Project Acronym:	**DELTA**
Project Full Title:	**Future tamper-proof Demand rEsponse framework through seLf-configured, self-opTimized and collAborative virtual distributed energy nodes**
Grant Agreement:	**773960**
Project Duration:	**36 months (01/05/2018 – 30/04/2021)**

ENERGY MARKET ANALYSIS AND REGULATORY GUIDELINES SPECIFICATION

D2.1_v1

Work Package	**Associated Innovative Market Analysis and DELTA Business Models Development (WP2)**
Task	**Energy Market and Regulatory Framework Exploration (T2.1)**
Document Status:	**Final**
File Name:	**DELTA_D2.1_v1**
Due Date:	**31 October 2018**
Submission Date:	**October 2018**
Lead Beneficiary:	**e7**

Dissemintation Level	
Public	X
Confidential, only for members of the Consortium (including the Commission Services)	

Authors List

Leading Author			
First Name	**Last Name**	**Beneficiary**	**Contact e-mail**
Klemens	Leutgöb	e7	klemens.leutgoeb@e-sieben.at

Co-Author(s)				
#	**First Name**	**Last Name**	**Beneficiary**	**Contact e-mail**
1	Christof	Amann	e7	christof.amann@e-sieben.at
2	Nikoleta	Andreadou	JRC	nikoleta.andreadou@ec.europa.eu
3	Mircea	Bucur	KiWi	mbucur@kiwipowered.com
4	Jack	Christie	KiWi	jchristie@kiwipowered.com
5	Ian	Cole	UCY	cole.ian@ucy.ac.cy
6	Evangelos	Kotsakis	JRC	evangelos.kotsakis@ec.europa.eu
7	Guntram	Preßmair	e7	guntram.pressmair@e-sieben.at
8	Efthymiou	Venizelos	UCY	efthymiou.venizelos@ucy.ac.cy
9	Venizelou	Venizelos	UCY	venizelou.venizelos@ucy.ac.cy

Reviewers List

Reviewers			
First Name	**Last Name**	**Beneficiary**	**Contact e-mail**
Andrew	Smith	CARR	andrew@carrcommunications.ie
Ioannis	Moschos	CERTH	imoschos@iti.gr
Dimitris	Papageorgiou	CERTH	dimpapageorg@iti.gr
Raúl	García-Castro	UPM	rgarcia@fi.upm.es

Legal Disclaimer

The DELTA project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 773960. The sole responsibility for the content of this publication lies with the authors. It does not necessarily reflect the opinion of the Innovation and Networks Executive Agency (INEA) or the European Commission (EC). INEA or the EC are not responsible for any use that may be made of the information contained therein.

Copyright

Executive Summary

The **DELTA project** aims to unleash the demand response (DR) potential of small and medium-sized electricity prosumers (those who both produce and consume) in Europe. DELTA proposes a DR management platform that distributes part of the aggregator's intelligence into lower layers of its architecture, in order to establish a more easily manageable and computationally efficient demand response solution. This approach includes the development of the DELTA Virtual Node (DVN) where a large number of customers (small to medium consumers, producers or prosumers) which share key common characteristics in terms of consumption, generation and available flexibility amongst others are clustered.

Against this background, the report pursues the objective to analyse the energy market and regulatory framework at EU level. This is required as input for the development of reliable, economically viable and **innovative DELTA business models** that enable the incorporation of small and medium-sized customers from the residential and tertiary sectors. The report clarifies the possibilities of development of such innovative business models within much regulated markets and identifies "windows of opportunity".

The main elements of the analysis can be summarised as follows:

- The DELTA business models largely depend on the competitive advantage of the DELTA platform. Therefore, at first the (envisaged) competitive advantages of the DELTA solutions have been elaborated and compared to existing DR platforms and to ongoing research work in this field. At its core, the **customer value proposition of the DELTA platform** is to offer to market players a full suite of automated DR services in a non-expensive and secure way, maximising end users' benefits through participation in all relevant markets – including small and medium-sized prosumers – and through deploying of smart contracts while ensuring grid stability.
- Based on experience from existing DR markets we have developed a **set of generic DELTA business models** which define the different roles and responsibilities of DR stakeholders in a nonspecific way. Altogether we have identified the following generic DELTA business models which set the frame for further development and configuration in the later phases of the DELTA-project: explicit DR as stand-alone service; explicit DR combined with energy efficiency services; implicit DR service aiming at the optimal utilisation of time-of-use contracts; implicit DR including power supply; and microgrid management.
- The **assessment of regulatory framework conditions** for the participation of demand response in European countries and the US - as a market with a long tradition in demand response - shows that there are big differences across Europe. In some countries the market is practically closed for DR, in others participation in DR is legally open to all markets, however, quite some barriers are still to be removed in order to increase the market share.
- Participation of small and medium-sized customers on the flexibility markets will strongly be reinforced by **clear definitions of the roles of market participants**, especially of **independent aggregators** and their relation to balancing responsible parties/retailers and other market participants. Furthermore, adaptation of technical requirements for flexibility products, roll-out of smart meters, clear requirements for measurement and verification and appropriate tariff structures are seen as important steps towards further development of the market for demand response.
- Participation of small and medium-sized prosumers in DR-markets fundamentally depends on the **availability of smart and switchable devices** which can be easily incorporated into a DR platform. The analysis shows that the market share of smart and switchable devices is low and is expected to grow only slowly over the next 5-10 years. There exist, however, a few areas where the prospects are more promising, such as heat pumps, air conditioners or buildings with building automation systems.
- Finally, we have analysed the **user perspective** assessing whether small and medium-scale prosumers are willing to participate in DR programmes and which incentives encourage them into offering their flexible loads to DR programmes. We conclude that only a limited share of

households will react to economic incentives for DR-participation, as the savings achievable for single households are expected to be quite small in most cases. In the tertiary sector the economic incentive has a higher weight than in the household sector, but in return comfort and availability consideration represent a more important barrier. Generally, there will be a need to complement economic incentives by environmental arguments, by guarantees on availability and security etc.

The assessment of the energy market and the regulatory framework as presented in this report is only the first step towards well detailed, practically implementable DELTA business models. During the following work steps of the DELTA-project – including a walkthrough analysis of currently applied DR strategies and a comprehensive testing of derived business models in two pilot projects – the results of this report will be scrutinised and further developed.

Table of Contents

List of Figures

List of Tables

List of Acronyms and Abbreviations

Term	Description
4CP	Four Coincident Peak
ADE	Association for Decentralised Energy
AMI	Advanced Metering Infrastructure
API	Application Program Interface
AS	Ancillary Services
BDEW	Bundesverband der Energie- und Wasserwirtschaft (Federal Association of the German Energy and Water Industries)
BEMS	Building Energy Management Systems
B&I	Block & Index
BRP	Balance Responsible Party
BM	Balancing Mechanism
CAM	Control Area Manager
CHP	Combined Heat and Power (plant)
CMU	Capacity Market Unit
CPP	Critical Peak Pricing
CRIDA	Complementary Regional Intra-Day Auction
CSA	Clearing and Settlement Agent
CSP	Concentrated Solar Power (plant)
CSP	Curtailment Service Provider
CVSS	Common Vulnerability Scoring System
DADR	Day-Ahead Demand Response
DAM	Day-Ahead Market
DAS	Day-Ahead Scheduling
DER	Distributed Energy Resources
DMP	Data Management Plan
DNO	Distribution Network Operator
DP	Delivery Point
DPIA	Data Protection Impact Assessment
DPO	Data Protection Officer
DR	Demand Response
DRSP	Demand Response Service Providers
DRR	Demand Response Resource
DRRS	Demand Response Registration System
DRS	Demand Response System
DS	Dispatch Scheduling
DSAS	Demand Side Ancillary Services
DSO	Distribution System Operators
DSR	Demand Side Response
DSF	Demand Side Flexibility
DVN	DELTA Virtual Node
EAB	Ethics Advisory Board

EC	European Commission
EDR	Emergency Demand Response
EE	Energy Efficiency
EES	Energy Efficiency Service
EGE	European Group on Ethics
ENA	Energy Networks Association
ERS	Emergency Response Service
ESCO	Energy (efficiency) Service Company
EU	European Union
EUR	Euro/€
FCR	Frequency Containment Reserves
FEID	Fog Enabled Intelligent Device
FEPAS	Forward Electricity Products Auction System
FFR	Firm Frequency Response
FLESCO	Flexibility Service Company
FRR	Frequency Restoration Reserves
FRRS	Fast Responding Regulation Service
FSL	Firm Service Level
FSP	Flexibility Service Provider
GB	Great Britain
GDPR	General Data Protection Regulation
GPS	Global Positioning System
GW	Gigawatt
HP	Heat Pump
HVAC	Heating, Ventilation, Air Conditioning
Hz	Hertz
ICT	Information Communication Technology
IDM	Intra-Day Market
IPTO	Independent Power Transmission Operator
ISO	Independent System Operator
IT	Information Technology
KOMP	KiWi Operations Management Platform
kW	Kilowatt
LED	Light Emitting Diode
LIDAR	Light Detection And Ranging
LMR	Load Modifying Resource
MCPD	Medium Combustion Plant Directive
MRC	Multi-Regional Coupling
MW	Megawatt
NDA	Non-Disclosure Agreement
NII	Non-Interconnected Islands
NMB	non-Balancing Mechanism
NOIE	Non-Opt-In Entities

NRA	National Regulatory Authority
OTC	over-the-counter
PPC	Public Power Corporation
PEIDA	Pan-European Intra-Day Auction
PTR	Peak Time Rebate
PV	Photovoltaics
R1	Primary Frequency Control
R2	Secondary Frequency Control
R3	Tertiary Frequency Control
RAE	Regulatory Authority of Energy
RES	Renewable Energy Sources
RFID	Radio Frequency IDentification systems
ROI	Return on Investment
RR	Replacement Reserves
RTD	Real-Time Dispatch
RTDR	Real-Time Demand Response
RTEG	Real-Time Emergency Generation
RTO	Regional Transmission Organization
RTP	Real Time Pricing
SAREF	Smart Appliances Reference Ontology
SCED	Security Constrained Economic Dispatch
SCP	Secure CoPy
SCR	Special Case Resource
SEDC	Smart Energy Demand Coalition
SFTP	Secure File Transfer Protocol
SG	Smart Grid
SGTF	Smart Grid Task Force
SME	Small and Medium Enterprise
SO	System Operator
SR	Strategic Reserve
SRD	Short Range Device
STOR	Short-Term Operating Reserve
TDSP	Transmission and Distribution Service Provider
TOU	Time of Use
TSO	Transmission System Operator
UK	United Kingdom
UKECA	United Kingdom Ethics Committee Authority
USA	United States of America
VDDR	Variable Dispatch DR
VDE	Verband der Elektrotechnik Elektronik (German electrotechnical association)
VPP	Virtual Power Plant
WP	Working Party

1. Introduction

1.1 Background and objectives of this report

The energy system is undergoing a paradigm shift as it evolves from the historic structure of centralised energy generation towards a network of distributed prosumers. Consumers are increasingly being encouraged and empowered to actively participate in the energy network with respect to consumption and generation. The future energy system will be a smart system, where all energy entities are given the opportunity to participate in the market place. This is reflected in the latest round of EU energy market legislation (European Commission 2018).

One of the main elements of energy transition implies an increasing share of renewable energy sources such as wind and solar in our energy mix, increasing volatility of the electricity system. However, that also implies that an energy system has to be managed in a more complex manner than it used to be. The supply of renewable energy is always subject to major fluctuations on a seasonal as well as on a daily scale and the future power network will require major investments in order to be able to cope with smaller and more decentralized generation units.

One important element in coping with the challenge of increasing need for flexibility is the demand side. If the demand side patterns are better adjusted to the supply patterns of the renewables this will reduce investments required on the supply to guarantee grid stability. This concept is called demand response (DR): Peaks and shortages of electricity supply are communicated to the consumers who reply by adapting their current consumption.

For large power consuming companies various DR approaches are already reality. But could the concept of DR also work for small and medium-sized customers from the residential or tertiary sector? And how could digitisation of our daily lives (smart meters, smart homes) help to make it economically feasible? For seizing the potential of renewables efficiently, widely spread demand response is necessary in order to minimise the investments in large scale energy distribution and storage units.

Technical solutions to realise the smart grid are already in place, but there is still a need for developing business models in order to make it economically feasible. There is some incentive for all parties involved to make use of demand response as it saves costs for consumers and for suppliers it can work as a tool to better balance their portfolio and optimise the sourcing costs. DR service providers also may be third parties that act as demand response aggregators, contracting directly with consumers, pooling together their demand response actions and selling them on the electricity market. Clarifying the roles and responsibilities of all these players needs to be accomplished in order to create a sound DR environment.

Against this background, the report pursues the objective to analyse the energy market and regulatory framework at EU Member State level expanded with a view on the US, where DR has a long tradition. As the markets and regulatory frameworks show strong regional differences, the study selects a few countries which are representative for differing degrees of openness for DR, while at the same time putting a stronger focus on the selected pilot site countries within the DELTA project (Cyprus and UK). By this way the report paves the way towards reliable and economically viable innovative business models that enable the incorporation of small and medium-sized customers from the residential and tertiary sectors. The report clarifies the possibilities of development of such innovative business models within much regulated markets and identifies “windows of opportunity”.

1.2 Context of the report in the DELTA project

The **DELTA-project aims to unleash the DR potential of small and medium-sized electricity prosumers (those who both produce and consume electricity) in Europe**. DELTA proposes a DR management platform that distributes part of the aggregator's intelligence into lower layers of its architecture, in order to establish a more easily manageable and computationally efficient demand response solution. This approach aims to introduce scalability and adaptiveness into the aggregator's DR toolkits. One of the project's main innovations is the **DELTA Virtual Node** (DVN). The DVN is a cluster of customers (small to medium consumers, producers or prosumers) which share key common characteristics in terms of consumption, generation and available flexibility amongst others. The DVN will transform clusters of small to medium scale consumers, producers and prosumers into entities which can present much larger capacities for delivering DR services to the aggregator. Additionally, under the framework established by the DVN each customer will be equipped with a **fog enabled intelligent device** (FEID) which will gather and monitor energy related data from field devices, such as home appliances, distributed energy resources, storage components etc. The DELTA FEID will allow for real-time reporting of a prosumer's flexibility to the DELTA Nodes, while also being able to receive DR requests and distribute them to the facility's equipment.

The following questions guide **the way towards innovative business model** utilizing the results of the DELTA-project for accessing small and medium customer flexibility through a secure and stable distribution grid and highly engaged and energy/emission aware consumers/prosumers:

- Which kinds of flexibility services are possible under current regulatory frameworks?
- How can the DELTA solutions extend the current opportunities?
- Which adaptations of the regulatory framework are required to facilitate the application of the DELTA solutions?
- Which DELTA-related business cases – making use of the results of the DELTA-project – can be derived from there?

Against the background of these guiding questions, the report consists of the following elements:

- At first, the (envisaged) **competitive advantages of the DELTA solutions** will be elaborated in further detail. This elaboration is done by comparing DELTA to existing DR platforms and to ongoing research work in this field.
- In the following step, we will present several **generic business models** that may be seen as possible scenarios for the application of the DELTA results on the electricity markets in future. The generic business models include descriptions of roles, information flows and revenue streams, but does not include feasibility assessment and an elaboration of success factors.
- Feasibility of DR business models depends largely on the regulatory framework conditions. Therefore, the next chapter includes a detailed **assessment of the regulatory framework in selected countries**. The assessment is guided by the (envisaged) competitive advantages of DELTA. Primarily it is focused on UK and Cyprus, since the DELTA pilot projects will be implemented in this regulatory framework. In addition, we have made a selection of EU countries representing a different degree of preparedness of the flexibility markets for DR: France, Belgium, Germany, Austria, and Greece. Furthermore, we have included the USA in our assessment, as in many respects the USA represents one of the most advanced markets related to the incorporation of DR in the electricity balancing markets.
- Since the involvement of small and medium-sized customers and prosumers requires a few prerequisites on their side, the following part of the report analyses the **preparedness of the demand side**. This includes two topics: At first, the technical basis for the involvement of the residential and tertiary sector is assessed by analysing current trends related to "smart appliances". To which degree the industry already enables or intends to enable external command signals to interfere with internal control systems of the appliances (including necessary data exchange between devices and DR platforms)? Secondly, the user perspective

needs to be assessed: Are small and medium-scale prosumers willing to participate in DR programmes? What are possible driving forces and incentives that beguile them into offering their flexible loads to DR programmes? What are the barriers that hinder them to do so? And how DR business models need to consider the user perspective?

- Finally, the main results of the analyses are summarised in a chapter with conclusions and recommendations. This chapter highlights the most important starting points for the derivation of innovative DELTA business models.

In the context of the DELTA project this report represents only a first step on the way towards innovative DELTA business models. The following additional work steps are part of the DELTA work plan:

- **Demand Response Strategies Walkthrough Analysis**: This analysis will go through a large number of available DR strategy and mechanism currently employed in the energy markets all over the globe (not only limited within EU borders), while also providing a state of the art on research and demo applications that can be found in the current literature, solutions and ideas that are considered suitable for the current and incoming energy retail market in Smart Grids. The mechanisms studied will keep in consideration the typical energy structure of markets and the actors involved.
- **Derivation of DELTA Business Models:** The outcomes of the preceding work steps will be solidified into a limited number of well detailed, practically implementable schemes. These business models will aim at enhancing and introducing new business roles in the energy markets, allowing small and medium customers (consumers, producers and prosumers) to participate through them in the energy market and the provision of innovative services to the DELTA actors.
- **Testing of DELTA Business Models:** The practical implementation of a selected number of business models identified will be analysed and discussed in the frame of two pilot cases in UK and Cyprus. New and enhanced functionalities – such as bi-directional DR mechanisms, distribution grid security and stability, pricing schemas, energy portfolio segmentation, automated clustering and self-balancing – will be tested and experimented in the project pilot sites, in order to evaluate their effectiveness and impact for all market stakeholders – and thus also the feasibility of DELTA business models proposed.

Figure 1 summarises the full context related to the development of DELTA business models and highlights the elements that are covered in this report.

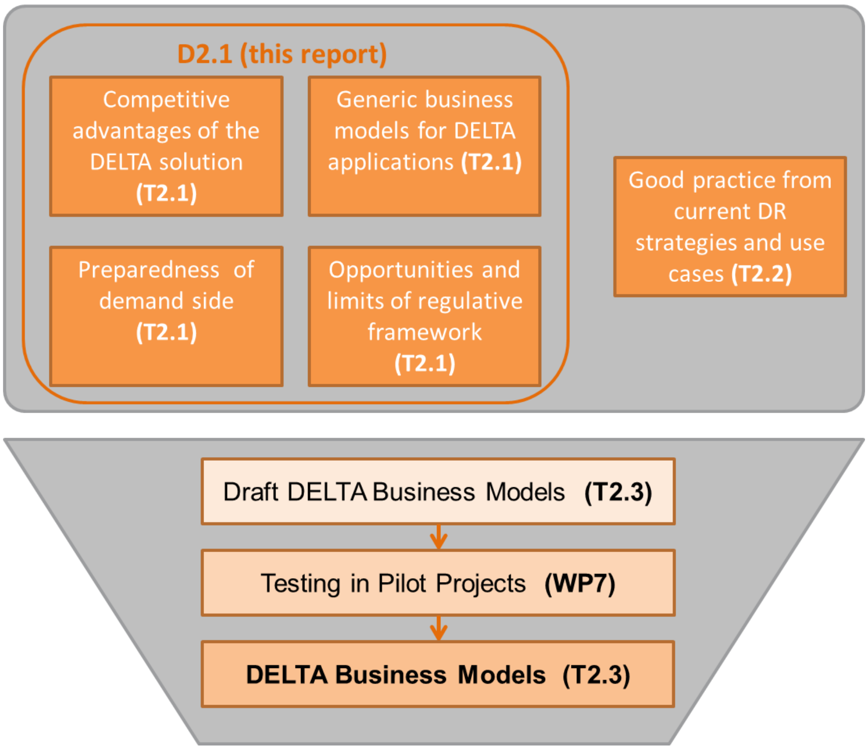

Figure 1 Context of DELTA Business Models Development

2. Competitive advantages of the DELTA approach

In the context of development of new products and services, it is important to understand how the product will perform in a competitive market place. As such, this section will focus on a comparative analysis with existing products for DR Platforms (KiWi Operations Management Platform, KOMP or Tridium platform) but also with similar research projects that are working on the next generation of DR services.

Future iterations of this analysis will allow us to build a relevant Customer Value Proposition based on the resonating focus approach. In essence, this technique is trying to respond to the following question: What is the most relevant feature that DELTA's future clients should remember and is not offered by other competing products? To answer this question, we propose a comparative analysis for all relevant feature introduced by the DELTA platform.

	Scalable	Secure	Price	User Clustering	Smart contracts	Automated DSR	Grid Stability	Load forecasting	Price forecasting	Interoperable	Small and medium loads	Prosumers management	Energy trading	VPP
KOMP+Fruit	●	●	$$	◕	○	●	○	◐	◐	◐	◐	◐	◐	◐
Niagara + various	●	◐	$$$	◔	○	●	○	*	*	*	*	*	*	*
DELTA	●	●	$	●	●	●	●	●	●	●	●	●	●	●
eDream	●	◐	$$	●	●	●	○	●	●	◐	●	●	●	●
Flexiciency	●	●	$$	○	○	○	○	○	○	●	●	○	○	○
DR BOB	●	●	$$	●	○	●	○	●	●	●	●	●	○	○
SEMIAH	●	◐	$$	●	○	◐	○	◕	◕	●	●	○	◐	○

(grey) - DSR platforms

(yellow) - Existing projects

● - Represents a fully developed feature

◐ - Represents a feature partially developed on the platform

○ - Represents a functionality not supported by the platform

$ is a measure of price, with $ platforms being rated as the least expensive and $$$ being the most expensive

* These features might be available through third party developers / application providers but are not part of the standard platform

Figure 2 Overview of features and functionalities of current DR platforms and next generation of DSR services (research projects)

In the case of the KiWi Platform, the comparative analysis included the edge proprietary hardware (KiWiFruit) that is installed on customer premises to allow for accurate metering and control of assets. Niagara platform is developed for commercial and industrial controls but has been successfully used to deliver DSR services with additional application layers developed by third parties. As such, it is very difficult to assess to what extent each functionality is fully supported.

Comparing **expected features and functionalities of the DELTA platform** with one of the most competitive existing DSR platforms in the market (KiWi Power's Operations Management Platform and its dedicated edge hardware Fruit), we observe that:

- On **scalability**, both platforms score high, with hardware being easy to deploy and core features on the platform being delivered as a service to upper layers, therefore avoiding high initial infrastructure cost;
- On **security**, again both platforms receive top points, with DELTA gaining an edge because of its holistic approach to security, for the introduction of the risk calculation model based on the Common Vulnerability Scoring System (CVSS) as well as for the introduction of the prediction mode of potential scenarios based on historical data. In addition, another key security feature for DELTA project currently missing on KOMP is the use of blockchain for validation of DSR data and the use of smart contract for secure automated execution of DSR action and automated settlements.
- On pricing, while is hard to make accurate **price predictions** on the combined cost of delivering and operating the platform, it is envisaged that DELTA will have some cost advantage compared to the KOMP and Fruit solution
- On **user clustering**, current functionality offered by the KiWi Power platform is based mostly on existing information about the asset that is captured on installation and commissioning, thus allowing a full classification of the asset. In contrast, the DELTA platform will allow automatic detection of assets based on energy consumption signature, disaggregation algorithms and other specific methods, allowing for classification of assets without consuming resources during equipment installation and commissioning.
- **Smart contract**: Currently this is an option that is not supported at all on KiWi Power platform, clear differentiator for the DELTA solution.
- **Automated DR**: While KiWi Power platform supports fully automated DSR – e.g. Dynamic Frequency Response programs where assets respond proportional to the grid frequency deviation from the standard 50Hz value, the DELTA platform will also allow automated settlements through smart contracts.
- **Grid stability assessment:** Currently KiWi Power platform does not have a module to assess grid stability as a whole. While certain elements of the market are analysed in real time with a view to provide better forecasting mechanisms for specific DSR markets and products, their use is rather limited and do not provide a holistic view of the grid status.
- **Load forecasting:** Existing tools from KOMP allow for load forecasting, however this is mainly for end-user's use and does not take into account external correlation and drivers. In contrast, the DELTA platform will allow for more accurate load forecasts, enabling near real time assessment of future availability assets to improve revenue from availability declarations.
- **Price forecasting:** Currently a limited in scope tool is available (for internal use of KiWi) for imbalance market price forecasting. It is envisaged that DELTA solution will have individual price forecasting tools for each significant market, allowing stakeholders to better monetise their assets.
- **Interoperability:** KOMP and Fruit can exchange data with other hardware and platform using some of the widest spread protocols and data formats in the industry. The key drivers in this development were the programme requirements from the system operator National Grid. However, it is expected that the DELTA platform will outperform KOMP in terms of interoperability, mainly due to its ontology mapping and translation engine allowing it to port data over multiple standards and physical interfaces.

- **Handing small and medium loads:** While KiWi's ambition is for its platform to allow all types of clients – including residential – it is obvious that this was migrated from commercial and industrial market segments, thus still inheriting a level of cost and complexity that doesn't recommend it for small loads. In contrast, DELTA will offer a solution that is making use of existing infrastructure through interfaces to AMI and allowing participation for all types of medium and small loads, including residential clients.
- **Managing prosumers:** Historically, KOMP will not discriminate between prosumers and other types of clients as platform would look at individual assets and their flexibility without taking into account local generation / consumption. In contrast, DELTA is introducing another layer of optimisation, allowing end-user which type of goal optimisation function should take priority – e.g. optimising local consumption vs. maximising flexibility revenues.
- **Energy trading:** This functionality is now under development on KiWi Platform, as KiWi does not hold a supply license required to participate in trading markets. However, due to recent bilateral agreements, KiWi is now able to offer this type of service to its clients and developing a tool to allow incorporation of these types for services into its portfolio. Full functionality is expected in the next 6 months.
- **Virtual Power Plant services:** KiWi platform is incorporating some elements of a VPP service; however these are not fully developed at the moment. Management of Energy Storage Systems in conjunction with RES generation is the key feature offered by KiWi under its VPP service, however the DELTA platform will allow a broader set of optimisations, including generation clustering, loads forecasting and full markets price forecasts, which will allow its VPP engine to produce better outputs.

When **comparing DELTA with other ongoing research and development projects** related to next generation of DSR services, we can observe the following distinctive features:

- The vision of the project **eDREAM** is for a novel near real time Closed Loop optimal block-chain based Demand Response ecosystem, where Distribution System Operators (DSO) and aggregators cooperate within a novel yet appropriate market framework, with a view to exploit to the largest possible extent the flexibility potential of a large variety of heterogeneous third party stationary and movable load assets, while keeping system reliability within prescribed limits and preserving continuity and security of supply. Compared to DELTA the focus is more on developing solutions and tools for aggregators rather than end users and system operators. DELTA's scope is a holistic one, including tools dedicated to the system operators such as grid stability engine, and its interoperability feature are more extensive than those of eDREAM as it takes into account a broader set of requirements.
- The aim of the project **DR-BOB**, a Horizon 2020 project, is to demonstrate the economic and environmental benefits of demand response in blocks of buildings for the different key actors required to bring it to market by integrating existing technologies to form the DR-BOB Demand Response Energy Management solution for blocks-of-buildings with a potential ROI of 5 years or less. The main difference compared to DELTA is the focus on a specific market vertical and its associated technologies – in this case, residential users in blocks on buildings and some associated infrastructure, such as district cooling and heating. In contrast, DELTA will offer a wider solution that can be applied to other market segments, regardless of the types of buildings.
- The objective of the project **FLEXICIENCY** is to demonstrate that the deployment of novel services in the electricity retail markets (ranging from advanced monitoring to local energy control and flexibility services) can be accelerated thanks to an open European Market Place for standardized interactions among all the electricity stakeholders and opening up the energy market also to new players at EU level. In comparison with the DELTA-project FLEXICIENCY is focusing mainly on data exchanges between partners (mainly metering data on cross border markets) without consideration of controlling equipment, controlling technologies, DSR strategies, and other key aspects of delivering a fully automated smart grid solution.

- The consortium behind the project **SEMIAH** project aims to pursue a major technological, scientific and commercial breakthrough by developing a novel Information and Communication Technology (ICT) infrastructure for the implementation of Demand Response (DR) in households. This infrastructure enables the shifting of energy consumption from high energy-consuming loads to off-peak periods with high generation of electricity from Renewable Energy Sources (RES). In comparison with DELTA, the project is focusing on a specific market segment – residential market – which in itself has its own limitations. Moreover, the focus is on delivering an ICT infrastructure which might not be fully transferable across markets in Europe, whereas DELTA aims for a wider customer base with a view to support interoperability with a wide range of existing systems to allow high levels of replicability across markets in Europe.

Based on the analysis above, we can formulate **envisaged customer value proposition of the DELTA platform** in a concise manner: The DELTA platform will offer to market players a full suite of automated DSR services in a non-expensive and secure way, maximising end users revenues through participation in all relevant markets – including small and medium size prosumers – and through deploying of smart contracts while ensuring grid stability.

3. Generic business models for aggregators/retailers

Over the last few years the DR Market has developed several business models by which the value of potentials for load shift is priced, offered and sold on the energy markets – and here mainly on the electricity markets.

We can call these models "**generic business models**" as they are **defining the different roles and responsibilities of stakeholders** related to DR businesses:

- Users/Clients are defined in our context as owners of technical equipment that comprises DR potential. For the operation of this equipment they have concluded an energy supply contract with a retailer
- A retailer is an individuals and legal body that is selling electricity to customers for profit. This can either be an electricity supplier with own power production facilitates or a wholesale company that purchases electricity for the purpose of resale.
- DR aggregator: are defined here as a third-party service provider that contracts with the individual demand sites (industrial, commercial or residential consumers) and aggregates them together so that their DR potential can be offered to TSO, DSO or BRP
- Transmission System Operator (TSO) according to Articles 2 and 12 of Directive 2009/72/EC (Internal Market in Electricity Directive) are responsible for providing and operating high and extra-high voltage networks for long-distance transmission of electricity as well as for supply of lower-level regional distribution systems and directly connected customers.
- Distribution System Operators (DSO) are responsible for providing and operating low, medium and high voltage networks for regional distribution of electricity as well as for supply of lower-level distribution systems and directly connected customers (Articles 2 and 25 of Directive 2009/72/EC)
- Balance Responsible Parties (BRP) are responsible to keep the supply and demand of their balance group members in balance. In this context, they are financially responsible for keeping their own position (sum of their injections, withdrawals and trades) balanced over a given timeframe (the imbalance settlement period).
- Facility management is defined as a party that provides services to the users/clients, such as maintenance and operation of the technical equipment of a facility, administrative services etc. Furthermore, there is a strong interlinkage between facility management and energy efficiency services (EES), i.e. some facility managers act also as EES providers – and vice versa[1].

A usual way to **categorise generic DR business models** is related to the different nature of the related income streams:

- Business models that refer to **explicit use of DR**: According to SEDC [2016] explicit demand-side flexibility is defined as committed, dispatchable flexibility that can be traded (similar to generation flexibility) on the different energy markets (wholesale, balancing, system support and reserves markets). This is usually facilitated and managed by an aggregator that can be an independent service provider or a supplier. This form of demand-side flexibility is often referred to as "incentive driven" demand-side flexibility and its main income stream is remuneration for flexibility services from TSO, DSO or BRP.
- Business models that refer to **implicit use of DR**: According to SEDC [2016] implicit demand-side flexibility is defined as the consumer's reaction to price signals. Where consumers have the possibility to choose hourly or shorter-term market pricing, reflecting

[1] According to EN 15900 **Energy Efficiency Service (EES)** is defined as follows: Agreed task or tasks designed to lead to an energy efficiency improvement and other agreed performance criteria. The EES shall include energy audit as well as identification, selection and implementation of actions and verification. A documented description of the proposed or agreed framework for the actions and the follow-up procedure shall be provided. The improvement of energy efficiency shall be measured and verified over a contractually defined period of time through contractually agreed methods (EN 15900, 2010)

variability on the market and the network, they can adapt their behaviour (through automation or personal choices). This type of demand-side flexibility is often referred to as "price-based" demand-side flexibility and its main income stream is the energy cost savings that are achieved by shifting loads.

Taking into account the competitive advantages of the Delta Virtual Node (DVN) we can **develop the generic business models further** by specifying the user of the DVN and the specific benefits that are based on the use of DVN in the given context. The following chapters describe in more detail the various generic DELTA business models that are derived in that way.

3.1 Generic DELTA Business Model 1A Explicit DR as stand-alone service

In this business model a DR Aggregator is bundling DR potentials from different clients, which as stand-alone potentials are too small to be offered to the various flexibility markets. The main characteristics of this business model are as follows:

- The **aggregator acts as facilitator**. He has access to the DR potentials of clients and manages them towards the various flexibility markets. Depending on the regulatory framework he may offer the DR potentials either on the electricity balancing market (tertiary or secondary control markets) or he may participate with these loads in a balance group, represented by a BRP.
- The **income streams** originate from payments either from the TSO/DSO or from the BRP – in the latter case, these payments would reflect reduced balance power expenses in a balance group. Depending on the contractual agreement, the aggregator will usually pass on a certain share of these payments to the clients in his portfolio.
- The service of DR aggregation has **no interlinkage to power supply** or any other service for the client. In turn this means that this business model is confronted with many interfaces that need to be managed.

