identify what the needs and potential benefits can be. Perhaps different segments can be identified that are targeted in different ways. Moreover, the approach should not just target individuals, but address the social environment and social norms within the organisation. Taking the example of indoor temperature again: in many offices the air-conditioning settings are such that people put on extra clothes during summer because of the low indoor office temperature. Addressing the dress-codes and discussing the status that is associated with (too) low air conditioning temperatures, may be useful to change social norms and AC-practices. Once an organisation is interested, the next step is to get the occupants enthusiastic about participating into DR programmes, accepting minor implications and possibly even modifying their behaviours to align with the DR events. One way to achieve that is making use of ambassadors that can fulfil an intermediary role between occupants and the initiators of the DR project.

3.2.5.3 Benefits

Depending on the building and its core activities different benefits will be relevant, of which most are likely not directly related to energy. Targeting these non-energy benefits can help to increase occupant's engagement or (in case of far reaching automation) social acceptance. Most occupants would feel good about helping their organisation to become greener and save energy if it does not negatively impact on their routines. The non-energy benefits (and also costs and risks) relate to how people go about their daily routines in the buildings, and how a comfortable and healthy environment is created (PG&E, 2006, 2008). The kind of benefits, costs and risks that are relevant highly depends on the type of DR solution that is implemented, its possible impacts on daily practices and activities and the level of occupant involvement (e.g. informing occupants, use input of occupants to decide which DR solutions will be taken). Benefits may consist of improvements of the indoor environment (e.g. comfort and health) and an increasing level of control (for non-automated DR systems). One of the possible benefits related to energy is that impacts of possible brownouts on processes and services are minimised (PG&E, 2009).

In a similar way that benefits may increase social acceptance, perceived costs and risks may lead to resistance against DR solutions. These costs and risks may be different for different DR solutions. Impacts of DR may entail intrusion, disruption, implementation, added complexity, lower comfort, time investments to cope with changes, loss of control. Table 12 shows some of the possible costs and risks.

Table 12 Overview of costs and risks relevant for different types of DR solutions (distinction made between high/low impact and high/low involvement)

	High impact	**Low impact**
High involvement	Intrusion, disruption during implementation, added complexity, lower comfort, time investments to cope with changes	Added complexity, time investments to cope with changes
Low involvement	Loss of control, lower comfort, intrusion, time investments to cope with changes	

4 CONCLUSIONS

Through this DR market and stakeholder analysis, it was possible to recognise that, despite the fact that DR solutions are increasingly penetrating the energy market in Europe, there are still several lasting barriers to the large deployment of Demand Response services. These are gradually being removed since there are recognised potential benefits of the wide implementation of DR. The application of the DR concepts to BoB would additionally exploit the synergies (e.g., different generation and consumption profiles allowing for energy exchange from one building to another within the cluster) and the advanced equipment often present in multiple building developments including production, storage and consumptions. Key drivers include the fluctuating and increasing price for electricity, legislation promoting DR, RES penetration calling for solutions to manage imbalances and increasing presence of smart and connected buildings.

The increased and gradually liberalised markets are opening opportunities for a range of companies offering services, hardware and software enabling DR. Many are active worldwide, while some are only present in some of the most active countries (France and UK). Their relevance for DR in BoB varies.

The DR market is underdeveloped compared to the most significant market (i.e., the USA) but is increasing due to the political pressures, the trends in the energy sectors and the benefits for a range of stakeholders. The level of readiness for DR of different European countries differ based also on the extension of the smart meter roll-out as well as the degree to which the market is open and fair. For explicit DR, France and UK are the most evolved markets with a regulatory framework promoting many forms of DR. In the UK, there are some barriers related to fair competition between generation and DR resources. Italy is a closed market that should however evolve and open in the near future. Lastly, Romania DR market is not developed and there are still missing clear guidelines for its deployment.

