MSc Program
Environmental Technology & International Affairs

CONTINUING EDUCATION CENTER

diplomatische akademie wien
Vienna School of International Studies
École des Hautes Études Internationales de Vienne

Provision of Flexibility in Electricity Networks in the Current Austrian and European Regulatory Framework

A Master's Thesis submitted for the degree of
"Master of Science"

supervised by
DI Dr. Werner Friedl

Ksenia Poplavskaya

1428141

Vienna, June 5, 2016

Affidavit

I, **KSENIA POPLAVSKAYA**, hereby declare

1. that I am the sole author of the present Master's Thesis, "PROVISION OF FLEXIBILITY IN ELECTRICITY NETWORKS IN THE CURRENT AUSTRIAN AND EUROPEAN REGULATORY FRAMEWORK", 92 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

Vienna, 05.06.2016

Signature

Abstract

This Master's Thesis focuses on the regulatory framework in Austria and the European Union with regard to provision of flexibility in electricity networks. It further contributes to an Austrian lighthouse project on the integration of Loads and Electric storage systems into Advanced Flexibility Schemes for low-voltage networks (LEAFS). Flexibility sources, such as distributed generation, storage systems and demand response allow not only to incorporate more energy generated from renewable sources into the grid but also to ensure its stability and carry benefits for grid operators, market actors and consumers alike.

Multiple grid and market services could be provided by distributed sources of flexibility on par with centralized flexible generators. Flexible components thus lie at the intersection of the electricity network and the market and can potentially be owned and operated by various actors in the evolving system. This research studies possible deployment scenarios of sources of flexibility in the national and European regulatory environment. It identifies existing gaps and inefficiencies with the help of legal and policy documents, a survey of expert opinion and best practices retrieved from relevant European projects, leading the way to a comprehensive gap analysis.

Results show that despite positive developments in the related EU and Austrian policy, current regulatory framework is still characterized by a number of grey areas with respect of the status and treatment of distributed flexible resources while different actors in the electricity systems lack adequate incentives for their deployment. This Master's Thesis thus analyzes the identified critical points and elaborates possible action plans needed in order to streamline the regulation of flexibility, improve incentives and reduce system complexity in ways consistent with the goals of the EU energy policy.

Table of contents

List of abbreviations

BRP	balance responsible party
CA	control approach
CAM	control area manager
CHP	combined heat-and-power
CSA	clearing and settlement agent
DER	distributed energy resources
DG	distributed generation
DR	demand response
DSO	distributed system operator
ElWOG	“Elektrizitätswirtschafts- und organisationsgesetz”; Austrian Electricity Industry and Organization Act
EnWG	“Energiewirtschaftsgesetz”; German Energy Industry Act
EMS	Energy Management System
EU	the European Union
EV	electric vehicle
GWG	“Gaswirtschaftsgesetz”; Austrian Gas Management Act
ICT	information and communication technology
IME-VO	“Intelligente Messgeräte-Einführungsverordnung”; Austrian Ordinance on the Introduction of Smart Metering Devices
KWK-Gesetz	Austrian Combined Heat and Power Act
NC	network code
ÖSG	“Ökostromgesetz”; Austrian Green Electricity Act
P2H	Power to Heat
PHEV	plug-in hybrid electric vehicle
PHSP	pumped hydro storage plant
SLP	standard load profile
SME	small and medium enterprise
SNE-VO	“Systemnutzungsentgelt-Verordnung”; Austrian Electricity System Charges Ordinance
TOR	“Technische und organisatorische Regeln für Betreiber und Benutzer von Übertragungs- und Verteilernetzen; Austrian Network Code
TSO	transmission system operator
VRES	variable renewable energy sources

"If I had asked people what they wanted, they would have said faster horses."

– Henry Ford, 1923.

1 Introduction

1.1. Changing electricity grid reality – a growing need for flexibility

Generation of electricity from renewable energy sources has undeniable environmental benefits and is one of the cornerstones of the future low-carbon development. However, practice has shown that a rapid build-up of renewable energy capacity alone does not automatically lead to greener energy generation. Even though the need for more electricity generated from renewable energy sources (RES) is self-evident, the big question is how to achieve a more sustainable future using practically applicable measures.

Renewable energy generation has been creating challenges for the grid, especially in those countries where their deployment has been rapid and significant. That should come as no surprise since the *traditional* grid characterized primarily by centralized generation connected at the high voltage level with passive networks was simply not designed, and hence not prepared to deal with, distributed and volatile generation. That said, the current renewable-energy riddle is not just about a change in technology; it is about *a paradigm shift* in the way the electricity system is designed. Sustainable development requires a switch from traditional to smarter, more flexible grids. Meanwhile, growing volumes of renewable and distributed generation have already changed the grid reality.

The activation of flexibility for safe and reliable integration of intermittent and inflexible sources of energy is likely to become relevant in the future electricity networks to ensure that RES can reach the same footing with other generation options without compromising the quality of electricity supply. The need for flexibility is also justified by the fact that the production delivered by RES often exceeds the amount of energy consumed, making such options as electricity storage a viable and preferred alternative to curtailment (Deutsche Energie-Agentur, 2012; EURELECTRIC, 2014). Thus, in these smarter grids, made possible by the information and communication technology (ICT), distributed energy generation coupled with a range of flexible resources would help system operators ensure system stability and create new value streams. At the same time, a potential opportunity arises for owners of flexibility to take an active part in electricity markets along with traditional players.

Flexibility is not an entirely new notion. Since the electricity network is an on-demand system that has to be balanced at all times, large-scale flexible generation (such as pumped hydro storage plants and fast-activation gas turbines) has been used to secure the system stability and manage grid constraints (Papaefthymiou et al., 2014). However, with the onset on distributed generation, surge of renewable energy sources and technological advances the need for flexibility has gained momentum. At the same time, more sources of demand-side flexibility are becoming available. Hence, flexibility is no longer associated with deployment at the transmission level only.

Technologies, such as distributed battery storage systems, heat pumps, electric vehicles (EVs) as well as demand response (DR), are all potentially capable of delivering the necessary flexibility to the system. Thus, flexibility has acquired a more multi-faceted meaning in the current setting. Given the initial stages of their use, the actual potential of these sources to create more value for the grid, the market and their implementation strategies present a relevant and fruitful subject for closer scrutiny.

1.2. Brief overview of project LEAFS

This Master's Thesis is intended to contribute to the Austrian project LEAFS by studying the use of flexibility sources in the current regulatory context though it is not limited to the scope of the project. LEAFS stands for the integration of Loads and Electricity storage into Advanced Flexibility Schemes for low voltage networks. Its goal is to evaluate the effects of increased consumer and energy market driven utilization of distributed generation, energy storage and load flexibility on distribution grids. As part of the project, technologies and operation strategies have been developed to enable optimal use of distribution grid infrastructure by activating flexibilities through the local grid operator or by utilizing incentives. Project developers affirm that

> *"the foreseen benefits include, among others, better integration of distributed energy resources at minimum network reinforcement costs as well as achieving a higher self-consumption level for customers operating their own distributed generation unit."* (AIT, 2015 p. 4)

LEAFS officially launched in November 2015 and, supported by the Austrian Climate and Energy Fund, seeks to test deployment of flexible technologies in three Austrian federal states, Upper Austria, Styria and Salzburg, from a technical, economical and legal point of view. Additionally, this Master's Thesis will zoom in on three specific control approaches proposed within the framework of the project:

1) DSO's direct control of central components where components belong to the system operators;
2) Direct access to decentralized components;
3) Indirect access to decentralized components through a customer energy management system, where components belongs to the customer. (AIT, 2015)

This Master's Thesis will present a comprehensive analysis of the Austrian national and federal-state level legal and regulatory framework in light of its treatment of the flexibility provision alongside the overarching pertinent policy of the European Union (EU). It is furthermore crucial to review the feasibility of the proposed approaches from the regulatory point of view to assess their feasibility in "real-life" settings.

1.3. State of the art and rationale

The overview of relevant literature has revealed a growing interest among scholars in finding ways of achieving greater grid flexibility, international organizations as well as the European Commission. Much current research has concentrated on finding a way forward for smart grids (de Bruyn et al., 2012; Deutsche Energie-Agentur, 2012) and on separate technologies (IRENA, 2015; Hollinger et al., 2013; Brauner, 2012; Vasconcelos et al., 2012), with a strong emphasis on electricity storage. Several publications address general regulatory and market barriers of tapping into the potential electricity storage and other strategies in the European context (Ugarte et al., 2015; CEER, 2013; Papapetrou et al., 2013; Kollau and Vögel, 2014). A number of national and international projects such as IGREENGrid[1] (EU), FENIX[2] (ES), INTEGRAL[3] (NL, ES FR), TWENTIES[4] (EU), Smart Energy Collective[5] (NL), to name just a few, have been conducted or are underway with the aim of exploring the possibilities for optimal integration of distributed generation from renewables, implementation of the information and communication technologies (ICT) and the overall development of smart grids. On the other hand, the objective of such demonstration projects as s-ChamaleonStore, Pumpspeicher Römerland[6], stoRE[7], MERGE[8] etc. is to test the implementability of flexible technologies at the distribution

---

[1] http://www.ait.ac.at/departments/energy/smart-grids/smart-grids-projects/igreengrid
[2] http://www.fenix-project.org
[3] http://www.integral-project.eu
[4] http://www.twenties-project.eu/node/1
[5] http://www.smartenergycollective.com/
[6] http://inren1.webnode.at/downloads/pumpspeicher-romerland/
[7] http://www.store-project.eu
[8] http://www.ev-merge.eu

level. Expert Group 3 of Smart Grids Task Force (2015), EURELECTRIC (2014), engineering consultancy SWECO (2015), as well as Dragoon and Papaefthymiou (2015) emphasized the future importance of the demand-side flexibility for the electricity systems on the EU level and discussed the changes in the roles that such a grid transformation would imply. They further point out that provision of flexibility bears potential not only from the point of view of the grid but also for the electricity market. The latter is especially important considering the ongoing efforts of the EU to create a single internal electricity market. This, however, cannot stand alone and has to be scrutinized in light of current market rules and how they could be adapted to set up a level playing field for flexibility sources (EG3 Smart Grids Task Force, 2015). Such interest in the distribution-level flexibility is justified by the fact that it can offer benefits to all actors in the value chain, both providers and procurers. Finally, provision of flexibility bears welfare benefits for consumers and the society at large, in the form of increased share of auto-consumption of electricity, CO2 emission reduction and more efficient use of resources.

While technologically feasible, implementability of flexible resources has yet to be assessed from the point of view of economic viability and regulatory preparedness. Concerning the latter, regulation of flexible technologies has been associated with some uncertainty, which subsequently hampers investment decisions and deployment. Yet the discussion of regulatory aspects with respect to the provision of flexibility has been rather fragmented. A comprehensive assessment is crucial since without considering regulatory framework, pilot projects are bound to run into difficulties during the stage of implementation in “real-life” conditions. This is likely to result in stalled scale-up of flexible solutions. On the other hand, an approach combining several technologies, which in turn would provide multiple services to the system, has a much greater potential to achieve more value for their operators and the system as a whole. Such services, as identified by EG3 of the Smart Grids Task Force (2015) and SWECO (2015) may include, among others, frequency and voltage control, peak shaving and overall portfolio optimization. Thus, in the specific case of project LEAFS (Section 1.2), photovoltaic (PV) systems, battery storage, heat pumps and electric vehicles (EVs) are deployed together with demand response creating a combined approach to optimize own electricity consumption and provide services for the grid (AIT, 2015).

That said, it is crucial to adopt a holistic approach to assessing possible inefficiencies and potential for value creation on different levels, be it distribution and transmission networks, markets or consumers. It is further assumed that demand-side sources of flexibility will be connected at the medium and low-voltage levels (from 36kV to 1kV and lower than 1kV or at levels 5 to 7 in the Austrian regulation), whose providers are either residential or commercial customers (small and medium enterprises (SMEs)).

This Master's Thesis seeks to assess the implementation models of flexible technologies and strategies to determine if the current legal and regulatory framework is prepared for their assimilation. It is also relevant to review what specific benefits the deployment of flexibility sources may have for different market participants (for instance, ancillary services), end users (reduced electricity bills or direct remuneration) and network operators (grid extension deferral) and how they can be incentivized. Finally, the ways in which flexibility sources can potentially change the electricity market structure and the work of electricity utilities are scrutinized. Thus, this research combines the study of existing Austrian and European regulatory framework, the market setting as well as a survey of expert opinion. It is meant to present the big picture of the current and future standing of flexibility provision and lay the groundwork for subsequent analysis.

This Master's Thesis will build upon the existing discussion and take it a step further by aiming to answer two interrelated research questions:

1. What are the existing gaps or inefficiencies in the current Austrian and European legislation and how can it be streamlined to create more value for electricity networks and markets through flexibility?
2. How can main stakeholders be incentivized to make use of flexibility sources and under which conditions can they do so?

Answering these questions, this research aims to achieve the following goals:

- Conduct a gap analysis based on own findings as well as on the survey of expert opinion.
- Assess the implementability of the proposed use cases for LEAFS in the current regulatory framework and formulate corresponding recommendations.
- Address possible future arrangements for scalability and transferability of the proposed operation strategies to further support the massive integration of renewable resources.

1.4. Methodology

First, the goals described above will be achieved by a comprehensive textual analysis of the related EU, national and federal-state-level laws, regulations and network codes as well as reviews of pertinent market rules. Second, a qualitative analysis of different grid integration strategies will be conducted and existing regulatory barriers to such integration discussed. This particular analysis will be augmented with a review of several national and Europe-wide projects conducted by European research agencies, national DSOs and suppliers with the focus on the regulatory context and ownership models. Third, a survey of expert opinion (Annex 2) will be carried out to identify trends and pave the way to a qualitative analysis of the legal and regulatory aspects of the provision of flexibility in the electricity networks.

Since the topic of this Master’s Thesis is fairly new and subject to a lot of debate, the survey of expert opinion will enable us to improve our understanding of the issues underlying the provision of flexibility, identify challenges, opportunities and solutions. It will also make it possible to distill the general opinion on the crucial points of the discussion and assess the level of consensus within the expert group. The expert panel consists of 23 consortium members of the LEAFS project (Section 1.2), representing Austrian DSOs, technology and service providers and researchers. These are actors who are “in the trenches” of implementation of flexible solutions in the electricity network on the operational side, which makes it possible to contrast views on the same issue from different perspectives.

The survey consists of 44 closed statements pertinent to the discussion of the regulatory aspects of the provision of flexibility. The experts are requested to provide their evaluation with the help of Likert-type statements, to choose from multiple options or to fill out tables. They also have the chance to comment on their choices. Likert type was chosen in most cases since it is a classical method for opinion surveys helpful to identify tendencies and existing assessment difficulties (Boone and Boone, 2012). The 4-point or 6-point scales were chosen to eliminate the possibility of a neutral response, that is, the experts are expected to make a choice for or against a statement to a varying degree. The use of closed statement structures the responses in a way that lends itself to a more precise analysis based on concrete answers and reduces the risk of misinterpreting the results on the basis of ambiguity.

The results of 23 completed surveys will be summarized into a final report (Section 6.1 and Annex 3). The goal of the survey is not only to identify the most preferred option but also the range of different reactions to the same statement, or in other words, the degree of consensus. Likert-type statements will be analyzed together while multiple-choice questions and tables will be considered on their own merits.

In case of Likert-type data, the main goal is to adequately illustrate the distribution of results. Clearly, it is dangerous to use means when the results are the same but find themselves in the opposing parts of the scale. Thus the median value is used instead. It also helps to identify outliers. According to Allen and Seaman (2007 p. 2), *"[n]onparametric procedures—based on the rank, median or range—are appropriate for analyzing these data, as are distribution free methods such as tabulations, frequencies, contingency tables and chi-squared statistics."* Thus, frequencies and diverging stacked bar charts, recommended by the American Statistical Association (Robbins and Heiberger, 2011) will be used to adequately represent the results (see Annex 3).

The obtained inputs will be summarized, discussed critically and further incorporated into the final gap analysis (Section 6.3). This analysis will address existing regulatory and market barriers vis-à-vis the inclusion of flexibility. Therein, target outcomes will be set and the means to fill the gaps between technology, regulation and markets and to streamline integration of flexibility will be discussed. It will incorporate previous discussions and best practices from case studies as well as the results of the survey. Based on the gap analysis, recommendations on the regulatory framework for flexibility provision and plans for action will then be derived.

Thus, this Master's Thesis brings assessment results from several areas of investigation together to form a compelling interdisciplinary intersection contributing to the current body of research in the area of deployment of flexibility. It will further make a positive contribution to current and future projects and provide practical use on both the Austrian and European levels.

2 Sources of flexibility and flexibility services

2.1 Definition of flexibility and its sources

So far, there is no official definition of flexibility either on the Austrian or the EU level. For the purpose of this research, the working definition by Expert Group 3 of the Smart Grids Task Force, an advisory body of the European Commission, will be used. It describes flexibility as *"the modification of generation injection and/or consumption patterns in reaction to an external signal (price signal or activation) in order to provide a service within the energy system*" (EG3 Smart Grids Task Force, 2015 p. 12). Following this definition, the sources of flexibility include demand response (DR) measures, different types of energy storage as well as some distributed generation

(DG) technologies, including combined heat and power (CHP) plants and variable renewable energy sources (VRES) (EG3 Smart Grids Task Force, 2015; SWECO, 2015). Following SWECO (2015 p. 18) this research uses the umbrella term “distributed energy resources” (DER) to refer to these different sources of flexibility. On the other hand, following IRENA (Kempener et al., 2013 p. 26), no distinction is made between the terms “demand response” and “demand side management”.