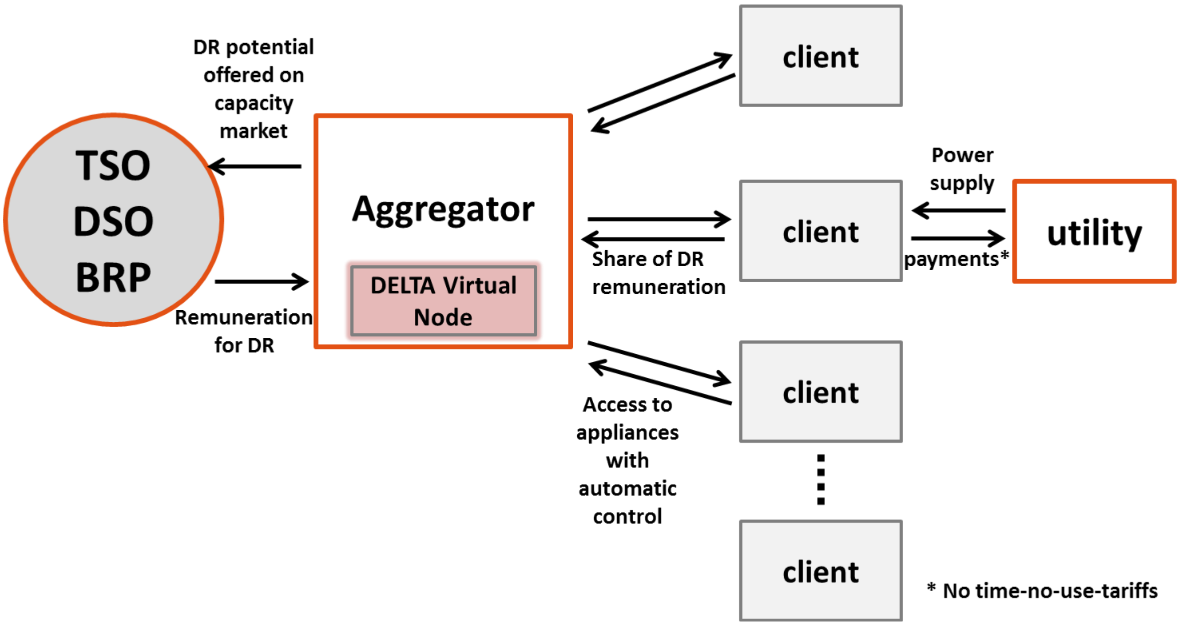

Figure 3 DELTA Business Model 1A Explicit DR as stand-alone service

As shown in Figure 3, in this business model it is the aggregator that will use the DELTA Virtual Node and draw benefits from its competitive advantages. In this context, this mainly refers to a better and cheaper incorporation of small and medium loads from the residential and tertiary sector and to higher reliability of DR potentials which are achieved by bundling of small- and medium-sized loads.

3.2 Generic DELTA Business Model 1B Explicit DR combined with EES

In its general approach, this business model is similar to explicit DR as stand-alone service – as described above – but the DR aggregation service is embedded into a more comprehensive EES. This approach, which is sometimes referred to as "**dual service**", is characterised by the following peculiarities:

- There exists a **trade-off between energy efficiency and demand response**, as load shifts in many cases will lead to an increase of energy consumption. Just to give one example: If a heat pump is producing heat outside of business hours and fills a storage this process will lead to additional losses compared to a "just-in-time" delivery of energy. Therefore, the main challenge of a dual service is to find an optimised solution for this trade-off on a day-to-day basis.
- EES and DR services require different fields of know-how and competencies. Whereas the core knowledge of EE service providers (frequently called ESCOs) is related to the operation of technical equipment, the success of DR service providers (usually provided by a DR Aggregator) is mainly based on a thorough understanding of the flexibility markets. Therefore, the combination of both services into one integrated offer is not easy and requires clear and transparent definition of the **ESCO's and the DR Aggregator's role**. Except of a few pilot projects, we are not aware that dual services are already offered on the European markets.

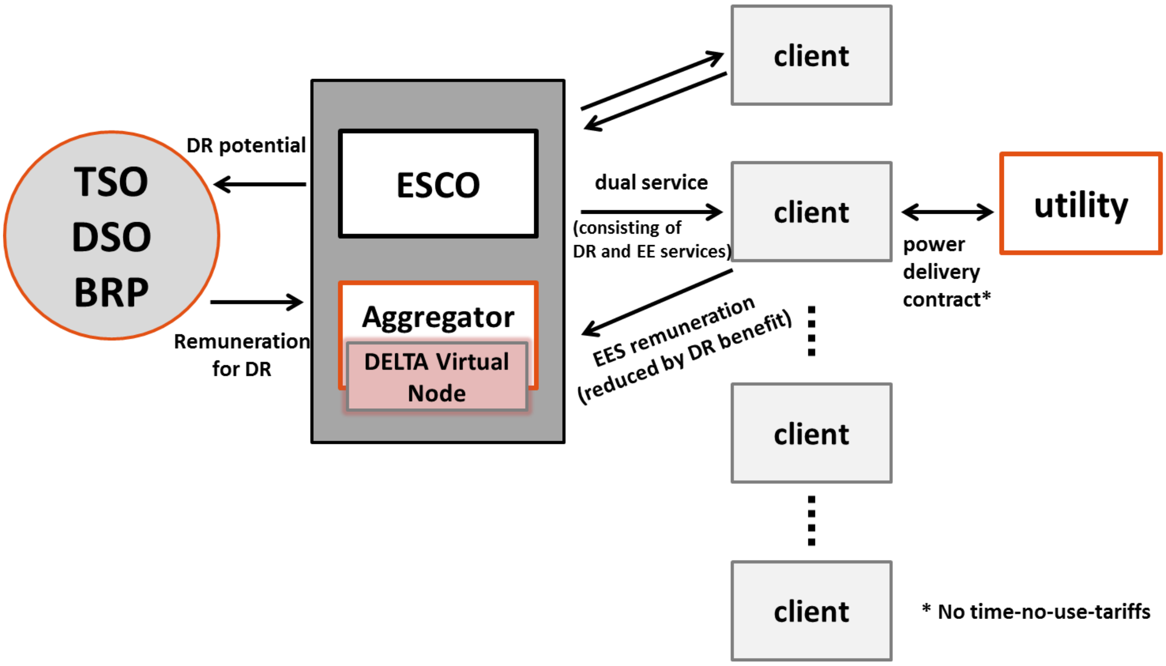

Figure 4 DELTA Business Model 1B Explicit DR combined with EES

In this business model DELTA Virtual Node is once again applied by the DR Aggregator. In the context of a dual service, it is the functionality of price forecasting that gains increasing importance as it supports solving the trade-off between energy efficiency and load shifting in optimised way.

3.3 Generic DELTA Business Model 2A Implicit DR service for optimal use of TOU-contracts

This business model starts from the fact that already now a certain group of electricity customers have a tariff with different price levels depending on the time of consumption. In theory, we can differentiate the following pricing arrangements (Cooke, 2011):

- **Time-of-use (TOU) pricing** refers to a flexible pricing structure incorporating different unit prices for usage during different time periods within a day. TOU rates reflect the average cost of generating and delivering power during those time periods.
- **Real-time-pricing (RTP)** refers to pricing based on real-time movements in electricity prices based on trade in spot markets, balancing markets or other exchanges. It links hourly or half-hourly prices to corresponding changes in real-time or day-ahead power costs. In this case, customers need to be informed about expected RTP prices on a day-ahead or hour-ahead basis to elicit load response.
- **Critical peak pricing (CPP)** is a hybrid combining traditional time of use rates and real time pricing design. The basic rate structure is time of use. However, provision is made for replacing the normal peak price with a much higher pre-determined critical peak pricing event price under specified conditions.

It has to be noted, however, that namely for small and medium customers RTP does not exist. For the moment, in this sector the only time-dependent pricing model available on the market are TOU contracts. Perhaps in future there CPP models may also be offered, mainly if, for example a customer with a larger portfolio will explicitly search for a time-dependent tariff for a whole pool of facilities.

The business model of implicit DR service for optimal use of TOU contracts is characterised by the following elements:

- The service provider – let's call it **flexibility service company (FLESCO)**, corresponding to the widely used term ESCO – takes care of load shifts at the equipment of the client in a way that the client takes maximum benefit of an (existing) TOU tariff. The FLESCO's remuneration may be either a fixed or a performance-based fee.
- If offered as stand-alone service it will only pay off if the tariff includes an extensive spread between high and low price. Otherwise the achievable savings will not be sufficiently attractive. If perhaps in future dynamic pricing models (CPP, RTP) will be increasingly available on the market there will be a higher need for external expertise.
- Furthermore, the service can be embedded in services which are already offered on the market. On the one hand, the service is strongly linked to the role of a technical facility manager, as they are usually aiming for a reduction of operating cost. On the other hand, there is an interlinkage with consultancy services related to the identification of the most attractive energy tariff.

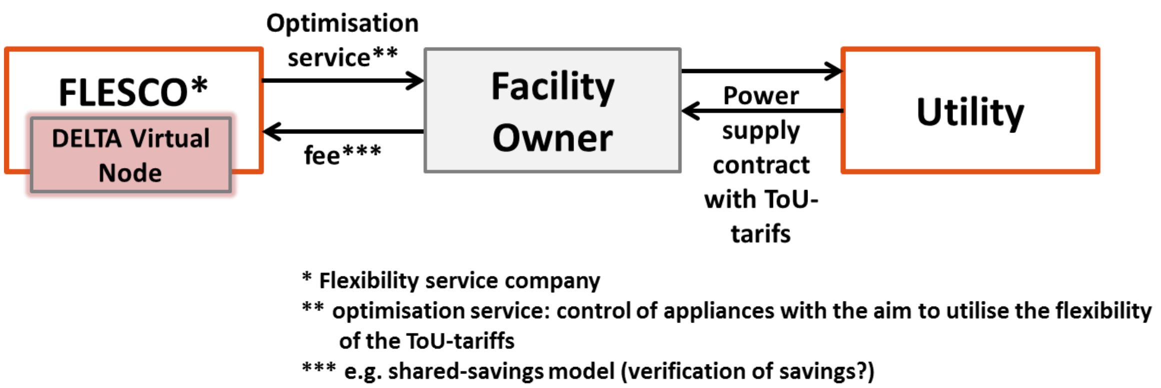

Figure 5 DELTA Business Model 2A Implicit DR service for optimal use of ToU-contracts

In this business model the FLESCO will apply the DELTA Virtual Node in order to manage its services for a larger number of customers. In this case, the functionality of administering information about – potentially dynamic – price signals at the customers metering points would be the most crucial success factor.

3.4 Generic DELTA Business Model 2B Implicit DR including power supply

This generic DR business model combines DR with the role of a retailer on the electricity market. The model is characterised by the following main elements:

- In addition to its usual function of selling electricity to customers the **retailer has access to DR potential at the customers' sites** and is allowed to shift loads within the contractually agreed limits.
- From the retailer's point of view the access to DR potential represents a value as it may lead to savings both in wholesale prices and in balancing energy payments.
- The **customer will require an incentive**, so that he is willing to grant access to his technical systems to an external party. The most obvious incentive is to receive a favourable electricity tariff. But for small- and medium-sized customers also non-financial incentives may be decisive – such as environmental considerations or enthusiasm for the most current technical developments. A detailed assessment of incentive perception of residential and tertiary customers is included in chapter 5.2.
- This business model is particularly attractive for retailers or producers with a high share of fluctuating renewables sources (wind, PV) in their supply portfolio. By activating DR potentials they can reduce the gap between supply and demand and thus reduce balancing energy payments.

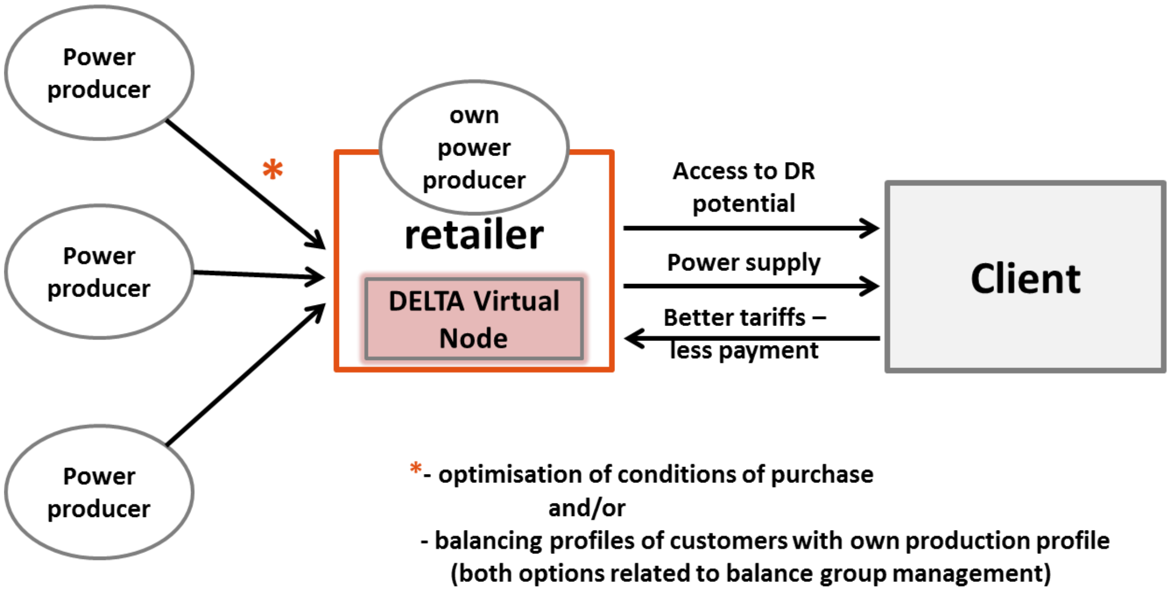

Figure 6 DELTA Business Model 2B Implicit DR including power supply

In this business model the DELTA platform is applied by the retailer with the aim to bundle and manage as many DR potentials at the costumer's side as possible. The retailer will have core interest in the platforms ability to synchronise the use of DR potentials with productions patterns – if the retailer is also an electricity producer – and/or with price signals on the wholesale market.

3.5 Generic DELTA Business Model 3 Microgrid Management

According to the US DoE Microgrid Exchange Group a microgrid can be defined a group of interconnected loads and distributed energy resources (such as distributed generators, storage devices, or controllable loads) within clearly defined electrical boundaries that acts as a single controllable entity with respect to the (macro)grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode (Berkley Lab, 2018).

- If operated in **island-mode** the microgrid manager has to ensure at each point in time that power supply is equal to power demand. In achieving this prerequisite the exploitation of DR potentials including proactive operation of storage devices is decisive.
- If operated in **grid-connected mode** the microgrid manager can make use of the DR potentials available internally in the grid microgrid. He can either offer the loads in tenders of TSO, DSO or BRP (explicit DR) of optimised the electricity cost by adapting the load profile of the microgrid to dynamic pricing (implicit DR).
- In practically all EU countries the **regulatory environment is a current blockage for microgrid development**. According to Energati (2018) Europe is accounting for just 9% of the global microgrid capacity. There are, however, several pilot microgrids, e.g. related to University campuses or to industrial and commerce centres.

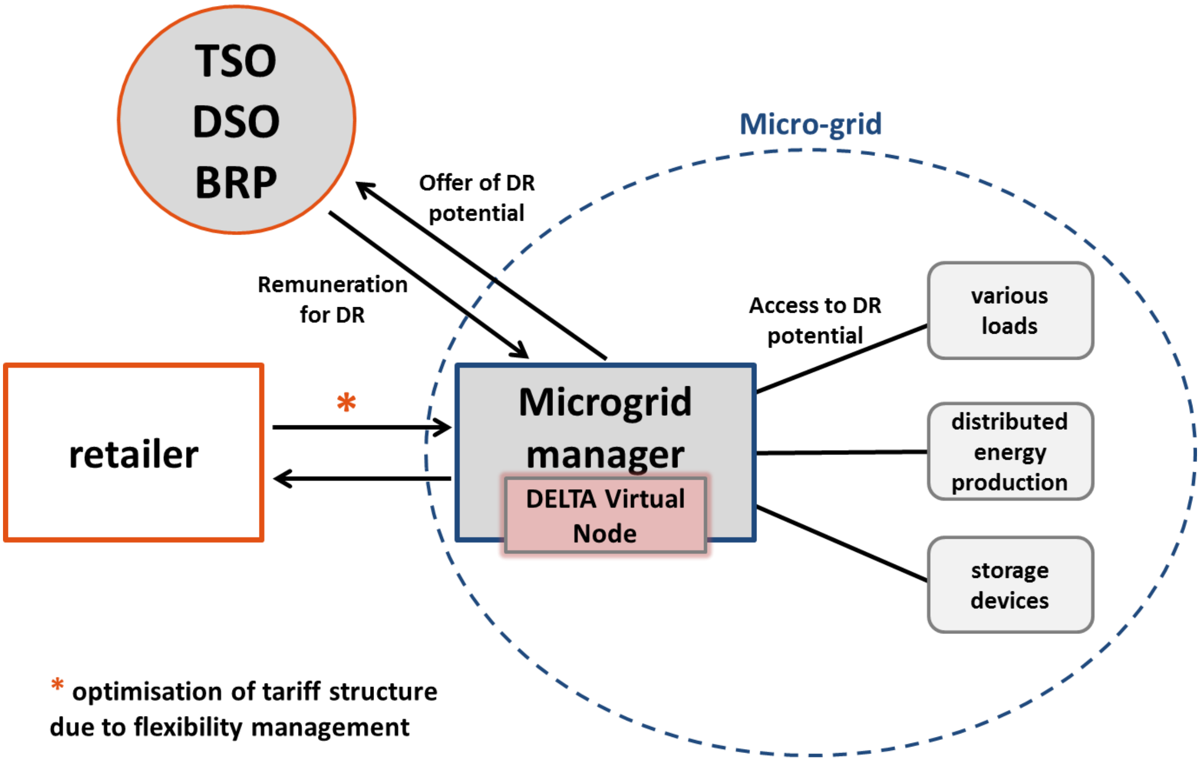

Figure 7 DELTA Business Model 3 Microgrid Management

The DELTA Virtual Node may have significant benefit for microgrid managers independent of whether they operate the microgrid in island-mode of grid-connected mode. The larger and more complex the microgrid the more relevant a professional platform is to dispatch the interconnected loads and distributed energy resources and to optimise the exchange with the external macrogrid.

4. Assessment of regulatory framework

4.1 Introduction

Technical solutions as well as business models have to be embedded in the existing regulatory framework. Even though liberalisation of the electricity market is a European project which started in 1996 with a first European directive and subsequently huge efforts that were made in harmonisation of regulations between Member States, regulatory framework conditions for the participation of demand response (DR) is still quite different in European countries (SEDC 2017).

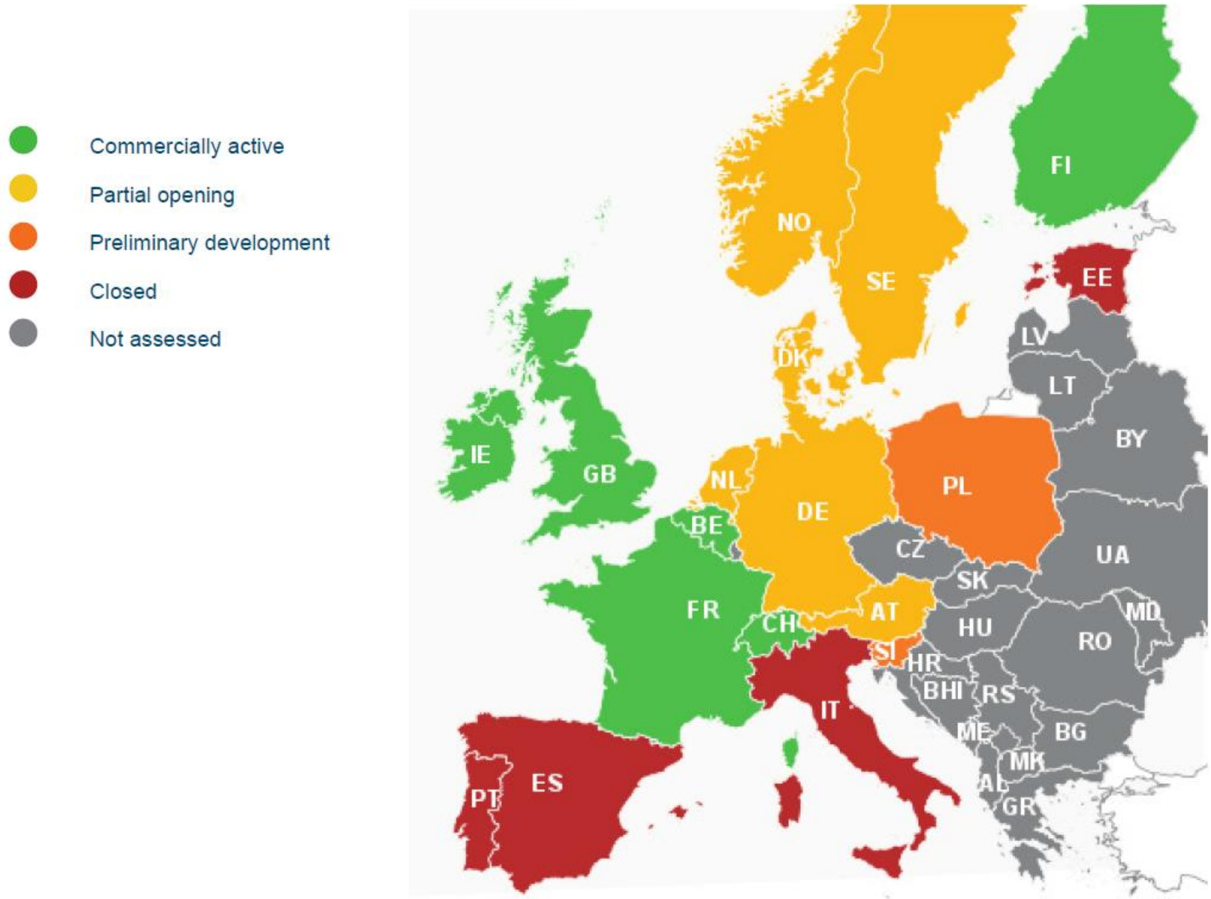

Figure 8 Map of explicit demand response development in Europe

In order to better understand framework conditions for the DELTA solutions, selected countries from the EU, supplemented by the US with a long tradition in demand response, were assessed according to their regulatory framework. The following for the selection of the countries analysed have been applied:

- Countries where DELTA pilot projects will be implemented: United Kingdom, Cyprus
- Advanced countries with an active DR market: France, Belgium, United Kingdom, United States
- Intermediate countries with a partially open DR market: Austria, Germany
- Countries with closed DR markets: Greece, Cyprus

This selection of countries allows learning from best practice examples in advanced countries, it shows typical barriers and it allows drawing conclusions for general framework conditions with high relevance for the DELTA solution.

The assessment had a clear focus on the DELTA solutions, i.e. on small and medium sized loads. Hence, definition of relevant demand response markets had to be specified:

Definition of flexibility market for DELTA
The flexibility market in the context of DELTA is understood as a part of the electricity market, where electrical loads on the side of final energy consumers are potentially or actually changed as a result of market activities (demand response, DR). This includes loads of consumption of electricity (heat pumps, ventilation, cooling, etc.) and of electricity production (PV, batteries, CHPs, etc.) as well as micro-grids. Possible activities are: switch loads on or off and adaptation of load levels.

The assessment focused on existing markets for small and medium sized loads in the residential, tertiary and SME sector. This includes small-scale producers, storages and micro-grids. Provision of flexibility by traditional power plants utilities and large industrial processes are excluded from this analysis.

4.2 United Kingdom

4.2.1 Market participants

Office of Gas and Electricity Markets (OFGEM)
Ofgem's role is to protect the interest of consumers by promoting competition in energy markets where appropriate. Ofgem issues companies with licences to carry out activities in the electricity and gas sectors, sets the levels of return which the monopoly networks companies can make, and decides on changes to market rules.

Gas and Electricity Market Authority (GEMA)
GEMA is the governing body of OFGEM. It comprises non-executive and executive members and a non-executive chair. GEMA's purpose is to ensure that all consumers can get good value and service from the energy market. In support of this, GEMA favours market solutions where practical, incentive regulation for monopolies and an approach that seeks to enable innovation and beneficial change whilst protecting consumers. The authority's powers and duties are largely provided for in statute (such as the Gas Act 1986, the Electricity Act 1989, the Utilities Act 2000, the Competition Act 1998, the Enterprise Act 2002 and the Energy Acts of 2004, 2008, 2010 and 2011) as well as ruling European Community legislation in respect of energy regulation.

Department for Business, Energy & Industrial Strategy (BEIS)
The department brings together responsibilities for business, industrial strategy, science, innovation, energy, and climate change. BEIS is responsible for:

- developing and delivering a comprehensive industrial strategy and leading the government's relationship with business
- ensuring that the country has secure energy supplies that are reliable, affordable and clean
- ensuring the UK remains at the leading edge of science, research and innovation
- tackling climate change

National Grid – System Operator in Britain
As system operator (SO) in Britain, National Grid makes sure gas and electricity are transported safely and efficiently from where it is produced to where it is consumed. It seeks to make sure that supply and demand are balanced in real-time and facilitates the connection of assets to the transmission system.

NG owns and operates the electricity transmission network in England and Wales, with day-to-day responsibility for balancing supply and demand. It operates but does not own the Scottish networks. National Grid is the main party contracting flexibility services in UK.

Distribution Network Operators (DNOs)
DNOs are companies that build, maintain and operate distribution networks that transport electricity from high-voltage transmission networks to customers. Distribution networks deliver electricity to domestic premises, small businesses and factories, i.e. mainly lower volume users. The electricity distribution networks are regional grids that branch from the national grids to deliver power to industrial, commercial and domestic users. The UK distribution network operators' regions are shown on the map below (Figure 9), together with those of independent distribution network operators who are ENA members.

Although each Distribution Network is a separate geographical area, they aren't separate electrical systems. This means electricity can flow between areas, and metering is placed at the boundaries of the areas so that these volumes can be measured.

The British Transmission Network can also import and export electricity from and to other countries through dedicated lines called Interconnectors. There are currently four interconnectors: France to Great Britain, Northern Ireland to Great Britain, the Republic of Ireland to Great Britain and Holland to Great Britain.

Demand Response activities are now being used by DNOs to help balance the Distribution Network and an alternative arrangement to avoid the cost of network reinforcement. This in turn delivers local grid balancing opportunities for UK businesses.

As some programmes are limited on a small geographic area, site location is important when accessing DNO programmes.

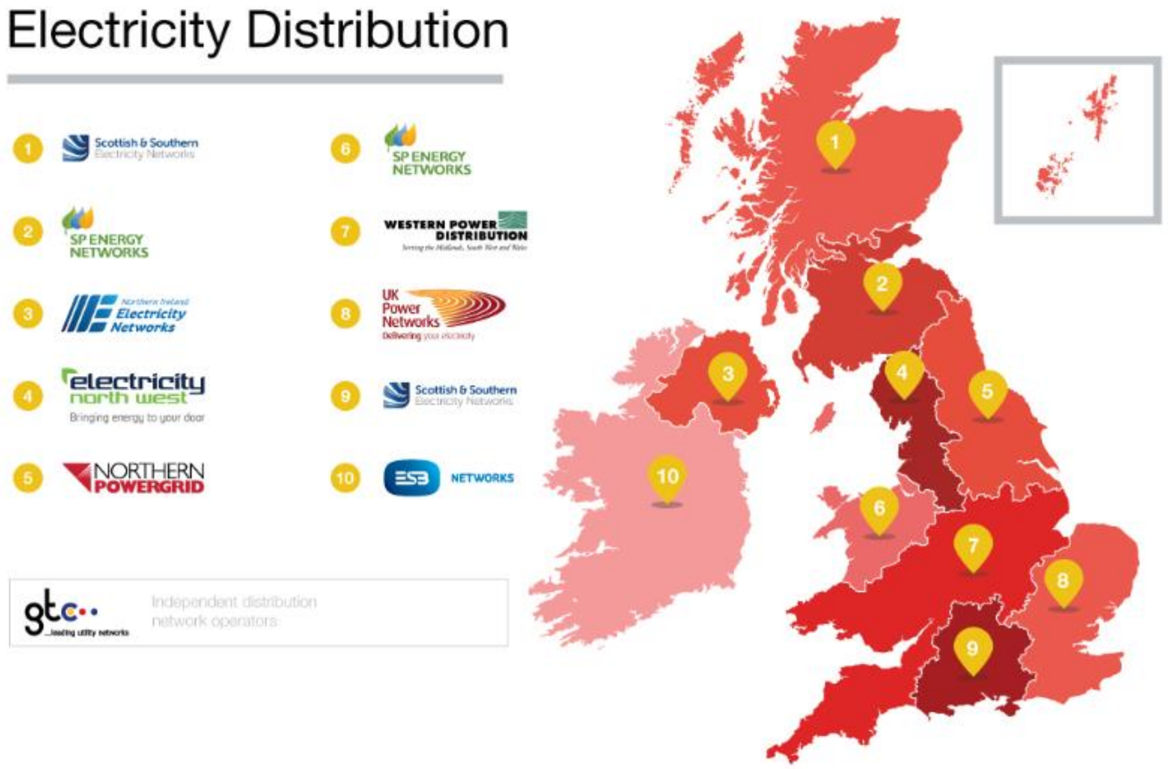

Figure 9 Distribution networks regions in UK and Ireland. Source: ENA

Aggregators
Aggregators are companies that aggregate small loads and participate in demand side markets on behalf of their customers. While traditionally aggregators will target commercial and industrial users, as the market evolved and the deployment cost per site/asset has declined, the focus now is on smaller

distributed loads, including residential market. Typical market functions performed by an aggregator will include:

- bidding into markets to secure capacity in various balancing programmes
- aggregating portfolios of assets to meet minimum capacity requirements for each programme but also to better manage technical risk
- supply and install metering and control equipment on client side
- provide data dashboard services and advance data analysis tools for clients
- provide turnkey flexibility management solutions for DNOs

As the markets constantly evolve, the role of the aggregator is also changing. There is an increasing trend in the market place for aggregators to also hold a supply license to allow them participation to wholesale market and maximise revenues for the assets they are managing on behalf of their clients.

Suppliers, generators and traders

Suppliers buy electricity from generators, traders and power exchanges in the wholesale market and sell it on to end consumers. Any discrepancies between their wholesale purchases and what their customers use are managed through the balancing mechanism. Suppliers operate in a competitive market where customers can choose which supplier provides them with electricity. There are six major suppliers and a number of smaller (often niche) suppliers.

Figure 10 Interaction between the wholesale and retail markets. Source: Elexon

Generators sell generation to suppliers who need the generation to meet the demand of their customers. However, it is not only generators and suppliers who can contract for and trade electricity. There is a type of participant referred to as a non physical trader that can also enter into contracts to buy and sell electricity.

A non physical trader doesn’t have any generation to sell, or any customers’ demand to satisfy, and is therefore trading electricity for profit. The non physical trader will buy electricity from a generator at a negotiated price, and will sell it on to a supplier, aiming for a higher price than it was paid for to make a profit. Most non physical traders try to sell exactly what they have bought; this is referred to as not taking a physical position.

Suppliers and generators also try to match their demand and generation, respectively, to their contract levels so that they do not have a surplus or deficit of electricity. This is one of the key objectives of the trading arrangements in encouraging all participants to have contracts covering all of their generation and/or demand.

4.2.2 Specific conditions for the participation in the flexibility market

Below is a summary table of National Grid balancing services for frequency and reserve with their requirements, relative value and contracting arrangements. Please note that suppliers and DNOs also offer opportunities to provide demand side response services, but these are not included in the table.

Table 1 National Grid balancing services

	Scheme	Minimum size*	Notice period	Duration	Regularity**	Value***	Contract
FREQUENCY RESPONSE SERVICES	**Static Firm Frequency Response (FFR)**	10 MW	30 sec	Max 30 min Typically 5 min	10-30	££	Monthly electronic tender
	Dynamic FFR	10 MW	2 sec	Max 30 min Typically 3-4 min	Daily	£££	Monthly electronic tender
	FFR Bridging	< 10 MW	30 sec	30 min	10-30	££	Bilateral contract of 12-24 months to transition in to the FFR market (either Static or Dynamic).
	Frequency Control by Demand Management (FCDM)	3 MW	2 sec	30 min	~10	££	Bilateral contracts for 1-2 yrs. Week ahead notification of daily load able to shed
	Enhanced Frequency Response (EFR)	1 - 50 MW	1 sec Dynamic	Max 15 min Typically 3-4 min		£££	New product – trial tender
RESERVE SERVICES	**Short Term Operating Reserve (STOR)**	3 MW	20 min	2-4 hrs Typically <20 min	Able to deliver 3x per week	£	3 tenders p.a. 'Committed' or 'Flexible' service
	STOR Runway	< 3 MW	20 min	2-4 hrs Typically <20 min	Able to deliver 3x per week	£	Bilateral contract
	Fast Reserve	50 MW	2 min, reaching 50MW in 4 min	15 min		£	Monthly tender
	Demand Turn Up	1 MW	10 min, sometimes requested day-ahead	Min 30 min		£	New product – trial tender

* to contract directly with NG (smaller loads via demand side providers)
** Average number of times called on per year, based on National Grid Data
*** Relative value to Participant
£ the greater the number of '£' signs indicates a greater value to the demand side participant
Source: Power Responsive: A guide to Demand Side Response

4.2.3 Programmes and products

The United Kingdom was the first country to open several of its markets to consumer participation in Europe. Unfortunately, in recent years it seems that the stakeholder process between providers, BEIS, Ofgem and national grid has not been as effective as would be expected in a mature market. As a result, the DSR market is not as functional as it could be due to various operational and procedural requirements. This makes the market difficult to access and reduces the potential number of demand-side MWs even as national generating capacity continues to decline.

Almost all ancillary services programmes in Great Britain are open to demand response and aggregated load even though the design is currently not optimal for customer participation. There is also an issue with transparency as comprehensive data regarding the share of demand response in the various balancing services programmes is not available. Many services are procured not through open markets but rather through bilateral contracts or through tenders in which the buyer, National Grid, has a great degree of discretion. This lack of information makes participation very risky for new entrants.