The implicit DR solutions are already active in France, Italy and UK through ToU. In these countries all users in the network have access to these programmes, which represent the main strategies for energy saving. Romania is behind with respect to this development since variable tariffs are not yet in place. It is expected that this type of tariff will appear in the next years.

These diverse country-specific conditions must be considered when defining the demonstration scenarios with the associated technical requirements. The most promising DR programmes for BoB are GVT, DLC and DER because the framework for implementing on-peak, and off-peak (for GVT and DLC) strategies are present, while for the large distributed energy generation needed to implement DER are often present in BoB; these will be assessed in greater details when studying the business models (D2.4).

Primary stakeholders (those with high influence and power with respect to DR) include TSO/DSO/Retailer, Aggregator, BMS & equipment manufacturer, Building owner/manager, and Policymakers. Secondary Stakeholders (those without high power/interest but still playing an important role) include ESCO, Building Designers, Builder/developer, Maintenance team, and Occupants. The stakeholder analysis highlighted the relevance, interest and power of a range of actors. Their needs and challenges were discerned and will drive the definition of value proposition for each of them and the fit between their desired and the proposed solutions. Four key challenges are identified:

- **Ensure fair payments**. Pay equality has seen little progress and is an issue in a majority of member states. Payments need to be considered as a resource in the electricity market and therefore paid in the same scale as the other services. Bi-lateral contracts are commonly confidential which difficult the transparency in the payment process.

- **Involve key stakeholders**. This must be achieved by setting clear rules and standardised process allowing, for example, consumers, which need a provider to access to the market, to obtain a defined offer from aggregators. In addition, the contracting process between utilities and aggregator must be open and fair.
- **Define fair measurement procedures**. Measurement standardisation that avoids contradictory requirements from retailer, DSO, TSO and aggregator. These standards should also set the baseline to measure the services according to the time of activation and the lead-time prior to activation. Measurement technology that increase the accuracy of DR services in order to ensure fair payment to all the actors in the value chain.
- **Design feasible products**. It is critical that DR products and programmes fit the capabilities of consumers, grids and relevant actors. It must be adjusted to maximise the use of their resources and renewables.

5 REFERENCES

1 Alstom (2016). Retrieved April 14, 2016 at Alistom: http://www.alstom.com/products-services/

2 Auto-Grid (2016). Retrieved March 6, 2016 at Auto-Grid: http://www.auto-grid.com/

3 BPIE (2016). Driving Transformation Change in the Construction Value Chain. Retrieved February 12 at http://www.bpie.eu

4 Breukers, S. and Mourik, R. (2013). The end-users as starting point for designing dynamic pricing approaches to change household energy consumption behaviours. Retrieved March 15, 2016 at: http://www.duneworks.nl/wp-content/uploads/2014/02/2013-Netbeheer-Dynamic-Pricing-and-behaviour-change_Duneworks_2013.pdf

5 BuildingIQ Solutions (2016). Retrieved March 3, 2016 at BuldingIQ: https://www.buildingiq.com/

6 Comstock, O. (2016). Demand response saves electricity during times of high demand. Washington.

7 Comverge (2016). Retrieved March 15, 2016 at Comverge: http://www.comverge.com/

8 Comverge - IntelliSOURCE (2016). Retrieved March 13, 2016 at GridPoint: https://www.gridpoint.com/

9 Crosbie, T., Vukovic, V., Short, M., Dawood, N., Charlesworth, R. & Brodrick, P. (2016) "Future demand response services for blocks of buildings". Proceedings of the 1st AIC Conference on 1st EAI International Conference on Smart Grid Inspired Future Technologies, Liverpool, Great Britain, May 19–20.