Apart from distributed generation, Austrian legislation does not provide a definition of flexibility or make a specific reference to it. Article 7(7) of the Austrian Electricity Industry and Organization Act (ElWOG) defines “distributed generation” as *“a power plant whose handover points connects it to a public medium-voltage or low-voltage distribution system and is thus close to consumers, or a plant that generates electricity for own use.”* (ElWOG, 2010) Echoing the EU Internal Market in Electricity Directive, the ElWOG also provides a definition of “demand-side-management”, which, alongside energy efficiency, includes demand response measures. Pursuant to Article 7(13),

> *“’demand-side management’ means a global or integrated approach aimed at controlling the amount and timing of electricity consumption in order to reduce primary energy consumption and peak loads by giving precedence to investments in energy efficiency measures, or other measures such as interruptible supply contracts, over investments to increase generation capacity if the former are the most effective and economical option, taking into account the positive environmental impact of reduced energy consumption and the related aspects of increased security of supply and reduced distribution costs.”* (ElWOG, 2010; (Art. 1 (29), Directive 2009/72/EC)

This definition, however, does not make any reference to specific technologies. The Energy Efficiency Directive 2012/27/EU of the European Parliament and Council of October 25, 2012 makes direct reference to demand response measures it is set to promote without, however, providing an explicit definition. The study of flexibility from DER conducted by SWECO (2015 p. 18) defines demand response as *“changes in electric usage by end-users from their normal consumption patterns in response to market signals such as time-variable prices or incentive payments”.*

At the national level, lack of a definition for electrical storage in ElWOG or other related laws can be contrasted with the existence of one for gas storage facilities in the national legislation of several EU Member States, including Austria (DG ENER, n.d.). The latter is clearly defined in the Austrian Gas Management Act (GWG 2011) as a separate category, *"a facility owned and/or operated by a natural gas company for storage of natural gas, except for the part used for the activities pursuant to the Mineral Resources Act; excluded are also the facilities that are reserved exclusively for system operators to carry out their functions"* (Art. 7(57), GWG, 2011).

Considering the fact that flexibility has traditionally been procured almost exclusively from central generation plants with fast ramping time and large storage capacities (e.g. pumped hydro storage plants (PHSPs)), the current changing setting raises the question of whether flexibility needs new conceptualization that would be reflected in official documents. Another related question is whether there is a fundamental difference between traditional sources of flexibility and the demand-side flexibility and whether they shall be treated differently from the regulatory point of view. Taking into account the fact that the use of distribution-level flexibility opens up inherently different value streams in the system, delineation may indeed be necessary. As (EURELECTRIC, 2014 p. 6) puts it, *"[t]he possibility of services from the demand side turns the value chain of the system upside down: from the system providing services to customers, to the situation where customers provide services back to the different actors in the system".* These questions will be addressed in the subsequent gap analysis (Section 6.3).

2.2. Sources of flexibility

With the increasing shares of VRES, the need for flexibility will only become greater (Papaefthymiou et al., 2014). Flexibility allows going beyond energy efficiency and reduction of consumption. Unlike currently most common flexibility providers, PHSPs, various small-scale flexible sources can be connected and operated close to the demand side, i.e. at the distribution level close to the consumer. Sources of flexibility include, for instance, electricity storage, batteries and EVs, and thermal storage provided by heat pumps or boilers. Heating and cooling technologies comprise the main sources of demand response along with smart electric appliances, which implies that a consumer adapts their consumption patterns guided either by the price signals or the needs of the grid. Finally, active power control of distributed energy resources (DER) such as solar and wind generation or micro CHP can also provide a limited number of services in response to an incentive. Distribution-level flexibility thus serves the purpose of optimizing load profiles by modifying electricity usage, balancing supply and demand as well as facilitating consumer empowerment (CEER, 2013).

2.2.1. Distribution-connected electricity storage

Electricity storage includes, among others, solid-state batteries, electrochemical capacitors, different types of flow batteries, compressed air energy storage, flywheels (storing energy in kinetic form by way of a spinning rotor) and capacitors. Electrochemical storage such as Li-ion, Nickel-Cadmium (Ni-Cd), Sodium Sulfur (NaS) and lead batteries has been the most common small-scale storage system used in the present while most other options find themselves in the research stage. Among the former, Li-ion batteries are seen as especially suitable for electric and hybrid vehicles and residential systems (IRENA, 2015). Notably, battery technologies are characterized by the learning curve effect: their costs have been on the decline thanks to the economies of scale, which makes this option, combined with intermittent DER, especially attractive for the future provision of flexibility. Yet, the extent of the price decrease is subject to a lot of discussion and uncertainty (DG ENER, n.d. p. 21).

In the same way as stationary battery storage technologies, electric and plug-in hybrid vehicles (PHEVs) make use of a car battery for flexibility provision. They can be used for time shifting and would charge predominantly in nighttime and during weekends when the electricity price is the lowest. Their use at other times is subject to the availability of charging stations. EVs can potentially operate both in the Grid-to-Vehicle mode similar to other demand response options as well as in the Vehicle-to-Grid mode similar to stationary batteries. They are seen as particularly useful for the provision of balancing energy (Papaefthymiou et al., 2014).

2.2.2. Distribution-connected thermal storage

Resistance heating, heat pumps and electric boilers are some examples of Power-to-Heat (P2H) technologies. These are so-called “functional storage” facilities (along with demand response) transforming electricity into “other forms of energy or services” that are able to provide flexibility to the system analogously to electrochemical storage (Hinterberger and Hinrichsen, 2015).

Heat pumps are employed to transform electrical into thermal energy with high coefficients of performance of up to 400%, meaning that per each kWh of electricity used in the compressor, new heat pumps can produce up to 3 to 4 kWh of heat. Their primary usage is space heating (cooling is also possible but less efficient as some waste heat is produced) by using external heat sources, the air, water or ground. The advantage of heat pumps is their flexibility as they do not necessarily have to replace existing heating systems but can be used to complement them, particularly in times of high heat/cooling demand or as a solution in the evolving decentralized system. Additionally, such systems are characterized by price stability as compared to oil or gas heating. Reversible heat pumps are capable of transforming thermal into mechanical energy, turning it into a heat engine. The attractiveness of a heat pump solution then depends on the electricity prices in the area, the price of alternative fossil fuels (primarily oil and gas) and the climatic conditions.

Boilers are another type of flexible loads which can provide end users with warm water at any time while using electricity from the grid at off-peak time, which can be upgraded to include an active demand control system. As they are basically water-warming devices, boilers can be used both for providing hot water for showers and dishwashing as well as be fed into pipes for indoor heating. They conventionally run on oil or natural gas although now also biomass or electric boiler types are becoming more widespread. Electric water heaters, heat pump water heaters and other types of boilers can be adapted to serve as thermal batteries, which can be aggregated to provide a service to the smart grid and keep the temperature of water needed for customer use stable. To a certain extent they can also use the energy produced by DER in excess of demand and thus help avoiding curtailment. Retrofitted with control equipment, they can be used for frequency control and balance power fluctuations throughout the day.

Finally, DG ENER (n.d. p. 22) points to the high flexibility potential of small and micro distribution-connected CHP if they are operated, not according to the heat demand – as is traditionally the case – but according to the electricity grid demand when storing heat. They argue that in such a setup a CHP would be a more cost-efficient solution as compared to electricity storage, although it does depend on the availability of a smart control system (DG ENER, n.d.).

2.2.3. Demand Response

The use of demand response (DR) alongside storage can improve system stability and postpone costly grid investments and be useful for frequency control and congestion management. The Smart Energy Demand Coalition (SEDC, 2015) distinguished between two complimentary types of DR: explicit and implicit DR. The former refers to the mechanism according to which a customer is remunerated for adjusting their demand in response to prices or needs of the grid. This mechanism furthermore allows aggregation in order to facilitate participation in electricity wholesale and balancing markets. Implicit DR, in turn, allows customers to profit from their flexibility through dynamic pricing made available by the suppliers (SEDC, 2015 p. 8).

So far, the DR option has mainly been available to big consumers such as industries. In contrast, the same strategy at a smaller scale like that of households or SMEs is either not economically viable or such providers are not incentivized sufficiently to be more responsive since time-of-use tariffs are most often the only incentive available. Additionally, there are few ways to make use of demand response practicable as small end users are insulated from the marketplace, i.e. they don’t have access to the spot market (Kollau and Vögel, 2014). At the same time, their balancing responsibility is also realized indirectly through the balance responsible parties (BRPs), which are in charge of maintaining balance within their respective balancing groups (EG3 Smart Grids Task Force, 2015). This, however, is likely to change with the introduction of aggregation and smart metering.

2.2.4. Combination of different sources of flexibility

The application of the different technologies described above are combinable with VRES as well as among each other and can help to enable the development and implementation of smart grid projects. For instance, in the heating system, thermal storage can be provided by a smart heat pump while the unused electricity is stored during the night in the Li-ion battery of a plug-in electric vehicle. EVs can be used either instead of or in conjunction with stationary storage systems to ensure stable power supply for self-consumption at times when renewable electricity is unavailable.

Thermostatically controlled loads can be aggregated. For example, a combination of P2H modules and micro-scale CHP plants have already been implemented to recover excess electricity produced from local RES or to provide balancing services (Hinterberger and Hinrichsen, 2015). Such a combination allows a flexible system to provide both negative response with the help of P2H as well as positive response from CHP facilities.

Heating and cooling systems can be used in tandem with battery storage for flexible load management. According to a study conducted in the Belgian context, with the help of “smart” heat pumps the procurement costs can be reduced by up to 18% while flexibility could be increased by up to 24% without affecting the users’ comfort (Georges et al., 2014). In a 2011 study conducted by ECOFYS, it was established that the use of heat pumps reduced annual electricity consumption costs by 25-40 euro per heat pump (despite a slight increase in electricity consumption of 10%), which is more than is achieved through the construction of new pumped hydro storage plants. Heat pumps proved most efficient in a market-driven model and optimized the whole system in the presence of renewable energy sources (ECOFYS, 2011).

Finally, different sources of flexibility facilitate optimization of production from VRES. For instance, the share of auto-consumption of PV generated energy can be increased by 30-60% when coupled with battery storage (IRENA, 2015) and thus increase the penetration of local generation from renewable energy sources. Finally, as compared to generation capacities, distribution-level flexibility is seen by the stakeholders participating in CEER's public consultation as a faster and more cost effective alternative to grid reinforcement (CEER, 2013).

2.3. Grid and market services provided by sources of flexibility

The technologies described in previous Section 2.2 represent responsive loads, which can ultimately be used for load management, shedding or shifting load to the times more "beneficial" for the grid as well as preventing the use of electrical energy during expensive peak load times. Such loads are suited for short-term control and are able to provide both upward or downward demand adjustment. Heat pumps and boilers can also be turned on and off remotely with the help of control components to suit the needs of the grid (or following electricity price signals) while controlling and maintaining heating availability. It is the possibility of remote control and management together with the ability of smarter devices to respond to weather forecasts or market price signals that would allow them to capture value streams for their users and providers. Flexible technologies further permit to avoid the curtailment of power production from renewable energy sources by improving its controllability, boost system resilience and possess a potential to provide services for the ancillary services and balancing markets.

Sources of flexibility vary in the degree of maturity, levels of efficiency and a range of services they are capable of providing (Table 1). On the other hand, most of the options can provide value both on the system and local levels while EVs are capable of delivering value only on the local level (SWECO, 2015).

Sources of flexibility vary in the degree of maturity, levels of efficiency and a range of services they are capable of providing (Table 1). On the other hand, most of the

options can provide value both on the system and local levels while EVs are capable of delivering value only on the local level (SWECO, 2015).

Table 1. System services that can be potentially provided by different sources of flexibility.

VRES	Electricity storage (incl. EVs)	Thermal storage (heat/cold)	Small and micro-CHP	DR
Limited curtailment services			Generation adjustment	
	Optimized consumption/higher self-consumption			
	Demand adjustment			
	Peak shifting			
	Reactive power			
	Inertia			
	Island operation			
	Black start			
	Balancing services			
	Portfolio optimization (balancing of supply and demand)			
	Arbitrage			

Today's unbundled electrical energy system consists of two interconnected but independent domains: the regulated one, which comprises the grid operators since the grid is a natural monopoly, and the deregulated one, that is, the electricity market characterized by a vast network of market participants (Section 4.5). Notably, flexibility sources can potentially provide services for both of these domains. Besides, each flexible source can potentially provide multiple services thus creating more value for the grid and the stakeholders in the electricity system.

In the evolving context, end users (with the help of aggregators) are to become the main providers of flexibility services, which can be taken up by a number of stakeholders such as suppliers, balance responsible parties (BRPs)[9] and system operators to fulfill their responsibilities (Figure 1).

---

[9] Austrian Electricity Market Code, Chapter 1 (Definitions) defines a Balance responsible party as "the entity representing a balance group vis-à-vis other market participants and vis-à-vis the clearing and settlement agent".

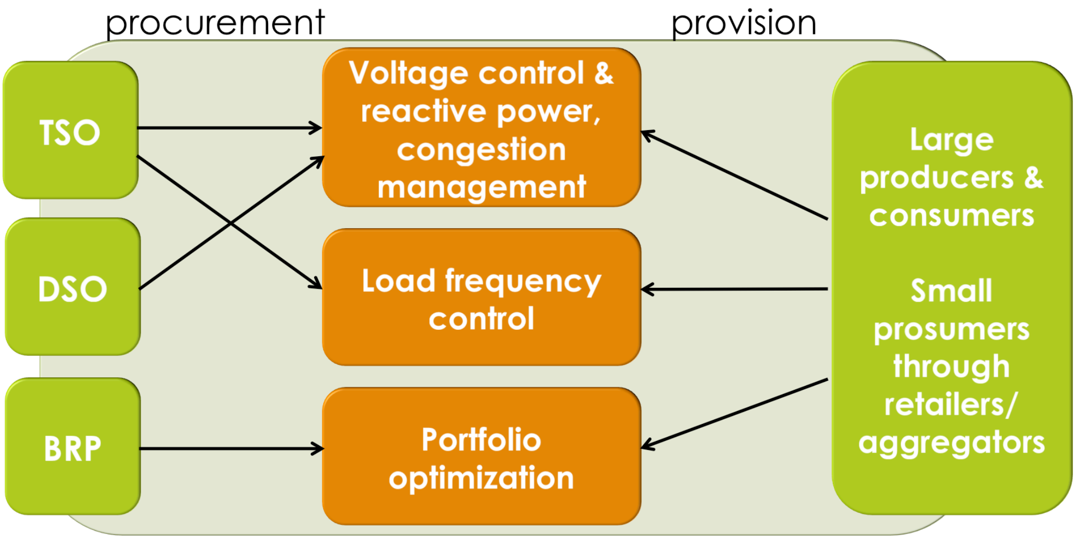


Figure 1. Procurement and provision of flexibility services.

2.3.1. Grid Services provided by flexible resources

One of the main functions of flexibility consists in safeguarding system adequacy – a direct responsibility of system operators who have to keep the system security and quality of power within well-defined standards at all times. That said, both transmission and distribution system operators (TSOs and DSOs) can make use of flexibility to deal with network constraints.

TSOs have an obligation to manage congestions (Art 40(11), ElWOG, 2010), remedy any occurring voltage or frequency deviations and maintain overall stability. Despite the fact that the discussed flexibility sources are connected at the distribution level, there are several ways in which their deployment can be beneficial for the TSO (EG3 Smart Grids Task Force, 2015 p. 3; SWECO, 2015).

Frequency control

For the purpose of frequency control a TSO has to activate reserves from its reserves portfolio in order to counteract disturbances. It requires both positive and negative reserve, which can be provided by distributed generation (e.g. micro-CHPs), storage systems or demand response. In the deregulated energy system, TSOs playing the role of a control area manager (CAM) already have to procure control energy through an open and transparent tender procedure, which will be discussed in the next Section 2.3.2).

Voltage control

In the presence of a high share of VRES connected to the grid, oversupply is more likely to occur causing voltage increases beyond acceptable limits. Flexible resources will be useful for local reactive power provision to enable more efficient voltage control for TSOs and DSOs. Improved voltage profile control will reduce the need for the significant curtailment of renewable generation, which will then also be beneficial for owners of distributed generation facilities such as solar panels.

Congestion management

The transmission capacity of the grid is limited, hence, in order to avoid power system congestion a TSO has to be able to either increase supply or reduce demand or shift peak loads to prevent grid overload. Flexibility options, particularly demand response, could be a cost-effective tool in congestion management thanks to its demand adjustment (SWECO, 2015). Furthermore, peak shifting for congestion management can be achieved by controlling energy production from VRES through storage facilities with fast regulation times (a matter of seconds for charge or discharge). At the same time, VRES themselves are also able to provide curtailment products to the system while distributed generation units such as micro-CHPs would provide generation adjustment to avoid congestions (EG3 Smart Grids Task Force, 2015).