The SO is however determined to reduce risk in the DSR market and is taking steps towards achieving greater transparency. National grid launched a new stakeholder-backed initiative called Power Responsive, with the goal of stimulating participation of flexible technologies in the electricity system. The power responsive report (Power Responsive 2017) gives greater detail as to the various demand side response participants engaged in the Non-BM. The report shows that onsite generation constitutes

the majority (about 67%) of demand side flexibility technology which participates in DSR. This is followed by load response (28%), Generation for export only (3%) and Energy storage (1%).
The relationship between the BRP and aggregator in the UK is not yet fully resolved. Due to this, aggregators are unable to access the balancing mechanism or wholesale markets as it requires a bilateral agreement from the BRP/retailer. On the other hand, aggregators can access balancing services and the capacity mechanism as there is no prerequisite for an agreement between the retailer and aggregator. This means that the retailer (rather than the aggregator) is exposed to imbalance payments or costs resulting from customers actions (SEDC 2017). In November 2016 Ofgem issued a call for evidence to inquire if a framework allowing independent aggregators access to the balancing mechanism should be initiated (Ofgem and Aurora Energy 2016). The results showed wide support for such a framework and a willingness by Ofgem to institute the desired measures (Ofgem 2017)
The Association for Decentralised Energy (ADE) has also developed a voluntary industry led code of conduct for aggregators and suppliers. The proposal focuses on five areas i.e.

- sales and marketing;
- proposals and pre-contractual information;
- contract;
- technical due diligence and site visit;
- and complaint

and will aim to be implemented in 2018 (Association For Decentralised Energy 2017). The Association for Decentralised Energy (ADE) also undertook a self-reporting survey of aggregators and suppliers, to offer a more comprehensive picture of DSF participation in different markets (reserve, frequency response, capacity, wholesale and network cost avoidance). This considered the assets delivering flexibility, the sectors participating and the regional spread of activity across GB.

Defining demand side flexibility (DSF) – breakdown by technology
Demand side response (DSR) is where electricity demand is changed (increased, reduced or shifted) at a particular moment in time in response to an external signal (such as a change in price, or a message). National Grid uses the wider term ‘DSF’ to include five categories of flexible response:
1. DSR by load response – load shifting or temporary demand reduction or increase (e.g. heating/cooling systems, business operations and appliances).
2. DSR by distributed generation (onsite) – standby, back up or other distributed and dispatchable generation, including Combined Heat and Power (CHP) – with a primary purpose to support a source of local demand.
3. DSR by storage (onsite) – use of energy storage assets (either offsetting demand or exporting to the network) where the primary purpose of the asset is in the support of a local source of demand.
4. Distributed generation (for export) – distributed and dispatchable generation, including CHP – not aligned with a source of demand.
5. Storage (for export) – use of energy storage assets that only export to the network and that are not aligned to an associated source of demand.

Where possible these categories have been used to classify the technology types participating in individual services. However, due to the format of raw data, other categorisations have been used, including Balancing Mechanism (BM) and non-Balancing Mechanism (NMB).

- **Balancing Mechanism (BM)** – the Balancing Mechanism is an additional tool for balancing the system, in relation to commercial Balancing Services. Through the BM, each power station makes a price ‘bid’ by which to reduce or increase the power they offer. This BM category here represents larger players delivering services through this route.
- **Non-Balancing Mechanism (NBM)** – refers to DSF providers or assets, who do not – or currently cannot – participate in the BM, and includes the first 5 categories above.

DSR Capacity Market Units (CMUs) can be classified as either proven if they have passed a DSR test prior to prequalification for the CM auction, or Unproven if they have not yet passed a DSR test. Capacity Market reporting does not recognise ‘DSF’ as a category.

A summary of all market services and the total capacity contracted in season 2016-2017 is presented below, data extracted from the SEDC report "Explicit Demand Response in Europe: Mapping the markets" published in October 2017 (SEDC 2017).

Table 2 Balancing and ancillary service

ENTSO-E's terminology	National Grid's terminology		Tot. Capacity Contracted	Demand Response Access & Participation (MW)	Aggregated Demand Response Accepted	Aggregated generation
FCR	Firm Frequency Response (FFR)[141]	Dynamic	~354.6 MW	✔ (data not available)	✔	✔
		Non-Dynamic	~0 MW	✔ (data not available)	✔	✔
FCR	FFR Bridging[142]		~10 MW	✔ (data not available)	✔	✔
FRR	Fast Reserve*[143]	Non-Dynamic	60 MW	✔ (data not available)	✔	✔
RR	Short-Term Operating Reserve (STOR)[144]	Committed	~2494 MW	✔ (data not available)	✘	✘
		Flexible	~898 MW	✔ (data not available)	✔	✔
RR	STOR Runway		78 MW	✔ 78 MW	✔	✔
RR	Supplemental Balancing Reserve (SBR)		4,035 MW[145]	0 MW[146]		
RR	Demand-Side Balancing Reserve (DSBR)[147]		0 MW	✔ 0 MW	✔	✔
RR	Demand Turn Up (trial)		300 MW[148]	300 MW	✔	✔
FCR	Frequency Control by Demand Management (FCDM)		Not public	✔	✔	✔
FCR	Enhanced Frequency Response		201 MW[149]	✔ 0**	✔	✔
	Balancing Mechanism[150]		3,700 GWh of "bid-offer acceptances" (i.e. actual trades) (2017)	Minimal	✘	✘
Capacity mechanisms (if any)	Capacity Mechanism[151]		52,425.302 MW	~1411 MW***	✔	✔
	Transitional arrangements		~641 MW	✔ 328 MW[152]	✔	✔
Distribution network services (voltage control and congestion management)	⃠	⃠	⃠	⃠	⃠	⃠
⃠	Triad avoidance		Not applicable	✔	✔	✔
⃠	Red Zone Management		Not applicable	✔	✔	✔

* The very high frequency of activations (10-15 per day) makes it practically impossible for DR to participate

** The product is designed around the capabilities of battery storage, and only storage bids were accepted in the tender

*** Proven and unproven DR

While National Grid has engaged in streamlining the participation requirements for balancing services and increasing transparency, DR still faces significant regulatory and operational challenges which limit the viability of the UK market for Demand Response providers.
The capacity mechanism, introduced at the end of 2014, did not place demand-side resources on an equal footing with generation. In the first market only one demand-side aggregator, of the approximately 15 in the market, secured a contract within the new market in the first auction. The most recent auction performed better with independent aggregators securing various MW of capacity and coal losing out. However a combination of low clearing price and derating factor means that battery storage finds it hard to compete with only 11% of projects securing capacity in the T-4 auction (Stoker 2018b) and storage making up less than 2% of the capacity procured via the T1 auction (Stoker 2018a)
The opportunity for demand response is in principle higher than ever. However, due to poor policy development and design choices, that opportunity has not yet been realised. And as pointed out in the Energyst research most of those who do not provide DSR would be interested in doing so if the route to the market was much clearer, if the complexity was reduced and the rewards were more certain and if it did not affect core business (The Energyst 2017).

4.2.4 Market mechanisms and business cases

Pre-qualification in demand side response programmes can be quite complex and involve numerous stages before participation is approved. The different programmes also have varying requirements which make technical assessment even more complicated.
These programmes usually require a contract, either directly with the procurer such as the National Grid or through a demand side provider. A process for assessing suitability to take part occurs, after which contracts are awarded either bilaterally or through a competitive process (Power Responsive 2017). Payments for the contract are then paid according to the pre-agreed contractual terms of participating in the programme.
Contracts for DSR programmes vary in length and the tendering process for the various programmes are also different. Conditions under which contracts are accepted are not particularly transparent and leave a lot to be desired in the market. The general outline for participation in demand response programmes are highlighted below.

Firm Frequency Response (FFR)
Firm Frequency Response is a frequency response service which aids the National Grid in fulfilling its statutory obligation to maintain the frequency of the National Electricity Transmission System within ± 1% of 50Hz (49.4 to 50.5Hz) (Grid 2017).
The programme is open to demand response providers with a minimum capacity of 1MW (recently reduced from 10MW), in both dynamic and non-dynamic profiles (SEDC 2017). Not many assets can singularly provide such a large volume of energy meaning that aggregators are required to play a role in the market.
Requirements for FFR are very strictly defined and require almost immediate response to deviations in the grid frequency. As a result, the need for specialised and suitable assessment of assets with potential to provide frequency relief when requested is essential. Independent aggregators play a part and are involved from the conception of the process to its delivery.
Engineers from aggregators go to such sites to examine the assets which may be suitable for Frequency response and then install a leading protection relay to monitor site frequency and second by second metering of the system.
Various tests are conducted to determine the sites ability to deliver and respond in the event of a frequency bandwidth deviation. If all this is successful the asset is tendered into the FFR market to obtain a contract with the National grid.
FFR contracts are obtained through tenders either done by owners of assets or independent aggregators. The tendering process for FFR takes place every month on the 1st business day for contracts which will begin on the 1st business day of the next month. Tenders are submitted for individual units, for specific times during the day and the national grid either accepts or rejects these

contracts. This is dependent on their fulfilment of certain requirements determined by the SO (price being a major factor).

The tenders for FFR are divided into short-term tender rounds and long-term tender rounds. The short-term tenders are for a duration of a month only while in the long-term tenders, submissions for contracts on a monthly, quarterly or seasonal duration are permitted.

The first short-term tender for FFR was held in December 2017 for contracts beginning in January. The SO have recently structured the tenders to allow two short-term tenders followed by one long term tender. This has inevitably meant that the duration of assured contracts has reduced and as such FFR providers are less likely to procure contracts for long durations. An uncertainty regarding revenues has resulted from this and therefore the market seems less and less profitable as time goes on. The uncertainty of not having a contract for a reasonable period of time and the lack of transparency in the market has meant that the prices for frequency contracts has seen a rapid drop in recent months, diminishing profitability and attractiveness in investments over the past couple of months.

Payments for participation in the FFR market are made on an availability basis and participants are paid for the hours they were available for an FFR event in a month but receive no payments for utilisation.

The other major source of income in the DSR market is the Short-Term Operating Reserve (STOR) programme which shall be discussed below.

Short Term Operating Reserve (STOR)

The STOR Programme is one of the DSR by load response programmes procured by the ESO to ensure balance in the electricity grid. STOR is a contracted balancing service whereby the service provider delivers a contracted level of power (within pre-agreed parameters) when instructed by National Grid (Grid 2013)

The various pre-requisites for a STOR agreement can be quite complex and difficult to those who wish to enter the demand response market. This is where the role of aggregators come in as they help simplify the process while also enabling those who would like to participate in DSR but do not necessarily have adequate energy capacity (which at the moment is a minimum of 3 MW).

The process of prequalification for the STOR programme would begin with engineers from the independent aggregator visiting the sites and meeting with the management and operations team in order to assess existing systems and identify the assets which are appropriate for use in the STOR programme.

A detailed project management plan is necessary during the subsequent steps which include a risk assessment, installation assessment and testing the asset to confirm its deliverable capacity. Metering installations are needed to determine the output of the asset as compared to its baseline and in some cases new control solutions which will enable remote activation of the asset. Tests are conducted to prove the assets capability to respond to a demand response event and the efficiency of the installed technology.

When a demand response event is requested by National Grid, the asset is activated and synchronised to the mains, sometimes exporting spare capacity back to the National Grid.

For STOR the tendering process is different to that of frequency response. In this case there are six tender rounds held for each STOR year which starts from April in one year till the end of March in the next. Tenders can be submitted for any approaching season in a STOR year. The opportunity to secure long term contracts in the STOR auction is much more favourable, however, the lack of transparency and comprehensive data regarding the assessment criteria and methodology makes it difficult for new entrants to participate in the reserve market. Many services are also procured through bilateral contracts and the tenders are not open meaning the National Grid has a great degree of discretion making information hard to access and therefore leading to market uncertainty. The National Grid also employs a lot of rule changes which leads to uncertainty by participants.

Participants who are qualified and accepted for participation in the STOR programme are required to install an SRD PC to be notified of STOR dispatch requests. They are also required to be available during STOR windows which are usually divided into an A.M window and a P.M window (with slight variations depending on the season). Participants are then paid for both availability and utilisation. The availability payments are made with regards to the number of hours or duration which the asset was made available during the STOR windows and the utilisation payments are made for the number of hours the asset was used during an actual STOR dispatch request.

4.2.5 Facilitation of demand response

Programme Requirements
Participation in the demand response programmes available by the ESO require certain technical capabilities which have to be met by each asset with potential to participate in the program. Various amounts of Data are required by the SO for assessment purposes.
These shall be highlighted for FFR and STOR below.

FFR
As stated earlier the minimum response capacity for a unit to be involved in the FFR program is 1MW which can be from a single unit or can be aggregated from several smaller units (Grid 2017).
Providers must have the capability to operate (when instructed) in a frequency sensitive mode for Dynamic response, or change their MW level via automatic relay for Non-Dynamic response.
There must be a single point of dispatch or a method in which the total output of the combined loads can be monitored to demonstrate to National Grid that the service is available.
For FFR the National Grid does not require installation of systems to communicate live readings to them for performance monitoring purposes. However, the asset must have the ability to download second by second FFR data which must be provided to the account manager via email upon request.
The tests taken for FFR depend on the specific FFR response being delivered. For this purpose, the tests are split into dynamic or non-dynamic.

Non-Dynamic tests
Non-dynamic FFR requires doesn’t require a real-time response to fluctuations in the grid unlike the dynamic FFR and only requires response at a certain threshold. Therefore, the tests are performed to assess this capability.
Firstly, an injection test is carried out using National Grids standardised injection profile as shown below.

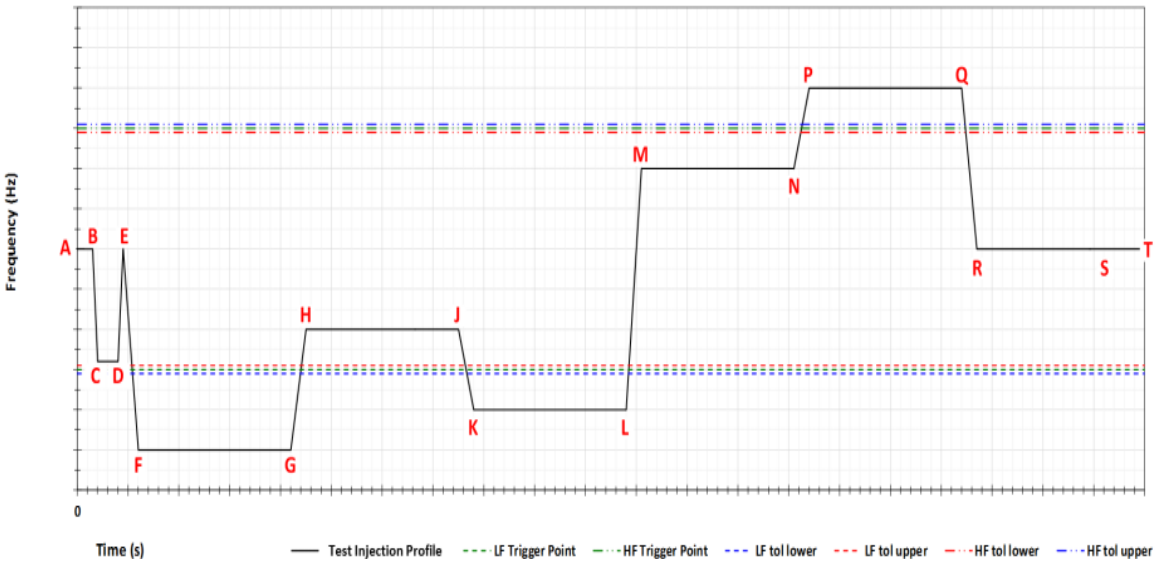

Figure 11 Non-Dynamic Low Frequency Response Injection Profile

The test is meant to determine that the response occurs at the correct contracted trigger frequency and within the permitted tolerance (± 0.01Hz). This response must be sustained for 30 minutes. The standard deviation of response error over a 30-minute period must not exceed 2.5% of the contracted

response. The injected frequency signals are 49.7 Hz / 50.3 Hz. The length of both tests is approximately 2,100 seconds in the case where the providers are providing a 1,800 second response.
If the agreed response time is longer or shorter than 1,800 seconds, the test may be proportionately increased or decreased.

Dynamic Test
The dynamic test is performed to ensure the system responds when the frequency moves outside the ±0.015Hz dead band.
A different injection profile is used for this test as shown below.

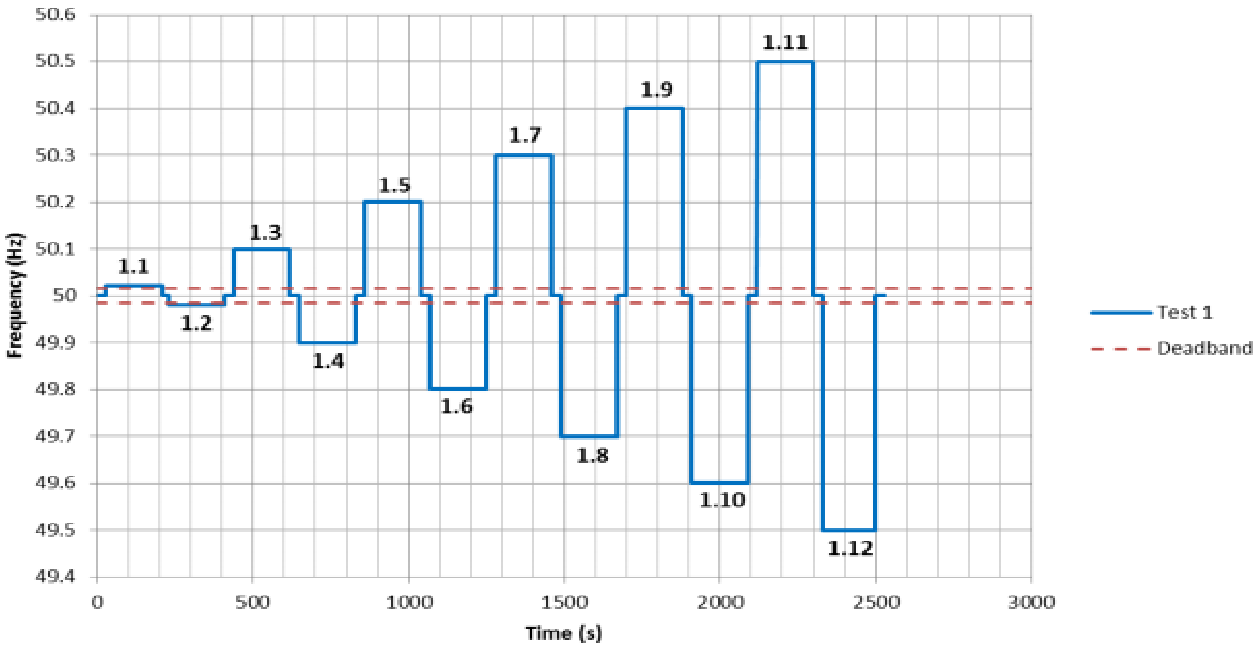

Figure 12 Dynamic Test

To pass the test the delay in response must be no greater than 2 seconds. Minimum response must be within the allowable tolerances for primary, secondary and high frequency timescales. The standard deviation of load error at steady state over a 180 second period must not exceed 2.5% of the maximum contracted response. Response should progressively change to its contracted output. Each step is sustained for 180 seconds.

STOR
Participation in the STOR programme requires a STOR provider must be able to offer a minimum of 3 MW of generation or steady demand reduction. Providers of STOR should be able to respond to an instruction within a maximum of 240 minutes. Generally, the National Grid accepts contracts that have a response time within 20 minutes. The response for STOR must be able to be sustained for a minimum of 2 hours and have a recovery period of not more than 1,200 minutes. To prequalify and tender for STOR a STOR framework agreement must be entered into before submitting tenders for STOR. On the part of the National Grid there is no testing requirement because the STOR dispatch PC pulls the real-time metered data to monitor performance during a STOR call. For non-BM STOR providers they must supply metering signals compatible with the STOR dispatch equipment and must be recorded on a minute by minute basis.

4.2.6 Opportunities of the existing regulatory framework for the application of DELTA services

Which are the most promising elements of the regulatory framework that support the application of DELTA services?

To facilitate the possibility of implementing the DELTA service, an assessment of the framework in place is necessary to determine how favourable it is towards developing and implementing such a service. The United Kingdom demand response market is one of the most developed and accessible in the EU. Though the present configuration of the demand response market is not perfect certain regulatory frameworks allow for the potential growth of including more energy consumers in the market and bode well for the DELTA service. These will be discussed below.

The United Kingdom was the first country in the EU to open several of its markets to consumer participation (SEDC 2017). This gives it a unique and early advantage in the implementation of new and beneficial changes to segments of the electricity market. Even though the synergy between the various stakeholders has not been perfect in recent years there are still elements which show promise to supporting the application of a new service. Firstly, almost all ancillary service programmes in Great Britain are open to demand response and aggregated load even though the design is currently not optimal for customer participation. With the right technology and implementation there are limited barriers to accessing these markets. If the right means for aggregating consumer loads become available, the potential for end-user contribution to demand response is promising seeing as the market structure has been open to consumer participation for a while.

In addition, the ESO’s move towards greater transparency and reduction of risk in the DSR market is also a promising development for the DELTA framework. The launch of the new stakeholder-backed initiative called Power Responsive which aims to stimulate participation of flexible technologies in the electricity system should generally improve access to the market and provide greater incentives for participation (Power Responsive 2017). There is currently a detailed measurement and verification framework for each DSR product which makes access by the DELTA platform feasible. Implementation of the DELTA platform in the wide range of DSR products currently available is also a plus and will support a wide range of use cases. This will make it possible to assess the most appropriate avenue to enter the market successfully.

Finally, the relationship between the BRP and aggregator in the UK is not yet fully resolved. At the moment aggregators are unable to access the balancing mechanism or wholesale markets without a bilateral agreement from the BRP/retailer. However, promising developments have taken place as the regulatory body announced that aggregators will in have the ability to access the balancing mechanism and the wholesale market by April 2019 (National Grid 2018). What this will mean for the relationship between the retailer and the consumer is yet to be determined as hypothetically the retailer rather than the aggregator will be exposed to imbalance payments or costs while the aggregator gains the benefits. It does however bode well for the expansion of the demand response market to include residential consumers and the implementation of new demand response services/programmes.

4.2.7 Further development and trends of framework conditions

Future of the DSR market

The DSR Market is evolving and in the future changes have to be made to ensure the system is adapted for modern use and the modern market. Reforms have to be made with regards to the services available to balance the grid and the accessibility of businesses and individuals to these markets. In addition, clarity has to be brought into the process as they are often unclear, complicated and not future-proof. With the constant expansion of the demand response market and its development towards a smarter and innovative grid, a number of changes in the near future which may facilitate that innovation will be considered.

Effects of smart grids

The development of Smart and interactive grids balancing the electricity network in real time is expected to have a significant impact on the demand response industry. The Energy Networks Association (ENA) is a major industry initiative that aims to transform the way our energy networks work, underpinning the delivery of the smart grid. The project aims to give households, businesses and networks the ability to take advantage of new energy technologies to take control of their energy and lower their costs by participating in demand response programmes. A number of new local markets emerging with the transition from DNO to DSO (Distribution System Operator), and continued work under the umbrella of the ENA's Open Networks project are expected to develop in the recent future. This could open up access to demand response by individual participants and residential consumers.

Electricity charging arrangements
With the evolution of the energy system the access and charging arrangements behind the electricity network are expected to evolve accordingly, providing a level playing field for the benefit of the end consumer. The charging futures forum (CFF) is set up to address this challenge. The CFF is a new forum designed to bring together Ofgem-led and industry-led electricity network charging reviews, both ongoing and emerging, into a joined-up work programme. The programme is meant to assess the development of half-hourly settlement of smaller business customers in wholesale markets and its impact on the electricity network.

Impact of MCPD in the DSR market
In an effort to reduce emissions of harmful air pollutants the environmental agency has passed regulations to implement the EU Medium Combustion Plant Directive (MCPD) on the 24th January 2018. The Directive aims to bring harmful emissions from medium combustion plant (those with thermal input between 1 and 50 MW) down via a pan-European standard. This will have a huge impact on the majority of demand side participants which include backup generators and may lead to a radical change in the shape of the market. This could have an effect of allowing new actors to enter the market but could also lead to instability if the transition is not managed carefully and effectively.

New actors entering the market, perhaps most specifically battery storage technologies
Battery storage has received a lot of attention in the past two years, as costs have declined and markets have begun to value their speed and flexibility (Ma and Cheung 2016). With the ability to provide a symmetrical service (i.e. the ability to charge or discharge upon instruction) in timeframes of one second or less, battery storage is highly valuable to system operators, particularly in short duration, power applications, such as frequency response products (Harper et al. 2017). With the continuous development of battery storage and its capabilities there is a likelihood that more DSR programmes are developed primarily to exploit the abilities of battery storage. This is especially the case if the duration with which electricity can be stored, charged and discharged increases over time.

Further innovation by DSF providers and aggregation intermediaries
With the introduction of electric vehicles into the electricity grid structure, radical changes are expected in how the power networks operate and what we can expect from the ESO in the future with regards to demand response. The ESO aims to continuously engage with this development and consider the infrastructure required to realise flexibility opportunities from electric vehicles. A major change is expected as this disruptive innovation expands which will probably increase the need for demand response programmes. This coupled with an increasing amount of intermittent renewables being connected to the grid will have a major effect on the electricity grid as a whole.

4.3 Cyprus

Cyprus is a Member State of the European Union (EU) hence, its national legislation and policy regarding energy regulation and the energy markets reflects the relevant EU framework[2]. Cyprus has been classified as a 'small isolated system' under both the Second and Third Energy Packages since the island's industry is not integrated with any other neighbouring systems. This status currently grants the island derogation from the application of various Articles of Third Electricity Directive 72/2009/EC including the basic models for Unbundling of Transmission Systems. Cyprus' size and geographical position as well as the fact that Cyprus has virtually no domestic production of any conventional primary sources of energy, provides for a domestic energy market that is still emerging and is in the early stages of reaching the envisaged liberalisation.

4.3.1 Market participants

There are 4 key stakeholders in Cyprus covering the field of energy, namely:

- Energy Service of the Ministry of Commerce, Industry and Tourism (ESMCIT)
- Cyprus Energy Regulatory Authority (CERA)
- Electricity Authority of Cyprus (EAC) that includes the Distribution System Operator (DSO) unbundled in management and accounting terms (named derogation in the Third Electricity Directive).
- Transmission System Operator of Cyprus (TSOC)

The roles and responsibilities of these entities are detailed below.

Energy Service of the Ministry of Commerce, Industry and Tourism

The Energy Service of the Ministry of Commerce, Industry and Tourism has the overall responsibility of energy in Cyprus and specifically for monitoring and coordinating the supply and availability of sufficient energy capacity for domestic needs. Moreover, the ministry suggests ways for the implementation of the European Acquis, assists in the preparation of laws, regulations, rules etc. and implements programs for their promotion. In addition, the ministry is responsible for preparing and implementing programs for energy conservation, the promotion of renewable energy source (RES) and the developing of technologies for the utilization of RES as well as assisting the government in the formation of the national energy policy for Cyprus in coordination with all other bodies involved.

Cyprus Energy Regulatory Authority

The Electricity Market Law [Section 4, Electricity Market Law[3]] and the Natural Gas Market Law [Section 4, Natural Gas Market Law[4]] established the Cyprus Energy Regulatory Authority (CERA), pursuant to the respective provisions of the Electricity Directive [Article 35, Electricity Directive] and of the Natural Gas Directive [Article 39, Natural Gas Directive]. CERA is the competent authority overseeing and regulating the electricity and natural gas markets in Cyprus. CERA also endorses and safeguards competition in the energy market, ensures the quality in energy supply and encourages the use of renewable energy sources. CERA is a separate legal entity and independent from any other public or private entity. CERA's functions, operations and decision-making processes are governed by the liberalization law N. 122(I)/2003[5], without requiring prior consent or approval by the Council of Ministers.

[2] CERA is the Regulatory Authority of Cyprus taking care of aligning Cyprus with the EU directives: www.cera.org.cy/
[3] See www.cera.org.cy/Templates/00001/data/nomothesia/europaiki/Hlektrismos/Odigia_2009_72_EK.pdf
[4] See www.cera.org.cy/Templates/00001/data/nomothesia/europaiki/FA/Odigia_2009-73-EK.pdf
[5] See www.cera.org.cy/Templates/00001/data/nomothesia/ethniki/hlektrismos/Nomos/Nomos%202003-2017.pdf

Electricity Authority of Cyprus

In Cyprus, the distribution system is operated by the DSO who is an independent entity in management and accounting terms within the vertically integrated utility of Cyprus the Electricity Authority of Cyprus (EAC). The transmission system is operated by the Transmission System Operator of Cyprus (TSOC) which is a legally independent entity covered by the electricity law of Cyprus N.122(I)/2003-2012. EAC is the only generator using conventional fuel in Cyprus and it owns and operates three main power stations of a total installed capacity of 1,478 MW which run on imported fuel, mainly heavy fuel oil.

Transmission Systems Operator of Cyprus

Another key body within the sector is the Transmission Systems Operator of Cyprus (TSOC). Pursuant to the Electricity Market Regulation Law the ownership of the transmission system has been unbundled from its operation with the creation of the TSOC, although the Distribution Systems Operator (DSO) remains under the EAC's control. The TSOC is deemed to regulate access to the electricity grid, codes for transmission and distribution and the overall maintenance or development of the grid. Therefore, the TSOC is able to act independently and avoid any conflict of interest. Ownership of the assets remains with the vertically integrated company EAC.

4.3.2 Regulation for Renewable Energy Source

As part of Energy Union governance, Cyprus has set-up ambitious collective targets on renewables and energy efficiency, aiming to achieve a share of 13% of renewable energy sources (RES) in its gross final energy consumption (after adjustment for aviation consumption) and a share of 10% of RES in final energy consumption of transport by 2020. The three main goals set by Cyprus are:

- the development of indigenous energy resources;
- the enhancement of security of energy supply and competitiveness; and
- the protection of the environment.

In this respect, Cyprus has transposed the Renewable Energy Directive 2009/28/EC into Cyprus law by enacting the Law for the Promotion and Encouragement of the Use of Renewable Energy Sources of 2013, and currently the renewable installed capacity from wind, solar and biomass is 157.5 MW, 85.7 MW and 9.7 MW, respectively.

In 2013, the government announced and implemented certain support schemes for the promotion of electricity generation using RES. One of these schemes involved the provision of state grants to vulnerable households for the installation of 2,000 photovoltaic systems of 3 kW each and their connection to the grid of the EAC via net metering. Net metering involves the calculation of the difference between annual imported energy from the grid and the exported energy into the grid from the PV system installed, and the consumer is billed that difference. It includes a capacity payment reflecting the cost of using the grid as a physical storage, complemented with government levies in support of disadvantaged families and green electricity. The purpose of this method is to facilitate the development of PV generation behind the meter in support of the RES policies of the country. This is estimated to save each participating household 80% on its electricity bill. A second scheme for the installation of a further 3,000 photovoltaic systems of 3 kW each (but without a grant) was also announced and implemented in 2013.

In 2014, the Ministry of Energy, Commerce, Industry and Tourism announced similar support schemes for the installation of photovoltaic systems of 3 kW each by vulnerable households (with a state grant) and by non-vulnerable households and local government authorities (without a state grant). Another support scheme was announced in 2014 for auto-generating photovoltaic systems. This scheme involves the installation of PV and biomass systems, which are used in commercial and industrial units for the production of electric energy for own-use. The range of power installed was 10 kW to 500 kW and the maximum power of each system cannot exceed the 80% of the maximum demand of the consumer, except for the installations that provide adequate storage systems that are allowed to go up to 100% of their maximum demand. In this tariff a capacity payment is in place for covering the cost of the grid in support of the needs of the consumer throughout the night and year.

This capacity payment is further complimented with the corresponding levies for handicapped families and green electricity.
In 2015, the Ministry of Energy, Commerce, Industry and Tourism announced a new scheme for the promotion of the installation of photovoltaic systems, which was amended in 2016, in relation to the following three categories:

- photovoltaic systems of up to 5 kW which are connected to the grid of the EAC via net metering with a total available power of 23 MW for:
  - vulnerable households, to which a grant of €900 per kW is given (1.2 MW);
  - non-vulnerable households, without the provision of a grant (8.8 MW); and
  - non-domestic consumers, including businesses in the sectors of agriculture, livestock breeding, fisheries and aquaculture, without the provision of a grant (13 MW);
- auto-generating photovoltaic systems of up to 10 MW each in commercial and industrial units, with a total available power of 40 MW; and
- auto-generating photovoltaic systems which are not connected to the grid (where every consumer has a right to submit an application for this category).

Renewables up until now are entitled of dispatch priority. Current call however, and future ones will require prospective RES generators to operate through the market rules like any other generator. Grid rules of Cyprus require as mandatory all the technical requirements of the VDE and BDEW standards/ codes of practice offering the quality service to the grid for the smooth penetration of intermittent PV. The adjustment of active power is based on the frequency. More specifically, if the frequency of the system exceeds the limit of 50.2 Hz, then the active power of the PV system will decrease by 4% for every 0.1 Hz increase. If the frequency reached 51.5 Hz then the PV is disconnected within 200 ms. In cases of automatic disconnection, the re-connection of the PV system will take place after the passing of 3 minutes from the restoration of the electric power and according to a gradual increase of power which will be 10% of the maximum power per minute.
The maximum capacity for all RES technologies is set at 212.5 MW (ch.6 SSRES 2017)[6] [7], which is distributed accordingly:

- PV: 120 MW (max. capacity for each plant: 8 MW)
- Wind energy: 17.5 MW
- Biomass: 5 MW
- CSP: 50 MW
- Wave: 20 MW

4.3.3 Regulation for Storage

Currently, there is no regulation regarding battery storage while the electric charging points are limited to only 18 and spread throughout Cyprus with a central system that offers all automated facilities to manage charging options and variations in tariffs. E-charging is allowed using the normal commercial tariff system.