10 Demand Response for Utilities (2016). Retrieved March 2, 2016 at EnerNOC: http://www.enernoc.de/info-service/case-studies/demand-response-for-utilities

11 Demand Response Management System (DRMS) - Smart Grid Solutions (2016). Retrieved March 12, 2016 at Siemens: http://w3.usa.siemens.com/smartgrid/us/en/demand-response/demand-response-management-system/pages/demand_response_management_system1019-6647.aspx

12 Demand Response programmes for industries in Europe (2016). Retrieved March 15, 2016 from REstore: https://www.restore.eu

13 Demand Side Response | National Grid (2016). Retrieved March 16, 2016 at National Grid Services: http://www2.nationalgrid.com/uk/services/

14 Directive, E. (2009). Cost-benefit analyses & state of play of smart metering deployment. Brussels.

15 EcoBee (2016). Retrieved April 1, 2016 at EcoBee: https://www.ecobee.com/

16 Elster (2016). Retrieved April 1, 2016 at Elster: http://www.elster.com/

17 Encycle (2016) Retrieved April 16, 2016 at Encycle: https://www.encycle.com/

18 Energy Intelligence and Smart Metering (2016). Retrieved March 19, 2016 at KiWi Power: http://kiwipower.co.uk/solutions/energy-intelligence-and-smart-metering

19 Energy Management - Control, Submetering & Monitoring (2016). (2016, April 6). Retrieved April 6, 2016 at GridPoint: https://www.gridpoint.com/controls-submetering-monitoring

20 Energy Pool (2016). Retrieved April 6, 2016 at http://www.energy-pool.eu/

21 ENTSO-E. (2015). Integrating intermittent renewables sources into the EU electricity system by 2020: challenges and solutions. Brussels.

22 European Comission (2010). *Energy 2020 A strategy for competitive, sustainable and secure energy.* Brussels.

23 European Commission (2015). Benchmarking smart metering deployment in the EU-27 . Brussels.

24 European Parliament (2009). Directive 2009/28/EC. Brussels.

25 European Power Exchange Spot (April 04, 2016). Accessed via EPEXPOST: https://www.epexspot.com/en/

26 Eurostat. (2014). Electricity and natural gas price statistics. Obtenido de http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_and_natural_gas_price_statistics

27 Global Industry Analyst . (2015). *Demand Response Market and Trends 2014.* USA.

28 IEA. (2015). ESAP Expert Workshop II: Demand Response. USA.

29 Navigant research. (2015). *Demand response enabling technologies.* USA.

30 Kiwi Power (2016). Retrieved April 3, 2016 at Kiwi Power: http://kiwipower.co.uk/

31 General Electric (2016). Retrieved April 1, 2016 at General Electric: http://www.ge.com/

32 Gulbinas, R., Khosrowpour, A., & Taylor, J. (2015). Segmentation and Classification of Commercial Building Occupants by Energy-Use Efficiency and Predictability. IEEE Transactions on Smart Grid, 1414-1424.

33 Honeywell (2016). Retrieved March 12, 2016 at Honeywell: http://www.honeywell.com/

34 Hurley, D., Peterson, P., & Whited, M. (2013). Demand Response as a Power System Resource; Program Designs, Performance, and Lessons Learned in the United States. Retrieved April 25th, 2016 at http://www.synapse-energy.com/sites/default/files/SynapseReport.2013-03.RAP_.US-Demand-Response.12-080.pdf.

35 Irrek W., Bunse, M., Duplessis, B., Labanca, N., Pagliano, L., Leutgöb, K., Renner, G., Rochas, C., Socher, P., Vethman, V., Boonekamp, P. (2011). How to develop profitable energy efficiency services and accelerate market growth. eceee summer study proceedings, 281-292.

36 MelRok Energy IoT (2016). Retrieved April 16, 2016 at MelRok Energy IoT: https://www.melrok.com/#/pages/applications_landing.html

37 Mendelow, A. (1991). 'Stakeholder Mapping', Proceedings of the 2nd International Conference on Information Systems, Cambridge, MA.

38 Molina-García, A., Bouffard, F. and Kirschen, D.S. (2011) Decentralized Demand-Side Contribution to Primary Frequency Control, IEEE Transaction on Power Systems, Vol. 26, No. 1, pp. 411-419.