Avoidance or deferral of grid reinforcement

More VRES may mean bigger need to reinforce grid infrastructure (as all of them are entitled to grid access) even if in practice that additional capacity will be needed only for several hours per year (EG3 Smart Grids Task Force, 2015). That need for extra capacity puts additional economic strain onto the DSOs. Consequently, DSOs may profit from the use of flexibility for the reduction of network reinforcement needs or its deferral thanks to intelligent technologies and demand response (de Bruyn and Markl, 2013). That said, a strategy that would offset the impact of growing volumes of distributed volatile generation by making use of available flexibility is likely to become a more cost-effective option as compared to a grid upgrade (CEER, 2013). Conversely, VRES can provide a flexibility service of their own by allowing for limited curtailment (down regulation) to satisfy the needs of the grid (Papaefthymiou et al., 2014). In fact, slight curtailment of 1 to 3% can reduce the need for grid reinforcement by up 30-40% respectively (Brunner, 2015). Nonetheless, it should be kept in mind that DER carries only a limited potential in terms of flexibility due to their stochastic nature and, consequently, have to be combined with other measures.

The big difference in the distribution of benefits, however, lies in whether procurement of services from flexibility is made mandatory, i.e. providers of flexibility are required to comply, or, alternatively, in a market-driven manner, which could potentially activate value streams for a larger number of participants (see Sections 2.3.2 and 6.2.1).

2.3.2. Market Services provided by flexible resources

There are several ways in which value streams from distributed flexible resources could be captured in the deregulated domain of the electricity system. Flexible technologies can open up new opportunities for end users to assume a more active role in the electricity markets. The value of different flexible resources can potentially be exposed through spot (day-ahead, intraday) as well as balancing and –potentially– other ancillary services markets.

To commercial unregulated actors such as BRPs or retailers flexibility allows shifting demand to times when electricity price is lower (arbitrage) and thus reduce costs of energy procurement or decrease needed amounts of balancing energy. Increasing shares of flexibility in the market, however, will push the price curve towards more and more flattening leading to enhanced price stability (SWECO, 2015). At the same time, arbitrage in the spot market through the use of flexibility is possible only in those settings where the spot price curve has enough peak-trough differences (in contrast, SWECO sees less value in those countries whose electricity mix is already dominated by flexible hydropower generation), i.e. is directly related to price volatility.

Since the EU electricity market still represents a patchwork of country- or region-specific setups and rules, the potential value of distributed flexible resources on the electricity markets varies from country to country and depends on several factors. Thus, the amount of investment in flexible technologies depends on “market price variability”, according to Papaefthymiou et al. (2014) who further argue that market spread decreases in situations of surplus capacity available in the market and the need for flexibility stressing the need to actively incentivize demand-side involvement. One of such measures could be adjustment of prequalification criteria for DER flexibility. To capture the value of flexibility in the close-to-real-time markets, short term contracts need to be available, which is not the case for all EU Member States (SWECO, 2015). However, the new Network Code on Electricity Balancing limits Imbalance Settlement Periods to not more than 30 minutes (ENTSO-E NC EB, 2014, Art 21, 2a). Additionally, SWECO (2015) suggests that geographical price granularity, that is, different price zones, especially for the congestion nodes, can expose the true value of flexibility.

Multiple bidding area setup has already been taken up by certain countries such as Italy (SWECO, 2015), while Austria forms a single price zone together with Germany.

Furthermore, BRPs may potentially make use of flexibility for portfolio optimization. So far, flexibility can be mainly procured from the transmission-level generation plants; more flexibility at different levels would give BRPs more options to fulfill their balancing responsibility by adjusting either supply or demand (i.e. short-term congestion management) along with energy trading (EG3 Smart Grids Task Force, 2015). With the increasing share of renewables connected to the grid, BRPs' access to flexibility sources such as demand response or distributed storage will allow them to offset the inflexibility of large volumes of VRES.

Already today, TSOs operate on balancing markets to procure balancing energy. In a similar way, there is potential for DSOs to make use of future marketplaces to procure distribution system services such as peak shifting or demand adjustment instead of the current arrangement under which loads and generation are forced to comply with the needs of the grid. Yet, current lack of organized markets for the provision of ancillary services (for example, voltage control) can prevent distributed flexible resources from delivering certain system services. SWECO (2015, p.135) observes the difficulty in creating such markets since quantification and pricing of these services is challenging.

3. Current and future roles and responsibilities.

Liberalization of the electricity market has created new market participants with a defined set of rights and responsibilities. The new reality of the electricity system entails further reconsideration of the traditional setup and the re-definition of relations between the actors in the energy system and rules for information exchange among market participants.

Growing complexity of the electricity system characterized by bidirectional energy flows

The deployment of DER enabled bidirectional energy flows (indicated with orange arrows in Figure 2) (IEA-ETSAP and IRENA, 2015). Since ever greater volumes of generation capacity will be connected at all network levels, DSOs' role will become much more active on par with the transmission grid (van den Oosterkamp et al., 2014). For the same reason, their tasks become more interconnected with TSOs and market actors. Besides that, in the future flexible resources such as demand response or distributed storage systems will interact with both regulated and deregulated actors in the system (Figure 2).

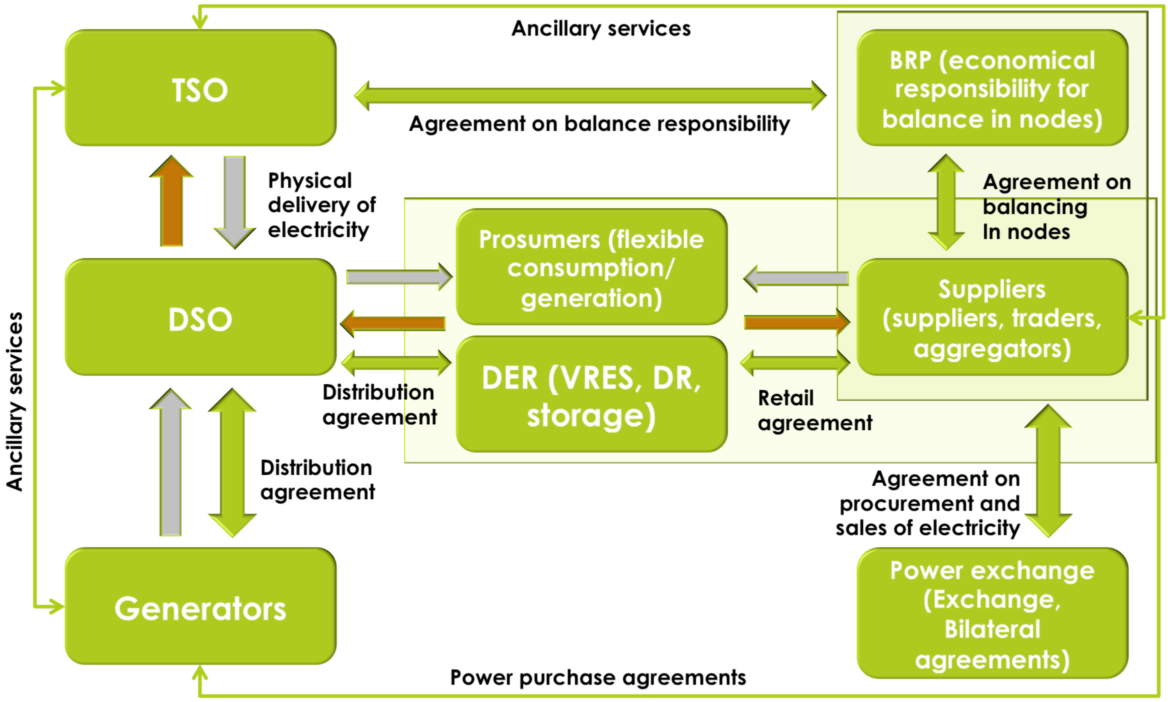


Figure 2. Evolving network of relations in the electricity system. Source: SWECO, 2015. p. 118.

Intensified cooperation between DSOs and TSOs

With tighter future interaction between DSOs and TSOs, the need for coordination between the two will increase. For instance, possible conflict situations may arise from the use of flexibility for balancing as opposed to grid services. Both uses will need to be coordinated in a way that procurement for balancing does not cause more constraints for the grid. Additionally, the transmission and distribution networks can potentially affect each other, for instance, by making the TSO unable to procure reserves from flexibility providers due to a bottleneck on the distribution level or balancing that can be affected by DSO's use of flexibility to manage grid constraints. (EURELECTRIC, 2014) These and other possible scenarios call for a greater momentum in developing the information exchange between system operators.

Emergence of prosumers and customer participation in the electricity markets

The interconnection between the end users and the rest of the system is set to intensify as they assume a more active role within it. The domestic VRES, especially PV systems, together with sources of flexibility (see Section 2.2) allow end-users to cover a share of their energy need through autonomous generation as well as creates a potential for their direct engagement in the energy system and participation in the energy markets.

Multiple studies (CEER, 2013; EG3 Smart Grids Task Force, 2015; SWECO, 2015; Deutsche Energie-Agentur, 2012) affirm the crucial future role of “prosumers”, a blending of “consumer” and “producer” used to describe the future two-fold role of flexible end users and DER owners, capable of energy generation. Their empowerment is one of the cornerstones of the smart grid development which will be realized by ensuring prosumers’ access to and (direct or mediated) participation in the marketplace on an equal footing with other actors.

Emergence of aggregators

Future involvement of prosumers and DER in the provision of flexibility services will require new institutional structures. In order to extract value from small-scale demand-side flexibility, aggregators are likely to become one of the central elements of the new structure. Aggregation is more likely to facilitate service provision at different grid levels than individual residential or commercial flexibility. As mentioned in the technology overview, not only electricity loads but also an array of thermal loads possess flexibility potential. Both types of loads can be aggregated and controlled directly or remotely and activated through market-based compensation mechanisms.

The concept of an aggregator was first introduced by the European Commission. In Directive 2012/27/EC (the Energy Efficiency Directive, Article 2(45)) aggregator is defined as *“a demand service provider that combines multiple short-duration consumer loads for sale or auction in organised energy markets.”* SWECO (2015) views aggregators as crucial enablers of wide implementation of demand response. In theory, a retailer, a telecommunications company, a new entity altogether could play the role of an aggregator. In practice, the role as well as the issue of who is in principle allowed to play the role of an aggregator is dealt with differently and to different extents in EU Member States. Thus, in Austria, the national regulator, E-Control, recognizes the emergence of aggregators and defines them in its Market Rules as “a service provider for energy management that pools together various short-term consumption or production capacities for purchase, sale or tender either in the organized energy markets or bilaterally.” (E-Control, 2015b)

Growing complexity of relations between market participants

Due to the increasing intensity of coordination tasks between the providers and procurers of services from flexible resources, the role of BRPs is also bound to grow more active and complex (SWECO, 2015). Both SWECO (2015) and EG3 Smart Grid

Task Force (2015) warn about a potential conflict of interest arising between aggregators and BRPs both acting in the deregulated electricity market when aggregators don’t have balancing responsibilities of their own.

As the number of DER owners and prosumers will grow, a competitive market for flexibility is likely to emerge (EG3 Smart Grids Task Force, 2015). Flexible consumers will need to sign a separate contract with an aggregator specifying the (monetary) reward for flexibility providers. At the same time, the system operators will be able to procure ancillary services such as demand adjustment or frequency reserve from aggregators under contractual relations (EG3 Smart Grids Task Force, 2015).

4. European and national framework concerning flexibility integration in power systems and markets

This section lays the groundwork for further discussion by presenting a comprehensive overview of the regulatory framework both in Austria and the EU (Figure 3). European and Austrian policy documents, laws and regulations are scrutinized to single out points pertinent to the provision of flexibility. As the EU is working towards an integrated energy market, flexibility sources can be relevant for the provision of a number of market services. That is why existing market rules will be presented and analyzed. Additionally, reviewing documents such as the Third Energy Package or the European plan for a new market design 2015 will make is possible to trace the general direction of the EU policy and see whether the value of flexibility has been reflected therein. On the other hand, national-level legislation will be contrasted with the legislation at the level of individual federal states to reveal possible divergence. Finally, the general terms and conditions for network operators (NOs) and their possible impact on the provision of flexibility services will be discussed.

4.1. Legal and regulatory aspects at the EU level

Pursuant to Art. 2(i) of the Treaty on the Functioning of the European Union (TFEU) energy is a competence area shared between the EU and its Member States. One of the priorities of the EU in terms of the energy system is the implementation of a single internal market in electricity, as specified in the milestone Directive 2012/27/EC. TFEU prohibits Member States from undertaking measures that would distort the market or undermine the transparency or competitiveness of its participants (Arts. 101-107, TFEU). Those articles also apply to state aid. However, aid in the form of green electricity subsidies falls under the exceptions to this provision, being *"aid to promote the execution of an important project of common European interest"* (Art. 107 (3b), TFEU). The provisions in the directives of the Council and the European Parliament shall be "approximated" in the national legal and regulatory framework for the purpose of achieving a single internal market (Art. 115, TFEU). Pan-European energy infrastructure is also mentioned as one of the goals enabling all the citizens of the Union to take equal profit from the energy system and points out at the importance of achieving *"the interconnection and interoperability of national networks as well as access to such networks"* (Art. 170 (1-2), TFEU, 2012).

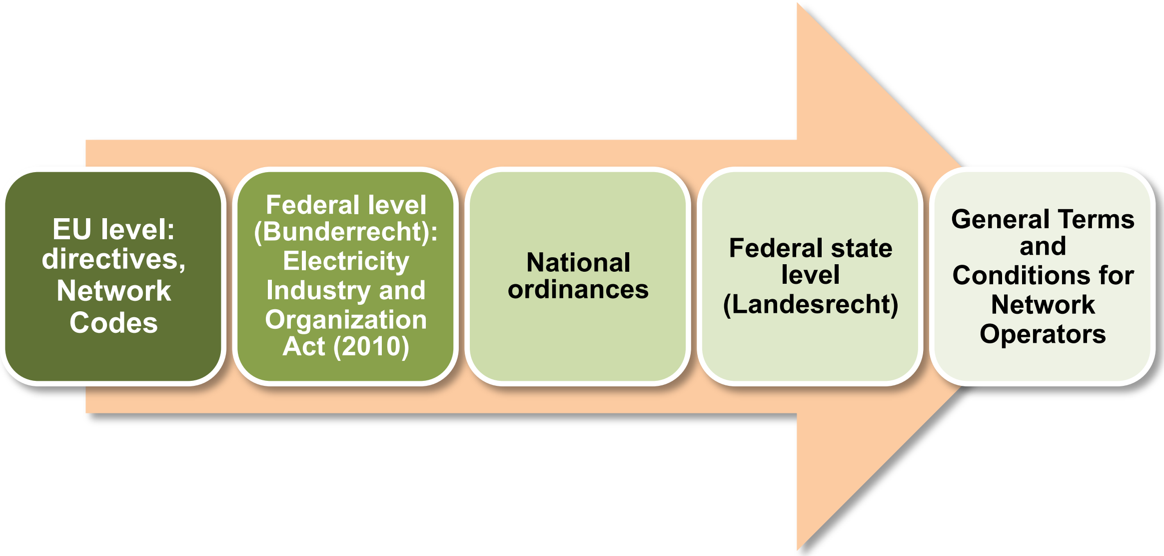


Figure 3. Structure of analysis of the legal and regulatory framework. [10]

The following EU Directives have been identified as relevant to the provision of flexibility and are subsequently examined:

- 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 ("Internal Market in Electricity Directive")
- Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC ("Renewable Energy Directive")

---

[10] Court decisions and decisions of the Regulatory Commission also form part of the national legal and regulatory framework. They remain, however, outside the scope of this discussion.

- Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC ("Energy Efficiency Directive").

The provisions thereof all have to be transposed into national law.

4.1.1. Internal Market in Electricity Directive (Directive 2009/72/EC)

The Internal Market in Electricity Directive forms a constituent part of the EU Third Energy Package, within whose framework the Agency for the Cooperation of Energy Regulators (ACER) (Regulation (EC) No 713/2009) and the European Network of Transmission System Operators for Electricity (ENTSO-E) were also created. The Directive prescribes ownership unbundling among transmission network operators, generators and suppliers in order to prevent conflicts of interest and market distortions as well as to ensure a fair competition. As a result, transmission network operators are not allowed to own or "exercise control over" generation facilities (Arts. 9 and 26, Directive 2009/72/EC). In this regard, ENTSO-E in its Ten-Year Network Development Plan 2014 recognizes the benefits decentralized storage facilities along with the centralized ones can provide to transmission system operators. It nevertheless affirms that the question of whether system operators should be allowed to own or manage such systems remains open in the current regulatory environment and is subject to future discussion (ENTSO-E, 2014) (see Section 5 for detailed discussion).

The Internal Market in Electricity Directive makes reference to some flexible technologies, namely to CHP plants, as well as to promotion of generation from RES, though doesn't explicitly mention distributed storage. Article 15 (3) of the Directive states that priority treatment shall be given to generation from RES as well as CHP installations. The promotion of flexible technologies is also implied in Article 3(11), under which the national regulatory authorities should encourage energy efficiency in innovation among electricity companies, including *"introducing intelligent metering systems or smart grids" (*Directive 2009/72/EC).