4.3.4 Smart Metering

Currently, there is no legislation imposing mandatory rollout of smart metering in Cyprus. However, current legislation does not restrict the development of a smart metering market. The DSO is ushering out the first phase of smart metering, rolling out a pilot scheme to replace existing damp meters with smart meters, instigating the full transformation from passive to active smart grids. Three-thousand smart meters will be connected to a Meter Data Management System and data will be collected from residential, commercial and industrial customers over the next phase of the project (Efthymiou 2012). Additionally, CERA (2018) has taken a decision for a full rollout of smart meters agreeing with the

[6] See www.mcit.gov.cy/mcit/EnergySe.nsf/All/24D7A7A5980258B7C225822F0023CCEC/$file/Update%20of%20the%20National%20Action%20Plan%202020.pdf
[7] See www.mcit.gov.cy/mcit/EnergySe.nsf/All/66ECFCBBA9BE2BE0C22581AE0030D439?OpenDocument

DSO an installation programme that will last 10 years, aiming to complete smart meter rollout by 2028.

4.3.5 Electricity Trading

TSOC has exclusive obligations to operate, synchronise and control the transmission system using impartial, non-discriminatory criteria. Its role is to ensure the property maintenance and development of the electricity network and to arrange for the trading of electricity on a daily basis. The TSOC coordinates actions for maintaining a continuity of supply to consumers for an efficient, coordinated, safe, reliable and economically viable transmission system. Despite the liberalisation of the electricity market, Cyprus' electricity market is still a monopolistic one. EAC is the only conventional generator and supplier of electricity at the moment. The related rules and regulation for electricity trading consists of the Market Rules and the Trading and Settlement Rules. The Trading and Settlement Rules are prepared by the TSOC in consultation with Trading and Settlement Rules Committee and are approved by CERA and the Minister. These rules enable the TSOC to fulfil its obligations and regulate the means by which participants may trade energy. The Market Rules govern the instrument prices and other terms and conditions and apply whenever authorisation holders buy or sell electricity though arrangements operated by the TSOC. The Market Rules aim to foster efficiency and competition in the purchase and sale of electricity through arrangements and are binding on EAC and TSOC. There are no restrictions as to who may apply to the TSOC to accede to the trading and settlement framework agreement that is approved by CERA.

4.3.6 Wholesale and Balancing Market

As prescribed by the market rules, bilateral energy contracts are concluded between the TSOC and the market participants. A wholesale and a balancing market have been established by the Trading and Settlement Rules. The TSOC will enter into proper purchase or sale contracts to achieve the obligatory balance whenever there is an imbalance of net supply and demand in the market. Due to the absence of any competition, the wholesale market and balancing market cannot function yet (Transmission Systrem Operator Cyprus 2011). Consequently, Demand Response (DR) is not covered by regulation nor the Grid Rules or the market rules of the country. Nevertheless, it is currently being discussed to be introduced in the summer of 2019.

4.4 France

4.4.1 Market participants

The main actors for demand response in France are the aggregators, the customers, the retailers/BRPs, the TSOs and DSOs. The French regulator is the French Energy Regulatory Commission CRE, which also plays an important role for demand response deployment, as will be discussed in the following sections.

In France, both the ancillary services and the wholesale market are open to demand response. This is mainly due to the fact that in 2013 the relations between aggregators and retailers/BRPs have been regulated and there is a standardized framework for the responsibilities of the different actors. In fact, France is one of the few countries with a clear framework on the role and responsibilities of the aggregator. A main barrier for the wholesale market is the high retailer's sourcing costs, since almost all revenues must be paid back to the retailer by the aggregator and consumers. Such costs involve the purchase of electricity in advance of the actual consumption by the BRPs in order to ensure enough amounts of energy so as to keep the balance (Bertoldi et al. 2016).

Residential consumers are also participating in demand response programs. In fact, residential consumers have been participating since 2007, whereas industrial consumers have taken part in since 2003. Although the major part of the demand response participants is industrial consumers, there are also around 10,000 residential customers involved (SEDC 2017).

There are specific programs for demand response (see following sections), like the primary reserve (FCR) and the secondary reserve (aFRR) that are in place; these two programs have been accessible to load participation since July 2014.

A particular program, the NEBEF, which was initiated in 2014, created a mechanism that allows curtailed load to bid as energy directly into the wholesale market. The first year a relatively small amount of energy has been the result of this program (313 MWh) and a small profit was made for the aggregators mainly due to the fact that sourcing costs need to be paid to the retailer(s). However, this value has risen in the years to follow.

Another issue raised, is the fact that open competition is questioned, since EDF is the only significant buyer and the main seller in the market. Consequently, EDF will be buying and selling to itself and any aggregator looking to provide resources will need to compete with EDF's own generation fleet (Bertoldi et al. 2016).

DSOs participate in demand response mainly through projects, whereas they are not able to contract flexibility for constraint management. The performance of the DSO is taken into account by the regulatory framework that includes also its operating costs (OPEX) (SEDC 2017). With respect to tariffs, critical peak pricing is introduced apart from the Time of Use tariffs, which are available. This critical peak pricing implies that customers can reduce their loads with a one-day notice signal for some days a year. The regulator (CRE) played an important role in this point, since they introduced this critical peak pricing for the medium voltage delivery point (1 kV – 50 kV) (Bertoldi et al. 2016 and SEDC 2017). A barrier for the deployment of demand response is that DSOs (like EDF) prefer to invest in network infrastructure rather than programs like demand response (Bertoldi et al. 2016).

An important facilitator of demand response is that, unlike the Belgian case, the aggregator does not require the consent of the retailer/BRP in order to reach each customer for load management.

An important demand response aggregator in France is Voltalis, which manages 500 MW of load distributed through 100,000 members. Although the integration is not perceived well by utilities, Voltalis offers free metering devices which facilitate the coexistence of different actors. In exchange, they are allowed to modify the consumption load. The concept is that they have a central platform that interacts with a device within the customer premises, which controls and monitors several appliances (DREAM-GO 2017).

4.4.2 Specific conditions for the participation in the flexibility market

Independent aggregation is enabled in France and standardised processes have been put in place between the BRP/retailer and aggregator. Since 2014, there is no need for consumers or aggregators to contract with a BRP in order to provide its flexibility to the markets (balancing, NEBEF, capacity mechanisms). In addition, there is a law indicating that the aggregator(s) should provide compensation

to the retailers/BRPs for the sourcing costs of the supplied energy. The aggregators find this a fair solution, in principle, since it enables the smooth integration of customers and aggregators in the demand response activities (Bertoldi et al. 2016).
The aggregator acts as a mediator for customers, evaluating the aggregated load and eliminating the need for them to have technical pre-qualification procedures. The TSO has adjusted programs' requirements to accommodate the capabilities of the demand side (SEDC 2017).

For the ancillary services market, it is considered difficult to enter. Possible reasons for this are:

- Large minimum bid – 10 MW aggregated load instead of the standard 5 or 3 MW.
- Annual bidding that hinders granular decision making.

In addition, aggregation possibilities are limited (not all sites can be aggregated with other sites).

There are particular requirements/conditions for some demand response programs. Participation of demand response to FCR and aFRR is only possible through a secondary market. For this reason, consumers and aggregators have to sign bilateral contracts with producers (generators) to sell them their products (Bertoldi et al. 2016). In addition, prequalification is required for these programs as well as for the mFRR. TSO performs the prequalification procedure, which is followed by validation of the portfolio's capacity. Specifically for NEBEF, it allows loads to participate in the day ahead and in intraday market. Prequalification is performed in order to evaluate the capability of the aggregator for load management. Qualification is also required for the DR RR program so as to participate in the balancing market or NEBEF.
Regarding the penalties, these are not proportional to availability payment but to the spot price for the FCR, aFRR and mFRR products. Unavailability is covered by the national secondary market. On the other hand, penalties are proportional to availability revenues for the DR RR product (SEDC 2017).
In general, for the demand response activation on the balancing and ancillary services, a 20% tolerance on delivery is in place for loads lower than 50 MW. On the other hand, for the activation of demand response on the wholesale market, over or under delivery can lead to imbalances and to the imbalance price (SEDC 2017).
Specifically for residential participation in demand response, there was a premium for the reductions in consumption that can be provided. In 2015, the premium was set to 16 €/MWh during daytime (7-23) and 2 €/MWh during night. Taxes included in the electricity tariffs were used to finance this premium. However, this has been cancelled by a decision from the Conseil d'Etat (Supreme Court for administrative justice) taken on the 16 March 2016. Some provisions on residential demand response are still under discussion at this stage (Bertoldi et al. 2016 and SEDC 2017).

4.4.3 Programmes and products

One of the main TSOs in France is RTE. Their products are adjusted to demand response and have been enhanced to allow for aggregation more easily, no matter what the type of network, electricity retailer, BRP etc. The following tables show the programs/products requirements and specifications in the wholesale market.

Table 3 Product requirements in the French wholesale market (SEDC 2017)

Product	Market place	Minimum size (MW)
Day Ahead	EPEX Spot	0,1 MW
Intraday	EPEX Spot	0,1 MW
NEBEF (DA & ID)	EPEX Spot	0,1 MW

Table 4 Product specifications in the wholesale market (SEDC 2017)

ENTSO-E's terminology	Market Place	Total bids volumes	Load access & participation	Aggregated load accepted	Aggregated generation
Day Ahead	EPEX Spot	106.4 TWh in 2015	Yes Through NEBEF (1.5 GWh in 2015, 10 GWh in 2016)	Yes (NEBEF)	YES
Intraday	EPEX Spot	5.43 TWh in 2015	Yes Through NEBEF (started Jan 2017)	Yes Through NEBEF (started Jan 2017)	YES

In France, generators and Demand Response providers can bid on EPEX Spot. This platform uses marginal price ('pay-as-clear') as clearing price.
The main products with respect to demand response are listed in the following table.

Table 5 List of balancing market products (Bertoldi et al. 2016 and SEDC 2017)

ENTSO-E's terminology	TSO's terminology	Total Capacity contracted	Load access & participation	Aggregated Load accepted
FCR	Primary Control	600-700 MW	(~60MW) through FCR cooperation	through FCR cooperation
aFRR	Secondary control	600-1000 MW	Q3-Q4 2016 for around 10 MW	Yes
mFRR	Fast Reserve	Max 1000 MW	480 MW	Yes
RR	Complementary Reserve	Max 500 MW	480 MW	Yes
DSR-RR	Demand response call for tender	Yes	Yes	Yes
Capacity mechanism	Capacity mechanism	89.7 GW	2017: 1700 MW of certified exchangeable capacities and 800 MW of capacity obligation reduction from retailers	Yes

The programs/products are described as follows:

- **FCR** (*Primary Control*) **and aFRR** (*Secondary Control*)**.** Minimum schedules for FCR & aFRR are 1MW. FCR & aFRR are mandatory symmetrical products. From July 2014, demand response participation is limited to the transmission grid and is based on bilateral contracts with generators (Bertoldi et al. 2016). The FCR program is directly open to demand response, whereas the aFRR program indicates that the larger generators can sub contract their provision in a secondary market (SEDC 2017).
- **mFRR** (*fast reserves*) **and RR.** The minimum bid is set at 10 MW for mFRR and RR since April 2014. Although this is not the 1-5 MW requirement achieved in most demand response friendly markets in Europe, it is a significant improvement over the earlier 50 MW requirement. There have been experiments for applying lower values (1-10 MW). As for the availability within mFRR, the RTE tender allows much flexibility; participation is not required always, but only for certain days. These two programs/products can include consumers located at the distribution level (SEDC 2017).

The activations of demand response are performed by the TSO, while the retailers are free to offer tariffs. The demand response program can be run by the TSO or DSO, depending on the tariff. The retailers can offer non-regulated tariffs with the same type of options based on the wholesale electricity market prices (SEDC 2017).

The French DSO (Enedis, former ERDF) has participated in demand response in terms of several pilot projects. Both industrial and residential demand response are applied in terms of the projects. In general, demand response has been limited to locations near the transmission grid. The consumers connected to the distribution network are also able to participate in demand response, whereas the load volumes and their origin are notified to RTE. Specific consumers with a curtailment clause in their retailer contract are blocked from participating in demand response, unless the curtailment period is before the demand response program and it is technically possible to measure the volume of demand response.

With respect to bids, these should refer either to aggregated generation only or to aggregated demand only. They cannot be included into one offer, which could be considered a barrier for further development, since demand response could be well combined with the variable output energy given by renewable energy sources (SEDC 2017). The main balancing product requirements accessible to demand response as well as the payment requirements are summarized in the following tables.

Table 6 Product requirements (SEDC 2017)

Product	Minimum size (MW)	Notification Time	Activation	Triggered (max. times)
Primary Control (FCR)	1 MW	< 30 s	automatic	Triggered continuously
Secondary Control (aFRR)	1 MW	< 400 s	automatic	Unlimited
Fast Reserves (mFRR)	10 MW	13 min	manual	Unlimited
Complementary Reserves (RR)	10 MW	30 min	manual	Unlimited
DR Call for tender (DSR – RR)	1 MW	2 h	manual (ongoing works on automation)	Up to 40 days/year

Table 7 Payment requirements (SEDC 2017)

Product	Availability payments	Utilisation payments	Access
Primary Control (FCR)	According to bid	According to spot price	Weekly tender together with AT, DE, NL & CH TSOs (from 17 January 2017)
Secondary Control (aFRR)	160 k€/MW/y for obligations. Free deals on secondary market.	Spot price	Obligation to provide (or contract a substitute) for generators, DSR participation through secondary market only; pro rata activation
Fast Reserves (mFRR)	24 k€/MW (2017)	Free bid price	Merit order based (energy)
Complementary Reserves (RR)	16 k€/MW (2017)	Free bid price	Merit order based (energy)
DSR-RR	12-20 €/MW/year114	100 €, 150 € or 200 €; or spot price based formula (min. 65 € and max. 500 €/MWh)	Merit order based (energy)
Balancing Mechanism	*Not available*	Free bids	Merit order based

4.4.4 Market mechanisms and business cases

In this section we present some characteristics of different markets and their financial adjustments.

Wholesale market

The wholesale market includes the NEBEF mechanism. The demand response operator is required to sign an agreement with the TSO in order to provide flexibility through NEBEF. The available demand response volumes are provided in specific hours within the day. One of the issues is that demand response based on retail prices has been valued based on wholesale electricity market prices for more than 40 years. Therefore, the low wholesale market prices do not contribute in the deployment of demand response (Bertoldi et al. 2016).

For the remuneration, payment, there are three regimes: there is a contractual arrangement between the demand response operator and the retailer to decide on the payment (contractual regime); the demand response operator makes a financial transfer to the retailer of the curtailed customers stands for the energy component of the retailer price for the ones participating in demand response (regulated regime); the retailer of the consumer that participates in demand response invoices the electricity related to demand response to the consumer or his/her aggregator (corrected consumption regime) (SEDC 2017).

Capacity market:

The capacity market could reveal a better picture of the value of flexibility that can be achieved because of demand response in comparison to the wholesale market. Thus, demand response in this market should be fully implemented. A decentralised market structure is the basis for the capacity market with the obligation that the retailer buys capacity certificates up to the level of their portfolio peak consumption. In the capacity mechanism, demand response can be valued without having to contract with retailers. The EPEX auction where capacity certificates are sold is centralized and anonymous. The capacity product could show the availability of demand response in the market. The NEBEF mechanism can also contribute in effectively activating the capacity products (Bertoldi et al. 2016).

Participation in the market for demand response operators can be guaranteed in two ways: have a contract with retailers or go through a certification process and act independently. The operators can switch from one method to the other in different years (SEDC 2017). Demand response operators are able to go through the certification process closer to real time than generators. Existing generators need to be certified 3 years ahead whilst demand response operators need to be certified only 1 year ahead of the delivery year. Such a solution is useful for demand response operators at it can give them bigger flexibility as far as planning their development is concerned.

Another important factor for the capacity market is that the aggregator is in the position to contract the customers after bidding in the market. Therefore, when the consumer is reached important information can be available, like the price and the possible profits (Bertoldi et al. 2016).

The activations of the capacity products are evaluated through the NEBEF or balancing mechanism. Compensation methods to the BRP are also taken into account. The product shows the availability of demand response (SEDC 2017).

Ancillary services and balancing market:

The participation in the balancing market and the NEBEF program can take place without bilateral contracts with a BRP. On the other hand, participation in the aFRR program can be achieved only through a secondary market; customers and aggregators need to have a contract with producers in order to sell them their products.

The market structure is such that aggregators should make agreements with Enedis who has control of most of the resources for selling and buying. Thus, Enedis owns the generation fleet giving aggregators a large amount of market power. New entries may be difficult to be achieved, but there has been several successful integrations noted.

The issue of compensation needed to be given to retailers/BRPs can result in different problems, for example overcharging of consumers and aggregators or not appropriate compensating retailers. They also pose an issue for residential consumers who tend to save more energy than industrial consumers and who have smaller profit margins per site than and industrial consumer. Another problem is that the providers cannot provide their flexibility for the entire period of time; instead they need to reduce their loads for a specific amount of time and abstain from participation for the following same amount of time (Bertoldi et al. 2016).

For the ancillary services and regarding the loads that are curtailed, they are invoiced in retail price to the consumers connected to the distribution network by the electricity retailer.
The same goes for the balancing mechanism at the transmission grid. At the distribution grid, electricity retailers are compensated from 2014 and onwards either by consumers based on regulated scales approved by the regulator or by a contractual arrangement between the electricity retailer and the demand response operator. In general, it is expected that demand response for customers connected to the distribution grid will be increased in the near future. The TSO makes bids on the balancing mechanism by merit order. The most cost-effective offer is activated, while technical requirements are taken into account (SEDC 2017).

Referring to the baseline methodology and the NEBEF and balancing mechanisms, there are three baseline methodologies available, which are published in the RTE website: based on values before and after the demand response program; historical values calculated statistically during a specific period of time; specific case-by-case method for large portfolios, usually for residential cases.
For the products FCR and aFRR, a different method of measuring and assessing the pool is required due to continuous activations. The performance is usually measured at the pool level; however, only some loads are activated each time of the pool. This can be a problem when it is necessary to validate the performance of a pool. The assessment methods have been adopted from old procedures used for generation assets, and these will need to be adjusted to fit the new situation of demand response.
It should be noticed that France is also part of the group of countries (Austria, Switzerland, The Netherlands and Germany) that have started the joint procurement of primary reserves (SEDC 2017).

4.4.5 Facilitation of demand response

The standardization that sets the relationship between BRPs and aggregators is crucial for the facilitation of demand response. This includes:

- Volumes: Standardised processes for assessment of the traded energy between the BRP and the aggregator.
- Compensation: A price formula to calculate the price for the transferred energy. In the case of demand reduction, the aggregator pays the BRP; in the case of demand enhancement, the BRP pays the aggregator. This price formula should reflect as closely as possible the average sourcing costs of the energy transferred.
- Data exchange: There is information of the data needed to be provided to the BRP through the TSO in order to avoid exchanging sensitive information and so as the respective actors can accomplish their duties.
- Governance structure: An appeals process and an appeals body, in case any issues need to be resolved.

Another fact that is considered to facilitate demand response is that the pooled load needs to fulfil specific requirements as an aggregate. This allows the aggregator to act as a mediator for end customers, whereas they are not freed from going through technical prequalification measures (Bertoldi et al. 2016).

4.4.6 Opportunities of the existing regulatory framework for the application of DELTA services

Participation of residential loads in demand response is still at initial stages and there is a lot to be done and defined for paving the way towards this direction. It has been stated that residential demand response can have a big potential in France, for example through automated electrical heating and could help face capacity issues referring to peak periods. A serious barrier for this capability is the requirement for availability all-year-long instead of peak time periods. In general, residential loads can offer flexibility if aggregated together.

On the other hand, aggregators who work with residential consumers claim that such small loads do not provide with a reasonable profit and they destroy their business model. Thus, there is the tendency to keep residential consumers from accessing the market. The issue has been challenged in court and through the parliament multiple times, by both sides (Bertoldi et al. 2016).

The DELTA architecture can give a solution to this problem, since it deals with nodes that represent multiple consumers; therefore, it can be considered as an optimum opportunity for residential consumers to participate in demand response programs while at the same time, providing with a potential motivation to aggregators to include them. Indeed, the concept of nodes gives another perspective to aggregators, meaning that many residential consumers could be dealt as a bigger consumer, thus opening a new business way for profit.

4.4.7 Further development and trends of framework conditions

There is continuous development in the framework conditions with respect to demand response. A draft decree of the Energy Transition Law that is being examined by the Conseil d’Etat (Court of administrative justice) can give a new financial settlement framework whereby a significant part of the payment to retailers with curtailed customers will be charged to retailers rather than to demand response providers. In addition, a merit order based for secondary control activation is also being discussed but will not be put in place in the short term (targeted implementation date: January 2020) (SEDC 2017).

4.5 Belgium

4.5.1 Market participants

The main actors in Demand Response in the Belgian market are: TSO, DSOs, aggregators, retailers/BRPs and consumers (industrial or residential). Elia is an active TSO in demand response and for this purpose, it has opened 5 of its 8 ancillary services programs to aggregated demand (Bertoldi et al. 2016).

There is also a regulator, CREG. The regulator is expected to issue a standardised payment methodology with respect to the retailer costs (SEDC 2017).

The status of demand response in the country is viewed differently by the various actors. For instance, it is stated by a consumers' representative, that customers have difficulty in assessing the ancillary services markets and that they cannot take part in the wholesale market, even after repeated requests for access. It is also stated that the ancillary services market opening is too limited and it does not depict the needs for improved capacity. For example, participation in the spot market, Belpex, is currently limited only to few large consumers.

On the other hand, the opening of the ancillary services market is considered as an important step for the facilitation of demand response by aggregators. It is noted, nonetheless, that full participation in the balancing markets and the wholesale markets is not possible, because permission from the retailer for a specific customer would be necessary for such an action.

Elia, the Belgium TSO, states that all markets are open to demand response in Belgium, including wholesale. They point out that consumers are able to access the wholesale and balancing markets through their retailer contracts with their retailer.

It can be concluded, that a barrier for demand response is the fact that permission is needed from the retailer in order to access the market, either it concerns a consumer or an aggregator, since the various actors can hold different perspectives for the market entry. This is apparently the main difficulty that needs to be overcome.

Another barrier for demand response can be considered the prequalification process required by the DSO, since it hinders demand response sourcing efficiency for specific programs. This is due to the fact that the DSOs have difficulty evaluating the potential congestion issues linked to market driven behaviour of DSO consumers and therefore tend to be cautious and discriminating towards allowing Demand Response (Bertoldi et al. 2016). In general, DSOs are interested in demand response in order to guarantee the network's stability. They collaborate with TSOs so as to permit their customers to take part in demand response. The procedure of enabling the DSO customers to participate in any demand response program can be long (SEDC 2017). Currently the DSO is able to block or refuse consumer access to demand response without taking responsibility for the costs incurred by the consumer, aggregator and TSO, or even providing transparent measurement and risk calculation (in fact the DSO is not required to take accurate measurements of the risks involved). Therefore, measurement and verification is an area that needs to be improved for the deployment of demand response (Bertoldi et al. 2016).

One of the objectives is to make demand response open for more customers, by fostering their participation in the spot market, Belpex, to which only a limited number of industrial consumers is participating. A new regulation with respect to the role of the aggregator is expected to facilitate demand response, since it will allow the aggregator to interact directly with the consumers without the consent of their retailer.

A demand response aggregator in Belgium is REstore, which operates also in other countries and offers services to industrial, commercial customers as well as utilities and TSOs. It has approximately 1,500 MW of load and among the entities in different countries that collaborate are: Elia (Belgian TSO), RTE (French TSO), National Grid (electricity and gas supplier in UK), Total (multinational oil, gas, solar power in France). It offers demand response services to industries and utilities as well as energy managers. There are no services for residential consumers for the moment. It is expected that the company will grow in the future, thus increasing its load capacity (DREAM-GO 2017).

4.5.2 Specific conditions for the participation in the flexibility market

Wholesale market
Specific conditions need to be fulfilled in order to participate in the wholesale market, which are summarized as follows:

- Make an offer greater to 1 MW
- Have a contract with a retailer or be a retailer

Residential consumers cannot take part in an explicit way in demand response (SEDC 2017).

Ancillary services and balancing market:
There are limitations as to how much load may participate in the ancillary services markets opened by Elia. For example, for the program of demand response, Tertiary Frequency Control (R3), there was a limitation of 60 MW in 2013. Each year the ceiling has been reached and in 2016, the R3 market size has been estimated to cover 50% of the market (200 MW) (Bertoldi et al. 2016).
For balancing services and strategic reserve, a prequalification procedure is required along with an approval from the DSO, given that customers are provided with quarter hourly meters; the customers can be connected to high, medium and low voltage grids (SEDC 2017).

As it has been mentioned in the previous subsection, the aggregator needs the retailer's consent for each customer before going on with demand response. Bilateral contracts can be accepted agreements. Customers cannot choose their aggregator and the retailer has the right to refuse to collaborate with a specific aggregator that the customer has selected. It should be also noted here, that the procedure to become an aggregator is difficult and expensive. A new regulation is expected to settle this issue and remove the barrier for the deployment of demand response. This new regulation indicates that the aggregator should be able to offer demand response services as long as the products fulfil the requirements and after a specific procedure has been followed. The aggregator should sign a contract with the TSO in order to offer such services. Participation will be enabled in the FCR, mFRR and strategic reserve (see next section) (SEDC 2017).

The participation of consumers connected to a DSO is feasible for specific products, like the R3-DP and the SR (from 2015-2016). However, there is a limited interest in including such customers in demand response programs, since this would include taking risks. These risks lie behind the fact that the DSO has the right to block a specific customer from demand response or to refuse offering such services for regional capacity security without the need to reimburse the TSO or aggregator. In addition, the blocking does not need to be justified through measurements, which is a barrier for fostering demand response.

The barrier of the necessity that the aggregator has a contract with the consumer’s retailer/BRP in order to participate in the demand response programs, results in low participation of consumers in the Belpex spot initiative, where demand bids can be entered by consumers. In general, the share of the electricity exchanged in the spot market is low compared to the total market volume (Bertoldi et al. 2016).

In the case of imbalances due to demand response actions, there are compensation options for specific balancing products. For the strategic reserve demand side products and the interruptible contracts - R3 ICH (see next section for the products), the curtailed energy is added back to the BRP’s portfolio; these products are destined for consumers connected to TSOs. The consumer needs to pay the energy curtailed to the BRP. There are demand response products that do not involve adding back the curtailed energy to the BRP’s portfolio, such as the R1-Load, R3-DP and one destined to consumers connected to DSO, the SDR 2015-16. Compensation is foreseen for imbalance. For products like the R1-Load, the R3-DP and the consumers connected to the DSO for the SDR products, there is no payment between aggregators/consumers and retailers (SEDC 2017).

With respect to payments, there are different rules for the various products. For example, for the R1 product, the activation and delivery of the demand response service is paid once. In R3, there is an auction process to arrange the payment, set by the TSO, whereas in the ICH program there is extra payment in order to accomplish the activation. The SR program compensates for activation. The table shows the payments in the balancing market (SEDC 2017).

Balancing and ancillary services

Table 8 Overview of availability and utilisation payments in the balancing market in Belgium (SEDC 2017)

Product	Availability payments	Utilization payments	Access
R1-Load	5-6 €/MW/h	0	Monthly tender
R3-DP	3.07 €/MW/h	0	Tender
R3 ICH	1.41 €/MW/h	linked to the bid prices for upward activation, min of 75 €/MWh	Tender
SDR	not public	68 €/MWh	Yearly tender

There are specific penalties in case the products are not delivered normally, described as follows:

- R1-Load: 130% penalty of the remuneration price
- R3-DP: 130% penalty of the capacity remuneration
- R3-ICH: 120% penalty of the remuneration, when over 3% of missing power reserve occurs
- SR: 130% penalty of the remuneration when there is unavailability; the DSO is also able to block consumer access to demand response

4.5.3 Programmes and products

Belgium is one of the countries that has opened the product requirements to demand response and has enabled aggregated load to participate. The following table gives an overview of the volumes traded in the day ahead and intraday market and the feasibility of including aggregated load or not.

Wholesale market

Table 9 List of balancing market products, including volumes and load accessibility in Belgium (SEDC 2017)

ENTSO-E's terminology	Market Place	Total Volume Traded (2015)[23]	Load Access &Participation	Aggregated Load Accepted
Day Ahead	Belpex	23.7 TWh	✔	✕
Intraday	Belpex	749 GWh	✕	✕

Ancillary services and balancing market

The ancillary services market is open to aggregated demand and there are products for demand response. The following table describes these available products and it can be seen that there are products that allow demand response, like the R1-Load, the R3-DP, the R3 ICH and the SDR, for which some of their specifications (i.e. with respect to penalties and imbalancing compensation) have been described in the previous section.

Table 10 Ancillary Services Markets open to aggregated demand (Bertoldi et al. 2016)

ENTSO-E's terminology	Elia's terminology		Market size	Load access & participation	Aggregated load accepted
FCR	Primary frequency control (R1)	R1-200 mHz	28 MW	No	No
		R1-Down 100-200	27 MW	Yes	
		R1-Load – 100 – 200 (up)	27 MW	27 MW	
aFRR	Secondary reserve (R2)	R2 – Down	140 MW	No	No
		R2 – Up	400 MW	No	No
mFRR	Tertiary frequency control (R3)	R3 – Prod	400 MW	No	No
		R3 – DP		60 MW 200 MW (2016)	
mFRR	Tertiary frequency control Interruptible clients (R3 ICH)		261 MW	261 MW	
RR	Voltage control and reactive power control		2700 MVAr	No	No
RR	Black start		n/a	No	No
RR	Strategic Reserve	SGR	750 MW	No	No
		SGR	97 MW	97 MW	

As it can be observed from the above table, secondary reserve cannot offer demand response, whereas primary and tertiary reserve do so. It is also noticeable that the strategic reserve entails a considerate portion of the demand response in total. This is due to the fact that they wanted to reassure security supply in case nuclear power was not sufficient, since there were noted several failures in some of the nuclear reactors. The Interruptible contract program is dedicated to demand response.

To describe the products more analytically, the following table gives an overview of some of their requirements.

Table 11 Description of some main Product requirements concerning the balancing products accessible to DR in Belgium (SEDC 2017)

Product		Min size (MW)	Notification time	Activation	Triggered (max times)
R1-Load (up)		1 MW	15 sec (50%) 30 sec (100%)	Automatic speed, rotation and frequency control system	No limit, but reasonable number of activations per year, about 80 min/year
R3-DP		1 MW	15 min	Remote control	Max 40 times/year
R3 ICH		1 MW	3 min	Remote control	Not more than 4 times/year
SDR	SDR_4	1 MW	6.5 h (warm-up) + 1.5 h (ramp-down)	TSO's website, day-ahead forecast + intraday correction	Max 40 times/year
	SDR_12	1 MW			Max 20 times/year

R1-Load (Primary Reserve): four products are offered by the TSO, described as follows:

- R1-symmetrical 200 mHz (activated between -200 mHz, +200 mHz)
- R1-symmetrical 100 mHz (between the range [-100, -200] mHz and [100, 200] mHz
- R1-upwards (-200 mHz, -100 mHz)
- R1-downwards (100 mHz, 200 mHz)

Consumption needs to be adjusted for deviations over 100 mHz and the volume should be kept stable for 15 minutes. In this product, load curtailment is combined with down-regulation from generation, which is more cost-effective from up-regulation from generation. This product is evaluated by the TSO with frequency-variation reports, where the activation of the program is verified.

R3-dynamic profile (Tertiary Reserve): The activation can last up to 2 hours, whereas the interval between activations is 12 hours, to avoid having too many activations for each customer. The baseline for this product is the measure of a quarter hour before the event. This product requires a meter with the capability of recording every 15 minutes. Sub-metering has also been introduced for this product for 2015-2016, exclusively to TSO consumers. The R3-DP is a product only for demand response but it competes with R3-Prod (generation). In general, there have been discussions to increase the share of demand response.

R3 ICH (Tertiary Reserve – interruptible service): This program is about to be phased out gradually. There is an interval of 24 hours between interruptions. Three possible levels of service are offered by the TSO:

A4: 4 hours per call, 16 hours per year
A8: 8 hours per call, 24 hours per year
A2: 12 hours per call, 24 hours per year

The product requires a baseline methodology for control and activation.

SR (Strategic Reserve): The 2014-2015 program entailed 100 MW of demand response, contracted for one year. For the winter 2015-2016, its size was increased to 1,500 MW; this number was even higher (3,500 MW), if two of the nuclear plants did not operate. Baselining is required also for this product. There are two programs under this SR program:

Table 12 Description of Strategic Reserves duration and activation characteristics in Belgium (SEDC 2017)

Program	Max duration of one activation	Min duration of one activation	Min time between consecutive activations	Max cumulated duration in winter period
SDR_4	4 hours	1 hour	4 hours	130 hours
SDR_12	12 hours	1 hour	12 hours	130 hours

Apart from these programs/products, there are discussions to open the Day-ahead and Intra-day market along with the setting of a platform for bids through which the different actors can offer their flexibility.

Recently (July 2017), a program was set by the TSO that allowed consumers/aggregators to bid in resources hourly without the requirement to be available on a yearly basis, which has been considered a great enabler of demand response.

4.5.4 Market mechanisms and business cases

In this section, the main market enablers and barriers are mentioned, whereas specific actions to facilitate demand response in the market are also reported.

The TSO Elia has been active in facilitating demand response within the ancillary services markets. For this purpose the primary frequency control has been designed to make the most out of the demand side resources. The market split in three parts: one part suitable for generators and the other two parts for increasing and decreasing consumption. The activation takes place between +/- 100-200 mHz, so as consumers can balance the larger changes in frequency (Bertoldi et al. 2016).

As it has been mentioned in previous sections, the secondary reserve does not offer demand response services. However, it is expected to open gradually until 2019, after the successful implementation of a pilot and following the TSO's SCADA system update (SEDC 2017).