39 Mourik, M., Rotmann, S., Mathijsen, T. (2014). 'The life of ESCo Project Facilitators; if only the client knew, understood, trusted, cared and engaged…'. Retrieved April 12th, 2016 at http://cl.ly/003R3T3Z2n1U/download/Task%2016%20final%20paper%20141001.pdf.

40 Ogwumike, C. (2016). Heuristic Optimization of Consumers Electricity Costs using a Generic Cost Model.

41 OpenADR. (2016). Demand Response Programme Implementation Guide .

42 PG&E. (2006). Adobe Raises the Bar for Energy Management in Commercial Buildings. Retrieved April 25, 2016 at: http://www.pge.com/includes/docs/pdfs/mybusiness/energysavingsrebates/demandresponse/cs/OfficeBuildings_Adobe_Integrated_CaseStudy.pdf

43 PG&E. (2007, August). *Hospitality: Marriott.* Retrieved from Demand Response Case Studies: http://www.pge.com/en/mybusiness/save/energymanagement/casestudies/index.page

44 PG&E. (2008, July). Case Study: Community Medical Centers. Retrieved April 25, 2016 at: http://www.pge.com/includes/docs/pdfs/mybusiness/energysavingsrebates/demandresponse/cs/HealthCare_CommunityMedicalCenters_DR_CaseStudy.pdf

45 PG&E. (2009, September). Kaiser Permanente Thrives on PG&E Partnership. Retrieved April 25, 2016 at: http://www.pge.com/includes/docs/pdfs/mybusiness/energysavingsrebates/incentivesbyindustry/healthcarebio/C-5113.pdf SEDC. (2015). Mapping Demand Response in Europe Today. Brussels.

46 SEDC (2015). *Mapping Demand Response in Europe Today.* Brussels.

47 Short, M. (2016). Load Forecasting and Dispatch Optimisation for Decentralised Co-generation Plant with Dual Energy Storage.

48 Sia Partners (2015). Demand Response: A study of its potential in Europe. Retrieved May 5, 2016 at http://energy.sia-partners.com/20150205/demand-response-a-study-of-its-potential-in-europe

49 SICAM SGU - Digital Grid – Siemens (2016). Retrieved April 12, 2016 at Siemens: http://w3.siemens.com/smartgrid/global/en/products-systems-solutions/substation-automation/remote-terminal-units/Pages/sicam-sgu.aspx

50 Silver Spring Networks Unveils New High-Precision UtilityIQ® Demand Optimizer; Oklahoma Gas & Electric to Leverage for Pioneering SmartHours DR Programme (2016). Retrieved March 11, 2016 at Silver Spring Networks: http://www.silverspringnet.com/article/silver-spring-networks-unveils-new-high-precision-utilityiq-demand-optimizer-oklahoma-gas-electric-to-leverage-for-pioneering-smarthours-dr-programme/

51 Smart Consumption for Commercial Building Operators – SureGrid (2016). Retrieved April 1, 2016 at Siemens: http://w3.usa.siemens.com/buildingtechnologies/us/en/energy-efficiency/suregrid/pages/suregrid-smart-energy-consumption.aspx

52 Smith, K. (2010). Scaling Demand Response through Interoperability in Commercial Buildings. Grid Interop forum, 2010

53 St John, J. (2013). Demand Response Markets in Europe Begin to Blossom . UK.

54 Talbott, S. (2013). Product Design Converges on Customer Experience. Retrieved April 25, 2016 at: http://www.demandresponsesmartgrid.org/Resources/Documents/Case%20Studies/PGE-CPP-CaseStudy_Final_13.09.07.pdf

55 Vanderveken, B. (2015). Demand Response : A study of its potential in Europe . Paris.

56 Walton, R. (2015). *The future of global demand response markets, explained.* USA.

57 WRI. (2014). Assessing the Post-2020 Clean Energy Landscape.

58 Zhou, L. (2015). Provision of Supplementary Load Frequency Contro via Aggregation od Air Conditioning Loads.

59 WRI (2015). Assessing the Post-2020 Clean Energy Landscape