In paragraphs 7 and 11 of the Introduction to the Directive the importance of creating a level playing field for all "electricity undertakings" and further promote access to new market entrants is stressed. Ugarte et al. (2015) do argue however, that in practice, on the EU level the preference is still tilted towards traditional fossil-fuel-based solutions for flexibility provision instead of creating a level playing field for storage options in the markets (see Section 6.2.6).

In light of the fact that flexible demand-side technologies are likely to gain relevance in the growing balancing energy markets, Article 15 (7) prescribes the TSOs to adopt rules which are "*objective, transparent and non-discriminatory, including rules for charging system users of their networks for energy imbalance*". Point 37 of the Introduction further provides for TSOs to "*facilitate participation of final customers and final customers' aggregators in reserve and balancing markets"* (Directive 2009/72/EC).

The costs avoided by network operators thanks to the use of DER flexibility should be accounted for by the national regulatory authorities in the calculation of tariffs (Point 36 of the Introduction). The Directive (Art. 1(29)) defines demand-side management and prescribes to the DSOs to consider it as an alternative solution to distribution network reinforcement, according to Article 25(7) of the Directive.

4.1.2. Renewable Energy Directive (Directive 2009/28/EC)

The goal of *the Renewable Energy Directive* is to achieve a higher penetration of RES in the EU and promote sustainable electricity supply, which would allow the Union to achieve the minimum target of a 20% share of all generated electricity to be produced by RES by 2020. In Article 16 (1), "Access to and operation of the grids", intelligent networks and storage systems are clearly viewed as some of the main enables for the achievement of the Directive's goal. Member states are encouraged to "take the appropriate steps" in order to facilitate their implementation (Art. 16, Directive 2009/28/EC) in line with the EU energy policy objectives (see also Section 6.2).

In line with Article 15(2, para. 2) of the Renewable Energy Directive, only the renewable power used by the operators of pumped hydro storage facilities for the purpose of storage and production is considered as electricity from RES (Riese et al., 2014). The same logic, however, could also be applied to energy produced from home-owned PV and stored in batteries.

4.1.3. The Energy Efficiency Directive (Directive 2012/27/EU)

The Energy Efficiency Directive regulates EU-wide energy efficiency measures needed in order to counteract increased dependence on energy imports as well as the effects of climate change, safeguard security of supply and boost innovation and economic growth. It is also one of the cornerstones of the European 2020 Strategy. In this context, energy saving measures necessarily include end users as much as generators and suppliers (particularly through full access to information). The Directive puts emphasis on the empowerment of end users to allow a more efficient management of their demand (Article 12) and on the encouraging of distributed energy generation (Point 37 of the Introduction). Installation of smart meters is viewed as one of such measures to improve demand-side energy efficiency and facilitate demand-side management (Points 26-27 of the Introduction, Directive 2012/27/EU).

In the Directive, demand response is explicitly recognized as a flexibility measure beneficial for various actors in the electricity system, including end users and system operators. This is the reason why "*conditions for, and access to, demand response should be improved, including for small final consumers*" (Points 44-45 of the Introduction, Directive 2012/27/EU). Incentive schemes for a wider deployment of demand response strategies, particularly in the context of implementation of smart grids, shall be put in place on the national level. Such schemes can include, among others, *"dynamic pricing for demand response"* without prioritizing supply loads over consumer loads in terms of participation in system services markets (Point 45 of the Introduction, Directive 2012/27/EU). Supply and demand side are thus to be treated equally when it comes to achieving higher energy efficiency and savings as well as participation in the system services markets. The structure of the national network regulation shall not be discriminatory of procurement of services from the demand side, in particular peak-shifting measures, demand response, "*the connection and dispatch of generation sources at lower voltage levels*" and energy storage as these measures allow cost savings and operation optimization for the grid and thus should be reflected in the tariff structures (Directive 2012/27/EU, Annex XI, esp. a), b), d), f)).

Article 15 echoes the Internal Market in Electricity Directive, stipulating that

> *"Member States shall ensure the removal of those incentives in transmission and distribution tariffs that are detrimental to the overall efficiency of the generation, transmission, distribution and supply of electricity or those that might hamper participation of demand response, in balancing markets and ancillary services procurement.*" (Directive 2012/27/EU)

An aggregator is in this regard seen as a facilitator of demand service procurement and consumer participation (Arts. 2 and 15(8), Directive 2012/27/EU).

4.2. EU Network Codes

Regulation (EC) 714/2009 prescribed the creation of EU Network Codes with the aim of further harmonization, improved coordination and cross-border electricity exchange on the European level (Art. 1). Pursuant to the Regulation, the development of the EU Network Codes lies within the competence of ENTSO-E and is based on the Framework Guidelines as elaborated by ACER (Arts. 5 and 6, Regulation (EC) 714/2009). The Network Codes represent a compilation of rules whose overarching objective is to lay groundwork for a stable, secure and reliable electricity system, integrated competitive markets. These Network Codes are subdivided into

- Connection Network Codes (including generators and demand-side connection),
- Market Network Codes and
- Operational Network Codes,

which are developed in an established prioritized order.

EU Network Codes are legally-binding for all Member States and, once the Comitology process is finalized, will overrule national codes to exclude national deviations. SEDC (2015 p. 11) emphasizes the significance of Network Codes in setting up the first "*high-level structure enabling the participation of demand-side resources across markets and Member States*" and considers that *"[t]he inclusion of Demand Response in the Network Codes represents a critical, positive step toward widespread consumer engagement in Europe".*

For the purpose of this research, the following Network Codes seem most relevant to the regulation of provision of flexibility and will be scrutinized below:

- Network Code on Requirements for Generators (NC RfG)
- Network Code on Demand Connection (NC DCC)
- Network Code on Electricity Balancing (NC EB).

The first two Codes are also connected to the Energy Efficiency Directive as well as to the EB NC. As of May 2016, NC DCC has successfully passed the Comitology stage is now pending revision by the European Parliament and the Council. At the same time, NC RfG has passed the revision and been turned into a full-fledged regulation (Commission Regulation 2016/631). EB NC paves the way for the setup and introduction of a Europe-wide market for balancing energy. Currently, it is awaiting the Comitology process.

NC DCC outlines requirements for demand facilities and both transmission and distribution levels and distribution facilities, which are capable of providing demand response services. Pursuant to Article 27 such services include active and reactive power control, transmission constraint management and frequency control. The Code further sets as one of its goals an improved integration of RES into the electricity system (ENTSO-E NC DCC, 2012, Art. 1). However, Article 3 (2b) excludes storage facilities from the scope of the Code and does not treat them as a demand facility. Neither does it apply to PHSPs that "have both generating and pumping operation mode" while "*any pumping module within a pump-storage station that only provides pumping mode shall be subject to the requirements of this Regulation and shall be treated as a demand facility*[11]" (ENTSO-E NC DCC, 2012, Art. 5 (1-2)).

The aim of *NC RfG* lies in ensuring *"fair conditions of competition in the internal electricity market, […] system security and the integration of renewable electricity sources"* (Art. 1, (Commission Regulation 2016/631). It further stresses the importance of a "level playing field" for all generation facilities. Art. 2(21) defines pumped hydro storage as *"hydro unit in which water can be raised by means of pumps and stored to be used for the generation of electrical energy"* (Commission Regulation 2016/631). Fulfillment of specific requirements by PHSPs as well as CHPs is addressed in Article 6 (paras. 2 and 5).

Since storage facilities are also considered generation units, provisions of *NC RfG* seem to be applicable to them, too. Yet, pursuant to Article 3 (para 2d), "storage devices except for pump-storage power-generating modules in accordance with Article 6(2)" are not subject of this Code (Commission Regulation 2016/631), which leads to the conclusion that storage technologies are still viewed differently depending on their type.

On the other hand, *NC EB* allows for the possibility of flexible technologies and specifically storage to play a role in the provision of balancing energy and capacity and sets as one of the objectives of the balancing market "*facilitating the participation of Demand Side Response including aggregation facilities and energy storage*" ((ENTSO-E NC EB, 2014, Art. 10 (1h)). Further on, pursuant to Article 27 (4b) of NC EB,

> "*the terms and conditions for Balancing Service Providers shall: (a) allow the aggregation of Demand Side Response, the aggregation of generation units, or the aggregation of Demand Side Response and generation units and (b) allow Demand Facility, Aggregators and generation units from conventional and*

---

[11] Demand facility is defined as "'a facility which consumes electrical energy and is connected at one or more connection points to the transmission or distribution system" (ENTSO-E NC DCC, 2012, Art. 2(1)).

> *Renewable Energy Sources as well as storage elements to become Balancing Service Providers*" (ENTSO-E NC EB, 2014).

It can be inferred from the wording of the provision that flexibility providers are seen as future pivotal elements in the balancing markets.

4.3. EU vision on future role of flexibility sources in electricity networks

The overview of the communications of the European Commission and other documents describing the EU's vision for the future reveals that the necessary policy foundation for the pan-European support for the provision of flexibility is being actively developed and promoted. In particular this is observed in the efforts to include flexible resources as well as a wider array of actors in a new internal market design. The following documents have been reviewed:

- COM(2013) 253 (Energy Technologies and Innovation)
- COM(2015) 80 (A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy)
- COM(2015) 339 final (Delivering a New Deal for Energy Consumers)
- COM(2015) 340 final (Launching the public consultation process on a new energy market design)
- European Electricity Grid Initiative Implementation Plan 2015-2017
- SET Implementation Plan

EU policy documents discussing the current and future priorities of the European energy system largely center on 3 main areas. These include ensuring a secure and diverse energy supply, support and integration of RES in line with climate goals and a progressive creation of an integrated and competitive internal market. In these areas, active involvement of all stakeholders, particularly consumers, is emphasized in the European Commission's communications. Smart technologies, in this respect, are viewed as crucial facilitators.

Security of energy supply is one of the pivotal objectives of the future Energy Union of the EU, which occupies the first place in its share of energy imports in the world (53%, (European Commission, 2015c). In its COM(2015) 80, the European Commission points to a wide variety of national regulatory and market frameworks as a barrier since these *"do not set the right incentives and provide insufficient predictability for potential investors."* (European Commission, 2015c) This gap has already partially been addressed through the creation of ACER and development of pan-European Network Codes. The incentive to innovate and invest in both future technologies and services will be further facilitated through the creation of fully “open and competitive markets” (European Commission, 2013).

Improved integration of VRES is included in the objectives of its 2015-2017 Implementation Plan. This improved integration is one of the key goals that will be achieved by increasing system flexibility, especially by “integration of medium and small DER” (EEGI, 2014). COM (2013) 253 further recognizes the equal importance of innovation at the distribution as well as transmission levels, particularly when it comes to consumer empowerment. Of particular note is the Commission’s recognition of the fact that *“[e]lectricity storage technologies will be important at transmission and distribution level”* (European Commission, 2013).

A new European market design requires greater flexibility both on the supply and demand side, which can be achieved by making price signals available to all market players “including flexible demand, energy service providers and renewables” as well as integration of storage (European Commission, 2015b). The Commission clearly supports the competitive market-driven approach (as opposed to the mandatory provision) to flexible services. It is set to *“promote the further development of smart appliances and smart grids, so that flexible energy use is rewarded.”* (European Commission, 2015c) The specifics of the new market are now being discussed within the public consultation process launched by the Commission.

Notably, it is deemed necessary to provide equal access to consumers to the electricity market while the insulation of the retail market from the wholesale market through the regulated electricity prices creates a clear barrier for such integration and are counterproductive in the long term (European Commission, 2015c; European Commission, 2015a). As an alternative based on positive experience from the Nordic countries, dynamic pricing is deemed an appropriate manner to “reward flexible consumption” (European Commission, 2015a).

The Energy Union includes as one of its core commitments *“[f]acilitating the participation of consumers in the energy transition through smart grids, smart home appliances, smart cities, and home automation systems”* (European Commission, 2015c). Aggregators and community schemes, in this context, are likewise seen as enablers of improved consumer participation. These initiatives, however, focus on providing consumers with access to new opportunities to reap the benefits of the changing system rather than compelling a more active role onto them.

EU policy is set to further support flexible demand in general and demand response in particular as the tools to expedite integration of RES and enable consumer participation in the market. Their so far passive role can be in part explained by lack of information and incentives and, on the other hand, burdensome processes. Besides, European Commission's Communication on "Delivering a New Deal to Energy Consumers" identified several current obstacles on the way to consumer empowerment. These – besides the above-mentioned – include *"a lack of reward for active participation", "insufficiently developed markets for residential energy services and demand response narrow consumers' choices", "preventing consumers from self-generation and self-consumption" and "network tariffs [that] discourage demand response."* (European Commission, 2015a)

Finally, following the stakeholder contributions to the Strategic Energy Technology (SET) Plan currently working on elaborating an Integrated Roadmap, wherein innovation is viewed as a tool for optimal VRES integration and consumer empowerment. The SET Plan will take different storage resources into consideration for system balancing and boosting its overall flexibility. Among necessary actions Joint Research Centre of the European Commission (JRC) calls for addressing "*important framework conditions such as regulations, codes and standards, business models and financial support schemes, required to foster widespread commercialisation of these technologies*" (JRC, 2014 p. 22). Furthermore, they point out the need for new "market frameworks and business models" and promotion of R&D as prerequisites for successful future integration of DR and flexible generation options (JRC, 2014). One of the tools to promote R&D on the EU level is the European Electricity Grid Initiative (EEGI), part of the SET Plan and a product of joint work by European transmission and distribution network operators (ENTSO-E and EDSO4SG).

4.4. Legal and regulatory aspects at the Austrian national level

For the sake of comprehensiveness, the following compendium of Austrian legislation and regulatory documents was reviewed:

- Electricity Industry and Organization Act 2010 as amended in 2013 (Elektrizitätswirtschafts- und organisationsgesetz ("ElWOG 2010"))
- Electricity System Charges Ordinance 2012 as amended in 2016 (Systemnutzungsentgelt-Verordnung 2012 ("SNE-VO"))

- Electricity Labeling Ordinance 2011 as amended in 2013 (StromkennzeichnungsVO)
- Regulation on Network Congestion Charge 2008 (Netzengpassentgelt-Verordnung (“NEP-VO“))
- Green Electricity Act 2011 as amended in 2012 (Ökostromgesetz (“ÖSG”)), together with Green Electricity Support Ordinance 2015 and Green Electricity Flat Rate Ordinance 2015 (Ökostromförderbeitrags-VO, Ökostrompauschale-VO)
- Combined Heat and Power Act 2008 as amnded in 2015 (“KWK-Gesetz“)
- Electricity Tax Act 1996 as amended in 2014 (Elektrizitätsabgabengesetz)
- Austrian Electricity Market Code[12]
- Pertinent national Network Codes („Technische und organisatorische Regeln für Betreiber und Benutzer von Übertragungs- und Verteilernetzen gem. ElWOG (“TOR”), TOR A, D).[13]
- Gas Management Act 2011 as amended in 2015 (Gaswirtschaftsgesetz (“GWG”)).

4.4.1. Electricity Industry and Organization Act (ElWOG)

The Austrian framework regulating the electricity system has so far largely reflected the traditional system structure characterized by centralized generation connected to the transmission grid while distributed generation facilities are covered to a much lesser extent. This explains the reason why so far, the only flexible technology covered in the current legal and regulatory documents remains pumped storage.

Thus, under the new amendment of 2013 of ElWOG 2010, Article 111(3) of the Act exempts *new* pumped hydro storage plants from network use charges and network losses charges until the year 2020, placing pumped storage at a clear economic benefit against other similar technologies. And yet, Riese et al. (2014, p. 56) point out that “*neither electricity storage nor PHSPs are identified in the relevant legal framework as an element of the energy industry value chain of its own*”.

Flexible generators are used to balance the gap in forecasting and mitigate supply and demand uncertainty. On the other hand, different demand response strategies can also

---

[12] Electricity Market Code is drawn up by E-Control in cooperation with market participants, it does not constitute a regulation but a set of rules binding on the participants.

[13] TOR is drawn up by E-Control in cooperation with system operators, it does not constitute a regulation, rather a set of technical norms.

either increase or decrease demand depending on the grid needs or price signals. This research, however, has not identified any coverage of the demand response in the national legislation. The only explicit reference made to demand-side flexibility can be identified in the Article 45(22) of Austrian Electricity Industry and Organization Act (ElWOG, 2010). Pursuant to this Article, when considering grid extension or reinforcement, a DSO should take into account, "*energy efficiency measures, demand side management or generation from distributed energy resources, with the help of which reinforcement or capacity replacement could become unnecessary*" (ElWOG, 2010). In this way, DSOs are encouraged to make use of flexibility available at the distribution level.

Article 51 (1) of ElWOG 2010 states that all network users without exception are to pay system charges to the system operators and CAMs for the services they provide, such as operation, maintenance, reinforcement of grid and control of power quality. ElWOG 2010 singles out eight charges as specified in para. 2 of the same article (see also Section 4.4.2). The charge for system losses is payable by both injecting and withdrawing parties. However, Art. 53 (1) of ElWOG 2010 exempts withdrawing parties with capacity equal to or lower than 5MW from paying it. The charge for system services (Art. 56, ElWOG, 2010) is also not applied to those injecting parties whose maximum electric capacity is equal or lower than 5MW.

4.4.2. Electricity System Charges Ordinance (SNE-VO)

The regulatory authority determines system charges and formalizes them in the SNE-VO, according to Arts. 48 and 51 of ElWOG 2010. Pursuant to Art. 1 of SNE-VO 2012, the grid charges consist of:

(1) a system utilization charge,
(2) a charge for system losses,
(3) a system admission charge,
(4) a system provision charge,
(5) a system services charge,
(6) a metering charge and
(7) a charge for other services.