The wholesale and balancing market are closed to demand side resources except if the retailer offers aggregation services to consumers. This is not perceived positively by large industrial consumers who wish to limit their consumption costs and make profit from their flexibility. For large consumers and aggregators to be able to participate in the market, it is necessary that no permission is requested from the retailer to reach each customer.

Another barrier for the deployment of demand response is that tenders take place annually; therefore, large investments are needed so that customers are protected from getting no contract at all. Alternative options should be examined, as for example to realize such bids on a more regular basis (Bertoldi et al. 2016).
With respect to the spot market (Belpex spot), the participants are only a few large industrial customers or some operators that act as an aggregator for small consumers (SEDC 2017).
Regarding the tariff setting, the federal regulatory authority is responsible for the transmission tariffs, whereas the regional regulators are responsible for the distribution tariffs. The payment is done in €/kW for high voltage consumers, whereas customers connected to low voltage may be charged with tariffs different in peak and off-peak hours (SEDC 2017).

4.5.5 Facilitation of demand response

Standardized solutions are needed for Belgium in order to facilitate demand response to enter the wholesale and the balancing market. First of all, demand response should be offered independently from the retailer; in the wholesale market the customer can take part in demand response programs only via a direct agreement with the retailer while in the balancing market, the BRP/retailer’s permission is required to reach each customer. This barrier can be solved through standardized solutions.
In addition, standardized options are necessary for the assessment of volumes, data exchange and compensation between the BRP and aggregator/consumer. Regulatory and policy intervention are required to solve the remaining barriers for the deployment of demand response.
These new regulatory settings are expected to be accomplished in Belgium, which should foster the deployment of demand response (Bertoldi et al. 2016 and SEDC 2017).

4.5.6 Opportunities of the existing regulatory framework for the application of DELTA services

The regulatory framework is under alteration in Belgium. Even though until now it did not favour the residential consumers’ participation in demand response, this is expected to change in the near future. In addition, a large amount of demand response remains inaccessible for aggregation, which is also due to measurement provisions which do not enable full customer load access to the market. Furthermore, it is expected that the right of every customer to participate in flexibility programs without being blocked by the respective retailer/BRP will be protected by a legal framework. A new actor is also anticipated, namely the Flexibility Service Provider (FSP) (Bertoldi et al. 2016 and SEDC 2017).
All these indicate that there is a big potential for residential load and the participation of residential customers is expected to be enhanced. DELTA offers a very good option for the utilization of residential flexibility in demand response, since it enables even small consumers to take part in such programs, by treating a number of end-customers as a node. The fulfilment of the DELTA project will be timed in a period where important barriers are expected to be solved in the Belgian market and thus it can be concluded that there are significant opportunities for the application of DELTA services.

4.5.7 Further development and trends of framework conditions

In 2018, there were no important alterations to the regulatory framework applicable for the regulatory period 2016-2019 in Belgium (Elia 2018).

4.6 Austria

4.6.1 Market participants

Electricity market in Austria encompasses the following market participants (E-Control 2018):

- Transmission system operators (TSOs)
- Control area managers (CAMs)
- Clearing and settlement agents (CSAs)
- Balance responsible parties (BRPs)
- Distribution system operators (DSOs)
- Energy suppliers
- Energy consumers
- Energy producers
- Flexibility service providers (FSPs, production and consumption)
- Electricity wholesalers, electricity retailers
- National Regulatory Authority (NRA)

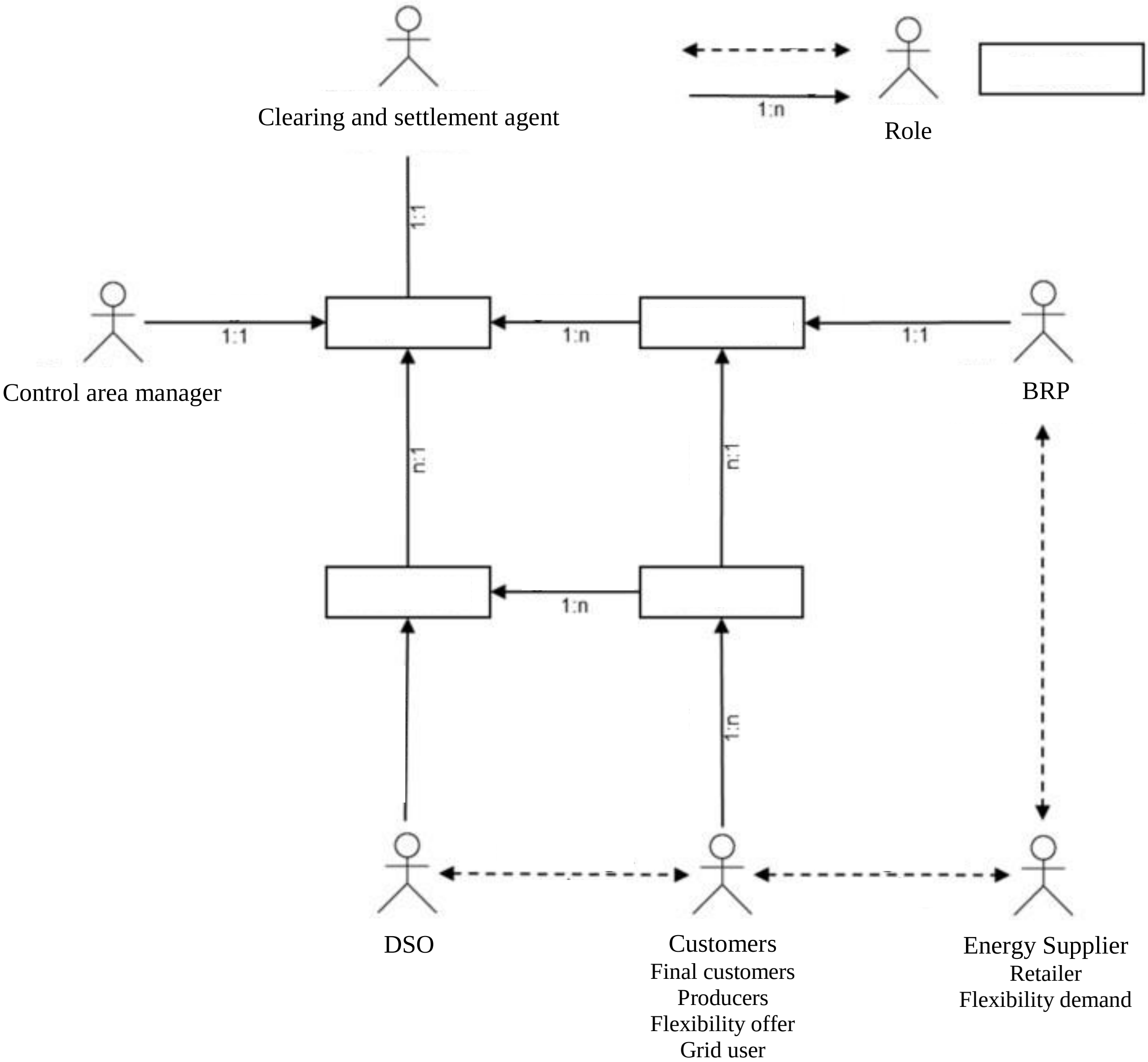

Figure 13 Austrian electricity market model (Source: E-Control 2018, translated)

Transmission system operator (TSO) and control area manager (CAM): Austrian Power Grid AG
Explicit demand response, i.e. the balancing market for the entire country (control area), is organized by the Austrian Power Grid AG (APG). As TSO (110, 220 and 380 kV) it is responsible for the operation, maintenance and developing of the whole Austrian extra high voltage power grid which also includes the tendering of the balancing market. At present, the balancing market is the most important market for flexibility; this will be described in the following chapters.

Distribution system operators
In Austria, 122 distribution grid system operators (DSOs) exist. Their role is focused on operation, maintaining and developing the distribution grid and they have only an indirect influence on the flexibility market. As fluctuations in the energy systems may have a direct impact on the grid, they are interested in reducing these impacts. Grid tariffs are part of the regulated sphere in the electricity market in Austria. DSOs are responsible for the installation of (smart) meters. Functionality of smart meters that will be installed in Austria in the coming years will only allow detailed metering (on a 15 minutes interval only on request of the customer, default interval is 1 day, by opting-out it will be 1 year) but beyond metering they will not have any functionality to remotely switch on or off any devices. As part of the regulated area, DSOs are not allowed to participate in the electricity wholesale market.

Balance Groups, Balance Responsible Parties (BRPs)
Balance groups are the main elements of the Austrian electricity system. Balance groups consist of energy providers and consumers that form a virtual group within which supply (supply schedules) and demand (delivery schedules) have to be balanced. Daily schedules are reported regularly to the control area manager. All market players are obliged to join a balance group directly or indirectly (e.g. final consumers that have a contract with an energy suppliers). The purpose of a balance group is to balance supply and demand fluctuations within the group as far as possible. Remaining deviations of all balance groups are reported to the clearing and settlement agent. The sum of the deviations of all balance groups is then sent to the control area manager who is responsible for tendering the remaining imbalance on the balancing market.

Energy Suppliers
Energy suppliers sell self-produced or traded electricity to their customers. Since October 2001 distribution system operators are obliged to grant all energy-suppliers access to their networks in a non-discriminatory way. All energy consumers have the right to select their preferred energy supplier. Structure of offered tariffs and other conditions of delivery are not regulated and can be agreed between the parties.

Energy wholesalers, energy retailers
Energy retailers are market participants that buy electricity from other market participants and sell electricity.

Energy producers, utilities
Traditionally, only a few large utilities participated in the balancing market. This has changed during the last years, where rules for participation in the balancing market were amended several times in order to open the market.

Energy consumers
In principle, it is not forbidden for energy consumers to participate in the flexibility market. However, in practice only large industrial facilities offer their loads on this market, be it on the wholesale or the balancing market.

Flexibility system providers (FSP)
In most cases, demand side flexibility is not provided directly on the market. So called aggregators merge flexible loads of various energy consumers (and/or producers) in order to be able to fulfil the technical requirements to participate on the flexibility market (mainly on the balancing market).

Regulator: E-Control
The Austrian regulator, the E-Control, plays an important role for the development of the flexibility market. It is responsible for the definition and further development of the market rules in the non-regulated area and it defines the tariffs for the grid that is part of the regulated area. The regulator aims to increase transparency and competitiveness of the market. As market integration is one of the main strategic goals, it closely collaborates on the European (e.g. as member of CEER and ACER) as well as on the regional level.

4.6.2 Specific conditions for the participation in the flexibility market

According to Austrian regulations, all parts of the flexibility markets are open with the exception of the primary control, which is only available to large power plants. However, in practice there are several restrictions and barriers for full participation of demand response in the electricity market.

Implicit Demand Response
The major precondition for the development of implicit demand response, i.e. time-of-use tariffs or similar models, is the availability of smart meters, where the roll-out started and will be continued in the coming years. Currently (2018) appr. 10% of energy consumers are equipped with smart meters. In any case, default setting is metering (and communicating) daily energy consumption data but consumers may select an opt-in, where 15 minutes data will be processed. It will also be possible to opt-out with metering only annual data, i.e. providing energy consumption data once a year making it impossible for demand response applications. Smart meters in Austria of the first generation will only be able to meter energy consumption; there is no additional functionality like bi-directional information exchange. Larger consumers with an agreed power above 50 kW or an annual energy consumption of more than 100.000 kWh are already equipped with load meters with similar functionality as smart meters.

Wholesale market
Participation in the wholesale market requires a certain size, approval by official bodies and economic strength. Final consumers can participate in this market indirectly via energy retailers which can be energy providers, balancing responsible parties, aggregators or operators of virtual power plants. All energy providers are directly part of a balance group whereas energy consumers may be members of balancing groups only indirectly via their energy providers. Offering demand response on the market requires bilateral agreements between energy consumers, energy providers and balancing responsible parties which create a significant obstacle to enter the market (SEDC 2017). The largest share of energy (appr. 75%) is traded over-the-counter (OTC) where bilateral agreements are necessary. Specific conditions have to be fulfilled for a direct participation at the energy stock market (European Energy Exchange EEX; DIHK/EFET 2018). According to EEX stock regulations and Stock Exchange Law brokers have to prove an exam, equity has to be larger than 50.000 EUR, IT connection has to fulfill specific technical requirements and they have to be approved as brokers by the European Clearing AG (ECC). In fact, administrative and financial requirements of accreditation and organisation are very high, hence, beside large energy retailers, financial institutions etc. only large industrial companies are able to directly participate. Furthermore, brokers have to establish an own balance group which leads to additional administrative efforts.

Balancing and ancillary services
The most attractive markets for demand response from a technical as well as from an economic point of view are the secondary and tertiary control markets. Since 2012, procurement of balancing energy is fully market based in Austria (E-Control 2013). Participation at the secondary and tertiary reserves market requires a contractual agreement with the control area manager (CAM), the APG. In 2014,

preconditions for pre-qualifications were amended, opening the market for direct participation of demand response consumers and aggregators of loads. Beside the agreement with the CAM, aggregators require agreements with BRPs prior to offering flexibility to the balancing market, slowing market development visibly (SEDC 2017). However, templates for contractual agreements are available. Prequalification has to be proven for each market (secondary and/or tertiary control) separately. For aggregators, prequalification is done at the pool level and it is valid for 3 years. Prequalification is necessary to enter into a framework contract with the CAM (APG).

The following table shows the main product requirement from a technical point of view (SEDC 2017):

Table 13 Description of main product requirements for the balancing market in Austria (Source: SEDC 2017)

ENTSO-E's terminology	APG's terminology	Minimum size (MW)	Notification Time	Activation	Triggered (max. times)
FCR	Primary Control	+/-1 MW	< 30 Sec.	Automatic	No limit
aFRR	Secondary Control	5	> 30 Secs < 15 Min.	Automatic	No limit
mFRR	Tertiary Control	1	> 15 Min.	Manual	No limit

Beside the reduction of minimum size of power from 10 MW to 1 MW in 2014 amendments, duration for activation was reduced from 16 to 4 hours, allowing aggregators to participate more easily. However, there are still some regulations that stem from the period before 2014 which focused on large generation plants instead of final consumers offering demand response. E.g. there is still the necessity to have a dedicated telephone line to the TSO which increases cost significantly and reduces the market size.
Grid tariffs have been amended in order to further develop participation of demand response in balancing markets. For the participation in the balancing market a reduced grid tariff is applied. Since January 2018, the reduced grid tariff can also be applied to grid level 7, where small and medium energy consumers are connected.

4.6.3 Programmes and products

Wholesale market

As described above, the wholesale market is open to consumers and aggregators; however, due to requirements only large industrial companies and aggregators with a certain size can participate. Currently, small and medium consumers offering demand response only play a negligible role.

Balancing market

With the exception of the primary control, balancing market is open to final consumers as well as for aggregators, combining all kinds of loads and generation units at the final consumers' side. Both, secondary and tertiary control, are attractive for flexibility service providers (FSPs). In 2017, 7 new market participants entered the balancing market due to changes in the conditions of prequalification and grid tariffs (Vögel/Süßenbacher 2017).

Table 14 Balancing market products in Austria (Source: SEDC 2017)

ENTSO-E's terminology	APG's terminology		Tot. Capacity Contracted	Load Access & Participation	Aggregated Load Accepted	Aggregated Generation
FCR	Primary Control	+ / –	67 MW	✗	✗ *	✗
aFRR	Secondary Control	+	200 MW	✓ n/a	✓ *	✓
		–	200 MW	✓ n/a	✓ *	✓
mFRR	Tertiary Control	+	280 MW	✓ ✓	✓ *	✓
		–	170 MW	✓ ✓	✓ *	✓

* Pooled loads normally comprise distributed generation, backup generation and demand response, as entry level for demand response alone are too high.

All three control energy types are tendered separately with different conditions and different products. As only secondary and tertiary control is accessible for demand response, only these two are described here.

Secondary control (aFRR, automatic frequency restoration reserves)
Secondary control energy is tendered daily, encompassing two different time slices: (1) whole day product (0.00 a.m. to 12 p.m.) and (2) 4-hour time slices (0.00 to 4.00, 4.00 to 8.00, ...).
Tender for day D is opened D-7 at 10.00 a.m. (7 days in advance) and closed D-1 at 8.00 a.m. First bid has be 1 MW or more, minimum amount for following bids must be between 5 and 200 MW (1 MW steps). Bids are accepted according to a price for power in combination with price for energy multiplied by a correction factor, published the day before the tender opens. Remuneration follows the pay-as-bid principle. Activation of secondary control is done according to energy prices.

Tertiary control (mFRR, manual frequency restoration reserves; includes RR, replacement reserves)
In tertiary control energy, two products are tendered: (1) weekly products and (2) daily products. Total volume is +280 MW (positive control power, additional generation, reduced demand/load) and -170 MW (negative control power, reduced generation, additional demand/load).
(1) Weekly products can be offered every Thursday from 9.00 a.m. to 1.00 p.m. Offers have to include prices for power (EUR/MWh) and prices for energy (EUR/MWh) for 4-hour time slices (0.00 to 4.00, 4.00 to 8.00, ...) for all working days or weekend (Saturday and Sunday), separated into negative and positive control energy. First bid has be 1 MW or more (up to 50 MW), minimum amount for following bids must be between 5 and 50 MW (1 MW steps). Bids are accepted according to their prize for power. Remuneration follows the pay-as-bid principle. Energy prices may be adapted daily. Activation of tertiary control is done according to energy prices.
Daily products can be offered on all working days between 8.00 and 10.30 a.m. except for Saturday. Offers are valid for the following day for 4-hour time slices similar to weekly products. Price for energy can be adapted accordingly. Acceptance of bids is similar to weekly products.

4.6.4 Market mechanisms and business cases
"While Demand Response and aggregation is legal, the business case is relatively weak. Aggregators can only attract customers with large amounts of flexible load and/or backup generation (e.g. industry) to contribute to a pool. This is due to the cumbersome rules surrounding market entry, the cost of prequalification and other historical regulations designed for centralised generation units." (Bertoldi 2016)
In 2017, 94 million EUR were spent for the balancing market (including primary control). This was a slight increase compared to 2016. However, in 2014 total expenditures were more than 200 million EUR and in 2015 costs were 143 million EUR. This reduction can be interpreted as a result of

changing framework conditions with an increasing number of market players participation in the balancing market.

4.6.5 Facilitation of demand response

Demand response is seen as an important instrument on the electricity market in Austria. In order to further develop the flexibility market, APG, the control area manager, organizes the so called market forum, where existing and interested market participants come together to discuss the further development of framework conditions of the Austrian balancing market. The market forum takes place 2 to 4 times a year. Contributions from participants are documented and processed by the organisator, APG.
Furthermore, the regulator promotes activities towards the development of framework conditions that foster activities on the flexibility markets. Focus is not only on the balancing market, where the regulator is quite active, but also on the roll-out of smart meters, introduction of a new energy tariff structure where the share of power consumption will increase (in contrast to energy consumption as the main element of the energy bill).

4.6.6 Opportunities of the existing regulatory framework for the application of DELTA services

The main challenge for the application of DELTA flexibility services in Austria is to reduce administrative burden in order to reduce transaction costs. Only this will allow small and medium loads to participate on existing and future flexibility markets. In general, framework conditions allow quite some additional activities; however, expected revenues are still quite low. Standardized contracts and automation of load switching are necessary preconditions.

4.6.7 Further development and trends of framework conditions

Framework conditions for the participation of demand response have continuously improved in the past years. A major step was the amendment of the requirements for prequalification in the balancing market in 2014. Adaptation of new grid tariffs for balancing energy were expanded to all grid levels in January 2018, where small and medium electricity consumers are included in the new scheme now.
By the end of 2017, a new Guideline on Electricity Balancing was set into force (APG 2018) which is expected to further influence the national and international development of the balancing market.
There are still some open tasks that are necessary for a further integration of demand response in the electricity market. Requirements for the prequalification for the balancing market should be further developed. Minimum duration of products (now 4 hour time slices) should be reduced to 1 or 2 hours, amount of minimum power offered should be reduced and paper work could be improved. Market participation still relies on the good will of energy retailers and BRPs which is a major obstacle. Finally, definition of roles of market participants (aggregators, FSP, energy consumers) in the flexibility market and their interactions need further improvements.

4.8 Germany

4.8.1 Market participants

Control area managers

Germany is divided into 4 control areas, where TSOs act as control area managers, responsible for the development, operation and maintenance of their grid. TSOs are: Ampirion, TransnetBW, TenneT, and 50Hertz. Duties and responsibilities of control area managers are defined in the power grid access ordinance (Stromnetzzugangsverordnung, StromNZV) and the transmission codes. Since 2005, all 4 TSO have to co-operate within the joint grid control (Netzregelverbund), where primary and secondary control energy is procured.

Regulator

As Germany's regulatory body, the Bundesnetzagentur (federal grid agency) is responsible for the for compliance with the Energy Act (EnWG) and their respective ordinances. It has the duty to guarantee the liberalisation and deregulation of the markets for energy via non-discriminatory network access and efficient system charges.

Balance Responsible Parties (BRPs)

Market access is organized via more than 5.000 BRP. All market participants have to be members of BRPs directly or indirectly. BRPs can correct their forecasts by trading energy on the intraday market within Germany. The market treats electricity regardless of its source (Penta SGIII 2017).

Flexibility service providers (FSPs)

In 2016, a guideline for independent aggregators was developed, defining framework conditions under the scheme of § 26a StromNZV (power grid access ordinance; 50hertz et al. 2016).

Energy consumers

Energy consumers that want to offer their loads to the flexibility markets need the permission from their energy supplier.

4.8.2 Specific conditions for the participation in the flexibility market

Most markets are open for demand response in Germany; however, due to a long list of barriers, actual participation is almost impossible for demand response.
Due to regulatory barriers, aggregation of demand response is seen as very difficult in Germany. Five different contracts have to be negotiated before entering the market:

- Consumer has to agree on participation
- TSO has to accept prequalification for control energy
- DSO has to agree and confirm prequalification
- BRP of consumer has to agree on schedule exchange and approve prequalification
- Retailer has to agree on payments

Currently there are no standard contracts and some of the parties see aggregators as competitors which lowers their interest for an agreement. In 2016, guidelines for third-party aggregation were published.

4.8.3 Programmes and products

According to Bertoldi (2016), demand response is legal in Germany; however, participation is actually almost impossible, aggregation is only enabled for the retailer. The wholesale market is closed for demand response (direct participation).

Capacity market

Market for capacity reserves is open for generation only.

Wholesale market

The wholesale market is closed for direct participation of demand response. Participation for aggregators of demand response is practically nonexistent and demand response has only a very small share in the portfolio of virtual power plants.

Balancing market and ancillary services
Except for re-dispatch, balancing market is open for demand response. Pooling of technical units is allowed, but prequalification will additionally have to be done on the level of technical units. Pooling across TSO zones is not possible; prequalification has to be processed at the level of one of the 4 control areas where the technical units are connected.
In *primary control reserve* participation practically is nonexistent due to requirements still focusing on large generation units.
For *secondary control reserves*, consumers' participation potential risk is related to grid tariffs for deviations from normal consumption patterns. This constitutes a significant barrier.
Even though technical requirements are lower in the *tertiary control reserves*, grid tariff structure constitutes a relevant market entry barrier.

4.8.4 Market mechanisms and business cases

From 2014 to 2017, the number of participants on the balancing market increased significantly. Number of participants on the secondary control market increased from 20 to 37, on the tertiary control market 52 market players were prequalified in 2017 (2014: 36) (Zehfuss, Kleine 2017).

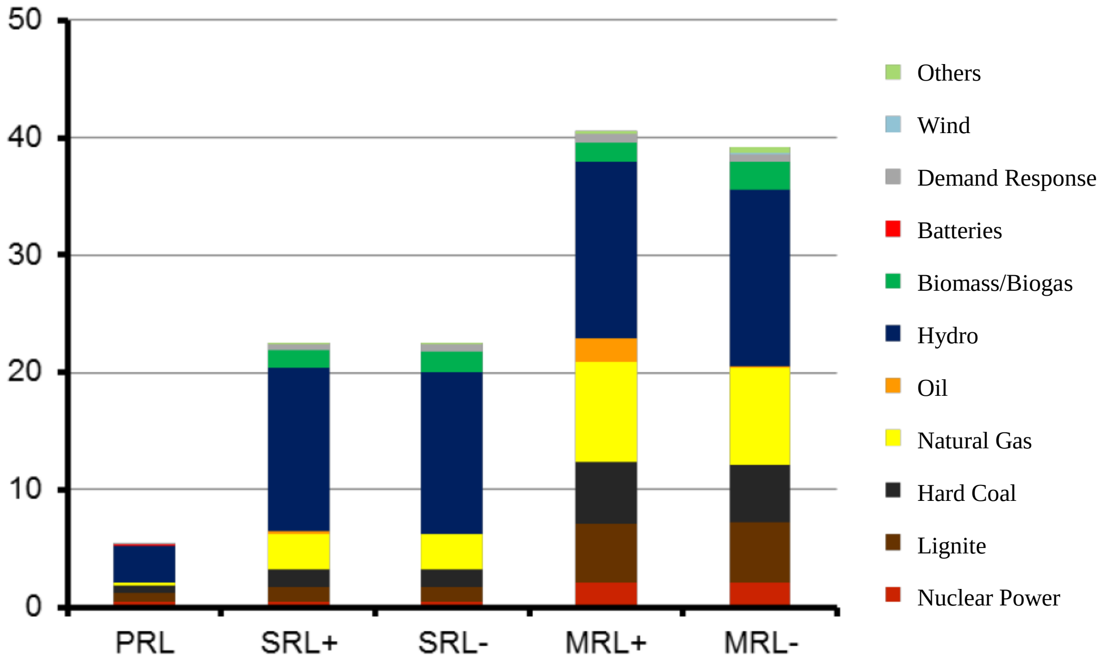

Figure 14 Prequalified power in GW (June 2018) in Germany (PRL - primary control, SRL - secondary control, MRL - tertiary control) (Source: Regelleistung.net 2018)

Only a small share (< 3%) of prequalified power stems from demand response.

4.8.5 Facilitation of demand response

"German Federal Ministry for Economic Affairs and Energy (the BMWi) is aware of the current barriers and is addressing them by running a broad discussion forum and consultation on the policy conditions for the future generation and supply of electricity". (Bertoldi 2017)

4.8.6 Opportunities of the existing regulatory framework for the application of DELTA services

Like in several European countries, demand response has to face numerous barriers. Regulation allows demand response to participate in most of the markets, however, in some cases only indirectly via an independent aggregator or an energy retailer/BRP. Until these major barriers are reduced or eliminated, application of DELTA services will only make sense for very specific cases.

4.8.7 Further development and trends of framework conditions

Further development of framework conditions is documented and concluded in a White Paper published by the Federal Ministry for Economic Affairs and Energy (2015). Implementation of the so called "corrected model" for aggregators (50hertz et al. 2016) should be completed in 2019 (Penta SGIII 2017).

4.9 Greece

4.9.1 Market participants

In this part, the description of the market participants in Greece will be analysed. It should be taken into consideration that the Greek electricity market is currently under transformation, since the operation will change from the mandatory pool to the adoption of the European Target Model. Officially, Greece will be become a Multi-Regional Coupling (MRC) member by Q3 2019. Furthermore, the Trading and Balancing Rulebooks are under public consultation.

Initially, the prices, volumes and number of participants are depicted in Figure 15. From this figure it is obvious that the Greek electricity market can be regarded as a closed market, which is highly regulated.

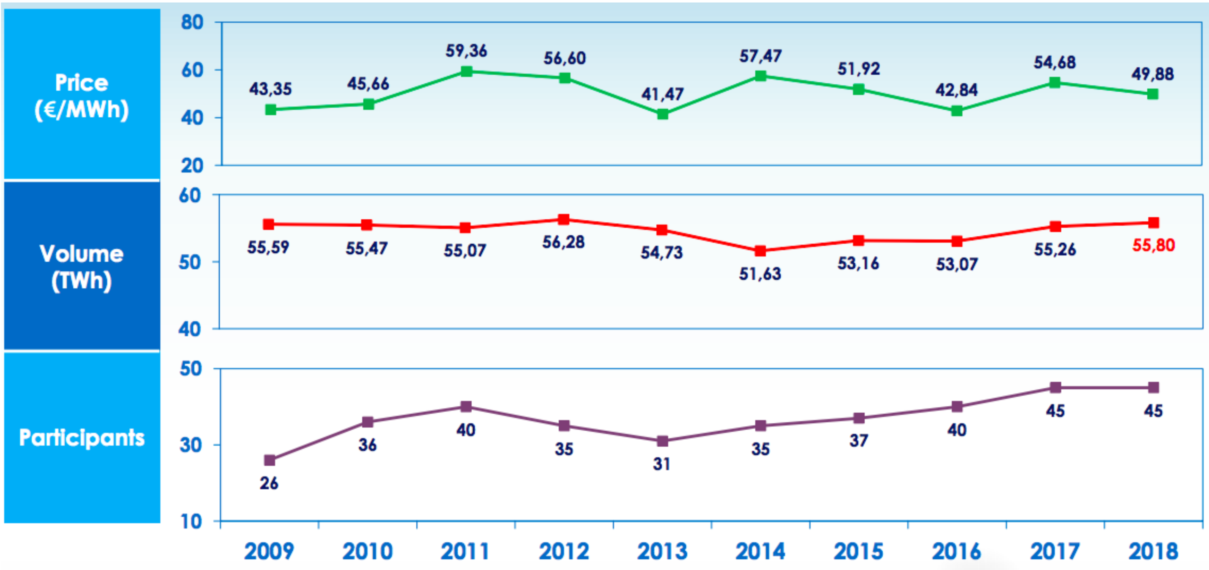

Figure 15 Evolution of energy prices, volumes and number of participants in the Greek Electricity Market

Dominant participant:

A problem of the operation of electricity market in Greece is the existence of a dominant participant, named the Public Power Corporation (PPC). The current market possession exceeds 80%, while the same company owns the lignite and hydro production of the electricity market. However, the target is to decrease gradually the power in order to become lower than 50% in two years' time. For this reason, a regulatory instrument named Forward Electricity Products Auction System (FEPAS) is entered in the Greek electricity market. The operation of this instrument is very similar to the respective forward tool, named "Nouvelle Organnization du Marche de l'Ekectricite (NOME)", which targets to promote competition in the retail electricity market. The regulatory framework is based on Law 4389/2016, which was adopted as a measure equivalent to the structural arrangement of the "small-PCC", meaning to privatize a small part of the PCC.

According to FEPAS, there is a yearly schedule of released energy capacities, which are linked to ambitious retail reduction targets. PCC as a seller of forward products and eligible suppliers enters into a supplementary transaction contract. These auctions have the obligation of physical delivery. Concerning the beginning price of the auction, it is predetermined and approved by the Regulatory Authority of Energy (RAE) and reflects the variable costs of lignite and hydro production. Furthermore, a secondary market is enabled for enabling the efficient market-based reallocation of volumes among suppliers and entry of traders.

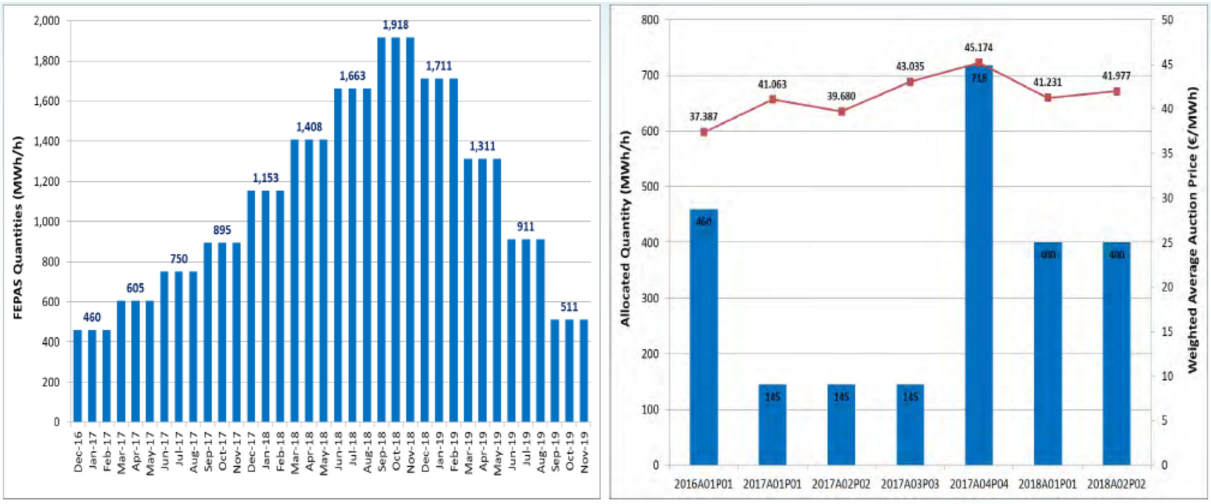

Figure 16 FEPAS quantities and prices

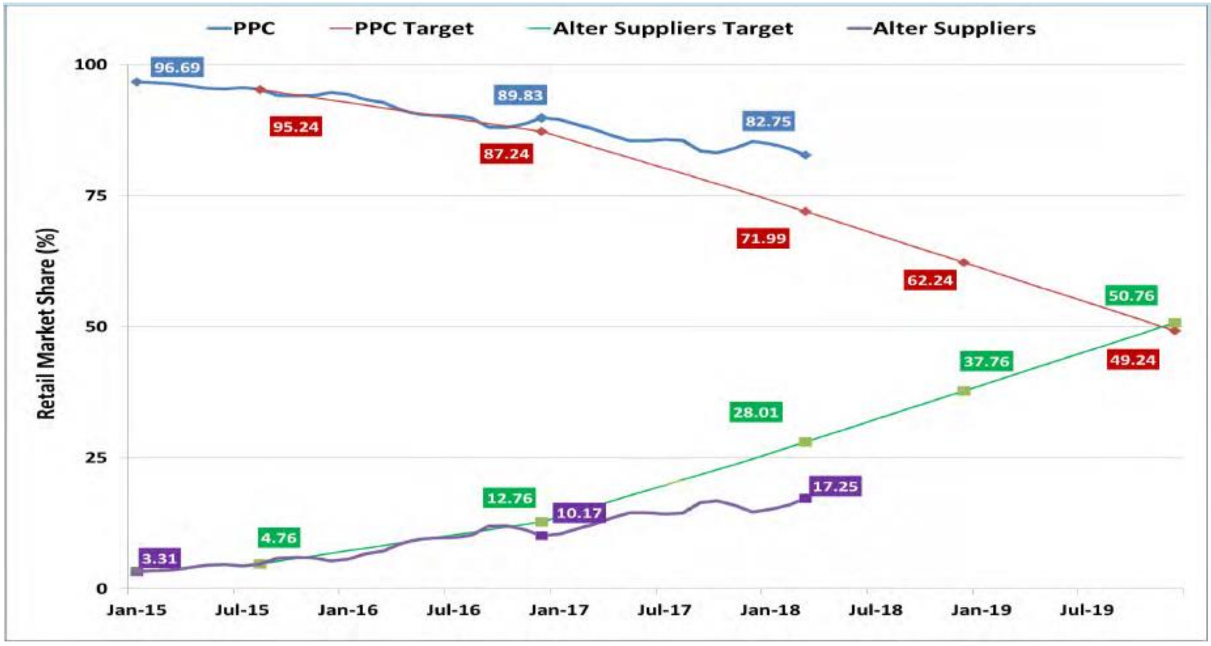

Figure 17 Evolution of incumbent power

Small-scale producers:

Since there is a dominant participant in Greek electricity market, there is not much space for the participation of small producers, as it can be seen from Figure 17. For this reason, the participation is restricted to small RES producers, mainly PV producers. The RES connections to the distribution network appear in Table 15.