Apart from the one-time system provision and system admission charges, the parties withdrawing electricity from the grid are to pay a network utilization charge and a charge for system losses. On the other hand, the injecting parties' bill includes a system services charge as well as the charge for system losses (Art. 52, ElWOG, 2010). These corresponding costs are determined in accordance with Art. 59 of

ElWOG 2010, apart from (3) and (6), vary according to the voltage level to which an end user or a facility is connected (Arts. 6-9, SNE-VO, 2012). Besides, different system utilization charges are stipulated for different federal states. Concerning network level 6, only three states differentiate between metered and interruptible loads (such as boilers and heat pumps), providing lower charges for the latter in case of Burgenland and Styria and slightly higher charges for interruptible loads in case of Lower Austria (Art. 4 (6), SNE-VO, 2012)). Conversely, for the low voltage network the differentiation between metered, non-metered and interruptible loads is made in all federal states. However, there are still differences in assigning the utilization charges. Namely, the lowest charge for interruptible loads is assigned in Upper Austria while in Salzburg and Styria charges for interruptible loads are higher than those for metered loads (Art. 4(7), SNE-VO, 2012)).

System charges are specified both for injecting and withdrawing parties, which ultimately may imply double charge for storage systems, which in Austria are considered both as electricity users and producers, due to the specifics of their operation. Such liability for the payment of double charges negatively affects the business case of distributed storage while an exemption currently covers only PHSPs (as observed in Section 4.4.1). Additionally, a separate network use charge is designated for PHSPs amounting to 0.075 c/kWh (which is equivalent to the utilization charge for facilities connected to the network level 1) and 100 cents per kW of capacity (Art. 4(8), SNE-VO, 2012)).

Furthermore, the most recent amendment of the Ordinance (2016) includes reduced tariffs for the providers of control reserve – excluding PHSPs – and amount to 0.075 cents per kWh of yielded energy and 100 cents per kW of capacity (Art. 4(9), SNE-VO, 2012 idF 2016). However, this option as of today is available only to loads connected the grid levels 1 to 6 (from 380kV to 1kV, Art. 63, ElWOG, 2010)

4.4.3. Electricity Tax Act (Elektrizitätsabgabegesetz)

All suppliers of electricity as well as all electricity consumers are subject to the electricity tax, as stipulated in Article 1.1(2) of the Electricity Tax Act, including the consumption of auto-produced electricity. The amount payable by all consumers corresponds to 0,015 cents per kWh (Art. 4(2)). According to Article 2.1(a) of the Electricity Tax Act 1996 idF 2000, those power generators that produce energy for own consumption rather than for grid feed-in are exempted from the electricity fee if their annual generation volume does not exceed 5,000 kWh. This provision is particularly advantageous for pumped storage power plants while the second part of Article 2 benefits oil or gas-fired generation units since it exempts them from being charged for electricity that is needed "*for the further transport of electrical energy from natural gas and oil.*" (Elektrizitätsabgabegesetz, 1996 idF 2000)

In 2014 a number of members of the Parliament of the federal state of Lower Austria called for the exemption of auto-consumed electricity from RES from the electricity tax (Parliament of Lower Austria, 2014). In the current state of the regulation, in cases of consumption exceeding 5,000 kWh per year, the electricity tax is to be levied on the whole generated and consumed electricity volume. They further argued that such conditions undermine the aims of the ÖSG and competitiveness of green electricity in the market. It was subsequently suggested to exempt auto-consumed energy generated from RES from the tax for the amount not exceeding 25,000 kWh per year (Parliament of Lower Austria, 2014). In their 2014 proposal, the members of the Parliament of Lower Austria stress the necessity of calling the Federal government to rethink the Electricity Tax Act in a way that would be more in line with the ÖSG 2012 as well as the national and EU-wide policy and make integration of RES more economically sound. As a result, the Electricity Tax Act has been amended accordingly to include the provision of a tax-free limit of 25,000kWh of yearly auto-consumed energy from RES in Article 1.1(b) of the Act (Elektrizitätsabgabegesetz, 1996 idF 2014). This exemption, however, applies exclusively to the energy *not* fed into the grid.

4.4.4. Network Congestion Charge Ordinance (NEP-VO)

NEP-VO contains provisions for congestion management services procured by the control area manager from producers, including pump storage power plants. It however refers only to the production facilities connected to the voltage levels 1 to 3 (ultra high voltage and high voltage), i.e. only the transmission grid. Producers lowering or incrementing their production to reduce congestion receive remuneration from the CAM (Art. 3(1), NEP-VO, 2008).

4.4.5. Green Electricity Act (ÖSG)

The overarching objective of the law is to stimulate production of electricity from renewable energy sources, increase their share and potentiate their maturity in the market conditions and long-term investment security (Art. 4(1), ÖSG, 2011 idF 2012) It also specifies the planned generation capacity out of hydropower, wind, solar and biomass power till the year 2015 and 2020 (Art. 4(4), ÖSG, 2011 idF 2012). According to the ÖSG, electricity produced from renewable energy sources does not include the energy obtained from pumping "*for the purpose of storage in storage systems*" (Art. 5(28), ÖSG, 2011 idF 2012).

Every installation is entitled to grid access, according to Article 6(1) of ÖSG and Article 15 of ElWOG 2010 except in cases of grid disturbances and insufficient available transmission capacity, in which situation RES and CHP plants are given precedence (Art. 20 and 21, ElWOG 2010). The same right to grid access is guaranteed to all end users and generators connected to the distribution network level (Art. 44(1), ElWOG, 2010). OeMAG, the Austrian settlement agency for green electricity (and the responsible party for the green electricity balancing group at the same time), is obliged to conclude feed-in contracts with renewable (and hybrid or mixed) systems for the uptake and payment of electricity produced from such sources, subject to availability of subsidies, pursuant to Art. 12, for a period of time established in Art. 16. Upon conclusion of a contract, the renewable system operators become members of the green electricity balancing group (Art. 14(2), ÖSG, 2011 idF 2012). Pursuant to Art 37 (4), OeMAG has to establish a balancing group for green electricity in each control area in Austria and to take all measures to minimize the necessary balancing energy amounts.
Electricity produced from PHSPs is considered within the Green Electricity Act to be electricity from RES, excluding the electricity used for pumping and storage (Art. 5(28) ÖSG, 2011 idF 2012).

The green electricity flat rate per metering point is in the same way levied on all connected end users (Art. 5 (24), ÖSG, 2011 idF 2012). For the mid- and low-voltage network, to which decentralized flexible resources would be connected, this rate amounts to 33 EUR per the grid users at the low-voltage level the period from 2015 to 2017 (Art. 1, (Ökostrompauschale-VO, 2015). These payments are designed to cover the investment grants for a number of promoted renewable technologies such as CHP (Art. 7(3), KWK-Gesetz, 2008 idF 2015) and small hydro power generation (Art. 45(5), ÖSG, 2011 idF 2012).

In addition to the flat rate for green electricity, green electricity aid is covered by the contributions from all end users connected to the grid (Art. 5 (24), ÖSG, 2011 idF 2012) and is required to cover those expenses not yet covered by the flat rate. The support payments are proportional to the charges for network utilization and network losses (ÖSG, Art. 48(1)) and amounts to 30,76% of the aforementioned charges (status of the year 2015, Art. 1, ÖkostromförderbeitragsVO, 2015). Since storage is viewed as a withdrawing party as well, storage technologies, including pumped hydropower storage, are not free from the support payments despite the fact that, for instance, battery storage is used to enable increased use for distributed generation from renewable energy. The support payments for network levels 6 and 7 are 11.005 and 11.951 EUR/kW capacity respectively and 0.442 cents/kWh and 0.691 cents/kWh of work respectively. It is noteworthy that flexible interruptible loads (such as boilers and heat pumps) are not charged for capacity but are levied a subsidy payment of 0.692 cents per kWh of performed work. The amount of support payable as a component of a charge for network losses constitutes 0.034 cents/kWh for loads at level 6 and 0.085 cents/kWh for loads at level 7 (Art. 2, ÖkostromförderbeitragsVO, 2015).

4.4.6. Electricity Labeling Ordinance (StromkennzeichnungsVO)

This Ordinance is linked to Arts. 78-79 of ElWOG (2010) and the provisions of the EU Renewable Energy Directive (Directive 2009/28/EC). These oblige electricity suppliers to include in the information provided to end users the exact energy mix used for the production of delivered electricity (electricity labeling), including the share of green electricity and the percentage breakdown as well as the information on environmental effects, including saved CO2 emissions.

Article 79a (2) of ElWOG 2010 and, consequently, Art. 8a of the Electricity Labeling Regulation include a special provision for pumped hydropower storage. Additionally, ElWOG provides for a special account (Art. 2(2)) in the register of "*guarantees of origin*" (ElWOG, 2010) for each pumped storage power plant. These guarantees of origin have to be transferred to the power plants account excluding 25% of the deleted guarantees as stipulated in Art. 79a(2) of ElWOG 2010. The explanatory note to the Electricity Labeling Regulation clarifies that such an arrangement is met in order to "map the technical losses of such a storage technology" since the efficiency of such a plant is assumed to be 75% (StromkennzeichnungsVO, 2011 idF 2013) According to Article 79a(2), electricity suppliers for pumped storage power plants have to transfer the guarantees of origin to the plant operators. The operators of such power plants have to provide guarantees of origin for the electricity supplied to them by the retailers that they subsequently used for electricity generation.

Finally, Article 8a of the Ordinance prescribes that the network operators report separately the electricity quantities used by the pumped storage power plants for the pumping and electricity produced by the plant. This provision is meant to keep track of the primary energy sources electricity is produced from and avoid double counting as the electricity quantities used for storage are not included in the electricity mix retailers provide to their end users.

4.4.7. Combined Heat and Power Act (KWK-Gesetz)

Both Acts are devised to promote energy efficiency measures, the reduction of CO2 emissions and heating/cooling demand and foresee investment grants for the implementation of such measures. The Act on the Promotion of Installation of District Heating and Cooling explicitly includes such newly installed technologies as heat and cold storage, pumping stations and hot water stations, among others, in its definition of „network infrastructure facilities" (Art. 3(7), KWK-Gesetz, 2008 idF 2015). In this context, only CHP facilities and those heat-generating facilities (e.g. boilers) corresponding to the criteria of high efficiency are entitled to support for efficient district heating (Art. 4 (2b, 3), KWK-Gesetz, 2008 idF 2015). These technologies fall under the eligible ones for subsidies (Art. 6) under the conditions described in Art. 5 (1,2) and Art. 6(3) of the Act.

Pursuant to the CHP Act, highly efficient combined heat-and-power plants capable of generating heat for the district heating networks and electricity are entitled to investment grants, varying according to the installed capacity (in the range between 100MW and 400MW) up to a maximum 10% of the total investment costs (Art. 7(3), KWK-Gesetz, 2008 idF 2015). Such power plants connected to the distribution grid belong to the group of flexible technologies which, as pointed out in Hinterberger and Hinrichsen (2015), can be combined with power-to-heat technologies to achieve a higher flexibility potential for the grid.

4.4.8. Technical and Organization Rules for the Operators and Users of Electricity Networks (TOR)

TOR are Austrian Network Codes. Part D of TOR is of special interest for this research as it focuses on the issues related to the distribution networks. In particular, Section D4 deals with the parallel connection and technically secure operation of generation facilities with distribution networks.[14] It is meant to ensure that DSOs are kept fully informed about the new installations or modifications of the facilities to ensure that such facilities do not cause negative effects for the grid's stability and power quality. The operation mode has to be agreed upon with a DSO based on technical specifications.

---

[14] Since the area of concern of this Master's Thesis are distribution-level sources of flexibility, Network Code B dealing with the connection and operation of generation facilities at the transmission level is outside of the scope of this discussion.

Previous version 2.1 of the Network Code D did not include a clear reference to flexible technologies such as storage systems. This, however, changed with the new version 2.2 of TOR D4, approved on February 22, 2016 and entering into force on July 1 of the same year. The new version recognizes the availability of a variety of technical generation solutions capable of assisting the grid, particularly in the increasing presence of PV systems. According to E-Control, the new version is meant to contribute to the "*further economically feasible generation of electricity from renewable energy sources.*" (E-Control, 2016a). This is the first time electricity storage is taken into specific consideration, in which the Austrian regulatory authority deems storage systems to be generation facilities *"in their effect on the distribution network […] unless specified otherwise"* (TOR D4, E-Control, 2016a).

Since storage systems are well capable of contributing to voltage control in middle- and particularly in low voltage networks Section 7 of the Code is also pertinent to storage too. Section 7 specifies that generation facilities should be able to provide both static and dynamic support to the grid, including disconnection from the grid or provision of reactive power in case of grid disturbances. According to the version 2.2 of TOR D4, point 7.1.3, "*the fulfillment of requirements with respect to reactive power has priority over injection of active power*". This version seeks to enable the use of a reactive power control for a larger number of technically capable generation facilities by providing more extensive rules and strategies for such provision.

Similar to other generation facilities, storage systems are not allowed to exceed the limit values with respect to circuit feedback specified in the D2 part of the Network Codes (11, TOR D4, E-Control, 2016a). Section 13 of TOR D4 foresees the possibility for a DSO to disconnect a facility from the grid in the event of a potential system failure. This is enabled by an installed disengagement switch serving as the point which uncouples the facility from the grid when necessary (Section 6, TOR D4, E-Control, 2016a).

Section 3 of version 2.2 identifies six electricity storage-specific operation modes:

> "*(1) grid-connected operation for the storage of excess generation from customers' RES;*
> *(2) grid-connected operation for the supply of energy in the event of energy deficit from customers' RES;*
> *(3) island operation for the storage of excess generation;*
> *(4) energy supply in the case of island operation;*

(5) storage of energy from the distribution network;

(6) injection of energy into the distribution network" (TOR D4, E-Control, 2016a).

Thereby multiple storage systems at the same connection point are considered as one. The overall capacity includes both the capacity provided by the customers' generation facilities and storage facilities together and whose maximum level has to be contractually fixed and observed (Section 3, paras. 4-6, TOR D4, E-Control, 2016a). However, if a storage system is implemented exclusively for its own consumption, i.e. excludes operation mode (6), only the capacity of generation facilities is accounted for when determining the maximum capacity (footnote 1). So far, the use of storage "to maximize own consumption" is the most common operation mode. Maximum allowed nominal apparent power should not exceed 30 kVA per grid connection point, which includes all generation facilities and storage systems together (Section 6, TOR D4, E-Control, 2016a).

4.4.9. Gas Management Act (GWG)

As previously mentioned in Section 2.1, GWG 2011 provides an explicit definition of gas storage, which is also conceivable due to the fact that gas storage has habitually been used for securing demand coverage at a short notice. The existence alone of a clear limitation of the concept of a gas storage facilities points to its specific role and relevance for the energy supply system (Art. 97,GWG, 2011). Yet, the fundamental difference between the two types of storage lies in the use of gas storage systems as part of the network infrastructure. In contrast, in the case of the mature pumped hydro storage technology, their use solely as a network infrastructure component would consequently inhibit its participation in the wholesale electricity market. As to other technologies adequate for electricity storage, although their use for network infrastructure is conceivable (Riese et al., 2014), alone it would considerably limit the value of such systems, particularly for the consumers.

4.5. Pertinent market rules

The Austrian liberalized electricity market model is shaped by the pertinent regulations and laws on the national and EU levels. Following the underlying rule of deregulation, network operation has been unbundled from the rest of the electricity supply chain – that is, generation, trade and supply to the end consumer. Additionally, liberalization made both consumers and generators free to choose their supplier or trader and to change one at any time. Thus, both electricity generation and trade and supply sides are now able to participate in the competitive market. On the contrary, transmission and distribution networks, being natural monopolies, remain in the regulated domain in order to avoid market distortions and potentially abusive (pricing) practices.

4.5.1. System of balance groups

Within the Austrian model, balance groups were introduced to ensure smooth operations among numerous market players and facilitate a balance between the electricity produced and consumed. Each market participant (both electricity users and suppliers) is obliged to join a balance group (Art. 85, ElWOG 2010). Balancing energy is allocated accordingly to different balance groups[15].

All balance groups are accountable to the clearing and settlement agent (CSA) and the CAMs. Each such group is led by a BRP, responsible for all the communication and data exchange with other market participants, particularly with the clearing and settlement agent. Balance group members can be connected to various grid locations (not necessarily in the same grid area) forming a “virtual group” (ElWOG, 2010), within which the amounts of electricity injected and withdrawn have to match.

Significant deviations from this balance disturb established system frequency of 50Hz and cause instability (in worst case followed by outages or blackouts) when not remedied at a short notice. Forecasting of future electricity generation or demand is an essential procedure that has to be performed by generators, suppliers as well as traders. All members of a balancing group are required to act in line with their balancing responsibility. As anticipated in Section 3, aggregators need to be accountable for their actions in terms of balancing energy, so as not to negatively affect other actors. Balancing responsibility of aggregators will be further discussed in Section 6.2.8.

4.5.2. Options for the procurement of electrical energy

So far, electricity trade can be realized in two ways: either through bilateral contracts (over-the-counter market) or over the power exchange. The wholesale electricity market is organized in a series of markets needed to match supply and demand. These include the forward, day-ahead, intraday markets. Due to the expansion of RES

---

[15] Apart from “unmediated” balancing group members that conclude a contract with the balancing group coordination for the accruing balancing energy, “mediated” members, network users and electricity traders, do not have a contract directly with the APCS but instead belong to the balancing group of their supplier (E-Control, 2015b)

generation the intraday market is likely to gain importance and will provide possibilities to guard against short-term fluctuations and to commercialize flexibility (Havranek, 2012).

Long-term forward contracts remain the most common way of guarding against electricity price volatility. Yet, positive developments can be observed in the wholesale markets favoring the use of distributed sources of flexibility such as demand response. The need for “more flexible wholesale market strategies” has been recognized by the Austrian regulatory authority, E-Control (Kabinger et al., 2014). In Germany and Switzerland 15-minute contracts have been in successful use since 2011 and 2013 respectively while Austria followed suit in October 2015 (EPEXSPOT, 2015). Contract matching closer to real time across the three countries will help to better internalize the actual value of flexibility and facilitate participation of DER. On the downside, if the end-prices continue to be regulated, the actual value of flexibility clearly escapes them. This, however, is not the case in Austria.

4.5.3. Load profiles and customer participation in the markets

Following up on the discussion in Section 3, with the help of smart flexible technologies and smart meters, customers would be able to take an active part in the electricity markets. Smaller customers and prosumers would then require mediation of aggregators. But so far in Austria, small loads are generally assigned so-called standard load profiles (SLP)[16] while the actual consumption is measured only once a year, which clearly hamper consumer access.

Concerning specific sources of flexibility, Chapter 6 of Austrian Market Rules on metering and load profiles addresses the load profiles of warm water storage, nighttime heating storage as well as mixed systems (E-Control, 2012). They are characterized by charging during night hours (from 6am to 10pm) with optional recharging from 1pm to 5pm. Standardized load profiles (SLPs) for nighttime heating storage systems have been drawn up assuming 80% of consumption during winter time, 20% of the annual consumption during inter-seasonal time and 0% consumption in summer. Regarding warm water storage, the consumption is assumed to be uniform throughout the year. The load profiles described above can be combined with the standardized consumption profiles of, for example, households, to produce a separate HA load profile for warm

---

[16] Standardized load profiles are used whenever the annual energy taken out or fed into the grid at a metering point does not exceed 100,000 kWh and the capacity is lower than 50kW. In such a case the system operator bears no obligation to install load profile meters (Chapter 6 (4), E-Control, 2012).

water heaters or HF load profile for a storage heater (Ch.6 (3.6), E-Control, 2012). In this case, the network operator can control these systems remotely.

4.5.4. Market rules and schedules

Representatives of balance groups are responsible for submitting their planned schedules to the CSA for balancing energy calculation, that is, the difference between the amount of electricity actually taken out or delivered by the balance group and the amount provided in the submitted schedule (Chapter 3, E-Control, 2015c). At the same time, they are to be submitted to the CAM to give a clear idea of the future availability of power plants and electricity deliveries. Balance groups use schedules to provide the CAM and the CSA with information about the planned/projected electricity injections and withdrawals (Section 7, ElWOG 2010).

Pursuant to Section 7 of ElWOG 2010, procurement schedules and delivery schedules are required to be balanced. Notably, additional schedules exist for generation, green electricity, network losses as well as for flexible pumped storage but not for other sources of flexibility. Technical grid losses are inevitable in the electricity transmission and distribution processes and the amount of the incurred network losses also has to be taken into account. The costs incurred by the network operator to neutralize network losses are settled between the operator and the grid users through the network losses tariff (see Section 4.4.2). For this purpose, special network losses balance groups have been designed to account for such losses.

Since it is impossible to predict with complete accuracy how much energy will actually need to be used or have to be generated, deviations occur between the forecasted schedules from the values metered *ex post* (collected and aggregated by the network operator) and have to be dealt with by the BRP. The amount of balancing energy is measured and the price is determined every quarter of an hour. Article 23, para 3 of ElWOG 2010 explicitly prohibits CSA's direct involvement in any energy production, supply or trading companies within the current decoupled energy system.

4.5.5. Load frequency control and balancing market

With the unbundling of the energy system, the procurement of balancing services has been moved to the deregulated domain of a balancing market. In Austria, with the ElWOG 2010 an auction-based balancing energy market has been introduced to substitute exchange at fixed prices. At the weekly auction organized by the CAM prequalified generators available to provide control power have to submit their bids, for which the CAM then establishes a merit order. Today in Austria the share of the business volume of the balancing energy market constitutes about a tenth of the spot market volume – a figure that is set to grow in the future (Mair, 2015).

The balancing market consists of primary, secondary and tertiary reserve, differentiated according to the reaction time. The participation in the balancing energy procurement is regulated and overseen by the CAM based on weekly auctions. In Austria current regulation foresees that balancing energy suppliers with capacity of more than 2MW can participate in the auctions for primary reserve, more than 5MW for secondary and from 5MW to 50MW for tertiary reserve (www.apg.at, 2016). The price of primary reserve is formed from the power price alone, while that of secondary and tertiary reserve consists of the power price in EUR/MW as well as the energy price in EUR/MWh. The secondary reserve is activated automatically. The choice of activation reserve is based on the tender procedure as well as the market-based merit order (Art. 69(1), ElWOG 2010). In contrast, tertiary reserve is activated within 15 minutes and upon request. The costs of control reserve are covered up to 78% by the generators (with more than 5MW maximum electric capacity) by way of a system service fee while the remaining 22% are covered by balancing groups (as balancing energy) (www.apg.at, 2016).

Tendering procedure is one of the ways that could capture the value of flexible resources. For the distributed resources to be able to participate no distinction would have to be made between whether balancing services are provided by centralized or by decentralized components. In practice, each potential supplier has to be prequalified (separately for primary, secondary or tertiary reserve) to participate in the balancing energy market (www.apg.at, 2016). In this respect, Kollau and Vögel (2014) recognize the potential importance of pooling that would make it easier for distributed flexible sources to fulfill the requirements for market entrance. Currently high costs in the balancing energy market further justify the use of flexibility. More suppliers of balancing energy will reduce the prices as so far few (qualified) providers of balancing energy keep pushing the prices higher up above and beyond the fluctuations in the electricity system caused by the RES. In Austria, several measures have been undertaken to facilitate the access to the balancing market for the distributed flexible resources, including revised prequalification criteria (Kollau and Vögel, 2014) and a new grid usage charge for balancing energy providers introduced with the new amendment of 2015 of the E-Control Market Rules.

All in all, the current market rules generally address PHSPs and thermal storage, among different available sources of flexibility. Despite this, some developments in Austrian electricity markets such as the introduction of 15-munte contracts on the wholesale market and availability of a pooling option in the balancing markets will likely help to boost DER participation. Important is to note that how much value will be extracted from such participation and who will be the main beneficiaries of DER participation in the markets will depend on specific setups, which will be further discussed in Sections 5 and 6.2.1.

4.6. Differences on the level of federal states (Upper Austria, Salzburg, Styria)

The Austrian electricity system is regulated on both the national level and the level of single federal states. The division of competences between the two levels is stipulated in the Austrian Federal Constitution (Bundes-Verfassungsgesetz ("B-VG")). Pursuant to Article 12 of the Constitution, the Austrian state provides framework legislation while the enacting legislation as well as the fulfillment of legislative prescriptions lies within the competences of single federal states, and specifically in the electricity sector (Art. 12 (5), (B-VG, 1930 idF 2014).

For the purpose of this discussion three Federal State Acts on Electricity Industry and Organization, namely those of Upper Austria, Styria and Salzburg[17], were reviewed:

- Oö. Elektrizitätswirtschafts- und -organisationsgesetz 2006, as amended in 2014 ("Oö ElWOG 2006")
- Steiermärkisches Elektrizitätswirtschafts- und - organisationsgesetz 2005, as amended in 2014 ("Stmk. ElWOG 2005")
- Salzburger Landeselektrizitätsgesetz 1999, as amended in 2015 ("Szb. LEG 1999")

All three Acts include the definition of the demand-side management recognized as a way to reduce peak demand and increase energy efficiency. The importance of considering alternatives to grid reinforcement including "energy efficiency, demand-side management or DER" for DSOs is also stated in the Federal State Acts (Art. 40 (19) of Oö ElWOG 2006, Art. 29(22) of Stmk. ElWOG 2005 and Art. 18(22) of Szb. LEG 1999). As to other flexibility options, none of the Acts bear any reference to electricity storage, electrical vehicles, heat pumps or other flexible technologies. Surprisingly enough, Oö

---

[17] Federal states in which the implementation of the control approaches for project LEAFS (see Section 1.2) are being tested.

ElWOG 2006, contrary to the Federal ElWOG 2010, does not mention pumped hydro storage in any context.

This research has further identified differences in wording with regard to demand-side measures. In the Stmk. ElWOG, the following provision was added to clause on “Principles Regarding the Operation of Electricity Undertakings”, Art. 4 (which is Art. 6 in Federal ElWOG 2010): “*undertakings act as customer- and competition-oriented providers of energy services according to the principles of secure, environmentally sound and efficient provision of the services demanded at reasonable cost, and of a competitive electricity market”*, and the following stipulation: “*considering all the supply and demand side options.”* (Stmk. ElWOG, 2005) This stipulation arguably puts the demand-side available solutions on the same level with the supply side in Styria.

Further on, only Stmk. ElWOG 2005, the Section on “Responsibilities of Generators” (Section 2, Art. 37) mentions pumped hydropower storage facilities with regard to data transmission to control area managers. This provision, however, is only concerned with facilities connected to the network levels from 1 to 3 (ultra high voltage and high voltage) and is the only point in the Act in which pumped storage is mentioned.

In Salzburg Electricity Act 1999 in “Exceptions from the general obligation to connect according to Art. 18 para.1”, Article 22, such an obligation is not applicable to the cases when such a connection is not deemed in line with the economic interests of end users or those end users for whom it makes more economic sense to cover their electricity needs with their own generation facilities. Finally, the obligation is not applicable to *“facilities for resistance heating of living areas using electric power, except for installations complementing space heating by solar energy, heat pumps, etc., for times of extraordinary demand for heating.”* (LEG, 1999). Notably, this provision is not included in the national ElWOG.

Both the extent to which the Federal ElWOG 2010 is reflected on the level of federal states and the emphases set in them differ. The fact that flexibility is hardly mentioned in any of the three examined Acts creates a regulatory gap. It is necessary to standardize the legal documents so they adequately reflect not only federal law but also EU directives and overcome possible barriers for project implementability and transferability from one federal state to another.

4.7. General terms and conditions for network operators

Besides the overarching Electricity Industry and Organization Act (ElWOG 2010), describing the responsibilities of network operators, their activity is also guided by the General Terms and Conditions that are authorized through the regulatory authority, E-Control, in accordance with Articles 41 and 37 of ElWOG 2010. For the sake of the present discussion the General Terms and Conditions of DSOs acting in Upper Austria, Styria and Salzburg were examined:

- General conditions and conditions for the access to the distribution network of Salzburg Netz GmbH 2014 ("AB VN Szb.")
- General terms and conditions for the access to the distribution network of Styrian network operators 2014, ("AB VN Stmk.")
- General conditions and conditions for the access to the distribution network of Netz Oberösterreich GmbH 2014 ("AB VN Öo.")

This analysis revealed substantial differences between the three documents when it comes to flexible technologies/demand-side flexibility.

The aim of General Terms and Conditions regulate the relations between DSOs and their customers and thus form part of their contract for network access (all, I(1)). Under this document, network access refers not solely to the connection but also to electricity injection and withdrawal – in other words not only to network access but also network use (all, I(2)) – making it relevant for the providers of flexibility. It is noteworthy that "exclusively" legal provisions are the only reason for a DSO to refuse grid access to a potential customer's facilities and bear the responsibility to justify such a refusal (all, III (5)).

During connection (including the connection of generating facilities at the demand side) to the technically appropriate grid connection point, DSOs are to take end users' economic interests into account (all, IV(1)). In this respect, the one-time network access charge is calculated according to the costs borne by the DSO due to the connection, including construction work and increase of network use (all, IV(3)). This charge is not payable in case the consumers took care of the connection themselves. Additionally, the system provision charge is payable by the customer to account for the carried out or pre-financed network expansion carried out by a DSO to enable the connection (all, IV(7)). Under the Section on Network Use (all, VI), network usage is inseparable from network access and is applied for simultaneously.

With respect to load profiles, a load profile meter is installed in case of an annual use exceeding 100,000 kWh or connected maximum electric capacity exceeding 50 kW. However, even if the last condition isn't fulfilled a customer can still explicitly request the installation of a load profile meter (XI (1-3), AB VN Szb., 2014)

These are only the General Terms and Conditions for Salzburg's DSOs that discuss mechanical and electrochemical storage facilities. Section VIII "Operation and Maintenance" of AB VN Strom Salzburger Netz GmbH, explicitly mentions electricity storage. According to point 4 of the Section, "*a customer is allowed to use generation facilities (incl. any mechanical or electrochemical energy storage) only after an explicit agreement of the system operator and only in connection with the installation of an appropriate meter and with a valid power purchase agreement.*" (AB VN Szb., 2014)

Both AB VN Oö. and AB VN Stmk. omit the specification of storage facilities[18] in the parenthesis but the latter adds in the same provision, *"[i]t is for the network customers to take all reasonable precautions to avoid in his area of responsibility accidents or damage that may result from power failures, interruptions or reclosure."* (VIII (4), (AB VN Stmk., 2014)

It is the network operator's right to conduct a technical check to determine whether the use of such facilities may have repercussions for the network or its components (AB VN Strom Szb., VIII (5)). *"Parallel operation of a power generator and/or mechanical or electrochemical energy storage without the consent of the network operator"* is considered a violation of the contract conditions and leads to contract suspension, according to Section XXIII (2e) of AB VN Strom Salzburger Netz GmbH. In the corresponding section of the Styrian and Upper Austrian DSOs' General Terms and Conditions (Section XXV, 2e, AB VN Stmk., 2014; Section XXVI, 2e, AB VN Oö., 2014), reference is made exclusively to unauthorized parallel operation of generation facilities, which would lead to contract infringement.

As mentioned earlier, smart meters are one of the prerequisites for end users' participation in the electricity markets. In the current version, AB VN Szb. however,

---

[18] AB VN Oö. (2014) in Annex 2, "Definitions", defines a generation facility as "a system for generating electrical energy with a capacity of more than 100W at a voltage greater than 42V with all auxiliary equipment serving for generation (for example, systems for converting electric power, switchgear), in so far as they do not fall under the Act for Electric Power Transmission 1970 of Upper Austria". Cf: AB VN Stmk. doesn't provide any definition of a generation facility.

makes no mention of the requirement to install smart meters established by the Ordinance on the Introduction of Smart Metering Devices (IME-VO). In contrast, AB VN Oö. and AB VN Stmk. take into account both IME-VO and the corresponding Article 83 (1) of ElWOG, specifying that the choice of a meter (conventional or a smart one) is the DSO's prerogative. However, in case smart meters haven't been installed before the year 2019, its customers have to be notified of the reasons (Section X (3), AB VN Stmk., 2014; Section X (3), AB VN Oö., 2014). Only in Upper Austria is a customer allowed to decline the planned installation of a smart meter at his or her premises after being notified by a DSO (X (4), AB VN Oö., 2014)

Once a smart meter has been installed, data protection provisions have to be respected at all times. Under point 4 of Section X of AB VN Stmk. and point 8, Section X of AB VN Oö., a DSO is allowed to "automate different processes and set up remote control" of a customer's facilities, including the right to remotely turn off or turn on customers' facilities. For those customers for whom smart meters have been installed, a DSO obtains daily meter readings. Stored 15-minute values are allowed to be transmitted subject to a customers' prior contractual agreement (Sections XIII (1) and XIV (1)) of AB VN Stmk. and AB VN Oö.).

In contrast, though not mentioning storage systems, the General Terms and Conditions for Styrian DSOs makes reference to functional storage, i.e. heat storage and their respective load profiles. According to the Annex 1 of AB VN Stmk., no system provision charge is levied on injecting and interruptible metered points but 70% of which is levied on direct and storage heating systems characterized by a so-called load profile "ULC-ULF" (these include "night storage heaters and mixing units with hotwater storage with/without additional daytime charging" (Annex 2, AB VN Stmk., 2014). Finally, General Terms and conditions for Upper Austrian DSOs make no reference to storage whatsoever.

5. Ownership and operation structures for distributed flexible resources

This section includes a general discussion on theoretically possible ownership models of flexible resources and their feasibility in the national and European contexts. It further provides an overview of a number of European projects with the focus on new potential operation structures and roles of flexibility owners. Finally, the "Special considerations" subsection will include such issues as future data exchange and consumer data protection.

5.1. Ownership and control approaches

Theoretically, there are several options for the ownership of flexible resources. Private residential and commercial customers, suppliers as well as DSOs are potentially interested in making use of flexible resources. For instance, distributed energy storage systems capable of providing versatile services to multiple actors have been actively discussed and surrounded by contention with regard to their ownership due to their status of both consumers and generators are (ENTSO-E, 2014; Ugarte et al., 2015; Görtz, 2015). Concerning demand response, this strategy has already been widely procured by DSOs from industrial and big commercial customers, yet rarely so from smaller commercial or residential customers (Kempener et al., 2013). In the case of the latter, customer-owned components can be controlled by them directly either manually or in an automated manner or, alternatively, controlled by the DSO (Kempener et al., 2013). The last version, however, raises privacy issues, which will be discussed in the subsequent Section 5.3.