Table 15 RES connected to the network (continental network with interconnected islands)

RES Interconnected and islands	Amount	Capacity (MW)
PV Roofs	41,421	374
PV Net Metering	272	4
PV LV	12,857	942

PV MV	1,621	1,220
Small Hydro	104	189
Wind farms	167	927
CHP	24	74
Biogas	22	52
Biomass	3	8
Total	**56,491**	**3,790**

Furthermore, there are RES producers in Non-Interconnected Islands (NII), as presented in Table 16:

Table 16 RES connected to Non-Interconnected Islands

RES in Non-Interconnected Islands	Amount	Capacity (MW)
PV Roofs	3,242	24
PV	1,758	136
Small Hydro	1	0,3
Wind farms	97	323
Total	**5,098**	**483**

Distribution System Operator (DSO)
The Distribution System Operator in Greece is named Hellenic Electricity Distribution Network Operator S.A. (HEDNO) and it is the single one DSO in Greece. HEDNO delivers electricity to 7.4 million consumers across Greece through Medium Voltage (MV) and Low Voltage (LV) networks. It is a large company, employing 7,000 people, while it owns a network of 236,000 km in total. The main responsibilities of HEDNO are the following:

- Operation of distribution network
- Network's inspection and maintenance
- restoration of faults
- provision of services to the users of the network (consumers, producers, suppliers)
- consumption metering
- new connections of consumers and producers
- network development

Regarding the smartening of the distribution network, HEDNO is currently in charge of a project in order to implement the remote-metering and management system for 200,000 electricity supply points of LV consumers. For this reason, the existing conventional meters will be replaced by smart electronic meters, being able to support the remote reading of the metering data. The implementation of this project will contribute to the preparation of the smart meters roll-out nationwide with economical and operational benefits. The customers will have access to real-time information for motivating – through proper incentives- rational electricity consumption, facilitation of competition in the retail electricity market, new business opportunities for energy services companies, facilitation of meter reading and inhibition of energy theft, improved network operation, reduced operational costs, etc.

Electricity Market Operator – Energy Power Exchange
The transformation of the current structure of the Greek Electricity Market is also followed by the establishment of a new company named Hellenic Energy Exchange S.A. (HEnEX S.A.), as a transformation of the former Operator of Electricity Market called LAGIE S.A.
Currently, HEnEX operates only the day-ahead scheduling (DAS), where only the participants from Greece and traders can participate. The DAS is based on co-optimizing the procurement of energy and

ancillary services. An obvious benefit of this procedure is that a more realistic view of the next day's conditions is provided. On the contrary, the complexity of the particular process compared to the energy-only model of the European countries is regarded as a drawback. In the future scheme of PCR, HEnEX will operate the Energy Financial Products Market with physical delivery or cash settlement, the day-ahead market (DAM) and the intra-day market (IDM). The latter will include both intra-day auctions with neighbour countries and continuous trading (operated by DBAG, named XBID IDM market). Furthermore, through the operation of the new electricity markets, new participants will arise, such as RES aggregators and DR aggregators. Such entities are not included in the current structure of the electricity market.
The characteristics of these markets and the respective implementation in Greece are summarized as follows:

- **Day-Ahead Market**: auctions in day D-1 (for physical delivery in day D) for transactions to buy and sell electricity with physical delivery. All transactions are energy financial products with physical delivery. The DAM will be optional for all participants, except for the producers, who are obliged to submit sell orders for the available capacity of the generating units they represent. The nominated energy quantities cannot be already allocated via energy financial products transactions or other transactions concerning wholesale energy products with obligation of physical delivery. Another characteristic of this market is the unit-based rule for offers of conventional power generating units, while the RES aggregators can submit portfolio offers. This specific characteristic was selected in order to reduce the power of the incumbent participant.
- **Intra-Day Market:** regional auctions after the closure of DAM (D-1 and D) for physical delivery at day D. The participation to this market is optional for all participants and will be implemented in two phases. In the first phase, only local intra-day auctions will take place, while in the second phase regional intra-day auctions and continuous trading will be added. In order to be aligned with the Pan-European Intra-Day auctions (PEIDAs), the Complementary Regional Intra-Day Auctions (CRIDAs) will have the same timing the respective PEIDAs.

4.9.2 Specific conditions for the participation in the flexibility market

Regarding the operation of the balancing market, where the flexibility is procured, again the current and the future situation will be distinguished. The responsible party for this market is the Independent Power Transmission Operator (IPTO), named also as ADMIE. The flexibility can be offered by the provision of Ancillary Services (AS). The target is to help the system operators to withstand certain grid issues, such as grid congestion, tripping of a generation units, large transient events, etc.

Current situation

IPTO executes the Dispatch Scheduling (DS) procedure in certain times, when it is needed, in order to adjust the unit commitment, scheduling and ancillary services quantities, corresponding to changes in the system, such as variation in demand or modifications to interconnection flows. Ancillary Services (AS) are categorized in primary, secondary and tertiary reserve, according to the day-ahead schedule (DAS), as modified by DS and in real-time. The target of the ancillary services is to keep the system in balance and respond to contingencies.
Another operation regards the Real-time dispatch (RTD), where the generating units are subject to optimal re-dispatch in real time to meet actual system demand. The design of the Greek market lacks in real-time market and therefore the RTD uses the bids of the day-ahead scheduling. The execution time is every 5 minutes and the results are the economic dispatch for the next 5-min time interval without performing any unit commitment. Additionally, RTD requires a load forecast, which is derived from the hourly load forecast and a load projection based on actual load data, which are derived by the SCADA system operated by IPTO.

Future situation
With the adoption of the Target Model in the Greek electricity market, the balancing market will also be transformed. The adoption of certain ancillary services will take place, which are also available in other European countries towards the integration of the European electricity market. These products are as follows:

- Frequency Containment Reserves (FCR): Active power to contain system frequency after the occurrence of an imbalance within 30 seconds.
- Frequency Restoration Reserves (FRR): second reserves, which are activated in order to replace the FCR in case the frequency deviation lasts longer than 30 seconds.
- Replacement Reserves (RR): reserves, which are manually activated in order to restore the secondary reserved of the system, in cases where the latter have been reduced. RR corresponds to the active power reserved available to restore or support the required level of FRR to be prepared for additional system imbalances.
- Primary Voltage control: automatic local control, activated within milliseconds and can last up to one minute.
- Secondary Voltage Control: voltage regulation at given pilot nodes through the contribution of several local reactive power resources.
- Tertiary Voltage Control: system-wide basis for about 10-30 minutes after a deviation occurrence.
- Black start capability: injection of energy to the system without any electrical energy supply external to the power generating facility.

Table 17 Ancillary services

Ancillary Services	Provider	Capacity
FCR	Generators only	<1MW
aFRR	Generators only	<1MW
mFRR	Generators only	-
RR	Generators only	-
Voltage Control	Production units >2MW (RES are exempted) Transformers	Transmission level
Black start capability	Predefined power plants must provide this service.	Transmission level

4.9.3 Programmes and products

Current structure

- Day-ahead Scheduling (DAS): both energy and ancillary services products
- Dispatch Scheduling (DS): take the products from the DAS market. It will operate in case of an incident.

Products: simple hourly offers (pairs of hourly energy and price)

Future structure

- Day-Ahead Market
- Intra-Day Market
- Balancing and ancillary services market

Products in spot markets (DAM and IDM): simple hourly Orders, block Orders
Products in Balancing market: FCR, aFRR, mFRR

The schedule of the future electricity market in Greece is summarised in Figure 18.

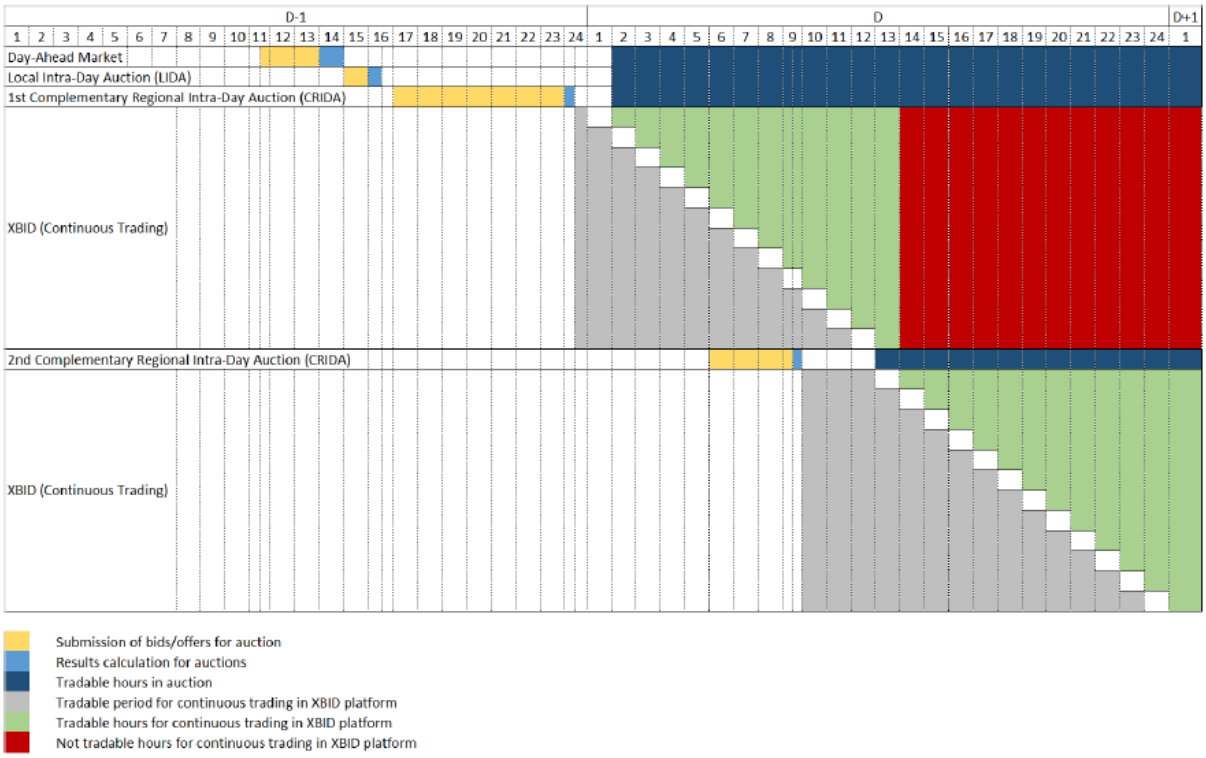

Figure 18 Schedule of the operation of DAM and IDM (spot markets)

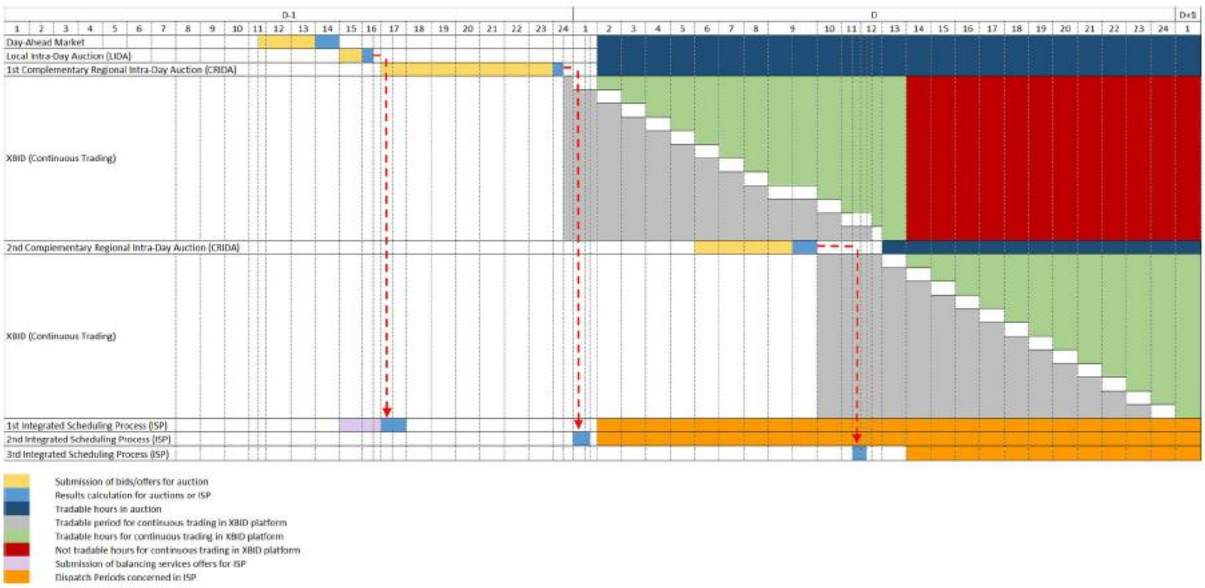

Figure 19 Interconnection between spot markets and balancing market

4.9.4 Market mechanisms and business cases

Currently in Greece there are no available products for flexibility. The tariffs are determined by the energy retailer and usually they are constant throughout the day. Some retailers offer different tariffs for the night consumption.

4.9.5 Facilitation of demand response

The demand response is not currently considered as a market product, which can be traded in the electricity market. However, following the already structure of the future scheme of the electricity market in Greece, the demand response will be available as a product in the Balancing Market, operated by IPTO.

4.9.6 Opportunities of the existing regulatory framework for the application of DELTA services

From the descriptions above the most promising elements are open market for ancillary services, the structure of the day-ahead market and the intraday market offering spot prices possibilities.

4.10 USA

4.10.1 Market participants

The USA has performed significant effort in the development of demand response. Technological innovations and demand response programs already exist in the country. The main actors participating in the market are utilities, retailers, operators and aggregators. The ISO/RTOs (equivalent to TSOs) also play an important role for the deployment of demand response; they reassure the energy transmission throughout the territory they control. Residential consumers have also initiated to access the energy markets in terms of demand response.
Even at the end of the 20th century there were economic incentives for consumers to change their consumption profiles. The fact that they are ahead with the deployment of demand response and initiatives like the implementation of distributed energy resources, is shown by the important established legislation, depicted in Figure 20 (DREAM-GO 2012).

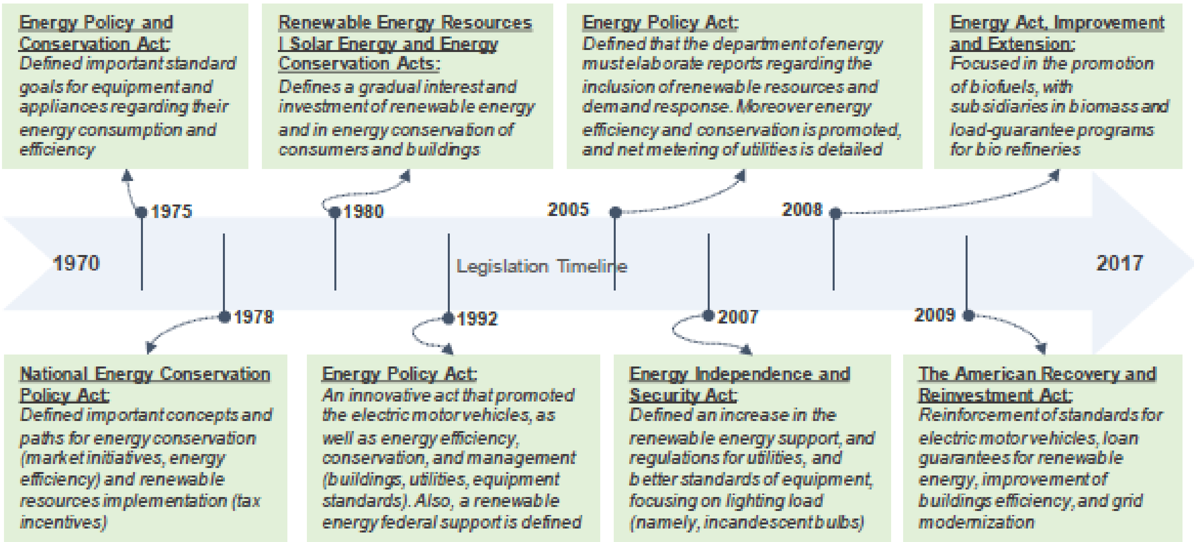

Figure 20 Legislation timeline from the 20th century until now in the USA (DREAM-GO 2012)

It is evident from Figure 20 that actions for the facilitation and the deployment of demand response are already present for many years in the country. Demand response can be offered by many entities in the USA depending on the location of the customers. There are several power markets in the country, as listed in Table 18.

Table 18 Electric power markets in the US and their characteristics (FERC 2015)

Electric Power Market	Acronym	Generation Capacity (GW)	Peak Demand (GW)	Population (Million)	States served
California	CAISO	60,00	50,00	30	2
Midcontinent	MISO	190,54	130,92	48	16
New England	ISO-NE	31,00	28,13	14	6
New York	NYISO	39,04	33,96	20	1
Northwest Power Pool	NWPP	75,96	69,62	14	10
Pennsylvania-New-Jersey-Maryland	PJM	171,65	165,49	61	14
Southeast	-	238,00	170,00	57	10
Southwest	-	50,00	42,00	11	6
Southwest Power Pool	SPP	78,95	45,30	18	14
Electric Reliability Council of Texas	ERCOT	75,96	69,62	24	1
Total		1011,10	805,04	297	80

The regulatory entity in the country is the Federal Energy Regulatory Commission (FERC).
In the USA there is also the North American Electric Reliability Corporation (NERC), which is a nonprofit corporation based in Atlanta, Georgia, and formed on March 28, 2006. It oversees eight regional reliability entities, namely the:

- Florida Reliability Coordinating Council (FRCC)
- Midwest Reliability Organization (MRO)
- Northeast Power Coordinating Council (NPCC)
- Reliability First (RF)
- SERC Reliability Corporation (SERC)
- Texas Reliability Entity (Texas RE)
- Western Electricity Coordinating Council (WECC)

It supervises the reliability of the North American bulk power system and provides an assessment of bulk power system reliability. Regarding demand response, NERC notes when more demand response resources are integrated in the system. It collects demand response data and results and tries to integrate economic demand response. The data is collected twice per year (FERC 2017).

In the USA, there are different ISO/RTOs that operate in different geographical regions. They have different activities in demand response and their products are described in the following sections. The next table shows the demand response programs participation in each of the US ISO/RTOs.

Table 19 Demand Resource Participation in different ISO/RTOs (FERC 2017)

RTO/ISO	2015		2016	
	Demand Resources (MW)	% of peak demand	Demand resources (MW)	% of peak demand
California ISO (CAISO)	2,160	4,4%	1,997	4.3%
Electric Reliability Council of Texas (ERCOT)	2,100	3.0%	2,253	2.9%
ISO New England (ISO-NE)	2,696	11.0%	2,599	10.2%
Midcontinent independent system operator (MISO)	10,563	8.8%	10,721	8.9%
New York independent system operator (NYISO)	1,325	4.3%	1,267	3.9%
PJM Interconnection (PJM)	12,866	9.0%	9,836	6.5%
Southwest Power Pool (SPP)	0	0%	0	0%
Total ISO/RTO	31,710	6.6%	28,673	5.7%

4.10.2 Specific conditions for the participation in the flexibility market

There are specific demand response programs offered by the different ISO/RTOs, which are presented in the following Section. Usually, each of the programs has its own specific conditions for participation in the flexibility market. Such requirements can have similarities when it comes to products of the same ISO/RTO. Here, we present some of these requirements for each ISO/RTO. A more detailed product description follows in Section 4.10.3, where the products are explained along with some of their specifications.

CAISO

The main two programs for demand response offered by CAISO, described in the next section, have a notification time of 1 p.m. of the day before, for the day-ahead market. The ramp time of the resource is considered for the real-time market. For consumers' participation, it is also necessary that adequate equipment is installed at customer premises used for bidding and certification.
There are two entities that can have access to customers' information for the accomplishment of the demand response programs. These are the Load Serving Entity and the Utility Distribution Company.

The Scheduling coordinator can also play the role of the former entity (DREAM-GO 2012 and CAISO 2015).

Regarding penalties, these refer, among others, to payments because of lack of delivering the service as agreed, termination of contract, etc. These penalties involve the customers and their equivalent service providers, like aggregators, DR providers, load serving entities, etc. (DREAM-GO 2012).

MISO
Compensation is foreseen for the programs that MISO offers. For DRR and LMR the location of the consumer plays an important role, whereas for the EDR programs, the bid made by MISO and the additional costs by the emergency request, like start-up and shut-down costs determine the remuneration given (DREAM-GO 2012).

NYISO
In order for consumers to participate in the demand response programs offered by NYISO, the Curtailment Service Providers (CSPs) are needed, since they make the connection between consumers and NYISO.
The programs are distinguished as reliability based and economic based. For the first category, activation is determined by NYISO (EDR and SCR programs – see next section), whereas for the second category, resources choose when to participate (DADR and DSAS programs – see next section). All programs can work with aggregation except for the EDR program, which refers to consumers with lower capacity and allows them to participate in demand response (DREAM-GO 2012).

PJM
Likewise the NYISO case, a Curtailment Service Provider (CSP) is required for the interaction between the consumers and the PJM. This entity can also play the role of an aggregator. One of the requirements for the participation in demand response programs is that the CSP has to do a training module, which will be known to PJM and afterwards participation in demand response is enabled. On the other hand, consumers need to review every year a training module with respect to the requirements, the business rules of the regulation and the synchronized reserve markets (DREAM-GO 2012).

4.10.3 Programmes and products
In general, there has been a lot achieved in the USA and significant programs/products are already there giving information about technical and commercial tools to offer to the clients. In this section we describe the main products offered in the USA and we give details for the programs offered by the ISO/RTO entities. The ISO/RTO entities examined here are: the CAISO, which is the independent system operator for the state of California; the MISO, which operates in the central USA; the ISO-NE, which operates in New England; the NYISO; the PJM; the SPP; and the ERCOT.

Demand response programs are adequately developed in different markets, like the wholesale and the balancing market. They deal with emergency situations and they use the demand resources for ancillary services management – frequency and voltage regulation and system balancing (ERCOT, ISO-NE, NYISO). The programs become available to the market through bids. The ISOs allow for a simplified procedure, by permitting the customers to contact directly with the demand response event organizers. Figure 21 shows the demand response programs in the US considering their type and implementation. It is obvious that there are a lot of “Load controlled” programs, in the sense that the activation of flexibility is determined by the system (MIT 2011).

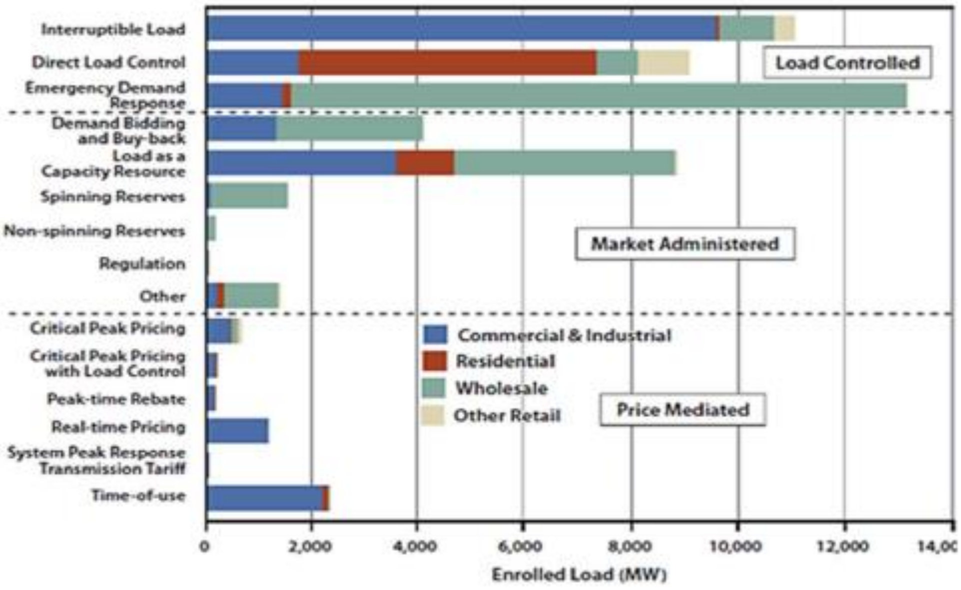

Figure 21 DR programs in US (MIT 2011)

Price-based demand response programs do not attract much the attention of any customers. Advance notification times are usually large (from the day before to several months in advance), while ramp times are small (a bit more than two hours). The programs can be lengthy in time or short, whereas bids are also a factor for this issue.

Many of these programs use messages, such as emails, notifications for communication with the customers. Therefore, they have a manual activation (DREAM-GO 2012).

CAISO

The demand response programs offered by CAISO are summarized in Table 20.

Table 20 Demand response programs offered by CAISO (DREAM-GO 2012)

Program	Conditions
Proxy Demand Resource	• Consumer/aggregator must have a minimum flexibility capacity of 0.1 MW, when • participating in the day-ahead and real-time energy market • 0.5 MW, in the day-ahead and real-time energy non-spinning reserve market • Aggregation is possible, with same conditions as individually
Reliability demand response resource (RDRR)	• Consumer must have a minimum flexibility capacity of 0.5 MW • Ramp time is 40 minutes • Minimum event duration of 1 hour, to a maximum of 4 hours • Load curtailment in discrete steps, i.e. full capacity or not any (max. 50 MW) • Cannot self-provide ancillary services nor ancillary services bids

MISO

The demand response programs offered can participate in the day-ahead, real-time and ancillary services market. The programs are described as follows (DREAM-GO 2012):

- Demand Response Resource (DRR) – type I and type II: Type I refers to interruptible load resource managed by an LSE, whereas Type II refers to flexible load resource, managed by an LSE that allows participation in the day-ahead and real-time reserve market as a controllable load. These programs have an advance time notification of 4 pm of the day before for the day-ahead market.

- Load modifying resource (LMR): it entails two programs, the demand resource which indicates that flexible resources can participate in emergencies as interruptible load or direct load control; the behind-the-meter generation which is designed for customers with generation assets activating them when in emergency.
- Emergency demand response (EDR)

ISO-NE

There are four demand response programs offered (DREAM-GO 2012):

- On-peak: it involves load reductions during peak time period (summer: peak hours for June, July, August: 1 to 5 pm, non-holiday weekdays; winter: peak hours for January and December: 5 to 7 pm, non-holiday weekdays).
- Seasonal peak: it is the same with the on-peak program; peak times are considered the ones, where real-time consumption is greater than 90% of the critical exceeding load value. There is no advance notification time.
- Real-time demand response (RTDR): it refers to a demand bidding program. The minimum reduction is 100 kW and there is an advance notification in the real-time market of 30 minutes, whereas this notification occurs at 4 pm the day before for the day-ahead market.
- Real-time emergency generation (RTEG): it refers to consumers with generation behind the meter. The energy generated is introduced, thus reducing the final load consumption, seen by the energy provider. There is a maximum capacity of 600 MW from demand response resources and there is a notification time of 30 minutes in the real-time market.

NYISO

There are four types of programs offered by NYISO, which are summarized in the following table:

Table 21 Programs offered by NYISO (DREAM-GO 2012)

<table>
<tr><th>Program</th><th>Min Flexibility (MW)</th><th>Advance time</th><th>Ramp Time</th><th>Details</th></tr>
<tr><td>Emergency demand response (EDR)</td><td rowspan="2">0.1</td><td rowspan="2">Day-Ahead advisory</td><td rowspan="2">2 hours</td><td rowspan="2">• Used for energy shortage/reliability risk conditions
• Usually performed by commercial and industrial consumers
• Consumers are paid by the NYISO when requested
• EDR is manual voluntary, while SCR is manual mandatory to participate since the payment is in advance
• EDR only is possible through the interaction with a Curtailment Service Provider, while the SCR needs a Responsible Interface Party
• One consumer cannot participate in both programs at the same time
• EDR minimum payment is 500$/MWh
• Both have a 4-hour minimum for event duration</td></tr>
<tr><td>Special Case Resource (SCR)</td></tr>
</table>

Day-ahead demand response (DADR)	1	Day-ahead by 11h00	-	• Enabled by demand reduction bids in the day-ahead market • Payment at the market clearing price • Minimum payment of 75$/MWh • Activation based on bid
Demand side ancillary services (DSAS)		Day-ahead by 11h00 or in 75 minutes for real time	Immediate/ 10/30 minutes	• Oriented for small consumers, is based on real-time bids (telemetry) for load curtailment, for operating reserve and regulation markets. • Minimum payment of 75$/MWh • Activation based on bid

PJM
The programs offered are described as follows:

Table 22 Programs offered by PJM (DREAM-GO 2012)

Program	Min size (MW)	Advance Time	Ramp Time	Details
Economic Load Response	0.1	up to 2 hours	30 minutes	• Can be used for energy, synchronized, regulation, and day-ahead scheduling reserves with distinct ramp times • Operation conditions are determined by the bid restrictions
Emergency Load Response			1 or 2 hours	• Activation depends upon network conditions and proposed offers
Full emergency Load Response				• Uses the 3 bid types, mentioned above • Is used together with reliability analysis

SPP:
Demand response is used for the wholesale and the retail market. Especially the retail market is more advanced in this sector and it includes more opportunities for demand response through internal and external entities.
With respect to the wholesale market, there is a program, the Variable Dispatch DR (VDDR), which is based on the behind the meter generation, meaning that the consumer has generation possibilities and can use this energy in order to decrease the consumption deriving from the energy provider. There is an advance notification time of 5 minutes and fast ramp up/down durations are necessary, whereas the duration of the program is up to one hour.
Interruptible loads are the main implementation for the retail market, whereas Direct Load Control, Dynamic Pricing and economic programs are also available through consumer service utilities (DREAM-GO 2012).

ERCOT
There are many demand response programs offered by ERCOT. These demand response programs are listed as follows (DREAM-GO 2012):

- Dispatched by ERCOT:
  - Load Resources
    - Ancillary Services
    - Security Constrained Economic Dispatch (SCED)
    - Fast Responding Regulation Service (FRRS)
  - Emergency Response Service (ERS)
- Non-Dispatched by ERCOT:
  - TDSPs Load Management Programs
  - Four Coincident Peak (4CP) Load Reduction

- Price Responsive Demand Response Products
    - Block & Index (B&I)
    - Peak Time Rebate (PTR)
    - Non-Opt-In Entities (NOIEs) Load Control

The ancillary services programs can be further divided:

- Responsive reserves: ERCOT sends an instruction for a 10 minute manual response, when the amount needed is less than or equal to 50%. If a greater amount is needed, then SCED is activated with a ramp time of 5 minutes.
- Regulation up/down: loads are controlled automatically by automated generation control.
- Non-spin reserves: the same with responsive reserves greater than 50%.

The rest of the products are described as follows:

- FRRS: As the name implies, fast responding demand response resources are used. The regulation market is the one to which this program is applied. Participation in this program has not been high.
- ERS: Interruptible loads have been used, which imply that the consumer needs to make the loads available within a time frame of 10 to 30 minutes.
- TDSPs: Price incentives are used to motivate customers in order to reduce their consumption.
- 4CP Load Reduction: When a curtailment of loads during peak hours takes place between June and September, then transmission costs are reduced for the customers. It refers mainly to industrial customers. The transmission cost is higher when consumption is done during peak hours and lower outside.
- Price Responsive: Price signals are sent by aggregators to consumers; such programs refer to the interaction between consumers and aggregators. Dynamic pricing is used, whereas ramp times can be absent, meaning that activation is done directly.

4.10.4 Market mechanisms and business cases

In this Section we will present the way the aforementioned programs work and the relationships between the different actors. The ISO/RTOs will be examined separately.

CAISO

Consumers can participate in demand response programs either directly or through an aggregator. The latter ones are also called Demand Response Service Providers (DRPs). A scheduling coordinator is required for the negotiations, whereas aggregators can also become scheduling coordinators through a certification procedure. The certified scheduling coordinator is also needed for communication and for creating bids with CAISO, in case the customers want to participate directly in demand response programs. The customers also need to become demand service providers for such direct participation in DR programs with CAISO; a proxy demand resource agreement is made between the two actors, consumer and CAISO. Two types of applications are defined for customers (DREAM-GO 2012):

- Demand Response Registration System (DRRS) – enables direct and aggregate interaction with the CAISO, considering also an Application Program Interface (API) that allows data storage of consumer’s participation;
- Demand Response System (DRS) – allows consumers to be automatically managed by the DRS computing, based on the metering data, a demand response energy measurement for both DR programs offered by the CAISO.