5.1.1. Theoretically possible ownership models

Flexible sources are capable of providing multiple services for regulated operators and also have the potential to serve the deregulated actors in the market. Two types of considerations are pertinent to the discussion of ownership of distributed flexible resources:

1) whether they are owned or operated by system operators or by third parties (consumers, suppliers, aggregators) and
2) whether they are deployed only for the provision of grid services or are also meant to participate in the markets.

These considerations give rise to a number of potential scenarios (Table 2), which will be discussed in this Section.

The delivery of value for the grid or for the market, especially if these benefits are obtained by different actors, is likely to continue to be disputed; the preference towards market or grid orientation largely depends on the actor making an investment. A regulated network operator cannot operate on the wholesale electricity market directly but has to be in a contractual agreement with a third party intermediary to be able to procure services from flexible components, which creates more complexity in the energy system. This fact creates the question of which ownership model would maximize system value.

Table 2. Theoretically possible ownership and operation scenarios.

Scenario	Ownership	Operation	Provision of infrastructure	Comments
1	DSO	DSO	DSO	DSO's complete control; not allowed in the Austrian context (see Section 5.1.2)
2	DSO	DSO + 3rd party	DSO	DSO procures grid services while 3rd parties for participation in the markets
3	DSO	3rd party	DSO	flexible component is leased to a 3rd party
4	3rd party	3rd party	DSO	full 3rd party control; grid services provision is market-driven or realized through direct contracts with DSOs
5	3rd party	3rd party + DSO	DSO	DSO procures grid services while 3rd parties for participation in the markets
6	3rd party	DSO	DSO	3rd party leases flexible components to the DSO

In the case where the owner of a flexible component is a DSO, they can theoretically both own and operate such a component to satisfy the needs of the grid (scenario 1). Alternatively, they could provide it to the third party for market purposes or lease a flexible component to a third party while acting only as an infrastructure provider (scenario 3). The first option gives a DSO the biggest flexibility as they would have total control of the component and could decide on the priorities in their deployment as they see fit (O'Boyle, 2015). PÖYRY, 2014a points out that when a storage-owning DSO does not participate in the wholesale electricity market, they can use the units exclusively to satisfy the needs of the grid but, as a tradeoff, lose out on extra value from offering storage capacity on the market – a clear reduction in return-on-investment. That said, the possibility of market participation would provide system operators with additional revenue streams, improving the business case of storage.

Under another possible scenario, a DSO would only use decentralized components for the procurement of grid services. Meanwhile, a third party would deploy these components in the wholesale electricity market or the balancing market (such as in case of SNS project, see Annex 1). In this way, a DSO receives additional revenue for providing the facility to a third party (scenario 2). On the other hand, it is constrained in terms of the availability of a facility for system services, which creates the need to specify the concrete arrangement under which availability for market participation would be provided. In the case where the DSO is the owner of a flexible component, it obtains the revenue streams from providing infrastructure and the unit itself. While it doesn't take part in its operation, a third party deploys a flexible unit for both system and market services.

Following the unbundling requirement, DSOs' participation in the deregulated markets is not applicable under any circumstances in the European Union. None of the cases involving DSO ownership are applicable in Austria.

Several ownership models are theoretically possible, under which a decentralized flexible component belongs to a third party instead of the DSO. The models under which a DSO would operate a third-party-owned unit would allow them to procure system services alone (scenario 6). Market services could be procured in case of shared operation with 3rd parties (scenario 5). Such setups, however, similar to the ones with DSO ownership, are prohibited in Austria since a DSO is not authorized to take part in generation. A possible solution would be for a DSO to procure the necessary services from a third party, operating a flexible component on a contractual basis (scenario 4). Austrian regulation does not prohibit such an arrangement. Remuneration is necessary to adequately stimulate further installation and deployment of flexible technologies for system services provision. In case of an available market setting, a DSO would procure system services not in a regulation-based but in a market-based way (for example, an activation fee or a capacity payment, like in the UK (PÖYRY, 2014a) or through tariffs.

5.1.2. Current EU and specific national regulation of ownership

The unbundling of the European electricity system has implications for the deployment of flexible resources and possible ownership models. In the liberalized markets, as stipulated in the EU Third Energy Package, regulated actors, TSOs and DSOs, are not allowed to participate in the electricity supply or own or operate generation assets, which is meant to offset "an inherent risk of discrimination" (Art. 9, Directive 2009/72/EC) and market distortion. This research concentrates on the unbundling requirements for DSOs, since it is at the distribution level where flexible facilities under consideration are connected (Art. 26, Directive 2009/27/EC). These include legal, functional and accounting unbundling requirements for the DSOs to whose grid more than 100,000 customers are connected (Art. 26, para. 4, Directive 2009/27/EC). In the Austrian context, these requirements are upheld in the ElWOG 2010 (as amended). This means that both in Austria and in other EU Member States current legislation based on the unbundling requirements does not allow system operators to generate any sort of revenues from participation in the electricity markets.

Despite the fact that the overarching regulation on the EU level is binding on all EU Member States, the exact transposition of its directives varies from state to state and resulting differences create loopholes in terms of the treatment of flexible resources on the national level. As a result, there are different approaches to integration of flexible components depending on the Member State.

Case of the UK

Specifically in the UK, although the requirements of the Internal Market in Electricity Directive have been fulfilled, following the national Electricity Act 1989 (as amended in 2000), Art. 6(2), DSOs are yet authorized to own smaller-scale storage systems. This is possible under the exemptions as outlined in the Electricity (Class Exemptions from the Requirement for a License) Order 2001. Units that

> *"do not at any time provide more electrical power from any one generating station than (1) 10 megawatts; or (2) 50 megawatts in the case of a generating station with a declared net capacity of less than 100 megawatts"* (Art. 3 (1)(a), Electricity (Class Exemptions from the Requirement for a Licence) Order, 2001)

fall under the class of "small generators". Considering that this provision is applicable irrespective of the units' collective effect, this also allows a DSO to own a number of aggregated small generators as long as each individual unit does not exceed the specified limits. On the other hand, DSOs are still unable to operate storage units, which means that third parties would have to operate storage facilities in the market.

DSOs are restricted not only in terms of licenses but also in terms of maximum turnover achieved from non-distribution-related activities. This restriction can significantly reduce the motivation of a DSO to invest in flexible components or to prefer it to grid reinforcement. In the current British framework, if a DSO owns storage facilities, it still has to contract the management of the unit to a third party. Alternatively, a third party both owns and operates, for example, a storage unit while a DSO procures ancillary services from flexibility to support the grid. In the last two cases financial flows would be directed from the DSOs to third parties (PÖYRY, 2014a).

Case of Italy

In Italy, in contrast, quite a different approach was adopted to the treatment of storage facilities, which, according to the Decree Law 93/11 (Art. 36), allows network operators to own and operate storage units (DG ENER, n.d. p. 30). Both TSOs and DSOs have an option to do so under condition that they conduct a cost-benefit analysis. This analysis must prove two things before adoption this option: that storage was a preferable alternative to grid reinforcement and that their revenues from choosing this option are not higher than in case of an alternative option.

Case of Belgium

In Belgium, in turn, system operators are confined within a strict set of rules, which ensure that despite a possible control of storage units, these are used exclusively for balancing purposes as a last resort. It is also subject to the prior approval by the regulator while their commercial use is not granted (Belgian Electricity Act, Art. 9(1)).

Case of Sweden

In Sweden system operators are allowed to own and use storage systems exclusively to offset grid losses and to quickly remedy power outages, i.e. as back-up solution (Görtz, 2015). Sweden thus substantially limits the potential benefits such systems could provide and reduces DSOs' incentive to deploy distributed storage resources. Other services potentially useful to a DSO such as voltage control can be provided to them from storage systems through independent third parties, electricity suppliers or aggregators, and factored into DSOs' operating costs (Görtz, 2015 p. 51).

This brief overview reveals different approaches to the integration of flexible components in the electricity system in different EU Member States, which still have a common characteristic: the integration is very limited, particularly when it comes to the range of applications by system operators.

5.1.3. LEAFS control approaches

The ultimate goal of project LEAFS (Section 1.2) is to ensure a common and synergetic utilization of electricity infrastructure for the integration of a greater share of RES. This goal is going to be achieved through a multifold approach to the use of flexible sources, including potential market participation, user integration and optimization of energy use as well as a reduction of the need for network reinforcement. LEAFS gives an alternative to the simple uncoordinated approach and seeks to offset the effects of uncontrolled, chaotic use of flexible technologies and distributed generation through testing several control approaches (CAs) for activation of flexibility. These approaches include:

- **CA1:** DSO's direct control of central components where components belong to system operators.

In this scenario tested, the DSO owns and controls a central component as well as decides on its exact location in the grid. It has the opportunity to rent shares of the storage capacity to other parties, including for its use in the market.

- **CA2:** Direct access to decentralized components.

Under this approach components (such as heat pumps and PVs) belong to the customer while a controller communicates directly with every single flexible technology installed in a household separately. Every day a limit in line with the needs of the grid are stipulated by the DSO. The components are connected to the Internet to transmit market signal within the announced limit while grid stability and secure operation remain the priority.

- **CA3:** Indirect access to decentralized components through a customer energy management system, where the component belongs to the customer (AIT, 2015).

Under the last approach the central controller communicates and sends orders to the Home Automation System or a Building Energy Agent. Remaining flexibility potential can be further marketed. It is fairly similar to the second approach with the difference that a DSO has no direct access to single flexible components and has no knowledge of which combination of loads is connected to the Home Automation System.

From the regulatory point of view, the previous discussion (see Sections 5.1.1 and 5.1.2) makes it clear that CA1 cannot be implemented in the current Austrian context as DSOs are simply not allowed to operate flexible components as long as these are considered generation. In contrast, it would be possible to implement this CA in the UK or Italy (Section 5.1.2) provided that the conditions of size or grid-relevant use could be proven. As a result, in real-life context the proposed CA1 is not in line with the actual Austrian regulatory framework. Furthermore, if flexible components do not belong to DSOs, direct or indirect access to them as in CA2 and CA3 would be possible through contractual agreements with customers and third parties. That said, the alternative arrangements would involve a third party operating flexible components while the DSOs would either own them and solely provide infrastructure or procure system services from third parties. However, a point of concern for DSOs in the latter case would be complete lack of control over flexible DER; the DSO might be lacking information about installation of new components and thus not be prepared for offsetting grid-destabilizing behavior in case third parties are guided by own incentives alone. Besides, the planned participation in the markets with storage and flexible loads clearly complicates the arrangement as, for instance, storage systems installed cannot be under any circumstances treated a purely network components. Finally, the possibility of marketing available capacities runs into a regulatory "grey area".

5.2. Relevant ongoing and accomplished projects

In the choice of relevant projects this research largely relied on the comprehensive list of projects in the area of smart grids compiled by the Joint Research Institute of the European Commission in the reference reports "Smart Grid projects in Europe: lessons learned and current developments" (Giordano et al., 2011) and "Smart Grid Projects Outlook 2014" (Covrig et al., 2014). This section focuses on the operating and ownership models in the selected projects. The criteria for the selection included the use of a single or multiple sources of flexibility at the distribution network level and the inclusion of at least two of the three crucial elements: the grid, the customer and the market (Table 3). More detailed information on each of the listed projects is summarized in Annex 1.

The overview (see Annex 1 for detailed description) shows that different approaches were adopted and different emphases were set in smart grid projects involving DER, such as network security or consumer empowerment using more traditional or innovative solutions. These projects exemplify the existence of viable options for reconciling grid, commercial and customer interests (see further discussion in Section 6.2.1).

Combined use of multiple sources of flexibility (projects *Flex4Energy* and *ADDRESS*) are shown to provide more value for the network and the market, as anticipated in Section 2.2.4. Besides, the combined use of multiple small-scale storage units as in project *SWARM* would make them liable for participation in the balancing market. The overview further reveals the need for smart meters and Home Energy Management Systems to enable combined uses of flexible components. Project *EcoGrid* illustrates how next-to-real-time markets would improve the conditions for the participation of demand response. Such projects as *ADDRESS, Flex4Energy* and *Green2store* suggest a multisided platform-based approach. Some projects involving new actors such as aggregators and platform managers. Hence, it is clear that the management systems require innovation in addition to the – almost inevitable – emergence of new actors in the system.

Table 3. Overview of the project selection

Project name	Country	Source of flexibility	Year	Grid	Customer	Market	Website
Green2store	DE	battery storage	2012-ongoing	yes	yes	yes	http://www.green2store.de
StromBank	DE	battery storage	2014-2016	yes	yes	yes	http://www.zirius.eu/projects/strombank.htm
Flex4Energy	DE	various	2015-ongoing	yes	yes	yes	https://www.ise.fraunhofer.de
Smart Network Storage	UK	battery storage	2013-2016	yes	no	yes	http://innovation.ukpowernetworks.co.uk/innovation/
ADDRESS	multiple	active demand	2008-2013	yes	yes	yes	http://www.addressfp7.org/
MERGE	multiple	EVs	2010-2011	yes	yes	yes	http://www.ev-merge.eu
EcoGrid	multiple	thermal storage, EVs	2011-2015	yes	yes	yes	http://www.eu-ecogrid.net
SWARM	DE	battery storage	2015-ongoing	yes	yes	yes	http://www.saftbatteries.de/local-sites/germany/
Flexibler Wärmestrom	DE	thermal storage	2014-2015	yes	yes	no	https://enbw-eg.de/ausgaben-energieprofiexpress/neues-vom-modellversuch-flexibler-waermestrom/

5.3. Special considerations: Data management

EU and national legal basis

Data management and protection belongs to one of the cornerstones of the “New Deal for Energy Consumers” (European Commission, 2015a). Data and security are bound to be seriously affected by the future technological development, yet, consumer privacy remains pivotal, in accordance with the EU Directive 95/46/EC. Pursuant to Articles 16-17 of the Directive 95/46/EC, “unambiguous” consumer consent is strictly necessary to gain access to data and consumption data must be processed in a secure and confidential way. Whether the access is legitimate and justified is determined in the light of the performance of a specific function. Once the access is deemed justified, the so-called principle of "data minimization" (Art. 6, Directive 95/46/EC) is applicable, according to which only as much data is used as is necessary to fulfill a defined purpose or to comply with a specific obligation.

With regard to the retrieval of stored data, it goes without saying that this is first of all the right of the consumers themselves both in terms of current meter readings and historical energy consumption (Directive 2009/72/EC, Annex I, para. 1(h)). Pursuant to the Austrian Ordinance on Data Format and Visualization of Consumprion Data (Datenformat- und Verbrauchs-informationsdarstellungs-VO 2012) the sole owner of the consumption data is the consumer while DSOs are solely responsible for its management. DSOs manage metering and user data in full confidentiality, making sure that relevant data reaches all market participants (balance group representatives, coordinators, the CAM, suppliers, etc,) in a transparent and non-discriminatory way, which only lets authorized entities obtain sensible data.

As mentioned in the earlier discussion (see Section 4.1.3), smart meters are crucial for enabling consumers' provision of flexibility and their active (mediated or unmediated) participation in the electricity market. The Internal Market in Electricity Directive encourages Member States' rollout of smart meters and, in case of a positive economic assessment, *"at least 80 % of consumers shall be equipped with intelligent metering systems by 2020."* (Directive 2009/72/EC) Following up on the Directive, the Austrian Ordinance on the Introduction of Smart Metering Devices prescribes nationwide deployment of smart meters in a minimum of 70% of customers by 2017 and a minimum of 95% of customers by 2019 (IME-VO, 2012).

Expert opinion on data management in the smart grid environment

Introduction of smart grids and smart meters brings the extent of available consumer data to a new level. On the positive side, the availability of such data can help boost consumer awareness, enable demand response and give them an opportunity to take profit of new services. However, the fact that consumer data is much more detailed, more easily identifiable and "de-anonymized" (EG2 Smart Grids Task Force, 2011), understandably, raises multiple concerns over the regulation of such a setup.

In this respect, EG2 of the European Commission's Smart Grids Task Force stresses the need for an accountability mechanism alongside compliance and control to ensure that data is used only for a specified period and for lawful purposes, which would require the involvement of Data Protection Authorities. They affirm that *"[t]he fact that smart metering may be necessary for the society as a whole should not suffice to override the fundamental right to protection of privacy."* (EG2 Smart Grids Task Force, 2011 p. 5).

Whether individual ("personal data" according to the Directive 95/46/EC since the subject is "identifiable", Art 2) or aggregated data should be used does not yield itself easily to one single answer. Data anonymization is one of the solutions although, technically, it can be traced back to its owner with relative ease and thus, EG2 rather suggests using non-identifiable data "whenever possible" (EG2 Smart Grids Task Force, 2011 p. 50).

Data storage is another crucial issue and EG2 defined a number of reasons for it, including network maintenance, billing, taxation, policy-making and various value adding services among others (EG2 Smart Grids Task Force, 2011). The handling periods regarding different purposes are not the same. At the same time, data can be stored at the operator's side or consumer's side (in a meter). Meanwhile, EG2 reasons that in the latter case it is preferable to have a centralized platform since it guarantees a higher degree of data protection (EG2 Smart Grids Task Force, 2011).