MISO

The programs are used in emergency conditions, for example when the grid stability is at risk. The LMR programs need to operate when requested in emergency conditions. DRR Type I takes part in the day-ahead and in the real-time reserve market. DRR Type II takes part also in the ancillary services market. The DRR products are mainly useful for assuring the grid stability, while the LMR are used for emergency situations (DREAM-GO 2012).

NYISO

The different demand response programs described in the previous section can participate in different markets, which are listed as follows (DREAM-GO 2012):

- EDR: wholesale (real-time) and capacity market
- SCR: wholesale (real-time), bilateral contracts and capacity
- DADR: wholesale (day-ahead) market
- DSAS: ancillary services market

PJM

One of the CSP's responsibilities is to assist the consumers regarding the demand response programs. Particularly, two initiatives are presented to the customer, the Day-ahead and the Real-time. For the former initiative, the CSP helps the consumers to make bids into the day-ahead wholesale market, whereas the second initiative implies that information about real-time prices is offered to the consumers, so as to help them decide on a possible load curtailing/shifting when the prices are convenient.

There is also a product offered in case of emergency, during which customers volunteer to cut off their loads for the sake of grid stability. Payment is offered according to the emergency market prices.

Demand response resources can act as spinning reserves for the capacity market. There is a three-year auction for this market, whereas CSPs assist consumers to make their bids. There can be bids of three types: limited product (max 10 activations up to 6 hours duration during emergency in summer); extended product (no limit for the interruptions up to 10 hours between May and October); annual product (no limit for the interruptions between June and May of the next year, up to 10 hours of duration).

Demand reduction bids are also offered by the CSP in other markets, like the synchronised reserve, regulation and day-ahead scheduling reserves market.

There are no programs for the retail market.

Efforts are done in order to include residential consumers in demand response programs (DREAM-GO 2012).

ERCOT

ERCOT has more than 3 GW of capacity for ancillary services. The daily based auctions in this market offer balancing advantages through load resources. There are two options for the programs: they are either managed by ERCOT or by the Transmission and Distribution Service Providers (TDSPs). In case of emergency, ERCOT can use the resources of the TDSPs. The first category (dispatched by ERCOT programs) refers to programs that ERCOT decides when they will be applied and not the consumers or demand response providers. These programs are based on the network security, whereas the second category programs (non-dispatched by ERCOT) are based on tariffs and schedule (DREAM-GO 2012).

According to the NERC regional reliability entities categorization, there are some figures that prove the penetration of demand response to consumers. The following tables show the customer enrolment in incentive-based demand response programs for 2014 and 2015 as well as their enrolment in Time-based demand response programs (FERC 2017).

Table 23 Customer enrolment in incentive based demand response programs (FERC 2017)

Region	Enrolment in Incentive-based Programs		Year-on-Year Change	
	2014	2015	Customers	%
AK	2,428	2,431	3	0%
FRCC	1,490,073	1,271,487	-218,586	-15%
HI	36,102	36,008	-94	0%

MRO	1,227,445	1,205,568	-21,877	-2%
NPCC	51,227	80,884	29,657	58%
RF	2,012,846	1,591,730	-421,116	-21%
SERC	1,303,339	1,410,799	107,460	8%
SPP RE	175,146	204,020	28,874	16%
Texas RE	302,913	307,089	4,176	1%
WECC	2,651,163	2,972,779	321,616	12%
Unspecified	12,947	11,343	-1,604	-12%
Total	9,265,629	9,094,138	-171,491	-2%

Table 24 Customer enrolment in time-based demand response programs (FERC 2017)

Region	Enrolment in Time-based Programs		Year-on-Year Change	
	2014	2015	Customers	%
AK	53	53	0	0%
FRCC	20,069	21,444	1,375	7%
HI	466	538	72	15%
MRO	94,176	129,558	35,382	38%
NPCC	252,323	262,030	9,707	4%
RF	2,553,434	2,923,239	369,805	14%
SERC	203,954	198,627	-5,327	-3%
SPP RE	1,188,004	1,198,489	10,485	1%
Texas RE	49,481	1,867	-47,614	-96%
WECC	2,416,960	2,683,400	266,440	11%
Unspecified	115,906	169,815	53,909	47%
Total	6,894,826	7,589,060	694,234	10%

4.10.5 Facilitation of demand response

Demand response in the USA has been facilitated through legislation and regulatory activities. Legislation and regulation continue to develop for fostering demand response. Lately, here has been a movement towards development of time-of-use rates, and there is the tendency to make them the default option for residential consumers. We list here some of the regulatory actions in different states that facilitate demand response (FERC 2017):

- Arizona: In September 2017, Arizona Public Service Company (APS) applied for approval of its 2018 Demand Side Management Plan with the Arizona Corporation Commission. In this plan, a demand response pilot destined to decrease peak demand has been included.
- California: In 2013, the CPUC (California Public Utilities Commission) set a rulemaking to improve the role of demand response so as to reach the goals for resource needs and operational requirements. In California, there is the observation that demand response is asked more for fast-responding loads rather than for peak-shaving purposes.
- Colorado: In November 2016, the Colorado PUC (Public Utilities Commission) approved a settlement agreement by the Public Service Company of Colorado. In the agreement, it was suggested a new rate schedule, for example, a critical peak price rating for commercial and industrial consumers.
- Hawaii: In July 2017, the Power Supply Improvement Plan Update by the HECO – Hawaiian Electric Companies – was approved, which forecasted around 115 MW available from demand response by 2021.
- Massachusetts/ Rhode island: There has been a partnership of National Grid and some curtailment service providers, CPower, EnerNOC, IPKeys, in order to offer the first demand response program to commercial customers.
- Michigan: In December 2016, the governor of Michigan signed Public Acts 341, 342 which indicate that the load management programs need to be promoted.
- New Mexico: In February 2017, the PRC (Public Regulation Commission) of the state approved the implementation of a demand response pilot program by the El Paso Electric Company.

- New York: In March 2017, an Order on Net Energy Metering Transition was released, indicating new values for demand reduction.
- Texas: In 2016, ERCOT issued a study studying the possibility that desalination projects participate as demand response resources in the market.
- Utah: In June 2017, the electric Vehicle Time-of-Use pilot program was approved by the Utah Public Service Commission along with a study of consumer response to time-varying prices under the proposed rate.
- Virginia: In June 2017, the Dominion energy Virginia's petition was approved by the Virginia State Corporation Commission in order to allow a specific number of customers that was already participating in a dynamic pricing pilot to remain under the rates of the pilot.

4.10.6 Opportunities of the existing regulatory framework for the application of DELTA services

Residential demand response has high potentials in the USA. The following table shows the potential of peak demand savings (MW) from retail demand response programs by region and customer class (FERC 2017). It is obvious that residential demand response has a great potential, since it accounts for more than 25% of the total peak demand savings.

Table 25 Potential peak demand savings (MW) from retail DR programs (FERC 2017)

Region	Customer Class				
	Residential	Commercial	Industrial	Transportation	All Classes
AK	5	13	9	0	27
FRCC	1,575	1,333	338	0	3,247
HI	15	20	0	0	35
MRO	1,989	734	1,789	0	4,509
NPCC	120	354	300	14	787
RF	1,491	754	3,128	0	5,372
SERC	1,906	841	6,512	0	9,259
SPP RE	146	284	1,493	0	1,923
Texas RE	164	345	187	0	696
WECC	1,292	2,311	3,416	0	7,019
All Regions	8,703	6,989	17,169	14	32,875

DELTA proposes a novel concept that would foster participation of residential consumers in demand response programs. It is evident that USA is an active country in the demand response sector, with many programs and on-going legislation that supports such activities. Therefore, the DELTA architecture could be positively perceived in such an open market, where especially residential demand response is recognized as an important factor in peak demand savings.

4.10.7 Further development and trends of framework conditions

In Section 4.10.6 it is obvious that the legislation and the regulatory framework are evolving in the USA. The most recent legislation that supports demand response in different states is presented in Section 4.10.6.

5. Preparedness of the demand side

5.1 Market assessment on switchable devices

To prepare the demand side for a future electricity system and to enable, in particular the participation of small and medium-scale prosumers, the availability of smart switchable devices is a crucial issue. This chapter aims to analyse current trends in the market and in the industry concerning devices enabling external command signals to interfere with their internal control systems (including necessary data exchange between device and virtual node), enabling the device to respond to changing supply in the grid.

The addressed devices include white goods, HVAC systems, heat pumps and energy storage systems. In the end of this chapter the issue of interoperability is discussed. At first it is helpful to have a close look at the term “smart” appliances. Market research reports use different terminologies and categories to classify smart appliances, which makes it difficult to compare figures and trends. The European Committee of Domestic Equipment Manufacturers CECED (Goossens 2018, 33) draws a distinction and defines the term “smart” and the term “connected” as follows:

- Connected appliances can join the Internet, and thereby offer a certain level of interactivity with the user […]. Many connected appliances provide remote access via a smart phone, tablet, or are part of a home automation system.
- Smart appliances (or: energy smart appliances) are connected appliances that embed innovative technologies that allow consumers to supervise their electricity consumption in real time. These appliances create a two-way exchange with the electricity grid. As a result, utilities can provide more efficient power delivery to the home, while increasing the efficiency of the entire grid […].

VITO et al. (2017, 9) identify two definitions of the term “smart” in their Ecodesign Preparatory Study on Smart Appliances. In the broadest sense “smart appliances” means appliances that are communication enabled. This may facilitate energy saving features (e.g. heat water shortly before typical hot water demand), demand side flexibility (e.g. remotely activated power modulation of water heater) and other smart home features (e.g. webcam in fridge, security).
For their study they define a smart appliance as an appliance that generally supports demand side flexibility, in detail as follows:

- An appliance that is able to automatically respond to external stimuli e.g. price information, direct control signals, and/or local measurements (mainly voltage and frequency);
- The response is a change of the appliance’s electricity consumption pattern. These changes to the consumption pattern is what we call the ‘flexibility’ of the smart appliance;

For this report the focus is on the access on switchable devices, which means that a distinction between connected and demand response ready smart devices is not relevant in the context of the DELTA-project. In fact, a device can be considered as switchable or “smart” in the context of this report if the following conditions apply:

- The device is able to communicate its energy consuming status (e.g. on/off, high/low performance, standby) to a higher-level node or gateway.
- The device is able to receive and process an external signal which interferes with its internal control system. The signal may come from a gateway, remote controlling device or the power line.

The appliances in a typical household have different potentials to shift their energy consumption in order to respond to varying supply. In this context Weygoldt and Hoffrichter (2018, 9) distinguish three groups of appliances:

- Group 1 - behavioural appliances: don’t have a storage unit or thermal inertia and need power supply when operated (e.g. lighting, cooktop)

- Group 2- periodical appliances: like group 1, but the process can be delayed to a certain extent without interfering with the user's comfort (e.g. washing machine, tumble dryer, dishwasher)
- Group 3 - continuous appliances: have a storage unit or thermal inertia and their periodical power demand can be shifted to ensure their continuous operation (e.g. refrigerator, freezer, indoor heating and cooling, hot water supply)

Only appliances of group 2 and 3 are suitable for demand response as a shift in energy consumption of appliances in group 1 interferes with the behaviour of the user which means that the consumers' acceptance is supposed to be low.

5.1.1 White goods

The household appliances addressed in this section are washing machines, tumble dryers, dishwashers and refrigerators and freezers. For each type of appliance, the features of a typical standard model are described in brief, the technical gaps to make the appliance demand response ready are shown and trends for development of the stock of smart appliances in European households are given per appliance type. Sources for this section are mainly the Ecodesign Preparatory Study on Smart Appliances (VITO et al. 2017) and the Smart-A project (Stamminger 2008).

Periodical appliances: Washing machines, tumble dryers and dishwashers
Standard appliances of this category are equipped with a step timer or/and an electronic control device for controlling the process. Time delay functions are incorporated in about 30-40% of the machines in stock in the EU and allow either to shift the starting time by a defined number of hours or to end the process at a predefined time (Stamminger 2008, 17 and VITO et al. 2017, Annex 1).

To make a standard appliance switchable or smart in the context of this report, there is a need for a connectivity module (antenna, wireless electronics and interface), which connects to the existing device electronics.

Models equipped with Wi-Fi (or other network connectivity), other type of gateway connection or frequency sensing, are already available in the European market, but the market penetration so far is believed to be marginal. Features of these connected devices usually include notification of the washing progress and remote start of the machine. For these appliances the criteria for a smart appliance according to the definition of this report are fulfilled.

Further, in their preparatory study VITO et al. (2017, 185) have estimated the following cost levels for preparing household appliances like dishwashers and washing machines for DR:

- A networked appliance only needing software modifications, testing, documentation etc.: 5-10 €
- A non-networked appliance also needing a network connectivity module etc.: 15-20 €

These are costs at the manufacturing level including testing and documentation, but without mark up for the distribution and retail level. Note that a pre-condition for these estimates is that modifications concern larger product series thus represent a situation after redesign and optimisation in the context of a future smart grid market.

The machines already being smart and with sufficient computational power may have all the components needed for demand response functionality. However, enabling these appliances for demand response functionality requires new control software. The software establishes the communication and receives the controls signals from the supply side. There are two possibilities how the software implements the demand respond feature:

- Remote or signal activation: The user selected programme is remotely activated before the user deadline is reached. E.g. the user fills the washing machine with clothes in the evening and selects 07:00 in the morning the day after as the deadline for having the clothes washed.

- Altered electricity consumption pattern: While the appliance is activated, the consumption patterns are changed through pausing the operation, changing the temperatures, changing heating power, changing spinning speed (in the case of washing machines and washer dryers) etc.

In the case of remote or signal activation the length of the delay window accepted by the user was estimated within the Smart-A project (Stamminger 2008, 214) and calculated in a pilot involving about 2000 families within the project Linear (2014, 78). This window varies from 3 hours (Smart-A) up to 8.5 hours for dishwashers, 7.3 hours for washing machines and 8.1 hours for tumble dryers (Linear).

The total energy consumption of dishwashers, washing machines, washer dryers and tumble dryers is relatively small in comparison to other household appliances (e.g. refrigerators or water heaters), as the operation time and number of operation cycles is limited. However, the higher power during operation, the larger delay windows and the high market penetration in Europe, especially in the case of washing machines and dishwashers, results in a significant demand response potential.

By taking into account all households in Europe, an energy shifting potential of washing machines of about 5 GWh for the year 2025 was calculated by VITO et al. (2017, Annex 1). For tumble dryers, it is between 3 and 10 GWh and for dishwashers, it amounts to 8 GWh. Furthermore, the Preparatory Study on Smart Appliances (VITO et al. 2017, 64) estimated the current share of smart demand response enabled appliances in the EU28 as well as trends for 2020 and 2030. These estimations are shown in Table 26 to Table 28 (Note: the figures are related to the definition of smart in the preparatory study and only include demand response enabled appliances. The amount of switchable smart devices as defined in this report is expected to be higher as it includes app-enabled or other connected appliances).

Table 26 Installed units of dishwashers in the EU28 in 2010 (reference) and 2015, 2020, 2030 (estimates) (adapted from VITO et al. 2017, 65)

	2010	2015	2020	2030
Total installed dishwashers	82,799,000	98,345,000	115,036,000	148,553,000
Number of smart dishwashers	0	0	575,180	29,710,600
Share of smart dishwashers [%]	0	0	5	20

Table 27 Installed units of washing machines in the EU28 in 2010 (reference) and 2015, 2020, 2030 (estimates) (adapted from VITO et al. 2017, 65)

	2010	2015	2020	2030
Total installed washing machines	185,828,000	196,821,000	200,805,000	204,744,000
Number of smart washing machines	0	252,335	10,040,250	40,948,800
Share of smart washing machines [%]	0	0.13	5	20

Table 28 Installed units of tumble dryers in the EU28 in 2010 (reference) and 2015, 2020, 2030 (estimates) (adapted from VITO et al. 2017, 66)

	2010	2015	2020	2030
Total installed tumble dryers	62,723,000	47818000	71801000	77778000
Number of smart tumble dryers	0	0	3590050	3111200
Share of smart tumble dryers [%]	0	0	5	40

To assess the current market situation on smart switchable periodical appliances, the product range of the German appliances manufacturer "Miele" was analysed.

In terms of connectivity they offer on the one hand products with the features WifiConn@ct (connectivity with a normal WiFi router) and Miele@home (Connectivity with a Miele smart home gateway) and on the other hand products with the feature SmartStart (machine starts automatically when the price is low – as long as there are no such price signals from the utilities, prices have to be uploaded to the gateway manually) (Miele 2017, 29 and 33 and Ummenberger 2018).

For dishwashers, 11 out of the 58 machines listed on the website were equipped with the features SmartStart, WifiConn@ct and Miele@home. For tumble dryers this was 3 out of 20 and for washing machines 6 out of 20 had the features SmartStart and WifiConn@ct (Miele 2018).

For this report all of these appliances can be seen as smart or switchable as they can provide information on their status and can receive and process external commands. Although only those appliances with the feature SmartStart can already automatically respond to price signals (provided by the Miele gateway).

According to Miele (Ummenberger 2018) their product development is rather focussed on the comfort aspect (app enabled controlling with the feature WifiConn@ct) than on demand response aspects, but the feature SmartStart still goes along with this trend.

Continuous appliances: Refrigerators and freezers
In a standard refrigerator or freezer, the whole process of cooling is controlled by a mechanical or/and an electronic thermostat control device. The compressor operates under normal conditions (no new load, normal ambient temperature) only 20 to 35% of the time the machine is connected to the power supply, but may increase up to 100% e.g. when a lot of items are loaded into the box which need to be cooled (Stamminger 2008, 96 and 113).

To make a standard appliance switchable or smart in the context of this report, similar adaptations as for the periodical appliances are necessary. There are two possibilities how the software can implement the demand respond feature (VITO et al. 2017, Annex 1):

- Remote activation: Based on demand response control signals or power grid measurements, start of the compressor may be delayed.
- Altered electricity consumption pattern: changes in the operational parameters of the appliance (motor speed, temperature settings, etc.) allow modification of the consumption pattern.

In the case of remote activation, the length of the possible delay window was estimated within the Smart-A project (Stamminger 2008, 214). This window is expected to range only from a few seconds to a few minutes as the appliance needs to maintain a certain temperature in the box all the time. Of course, this applies only for the case that “over-cooling” is not applicable. In this case the flexibility depends only on the thermal storage capacity of the appliance. In general, refrigerators and freezers offer a high flexibility in energy shifting operation as consumers’ acceptance is assumed to be quite high if there is no loss of comfort and if food quality is not compromised, but the interruptions of the compressor can be only short time which results in low shifting potential.

VITO et al. (2017, Annex 1) assume a potential for short term interruptions of 5 Wh per household in Europe, which results in an energy shifting potential of 1.56 GWh for refrigerators and freezers in 2025.

Furthermore, the Preparatory Study on Smart Appliances (VITO et al. 2017, 64) estimated the current share of smart demand response enabled appliances in the EU28 as well as trends for 2020 and 2030. The estimations for household refrigerators and freezers are shown in Table 29 (Note: the figures are related to the definition of smart in the Preparatory Study on Smart Appliances).

Table 29 Installed units of household refrigerators and freezers in the EU28 in 2010 (reference) and 2015, 2020, 2030 (estimates) (adapted from VITO et al. 2017, 68)

	2010	2015	2020	2030
Total installed refrigerators and freezers	297,800,000	303,200,000	308,000,000	317,600,000
Number of smart refrigerators and freezers	0	147,810	15,400,000	63,520,000
Share of smart refrigerators and freezers [%]	0	0.05	5	20

To assess the current market situation on smart switchable periodical appliances, the product range of the German appliances manufacturer "Miele" was analysed.

For refrigerators 8 out of 37 machines listed on the website were equipped with the feature Miele@home. 1 additionally had WifiConn@ct. For freezers 5 out of 10 had Miele@home, and for combined refrigerators and freezers this was 3 out of 13.

All these appliances can be seen as switchable or smart in context of this report. The refrigerators and freezers can communicate their current temperature and the user can adjust the temperature within a specific range (refrigerators 5°C to 12°C, freezers -5°C to -20°C). However, the appliances cannot be completely turned off via this connectivity (Ummenberger 2018).

5.1.2 Electric radiators

The only controlled variable that modulates electric radiators is the indoor temperature, using an electronic thermostat. Most common installed electric radiators only have the operating modes on/off. To enable demand response, the radiator needs to have a communicating electronic thermostat (VITO et al. 2017, 186).

Portable electric appliances have generally no planned connection to a central controller and are operated manually (switch on-off, temperature setting and fan speed for fan heaters). Newer installations of fixed joule heating have multiple standard control modes (4 or 6 modes) enabling a central controller to send standardised orders to reduce consumption over a period of time chosen by the end-user (Typically: Comfort - heating at locally adjusted set point, Eco - locally set point temperature minus 1 or 2 °C, night or absence setback, anti-freezing set point, stop). The physical link between the radiator and the controller has become a national industry standard in France. However, concerning the total stock, this control approach is only applied to a small portion of the installed systems (VITO et al. 2017, Annex 1).

Generally, current electric heating controllers cannot exchange information with the grid. Only for very specific DR programs, such connections are made (for instance, the firm Voltalis in France installs a box in the fuse box on the electric heating cable to enable consumption measurement and control of the electric heating) (VITO et al. 2017, Annex 1).

More recently, smart heating thermostat have been offered to customers by energy providers. Those smart thermostats are two-way (internet) communication devices, which monitor a combination of several variables in the houses (like air temperature possibly by zone, occupation possibly by zone, user comfort habits and satisfaction), and can also include GPS position tracking of the dwelling's tenants, price tables or signals, and weather previsions, in order to help customers to reduce their heating bills by improving the control of the heating system. These systems are only beginning to spread and in Europe. Nevertheless, solutions do exist for electric heating which could be a support to realise DR potential (VITO et al. 2017, Annex 1).

Shifting potential of electric radiators is limited by the comfort of the occupants. According to VITO et al. (2017, Annex 1) the heating load can be typically shifted by 1 hour per day for old buildings and by up to 2 hours for new buildings. This situation can be improved if heat pre-charging of the building is allowed, which is less energy efficient but enables to gain acceptance from the end-users' point of view. The potential could amount to about two hours, but this requires two-way communication with the indoor thermostat, which is commonly not available today.

The Preparatory Study on Smart Appliances (VITO et al. 2017, 82) estimated the current share of smart demand response enabled appliances as well as trends for 2020 and 2030. The estimated share of demand response enabled electric radiators in the EU27 is shown in Table 30.

Table 30 Estimation of the installed base of demand response enabled radiators in the EU27 (adapted from VITO et al. 2017, 83)

	2010	2015	2020	2030
Total installed electric radiators	221,000,000	220,920,000	213,000,000	203,275,000
Number of smart electric radiators	442,000	6,627,600	19,170,000	42,687,750
Share of smart electric radiators [%]	0.2	3	9	21

5.1.3 Air conditioners

Air conditioning units are usually equipped with sophisticated controllers and except for small split units using a remote control, a central controller is generally installed with the unit. The controlled variables are indoor temperature via a thermostat and sometimes compressor speed. To get smart, air conditioners may require enhanced connectivity that can be incorporated, via Ethernet or wireless technologies (e.g. Wi-Fi). However, most air conditioners already have a thermostat that allows communication and external control. If such a smart thermostat exists, no further components are needed to make it switchable (VITO et al. 2017, 20 and 193).

Australia has adopted a standard (AS 4755) for air conditioners to be equipped with specific DR signals (stopped, working at 50% or 75% of their demand) in order to ease the interaction with a standardised DR enabling device which can be operated by external agents. The units sold in Europe do not have this functionality so far even if the Australian example shows that it does not require a large adaptation. There are two different mechanisms described in AS 4755:

- on/off
- modulating the charge of the air conditioner (25%, 50%, and 75%)

However, this intervention does not allow feedback from the demand side; therefore, it is only a unidirectional mechanism, which means it is not part of the definition of smart in the context of this report (VITO et al. 2017, 20 and 193).

Concerning the potential shifting window evaluation of DR capability in the USA (NREL, 2013) have evaluated that between 20 and 70 % of the load can be shifted of at least one hour twice a day in the residential sector. The Smart-A project (Stamminger 2008) states that for residential air conditioners, the acceptance by residential end-users may be limited to about 10% of dwellings and for air conditioning stopped from 15 to 60 minutes per day.

The Preparatory Study on Smart Appliances (VITO et al. 2017, 82) estimated the current share of smart demand response enabled appliances as well as trends for 2020 and 2030. The estimated share of demand response enabled air conditioners in the EU27 is shown in the Table below. Total numbers are not given in the study (Note: the figures are related to the definition of smart in the Preparatory Study on Smart Appliances).

Table 31 Share of installed demand response enabled air conditioners in the EU27 (adapted from VITO et al. 2017, 82)

	2010	2015	2020	2030
Share of smart air conditioners [%]	7	16	30	45

5.1.4 Heat pumps

Most of the installed heat pumps already have a thermostat that allows communication and external control. Therefore, to enable demand response, usually no extra pieces or hardware is required. Only software adaptability must be done, in order to allow an external signal from a grid operator to control the equipment (VITO et al. 2017, 55). The potential for shifting the energy demand of heat pumps depends on the thermal inertia of the building and on the size of a possible storage.

The Preparatory Study on Smart Appliances (VITO et al. 2017, 82) estimated the current share of smart demand response enabled appliances as well as trends for 2020 and 2030. The estimations for heat pumps in the EU27 are shown in Table 32 (Note: the figures are related to the definition of smart in the Preparatory Study on Smart Appliances).

Table 32 Estimation of installed base of smart enabled heat pumps in the EU27 (adapted from VITO et al. 2017, 82)

	2010	2015	2020	2030
Total installed heat pumps	7,400,000	9,750,000	10,430,000	10,930,000
Number of smart heat pumps	518,000	1,560,000	3,129,000	4,918,500
Share of smart heat pumps [%]	7	16	30	45

In 2013 the German heat pump association (Bundesverband Wärmepumpe BWP) established a label for smart grid ready heat pumps, enabling demand response functionality for the labelled products. This SG-ready label requires that four different operation states of the HP can be triggered by an external signal. The four operation states mandatory are called: “Switch off”, “Normal operation”, “Recommended on” and “Forced on” (Fischer et al. 2017, 4). As argued by Hartl et al. (2016, 109) the interface of SG-ready heat pumps is unidirectional, so the heat pump does not send information on its current or future state which is necessary for demand response business models where a pool of heat pumps has to be managed. Due to this lack of bidirectional communication, according to Tony Krönert (2018), head of BWP Marketing and Service, a roll out of this label to other countries or on EU level will not happen. The Swiss initiative “Smartgridready” is one step ahead and proposes a smart grid ready label including bidirectional interface (SGR 2017).

On the website of the German heat pump association (BWP 2018) all the currently available models equipped with the SG-ready label are listed. According to this database, there are 1485 SG-ready models of heat pumps on the market, produced by 49 different manufacturers.

5.1.5 Storage

Battery Storage

According to VITO et al. (2017, 84) the only market for home battery storage applications in Europe that can be considered mature is Germany. There batteries are usually operated in combination with PV-installations. In August 2018, the 100,000th home battery (combined with photovoltaics) was installed in Germany (Hallerberg 2018) and as estimated by VITO et al. (2017, 84) in 2020 there will be a total of 500,000 installed units. In general, battery energy storage systems are still in an early phase of commercialisation, so the installed base is currently very small. From its nature it has a large potential once installed in larger numbers (VITO et al. 2017, Annex 1).

Thermal storage

Domestic thermal storage units may be powered by different heating systems using different heating media such as gas, oil, electricity and biomass, for instance. For this study on demand response, only storage units using electric energy are relevant. To address all storage units powered by other media than electricity it is necessary to know the share of installed storage units equipped with an immersion heater as a backup. According to Hackstock (2018) there is currently no data available on this issue.

As a result, the rest of this section addresses electric boilers and electric thermal storage heaters as they are fully electrically powered thermal storage units.

For an **electric boiler**, usually the only controlled variable is the boiler's exiting water temperature, adjusting it to modulate the charge of the boiler. For making a boiler switchable or smart in the context of this report, a communication enabled thermostat is necessary.

To shift the demand of the boiler, start and stop can be done with flexibility depending on the heat capacity of the storage tank. The shifting window therefore depends on the heat capacity (VITO et al. 2017, 188).
The Preparatory Study on Smart Appliances (VITO et al. 2017, 82) furthermore estimated the current share of smart demand response enabled appliances as well as trends for 2020 and 2030. The estimations for electric boilers in the EU27 are shown in Table 33. (Note: the figures are related to the definition of smart in the Preparatory Study on Smart Appliances).

Table 33 Estimation of installed base of smart enabled electric boilers in the EU27 (adapted from VITO et al. 2017, 83)

	2010	2015	2020	2030
Total installed electric boilers	1,100,000	1,100,000	1,100,000	1,100,000
Number of smart electric boilers	4,400	22,000	77,000	198,000
Share of smart electric boilers [%]	0.4	2	7	18

Electric storage heaters are capable to store heat in the radiators, when energy prices are low (off-peak hours during the night) due to the fact that they have a core made of refractive bricks, granite, aluminium or ceramic material. These systems are normally controlled with a variable speed ventilator that modulates the quantity of air that will pass through the radiator. The controlled variable that modulates electric thermal storage heaters is indoor temperature, using an electronic thermostat and another thermostat that indicates when the "heat" charging takes place.

As electric storage heaters are conceived to benefit from night tariffs, they are most probably linked to the grid operator at the fuse box level so that their charging may be operated distantly. However to enable two-way communication, an electric storage heater needs to have a communicating electronic thermostat. The charging usually takes place during the night, therefore these appliances have a shifting potential of several hours (typically half a day) (VITO et al. 2017, 187 and Annex 1).

The Preparatory Study on Smart Appliances (VITO et al. 2017, 82) furthermore estimated the current share of smart demand response enabled appliances as well as trends for 2020 and 2030. The estimations for built-in inertia radiators in the EU27 are shown in Table 34 (Note: the figures are related to the definition of smart in the Preparatory Study on Smart Appliances).

Table 34 Estimation of installed base of smart enabled built- in electric inertia radiators in the EU27 (adapted from VITO et al. 2017, 83)

	2010	2015	2020	2030
Total installed inertia radiators	13,800,000	13,775,000	13,700,000	13,550,000
Number of smart inertia radiators	6,900	137,750	548,000	1,084,000
Share of smart inertia radiators [%]	0.05	1	4	8

5.1.6 Interoperability

The problem of technological fragmentation of smart devices is seen as the largest barrier for the connected home and therefore for the development of demand response. Currently, there are many networks, standards, and devices being used to connect the smart home, creating interoperability problems and making it confusing for the consumer to set up and control multiple devices (VITO et al. 2017, 55).

Interoperability can be an issue on different levels, as shown by VITO et al. (2018, 199). Important levels are the syntactic interoperability (focuses on the data formats) and the semantic interoperability (focuses on the interpretation of the data, meaning the same signal triggers a correct event or the data is interpreted the same by systems from different vendors).

The problem of limited semantic interoperability is tackled by the SAREF ontology, which was developed in close interaction with the industry with financial support from the European Commission in 2015. It is considered as the European standard reference language for energy-related data (Šajn 2016, 4). That means that SAREF is not intended to replace existing standards used by different producers, its intention is to link information coming from different smart appliances, based on different standards (Poveda-Villalón and Garcia-Castro 2018, 5). Therefore, it can be seen as a gold standard for technology-specific ontologies (Den Hartog 2018).

Today SAREF is mainly creating interoperability by the following activities (Den Hartog 2018):

- Informing developers how to make two networks interoperable via direct translation; so here SAREF is used as a tool, not as a means.
- Influencing the development of new versions of technology-specific ontologies such that they better enable interoperability in the future.

5.1.7 Regulation Attempts

As part of the Ecodesign framework there exist the first ideas to push forward the market penetration of smart devices by policy instruments. The Ecodesign Preparatory Study on Smart Appliances (VITO et al. 2017b) describes different policy options and also highlights one recommended option. This proposed option is a label for smart appliances showing that the product complies with criteria for energy smart functionality (VITO 2017b, 10). According to George Paunescu (2018), responsible policy manager at DG Energy, further work is needed (e.g. on standardisation) before the topic would become mature enough for being regulated under Ecodesign and Energy Labelling. Therefore no regulation is expected to be implemented on a medium term horizon.

5.2 Incentives and barriers for the participation of small/medium consumers/prosumers

5.2.1 Overview

The situation today regarding small to medium customer participation in demand response (DR) is one of significant untapped potential. Inadequate metering facilities, lack of means for customers to respond to real-time signals, limited actual commercially exploitable incentives, undue complexity in the information provided, and the absence of scalable integrated tools to support such endeavours; are some of the many reasons that small to medium customers are not typically participating in DR services. Furthermore, it demonstrates why aggregators tend not to include them in their asset portfolios.

The set of small to medium prosumers covers a wide range of building types and uses, each with a specific purpose. Domestic buildings, offices, commercial outlets and service building such as hospitals or schools each have significantly different designs and operational principles that affect their energy requirements. The different purposes of these building types lead to different considerations of the incentives for and barriers to participation in novel technologies. Participation of small to medium prosumers is then best considered from several perspectives.

5.2.2 Incentives

5.2.2.1 Economic Drivers & Barriers

The economic incentives for DR participation for small to medium prosumers are generally small. The differentiation of these entities from larger prosumers is an important one in the consideration of incentives. Larger prosumers tend to undergo regular energy audits and employ personnel to ensure that their energy efficiency measures lead to direct savings. There is familiarity with complexity in the energy efficiency market for large prosumers and efforts to understand and engage in demand response programs are a small addition to efforts already in place. However, for small to medium prosumers the dedication of person time and effort to energy related issues is often simply not economically viable.

Larger energy users are not only typically familiar with energy management strategies but also have more active energy management capabilities. For these users, participation in complex markets, such as those requiring frequent bidding, are acceptable endeavors. On the contrary, smaller electricity customers with fewer active energy management capabilities need incentives that are easy to understand. They may not have the technical skill sets required to interpret the market information and may lack the person time required for active participation. Small consumers that do not actively manage their energy use may prefer regular reservation payments in exchange for being available to adjust demand occasionally. If customers in this category often need to adjust load manually, they likely require advance notice. They may not want to curtail frequently, and the length of curtailment will be limited by user comfort. They can participate in emergency/standby programs that give advance notice and require participation only a few times a year however, they are unlikely to participate in ancillary services programs that call DR in real time or near-real-time without additional energy management tools. Software can engage these customers and help them make curtailment decisions by simply presenting energy use options and the associated costs and program expectations.
Demand response economic incentives are often categorized as either ‘price-based’ or ‘additional incentive-based’. An overview of commonly implemented ‘tariff-based’ and ‘additional incentive-based’ DR incentives is given in Table 35.

Table 35 Categorised Economic Incentives for Demand Response Participation (US Department of Energy 2006)

Tariff-based	Additional Incentive-based
• **Time-of-use (TOU)**: a rate with different unit prices for usage during different blocks of time, usually defined for a 24-hour day. TOU rates reflect the average cost of generating and delivering power during those time periods. TOU rates often vary by time of day (e.g., peak vs. off-peak period), and by season and are typically pre-determined for a period of several months or years. Time-of-use rates are in widespread use for large commercial and industrial (C/I) customers and require meters that register cumulative usage during the different time blocks. • **Real-time pricing (RTP)**: a rate in which the price for electricity typically fluctuates hourly reflecting changes in the wholesale price of electricity. RTP prices are typically known to customers on a day-ahead or hour-ahead basis. • **Critical Peak Pricing (CPP)**: CPP rates include a pre-specified high rate for usage designated by the utility to be a critical peak period. CPP events may be triggered by system contingencies or high prices faced by the utility in procuring power in the wholesale market, depending on the program design. CPP rates may be super-imposed on either a TOU or time-invariant rate and are called on relatively short notice for a limited number of days and/or hours per year. CPP customers typically receive a price discount during non-CPP periods. CPP rates are not yet common, but have been tested in pilots for large and small customers in several states (e.g., Florida, California, and North and South Carolina).	• **Direct load control**: a program in which the utility or system operator remotely shuts down or cycles a customer's electrical equipment (e.g. air conditioner, water heater) on short notice to address system or local reliability contingencies. Customers often receive a participation payment, usually in the form of an electricity bill credit. A few programs provide customers with the option to override or opt-out of the control action. However, these actions almost always reduce customer incentive payments. Direct load control programs are primarily offered to residential and small commercial customers. • **Interruptible/curtailable (I/C) service**: programs integrated with the customer tariff that provide a rate discount or bill credit for agreeing to reduce load, typically to a pre-specified firm service level (FSL), during system contingencies. Customers that do not reduce load typically pay penalties in the form of very high electricity prices that come into effect during contingency events or may be removed from the program. Interruptible programs have traditionally been offered only to the largest industrial (or commercial) customers. • **Demand Bidding/Buyback Programs**: programs that (1) encourage large customers to bid into a wholesale electricity market and offer to provide load reductions at a price at which they are willing to be curtailed, or (2) encourage customers to identify how much load they would be willing to curtail at a utility-posted price. Customers whose load reduction offers are accepted must either reduce load as contracted (or face a penalty). • **Emergency Demand Response Programs**: programs that provide incentive payments to customers for measured load reductions during reliability-triggered events; emergency demand response programs may or may not levy penalties when enrolled customers do not respond. • **Capacity Market Programs**: these programs are typically offered to customers that can commit to providing pre-specified load reductions when system contingencies arise. Customers typically receive day-of notice of events. Incentives usually consist of upfront reservation payments, determined by capacity market prices, and additional energy payments for reductions during events (in some programs). Capacity programs typically entail significant penalties for customers that do not respond when called. • **Ancillary Services Market Programs**: these programs allow customers to bid load curtailments in ISO/RTO markets as operating reserves. If their bids are accepted, they are paid the market price for committing to be on standby. If their load curtailments are needed, they are called by the ISO/RTO, and may be paid the spot market energy price.

5.2.2.2 Use Case Dependent Perspectives

The different schemes outlined in Table 35 are acceptable in some use cases and unacceptable in others. The hierarchy of use cases begins two-fold in the small to medium prosumer category: the tertiary sector (trade, commerce and services) and the domestic sector.

5.2.2.2.1 The Tertiary Sector

The tertiary sector can be split into several subsectors. Regarding potential for flexibility and effectiveness of participation in demand response, three subsectors have been identified for focus in previous studies (Wohlfarth and Klobasa 2010), contributing between them over 60% of tertiary sector potentially flexible load (as opposed to 55% of actual load) namely: office-like enterprises; retail trade; and hotels and restaurants. These sectors tend to have a high level of active occupancy per capita and a relatively large demand for temperature dependent controls. Small to medium enterprises are also mentioned explicitly here for completeness.

Office-like enterprises are particularly concerned with the comfort levels of their staff. In general, there is a concern that engagement with demand response programs can lead to reductions in their productivity, which is also a key concern of the industrial sector. However, many office-like enterprises have already benefited from energy efficiency measures such as switching to LED lighting and installing Building Energy Management Systems (BEMS); and their positive past experiences here mean that they are open to participation. Payments schemes for pre-cooling and/or heating of spaces prior to occupancy are an immediate potential attraction but demand response during active occupancy is perceived as potentially difficult to implement. Technological requirements and valuations for participation remain unrealized informational perquisites for participation.

Retail trade entities are the tertiary subsector with the largest identified flexible load. They are generally aware of energy efficiencies measures and have benefited in the past from their uptake. The principle consideration that is identified as a barrier to DR participation in the retail trade is that the customer must be able to do what they want when they want. The customer cannot be made to wait before their food is heated or before they open refrigerators to purchase cold items. That being said, the retail trade sector is generally keen to participate in DR as it recognizes that realizing the financial incentives may give them an edge over the competition. However, this itself may cause a problem with potential aggregation of retail units. There is also a potential pathway to logical aggregation of retail units through retail chains, many of which are already interconnected to central ICT systems.

Hotels and restaurants tend to have power peaks in their load profiles and often, due to their significant energy consumption, have contractual agreements with energy suppliers that reflect their specific use cases. They are thus actively engaged with their energy requirements and some entities already engage in demand response, scheduling appliance load to mitigate peaks using intelligent energy management systems. Applications with high thermal mass such as space heating in hotels or hot plates and refrigerators for food storage in restaurants are well placed for DR. However, there are key appliances that cannot be used in DR as they may result in noticeable custom satisfaction issues. Again, interconnected chains in this sector offer a natural pathway to aggregation.

For **Small to Medium Enterprises** (SMEs), there are rarely enough available resources (person time & expertise) to exploit energy efficiency options and coupled to the lack of available resources is a lack of information about where and how energy is used in their companies. Energy efficiency measures are often low on a priority for SMEs although simple measures requiring little effort and resulting in direct savings tend to be implemented when the evidence is strong (lighting efficiency). In many cases, their access to financing for energy efficiency actions is limited by inadequate capacity to develop bankable projects with financial institutions, which frequently remain unwilling to provide financial products due to apparent risks and a shortage of appropriate financial products. DR can support SMEs by assisting them to cut electricity costs, freeing up resources that can be invested in more productive activities therefore making their company more resilient and competitive. Besides cost savings, DR can deliver other benefits that can help the development of the SMEs, such as by improving productivity and product quality (IEA 2014b). Demonstrating these wider benefits for participating is a key to effectively recruiting SME participation (IEA 2015).

A common barrier for the participation of small to medium prosumers in matters of energy efficiency is the lack of information on energy use. Many have no knowledge of their energy use and do not dedicate any resources to managing their energy infrastructure as it is not considered economically viable to do so. A key advantage of DR is that the toolset generates information in this domain. By participating in DR, information on energy use that would otherwise be missing is made available without the need for resource commitment to energy auditing practices. If the information can be presented to the user in a simple yet effective manner, it can be used to generate further savings without significant resource commitment. Although direct savings from DR may be small, the wider effects can be more significant.

For several entities in the tertiary sector, independent of subsector, participation in demand response is itself a marketing tool that can boost reputation and user engagement of both staff and customers. Many companies today advertise their efforts towards energy efficiency and ecological considerations. For some companies it is an aspect of their image that is embedded in their business model, both motivating staff and relating to their customers. These entities in particular are interested in seeking more significant involvement with DR and may wish to advertise the ecological benefits of their participation as part of their marketing strategy. These entities may also be willing to adapt practice hours as part of demand response programs, but they are a small proportion of the sector today.

5.2.2.2.2 The Domestic Sector

The domestic sector is one driven by several perceptions and habits. It is inappropriate to consider an ‘average’ domestic user in terms of energy flexibility. The average domestic user does not exist and the prescription of one is misleading. A study on the energy flexibility and demand considerations of upper middle-class detached homeowners in the Walloon region of Belgium alone puts forward a convincing argument for the separation of 66 participants into 4 separate typologies (Gaye and Wallenborn 2015), namely: the environmentalist, the compromiser, the technician and the economist. The primary incentive for the environmentalists is the conservation of the environment and a focus on ecological issues. The compromisers are incentivized by environmental issues but must find them financially satisfactory. The technicians are incentivized primarily by maximizing the control they have over their devices and optimizing the performance of their systems. The economists are primarily driven by the maximization of their utility. In short, the incentives for and barriers to DR in the domestic are complex and driven by multiple perspective and motivations.

There is much that can be learnt from previous studies pertaining to participation and investment in clean energy technology systems. Key findings from previous studies regarding energy efficiency measures include:

“In the household sector, there are different barriers to improving energy efficiency, and three predominate: lack of information, high upfront costs, and hassle and disruption [...]. Even relatively well-informed consumers are often more interested in renewable energy […] but will not install cost-effective energy efficiency measures in their home.”(DEFRA 2004)

“A better understanding is needed of the key motivations and influences of different groups of consumers. [...] In this way, energy efficiency messages can be targeted and made more effective.”(NCC 2006)

“Most households that have purchased solar panels or wind turbines have tended to be early adopters who are not necessarily motivated by a rational cost benefit-analysis…. They are instead motivated by other factors. For example, they may be technology enthusiasts who are keen to own the latest environmental innovation [...].”(House of Commons 2007)

"*The main drivers for installing [clean energy] systems were environmental concern and saving money, while the main barriers were capital cost and lack of trustworthy information or reliable brands." (Caird et al. 2008)*

A key point raised by the above findings and highlighted in the literature (Oikonomou et al. 2009) is that the domestic energy consumer does not simply act according to cost-benefit rationality (Abrahamse 2007) but that they are also influenced by general values (Stern 2000). In this way, the compensation a user receives for the expenditure of effort is considered both in terms of monetary and psychological value. The perceived psychological value is dependent on the both user's perception and the wider social perception of the technology.

Studies of market participation for a wide range of users in demand response in the UK has shown that the wider benefit of technological upgrades deployed cost free as part of the scheme was both a key motivator for participation and a frequently cited reason for satisfaction with the scheme in general (BEIS 2017). These upgrades typically lead to increased efficiency, longevity and automated control for user comfort. It is recognized that DR enrolment can have a positive effect on users' lifestyle, comfort and health (SEDC 2016). Smart applications or home energy management systems are typically intended to improve the comfort of living by automatically modifying energy consumption to the consumers' preferred settings (e.g. adjusting humidity and manage ventilation within homes). Additionally, DR also allows consumers to access information on their usage, hence increase their understanding and awareness regarding energy consumption and environmental footprint, while gaining a sense of control. In this way, consumers are empowered to actively participate in the transition towards a more efficient and sustainable energy system.

5.2.3 General Considerations

5.2.3.1 Public Awareness

In general, public awareness and understanding of energy efficiency and the wider implications of associated greenhouse gas emissions is steadily increasing, as demonstrated in Figure 22.

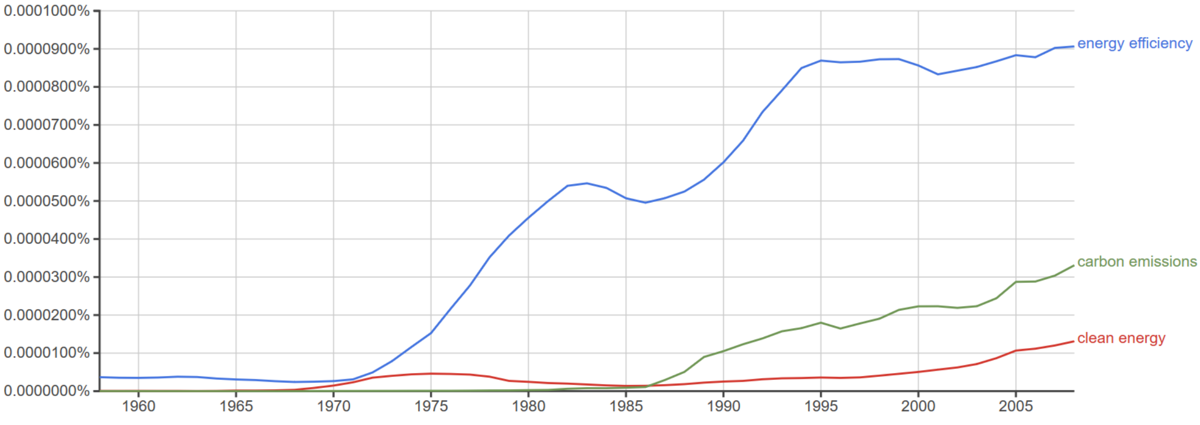

Figure 22 Google Ngram from 1958 to 2008 (most recent available at the time of publication - October 2018) for Energy Efficiency Associated Terminologies. Demonstrating the Percentage of Publications in Which the Phrases Occur Over Time.

Energy efficiency is seen by many as more than simply an economically beneficial practice, but as a role of a responsible citizen. As public awareness around energy efficiency grows, participation in efficiency measures becomes commonplace. Communication and education of the wider implications of demand response participation is thus a key to effective recruitment of participants.

5.2.3.2 Energy Security

Energy security is another major benefit of DR. Blackouts impose terrific economic and social costs, including equipment damage; and loss of revenue from spoiled products and reduced productivity. Such conditions can be alleviated or averted by increased participation in DR programs.

The extent to which energy security concerns are recognised by the energy consumer is dependent on consumer's experience of supply; this can be considered predominantly a geographical dependency. There are several energy systems today that exhibit frequent blackouts and yet are committed to increasing both variable generation from clean energy technologies and increased load from the electrification of transport. India is a key example here, with a commitment of introducing 100 GW of total installed PV by 2022 (with 20 GW installed to date) and a commitment to sell only electric vehicles from 2030. The value of demand response in such scenarios is high. Where it can be shown that demand response increases energy security and reduces blackouts that are commonplace today, the incentives for demand response participation are increased.

6. Conclusions and Recommendation

The preceding analysis aimed at identifying the "starting conditions" and possible "windows of opportunity" for the development of reliable, economically viable and innovative DELTA business models that enable the incorporation of small- and medium-sized customers from the residential and tertiary sectors. In a nutshell, we can **summarise the main results of the analysis** as follows:

- Participation of **demand response in European countries differs to a large extent across Europe**. In some countries markets are practically closed for DR, in other countries markets are legally open; however, some barriers for DR are still to be removed in order to increase the market share, which is quite low for small and medium-sized customers, even in developed markets.
- Main barriers are seen in the **lack of a clear definition of the role of independent aggregators** which is of decisive importance for the participation of small and medium-sized customers in the flexibility markets and in demanding technical requirements (e.g. for prequalification for the balancing markets) which traditionally were customized for large generation units.
- Demand response is widely recognised as an important element for the future energy system and therefore **framework conditions are continuously further developed and improved** in most countries.
- The **DELTA solution may help to increase participation of small and medium loads** as it is expected to **reduce administrative efforts and upfront costs for aggregators**. However, this will largely depend on availability of smart and switchable devices.
- The market share of **smart and switchable devices** which enable the participation of small- and medium-sized prosumers in the DR-market is low and **is expected to grow only slowly over the next 5-10 years**. Although there exist preliminary considerations to put forward regulation on smart devices in the frame of the Ecodesign-Directive, this will not influence the market penetration quickly due to lack of standardisation in this field. There exist a few exemptions where the devices are comparably well prepared to be included into a DR platform: This refers mainly to heat pumps, air conditioners and to buildings with building automation systems.
- Only a **limited share of households will react to economic incentives for DR-participation**, as the savings achievable for single households are quite small in most cases. In the tertiary sector the economic incentive has a higher weight than in the household sector, but in return comfort and availability consideration represent a more important barrier.
- Furthermore we have assessed the envisaged **competitive advantages of the DELTA platform**, coming to the conclusion that the DELTA platform will offer to market players a full suite of automated DR services in a non-expensive and secure way, maximising end users benefits through participation in all relevant markets – including small- and medium-sized prosumers – and through deploying of smart contracts while ensuring grid stability.

When linking the DR-opportunities defined by the regulatory frameworks, which in fact are differing considerably between EU-countries with the envisaged competitive advantages of the DELTA platform and with generic business models that may be interpreted as possible scenarios for the application of the DELTA platform on future electricity markets we come up with the **following preliminary conclusion and recommendations**:

Further development of the regulatory framework for DR required

- Participation of small and medium-sized customers in the flexibility markets (wholesale market, balancing market, capacity market) is largely depending on the regulatory framework conditions. During the last years, conditions and requirements for market access of demand response improved in most countries. For the entry of new market players in the context of the DELTA solutions, the definition of the **role and responsibility of independent aggregators**

and their relation to BRPs/retailers and/or other market participants is crucial. As long as BRPs/retailers - which are in direct competition to independent aggregators - may restrict participation of consumers on the DR market, development is slowed down. A clear - and fair - framework allows for real competition in an open market and it reduces costs while ensuring sufficient revenues.

- In order to achieve **reduction of administrative efforts and upfront costs**, standardisation of contracts, definition of technical standards (e.g. for data exchange) and requirements for measurement and verification should be further developed within the national context but also across Member States.
- The vast majority of products on the electricity market were traditionally created around large generation units. Actual **system needs and technical requirements have changed** and this has **to be reflected in the definition and requirements of products**. Minimum size of the aggregated load, maximum duration of availability, recovery periods and standardised procedures for prequalification (aggregated loads instead of technical units; one prequalification for several products etc.) are the most important factors necessary to intensify participation of DR. This is of utmost relevance for the DELTA solutions, where a large number of small and medium loads will be aggregated automatically.
- Methodology and procedures of **measurement and verification should be standardised**, transparent and fair and it should take place on the level of aggregated loads. In this context, grid tariff structure should be adapted according to the requirements of DR, e.g. by the application of reduced grid tariffs in the case of DR activation on the balancing market.

Focus of DR business models on the most promising appliance groups

- Currently the stock of white goods is generally not adapted for DR application and situation may change only if smart white goods are pushed by regulatory measures, which may be adopted in the medium to long run. Therefore, in the short term larger buildings with building **automation systems, eventually heat pumps, air conditioners** and similar appliances are more promising for DR business models. Also **electric batteries** might be relevant in this context, but their market is yet quite limited.
- To certain degree energy retailers (utilities) are able to play a role on increasing the share of smart devices. They could prepare and distribute **programmes where the (subsidised) sale of smart devices is combined with a special tariff** that allows for implicit DR (generic DELTA business model 2B). In the past similar programmes have been successfully implemented by utilities related to the dissemination of highly energy efficient appliances and might be adapted to the case of increased DR participation of small and medium-sized prosumers.

Differentiate incentives for DR participation by target groups

- We assume that the **economic incentive is definitely insufficient to achieve broad participation of households** in DR. For a large share of typical household customers (mainly for the so-called categories of "environmentalists" and "technicians") other incentives will be much more convincing, such as: Be part of the energy transition! Take profit from the most current and sophisticated technologies! etc.
- In the **tertiary sector**, it seems that the sub-sectors of office premises, retail trade and hotels are promising target groups for the DR business models. The economic incentive is important in the sector, but we assume that it needs to be complemented by other elements, such as environmental considerations, guarantees on availability and security, etc.

Different business models require different functionalities of the DELTA-platform

- Depending on the business models applied **different (envisaged) functionalities of the DELTA platform may become decisive from the operators' point of view**. Just to give a few examples: For business models based on explicit DR, a major feature is the better and cheaper incorporation of small and medium loads from the residential and tertiary sector as well as higher reliability of DR potentials which are achieved by bundling of small- and medium-sized loads. Furthermore, if explicit DR is combined with energy efficiency services the functionality of price forecasting that gains increasing importance as it supports solving the trade-off between energy efficiency and load shifting in optimised way. For business models based on implicit DR the functionality of administering information about – potentially dynamic – price signals at the customers metering points becomes a crucial success factor.

- Altogether, the success of any DR business model aiming at the residential and tertiary sector is **largely dependent on cutting down transaction cost**. As the financial savings may be small for the single user all cost related to distribution to and communication with the potential customer need to be very low, too. Therefore, it may be decisive to **make use of existing distribution and information channels** related to the target groups addressed.

The conclusions and recommendations presented above will be scrutinised and further developed in the work steps following to this assessment of the energy market and the regulatory framework. Furthermore, against this background a limited number of well detailed, practically implementable DELTA business models will be derived and tested in pilot projects in the UK and Cyprus.

7. References

50 hertz et al., 2016. Branchenleitfaden. Regelleistungserbringung durch Drittparteien-Aggregatoren gem. § 26a StromNZV.

Abrahamse, W., 2007. Energy conservation through behavioral change : Examining the effectiveness of a tailor-made approach.Association For Decentralised Energy, 2017. Consultation - ADE Demand Side Response Code of Conduct July 2017.

APG, 2018. Austrian Power Grid AG. Geschäftsbericht 2017. Vienna.

Berkley Lab (2018), Website Microgrids at Berkley Lab, https://building-microgrid.lbl.gov/microgrid-definitions, 10 Oct 2018

Bertoldi,P., Zancanella, P., Boza-Kiss, B., 2016. Demand Response Status in EU Member States. JRC Science for Policy Report 2016.

BEIS, 2017. ELECTRICITY DEMAND REDUCTION PILOT - Interim Evaluation Findings Report, (February).

BWP; 2018. SG-ready Datenbank. Retrieved from: https://www.waermepumpe.de/normen-technik/sg-ready/sg-ready-datenbank/ [18.09.2018]

Caird, S., Roy, R. and Herring, H., 2008. Improving the energy performance of UK households: Results from surveys of consumer adoption and use of low- and zero carbon technologies. Energy Efficiency, 1(2), pp. 149–166.

CAISO, 2015.Demand Response User Guide.

CEER, 2013. Regulatory and Market Aspects of Demand-Side Flexibility. A CEER Public Consulting Document. C13-SDE-38-03. Brussels.

CEER, 2014. CEER Advice on Ensuring Market and Regulatory Arrangements help deliver Demand Side Flexibility. C14-SDE-40-03. Brussels.

CEER, 2016. Scoping of flexible response. CEER discussion paper. C16-FTF-08-04. Brussels.

CERA, 2018. Retrieved from: https://www.cera.org.cy/Templates/00001/data/nomothesia/ethniki/hlektrismos/rythmistikes_apofaseis/2018_02.pdf

Cooke, Douglas (2011), Empowering Customer Choice in Electricity Markets, International Energy Agency, Information Paper, Paris, 2011

Den Hartog, F.; 2018. UNSW Canberra. Written communication [E-Mail]. 18.09.2018.

DEFRA, 2004. Energy Efficiency: The Government's plan for action, Department of Environment, Food & Rural Affairs, London, April.

DIHK/EFET, 2018. Strombeschaffung und Stromhandel. Berlin, Brussels.

Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC, OJ L 211, 14.8.2009, p. 55–93

DREAM-GO, 2017. Identified Short and Real-time Demand Response Opportunities and the corresponding requirements and concise systematization of the conceived and developed DR programs. Deliverable D2.1 – v3.0, DREAM-GO project, Mar 2017.

E-Control, 2013. Demand Response from the regulatory viewpoint - Austria. Presentation. Vienna.

E-Control, 2018. Das Strommarktmodell. Retrieved from: www.e-control.at/marktteilnehmer/strom/strommarkt/strommarktmodell

Efthymiou, V., 2012. Smart Grids for Sustainable Cyprus. EUROLECTRIC DSO Directors Gathering, 3 Oct 2012.

Elia Group 2018. Consolidating our position in 50Hertz while delivering solid operational performance. Press Release, 27 July 2018.

EN 15900 (2010) Energy efficiency services - Definitions and requirements; published in June 2010

Energati Quaterly (2018), Web-Magazine http://publications.engerati.com/engerati-quarterly-feb#!/microgrids, February 2018

European Commission 2018. Market legislation. Retrieved from: https://ec.europa.eu/energy/en/topics/markets-and-consumers/market-legislation

Federal Ministry for Economic Affairs and Energy, 2015. An electricity market for Germany's energy transition. White Paper. Berlin.

FERC, 2015. Electric Power Markets: National Overview. Federal Energy Regulatory Commission.

FERC, 2017. Assessment of Demand Response and Advanced Metering. Federal Energy Regulatory Commission, Staff Report

Fischer, D., Wolf, T. and Triebel, M-A.; 2017. Flexibility of heat pump pools: The use of SG-Ready from an aggregator's perspective. Rotterdam: 12th IEA Heat Pump Conference 2017.

Gaye, G. and Wallenborn, G., 2015. A typology of flexible users in a smart grid project. Proceedings of the European Council for an Energy Efficient Economy Summer Study, (Ferc), 2027–2038.

Goossens, S.; 2018. Smart appliances for a circular society - Changing the world from home. Brussels: European Committee of Domestic Equipment Manufacturers (CECED).

Grid, N., 2013. Short Term Operating Reserve (STOR), 44(January), pp. 3–4.

Grid, N., 2017. Legal disclaimer and Copyright How to use this guide, (December), pp. 0–35. Retrieved from: https://www.nationalgrid.com/sites/default/files/documents/Firm Frequency Response %28FFR%29 Interactive Guidance v1 0_0.pdf.

Hackstock, R.; 2018. Austria Solar. Written communication [E-Mail]. 24.09.2018.

Hallerberg, C.; 2018. Meilenstein der Energiewende: 100.000ster Solarstromspeicher installiert. Retrieved from: https://www.solarwirtschaft.de/presse/pressemeldungen/pressemeldungen-im-detail/news/meilenstein-der-energiewende-100000ster-solarstromspeicher-installiert.html [21.09.2018]

Harper, T. et al., 2017. International opportunities for demand response and battery storage, (July).

Hartl, M., Biermayr, P., Schneeberger, A. and Schöfmann, P.; 2016. Österreichische Technologie-Roadmap für Wärmepumpen. Vienna: Bundesministerium für Verkehr, Innovation und Technologie.

House of Commons, 2007. Local energy – turning consumers into producers, HC 257 First Report of Session 2006-7, January. London: The Stationery Office.

IEA, 2014b. Capturing the Multiple Benefits of Energy Efficiency: A Guide to Quantifying the Value Added, IEA/OECD Publishing, Paris. DOI: http://dx.doi. org/10.1787/9789264220720-en.

IEA, 2015. Accelerating Energy Efficiency in Small and Medium-sized Enterprises, Al-Homoud, M. S. (2001). Computer-aided building e.

Kollau, M. and Vögel, S., n.d. Demand Response im Österreichischen Kontext der Energieeffizienzrichtlinie 2012/27/EU - Analyse internationaler Erfahrungen. Wien.

Krönert, T; 2018. Bundesverband Wärmepumpe. Written communication [E-Mail]. 21.09.2018.

Ma, O. and Cheung, K.,2016, Demand Response and Energy Storage Integration Study, (March). doi: DOE EE-1282.

Miele; 2018. Produktauswahl. Retrieved from: https://www.miele.at/haushalt/produktauswahl-kuehl-gefrier-und-weinschraenke-1723.htm#5,11 [17.09.2018]

MIT, 2011. "The future of the electric grid", Massachussetts Institute of Technology, 2011.

National Grid, 2018. Wider Access to the Balancing Mechanism Roadmap Wider BM Access Roadmap, p. 38. Retrieved from: https://www.nationalgrid.com/sites/default/files/documents/Wider BM Access Roadmap_FINAL.pdf.

NCC, 2006. A sustainable energy policy for all, NCCs response to DTI's consultation, Our Energy Challenge. National Consumer Council, London, April.

NREL; 2013. Grid Integration of Aggregated DR, Part II: Modeling DR in a Production Cost Model, Technical Report NREL/TP, 6A20 – 58492.

Ofgem, 2017. Ofgem's views on the design of arrangements to accommodate independent aggregators in energy markets, (July), p. 3. Retrieved from: https://www.ofgem.gov.uk/system/files/docs/2017/07/ofgem_s_views_on_the_design_of_arrangements_to_accomodate_independent_aggregators_in_energy_markets.pdf.

Ofgem and Aurora Energy, 2016. A SMART, FLEXIBLE ENERGY SYSTEM A call for evidence, (November), p. 6.

Oikonomou, V., Becchis, F., Steg, L., and Russolillo, D., 2009. Energy saving and energy efficiency concepts for policy making. Energy Policy, 37(11), 4787–4796. https://doi.org/10.1016/j.enpol.2009.06.035

Paunescu, G., 2018. Policy officer at European Commission. Written communication [E-Mail]. 15.10.2018

Penta SGIII, 2017. Expert Group 2 on Demand Side Response: Final Document.

Poveda-Villalón, M. and García-Castro, R.; 2018. Extending the SAREF ontology for building devices and topology. London: LDAC2018.

Power Responsive, 2017. Demand Side Flexibility Annual Report 2016.

Regelleistung.net, 2018. Präqualifizierte Leistung in Deutschland. Retrieved from: www.regelleistung.net/ext/download/pq_capacity

Šajn, N.; 2016. Smart appliances and the electrical system. n.l.:European Parliamentary Research Service.

SEDC (2016), Smart Energy Demand Coalition, Explicit and Implicit Demand-Side Flexibility – Complementary Approaches for an Efficient Energy System, Brussels, 2016, www.smartenergydemand.eu

SEDC, 2016. Empowering Residential and SME Consumers, Smart Energy Demand Coalition, White paper.

SEDC, 2017. Explicit Demand Response in Europe Mapping the Markets 2017, pp. 1–223. Retrieved from: http://www.smarten.eu/wp-content/uploads/2017/04/SEDC-Explicit-Demand-Response-in-Europe-Mapping-the-Markets-2017.pdf.

SGR; 2017. Provisorische Funktionsbeschreibung Nr. 2017/1 (Meilenstein 1) - Funktion SmartGridready® mit Wärmepumpen.Switzerland: Gruppe SmartGridready.

Sorrell, S., Dimitropoulos, J. and Sommerville, M., 2009. Empirical estimates of the direct rebound effect: A review. Energy Policy, 37(4), 1356–1371. https://doi.org/10.1016/j.enpol.2008.11.026

Stamminger, R.; 2008. Synergy Potential of Smart Appliances. Bonn: University of Bonn.

Stern, P. C., 2000. New Environmental Theories: Toward a Coherent Theory of Environmentally Significant Behavior. Journal of Social Issues, 56(3), 407–424. https://doi.org/10.1111/0022-

4537.00175

Stoker, L., 2018a. EFR batteries and DSR victorious as coal exits T-1 auction, Clean Energy News. Retrieved from: https://www.cleanenergynews.co.uk/news/storage/efr-batteries-and-dsr-victorious-as-coal-exits-t-1-auction.

Stoker, L., 2018b. T-4 auction clears at record low price as battery storage underwhelms, Clean Energy News. Retrieved from: https://www.cleanenergynews.co.uk/news/storage/t-4-auction-clears-at-record-low-price-as-battery-storage-underwhelms (Accessed: 10 February 2018).

The Energyst, 2017. Demand Side Response: Shifting the balance of power, p. 2558. Retrieved from: http://theenergyst.com/wp-content/uploads/2017/09/DSR-Report-2017.pdf.

Transmission System Operator Cyprus 2011. Integration of electricity from renewable to the electricity grid and to the electricity market – RES-INTEGRATION, National Report: Cyprus, 20 December 2011. Retrieved from: http://www.dsm.org.cy/media/attachments/kanones%20Agoras/KanonesAgoras_1.0.0_FinalEll.pdf

Ummenberger, P.; 2018. Miele Austria. Written communication [E-Mail]. 17.09.2018.

U S Department of Energy, 2006. Benefits of Demand Response in Electricity Markets and Recommendations for Achieving Them. U.S. Department of Energy, (February), 122. https://doi.org/citeulike-article-id:10043893

VITO, Viegand & Maagøe, Armines and Bonn University; 2017. Ecodesign Preparatory study on Smart Appliances (Lot 33) – Final report. Mol: Flemish Institute for Technological Research NV.

VITO, Viegand & Maagøe, Armines and Bonn University; 2017b. Ecodesign Preparatory study on Smart Appliances (Lot 33) – Task 7 Policy and Scenario analysis. Mol: Flemish Institute for Technological Research NV.

VITO, ECOFYS and OFFIS; 2018. Support for Setting upa Smart Readiness Indicator for Buildings and related Impact Assessment – Final report. Mol: Flemish Institute for Technological Research NV.

Vögel, S. and Süßenbacher, W., 2017. Flexibiltät am Strommarkt - Ordnungsrahmen, Anreize und Hemmnisse in der Marktintegration. Presentation at IEWT 2017. Vienna.

Weygoldt, L. and Hoffrichter, A.; 2018. Einordnung des Potentials von Demand Response in privaten Haushalten. Berlin: Technische Universität Berlin.

Wohlfarth, K., & Klobasa, M. (2010). Demand response in the service sector – setting course for energy flexibility and efficiency, 1165–1175.

Zehfuss, M. and Kleine, P., 2017. Märkte für Regelenergie. Kaiserslautern.