EG3 Smart Grids Task Force (2013) identifies 3 potential scenarios for handling smart grid data with a differing emphasis on stringency of data protection, transparency and innovation. The DSO model envisages the DSO as having the role of a neutral regulated data hub operator facilitating access to authorized market players (suppliers, aggregators, other service providers) subject to consumers' consent. Another model is focused on a Central Data Hub (CDH) operated by an independent third party in charge of data storage, aggregation, processing and overall market facilitation. Such a hub and, subsequently, its operator are monitored by a corresponding regulatory agency. At the same time, metering and data collection would remain within the DSO mandate. Finally, the Data Access-Point Manager (DAM) model enables access of both regulated and deregulated actors, service providers, consumers and devices. Arguably, this is the most innovative and flexible model, and every market player acts through their own DAM. Unlike the CDH model, DAM is not regulated but works in a competitive environment. The tradeoff is, however, that such an arrangement makes privacy and security provisions harder to enforce (EG3 Smart Grids Task Force, 2013).

National practice with regard to data management

So far, there is no unified approach to meter data management in EU Member States. Meeus and Hadush (2016) point to several existing models for data handling. In Austria, *"responsibility for secure grid operation, for metering and for handling and processing grid user data generally lies with the distribution system operators (DSOs).*" (CEER, 2012 p. 12)

The role of a data collector and operator is one of the key issues to be settled and can be potentially performed not only by a DSO although that is generally the case. Covrig et al. (2014 p. 91) observes that "*in 15 out of the 16 Member States that have decided to proceed with a large-scale roll-out, the distribution system operators (DSOs) are responsible for implementation and own the meters*." Alternatively, this function can be carried out by an ICT company or by an independent third party. Data can then be transmitted through bilateral or centralized arrangements. The second case would either imply the existence of a communication platform (transmittable data is not stored, for example, case of the Netherlands) or a Data Hub (data centrally stored, case of Estonia, UK, Poland and Denmark) (EG3 Smart Grids Task Force, 2013; Covrig et al., 2014; Bremer Energie Institut Forschungsinstitut für Regulierungsökonomie an der Wirtschaftsuniversität Wien, 2014). The data hub operator's role is tendered like in the UK but could also be assigned to a DSO (Belgium), a TSO (Denmark) or a third party (Italy) (Meeus and Hadush, 2016).

Prospective development of data management in the smart grid environment

Smart grids and smart meters will enable the provision of new value-adding services to consumers by market actors. Thus, it is important to evaluate to what extent and what sort of data they will have to be granted access to. Hence, the complication lies in the fact that access to smart meter data is likely to be needed not only in grid (DSO)-consumer relations but in market-consumer relations as well. The Appliances Management Support Unit (AMSU), the concept put forward by van den Oosterkamp et al., (2014), is meant to simplify differentiation between the grid- and market-related uses of smart metering equipment. Installation of an AMSU by commercial actors would allow collection and presentation of specific data using DSO databases and enable provision of innovative value adding services to customers (van den Oosterkamp et al., 2014) subject to their approval.

In this respect, the use of cloud technologies proposed in some projects (see Annex 1) is likely to make data handling more challenging and would need well-defined rules related to this specific approach and for all potential participants.

To sum up, with even greater data flows and availability customers' right to data protection is remains inalienable and all handling of such data will require their authorization. The exact rules for data management be it by DSOs or a data hub, need to be further specified with regard to expanding smart meter roll out and introduction of home automation systems. Finally, Responsible data management is important not only for safeguarding consumer protection but also to avoid circumstances which could jeopardize further introduction of smart grids and smart meters and pose threat to public acceptance of smart technologies. The transformation of the energy system and the activation of the consumer's role requires further comprehensive research with regard to future issues connected to data handling, customer data protection and contractual arrangements.

6. Results and discussion

This section presents the results of the survey of expert opinion and subsequent comprehensive discussion critical points singled out through the conducted research highlighting different views, alternative actions and recommendations. It incorporates previous analysis, the results of the survey as well as best practices from other projects. The results of the discussion will be distilled into the gap analysis (Section 6.3). Therein, target outcomes directly linked to EU energy policy priorities will be set and the means to fill the gaps and overcome inefficiencies related to the integration of distributed flexible resources will be elaborated.

Such analysis will ultimately allow us to answer the two research questions set and the beginning of this Master's thesis, namely:

1. What are the existing gaps or inefficiencies in the current Austrian and European legislation and how can it be streamlined to create more value for electricity networks and markets through flexibility?
2. How can main stakeholders be incentivized to make use of flexibility sources and under which conditions can they do so?

6.1. Results of the survey of expert opinion

The main goal of the survey (see Section 1.4) is to identify which of the answers got most support from the participating experts as well as to evaluate the spread of their answers to different statements.

Concerning harmonization of incentives for the provision of flexibility, the experts split over whether the EU, individual Member States or rather both have to handle “grey areas” in the current regulation of flexibility (see Annex 3, question 16). One of the reasons for such results may be that grid problems can be different in EU countries and harmonized incentives could then be a barrier for selected service needs. However, a vast majority of experts agreed that the differences in the treatment of flexibility on the EU, national and federal-state levels hinder their deployment and investment and thus have to be addressed relatively urgently while one forth sees it otherwise (question 17).

Most experts seem to be in agreement that flexible DER should be placed on the same footing with traditional sources of flexibility and, hence, provision of flexibility has to be managed on both transmission and distribution network levels. Whether the use of flexible technologies is preferable to grid reinforcement is highly dependent on the case (age and state of the grid) as well as comparative costs, several participating experts reasoned while two thirds agreed with the statement (question 4). Although most respondents believe that the range of responsibilities assigned to the DSO will significantly expand as distribution network becomes more “active”, one of the respondents views their expansion into the market domain as highly doubtful. On the other hand, half of the respondents hold the opinion that DSOs should be able to procure flexibility from its providers without intermediation of aggregators while a third supports intermediated procurement. Others see both intermediated and unintermediated options possible depending of the type of services provided (see Annex 3, question 3). Besides, several experts cited DSOs’ direct investment into flexible resources as an alternative.

Contrasting opinions were revealed with regard to the question whether the presence of a small group of flexible consumers might provoke unequal allocation of benefits and indirect subsidization (question 20). One of the solutions to avoid higher cost socialization, most experts agreed, would be the introduction of different user-profile-dependent network charges. Yet, this solution didn’t find support of a fifth of the participating experts. Slightly more experts are inclined to believe that grid users have to be able to profit from their behavior even if it comes at the cost of the network paid jointly by all network users. In a similar vein, it is apparently still up to debate whether in the future in adapting their behavior grid users can be guided by their own incentives alone without regarding the planning criteria of the grid. When it comes to energy self-consumption, most experts agree, that it shall be supported rather than unjustifiably penalized (see Annex 3, question 26). However, the cost allocation has to be more causer-oriented, which made a small number of experts to rather disagree with the statement.

With regard to access to electricity market, the experts seemed to be in agreement that flexible DER with a capacity of 100kW to over 5MW should be facilitated access to electricity markets. However, in case of a similar access for the capacities of less than 20kW little consensus was reached, which is evident from a wide spread of answers (see Annex 3, question 10). Most experts agreed that provision of such services as reduction of electricity procurement or balancing energy costs, arbitrage and provision of control power from flexible components should be market-based. At the same time, mandatory provision should be foreseen for such services as reduction of peak load, provision of reactive power, black start capacity and power quality. Bilateral contracts are seen as the most optimal option in case of islanding and virtual inertia. Altogether fifty-six percent of participants agreed that new tariff structures (particularly for small-scale units) together with markets are the optimal channels to facilitate procurement of flexibility.

With respect to different sources of flexibility, most experts agreed that more regulatory support of inclusion of demand response in energy and balancing markets in Austria would help to exploit its potential for the grid. Yet, a small number of experts didn’t side with the majority and countered that as long as overcapacities exist in the market, the conditions for the activation of small-scale flexibility will remain unfavorable and trying to support DR flexibility through regulation will distort the market. Furthermore, although over half of the respondents concluded that improved price signals for customers will enable active participation in DR schemes, several experts countered that this measure alone wouldn’t be sufficient in the long run and home automation is the first priority.

Concerning storage, mixed opinions were received with respect to whether same conditions have to be applicable to all storage systems or whether they have to be assigned an own special category separate from generation. However, in the latter case a preference for positive answer can be traced (see Annex 3, question 31) with a few experts not siding with the majority. A similar picture can be observed with regard to the treatment of distributed storage on par with centralized PHSPs. Besides, the experts are fairly aligned in the opinion that storage systems have to be exempted from double taxes and charges in order to improve their business case, with a fifth of the respondents not supporting the idea.

When asked which of the control approaches tested in LEAFS has the greatest potential to be deployed in “real-life” context, slightly more respondents of the survey expressed preference for the control approach 3 as opposed to CA1 and CA2 (see Section 5.1.3). One of the reasons for the support of CA3 characterized by DSO’s indirect access to the customer-owned flexible loads is customer acceptance. Furthermore, CA3 seems feasible with the help of bilateral contracts where the grid operator pays for the needed service. In fact, bilateral contracts were deemed the most viable option by the majority of the experts (see Annex 3, question 34). Yet, half of the experts were of the opinion that a network operator has to be allowed to own and operate storage systems to suit the needs of the grid. Slightly less than half considers a similar logic to be applicable to thermal storage, EV charging infrastructure and appliances involved in provision of demand response. Since DSOs responsibility consists in ensuring security and quality of power supply, the overwhelming majority of the experts agreed that in case of conflict of market incentives and needs of the grid, the latter should be given priority (Annex 3, question 15). Nevertheless, transparency is paramount, according to one of the experts, in order to guarantee that there is no abuse by the grid operator to hamper market access of actors.

The participants in the expert survey largely agreed on the need for an aggregator in the new “smartening” grid, while two experts disagreed and one observed that current market conditions do not yet offer high revenues for aggregators. It is much less clear which entity should perform this function, a completely new one, a DSO, a telecom company or a retailer. The latter got most support from the experts, with the other options not far behind and one expert argued that instead of becoming a new role in the market model, the aggregator is likely to emerge as a new business model combining several roles in an innovative way.

In the changing system and growing deployment of smart metering the majority of experts agreed that data handling should still lie within the area of responsibility of the DSO and that it should also be able to obtain information about the changes in behavior of customers following market signals (see Annex 3, questions 41 and 42). A significant number of respondents, however, were of the opinion that an aggregator, a metering or ICT company. More than a half of experts believed that the DSO should be the one controlling smart metering equipment for safety reasons while several respondents saw that function being performed by a retailer or a metering service company. Finally, slightly less than a half of the participating experts shared the view that it is a joint venture of several parties (e.g. DSOs, TSO, third parties) that should perform the role of data hub for the purpose of market facilitation. About a third, in turn, would keep that function with the DSO and a few experts – with a third party.

Generally, the survey revealed a wide range of assessments with respect to most questions and particularly the ones related to operation strategies and future arrangements and incentives. Such an outcome stresses the need for further clarification of these aspects and will be taken into account for the discussion in the next section.

6.2. Discussion of critical points in the light of the EU energy policy goals

Previous discussion (Section 3) makes it evident that the sheer presence of multiple stakeholders in the electricity system and their often divergent interests make the task of determining the “right” approach often highly complex. Thus, the analysis of possible approaches relied on specific benchmarks. A valid base for such benchmarks are the ultimate interrelated goals of the European energy policy and the Energy Union, security of supply, competitiveness and sustainability tightly linked to climate goals (European Commission, 2015c) (Figure 4).

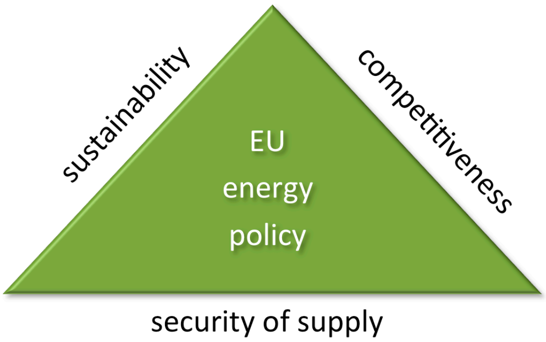


Figure 4. Triangle of the EU energy policy. (compiled from European Commission (2015))

Provision of flexibility can become instrumental in fulfilling these goals in manifold ways. Furthermore, different benefits provided by sources of flexibility can contribute to different goals to a varying extent. For example, distributed storage systems can boost energy efficiency through facilitating customer demand response, security of supply through providing ancillary and balancing services for a more stable and resilient system and decarbonization through enabling greater levels of RES penetration and preventing their curtailment. At the same time, by addressing one gap or inefficiency several goals might be fulfilled. As a result, the 3 main "pillars" were subdivided into a number of sub-goals (Table 4). These were then used as the decisive criteria in the assessment of the most appropriate options and derivation of recommended action in terms of regulation and policy change.

Table 4. Overarching goals and their elements consistent with EU energy policy

Sustainability	Competitiveness	Security of supply
Wider deployment of RES	Optimized market design	Stable system resilient to shocks and disruptions
Higher rate of energy efficiency and resource conservation	Improved incentives for various actors	Increased shares of local generation and consumption
Decarbonization of the economy	Customer involvement and empowerment	Secure and diverse energy supply
Reduced dependency on fossil fuels	Cost-effectiveness	

Despite the existence of various contentious issues related to the provision of flexibility in electricity networks, a number of positive developments has been identified on both the EU and national levels, particularly when it comes to the status of demand response.

On the EU level demand response is a source of flexibility that is given by far most attention. Its importance is recognized not only in case of large industrial customers but smaller consumers as well and it is seen as one of the crucial elements of consumer empowerment (Electricity Directive, Energy Efficiency Directive, Section 4.1). Consistent with the Internal Market in Electricity Directive (Art. 27), DR is recognized in ElWOG 2010 as a measure alternative to grid reinforcement as well as explicitly supported on the level of federal states (see Sections 4.4.1 and 4.6).

As to other sources of flexibility support for energy efficient and potentially flexible CHPs and heat/cold storage facilities is provided on national level in the form of the KWK-Gesetz and are eligible for subsidies (Section 4.4.7). Additionally, positive developments include the recognition of the value of distributed flexible resources for balancing markets (NC EB, SNE-VO 2012 idF 2016) and adjustment of imbalance settlement periods. Imbalance settlement periods were reduced in the EU to a maximum of 30 minutes (ENTSO-E NC EB, 2014, Art 21, 2a) while in Austria 15-minute contracts were introduced (Section 4.5.2). Finally, the future crucial role of aggregators is upheld in EU directives and legalized in Austria although a lot of aspects of their actual activity still remain to be clarified.

Based on the preceding overview of the legal and regulatory framework and market rules and keeping in mind the (sub)goals identified in Table 4, the following critical points have been identified and will subsequently be addressed in more detail:

1. Optimal setups for flexibility provision
    a. market vs. customer vs. network-driven use of flexibility
    b. ownership of storage systems
2. Lack of appropriate incentives
    a. insufficient incentives for DSOs to invest or make use of sources of flexibility
    b. insufficient incentives encouraging consumer-driven flexibility
    c. insufficient or inadequate incentives for self-consumption by DER owners
    d. unfavorable network charge and taxation regimes for distributed storage
3. Market access for flexibility owners and operators irrespective of their size
4. Need for new market roles in the energy system: Role of the aggregator

A few critical points, as listed in this Section, are linked to distributed storage systems, which speaks for the fact that their treatment is generally associated with a lot of contention. It is clear, however, that storage is one of the most flexible sources, which can deliver a wide array of services and fulfill numerous goals and thus requires special consideration.

It is further important to point out that strong reference is made to the Austrian national conditions and the EU framework conditions since the regulatory environment in different Member States still can differ in details (as was, for example, shown in Section 5.1.2). Hence, the type of critical points and required action would not be the same.

6.2.1. Optimal setups for flexibility provision: Market vs. customer vs. network-driven use of flexibility

As discussed in Section 2.3 different actors in the system can potentially draw benefits from the use of flexible resources. These benefits, however, are not always complimentary and are bound to clash. The most obvious example has to do with customers installing storage facilities at their premises for optimized consumption leaving grid operators “in the dark” and unable to plan accordingly. Another possible situation would involve unlimited use of flexible sources by market players without considering possible constraints of the grid.

That said, despite the fact that commercial exploitation of flexibility potential is in line with the goals of the EU energy policy and is likely to tap the value of flexibility, technical aspects of the grid have to be considered. Operation of flexible components exclusively by profit-motivated commercial actors can lead to suboptimal results (E-Control, 2016b; Hartwig and Kockar, 2016) and subsequently more necessity for grid reinforcement or curtailment of VRES (Deutsche Energie-Agentur, 2012). This is the reason why EG3 of the Smart Grids Task Force (2015 p.66) argues for grid operators’ right *“to require modification of flexibility activations in accordance with [constraint management] procedures”* and to access *“all technical relevant data needed to perform their activities”.*

Hartwig and Kockar (2016) further show that storage operation by independent traders leads to welfare losses for the entire system (see also Section 5). They conclude that

> *“[t]he welfare lost due to selfish [energy storage system] behavior grows with increased network congestion, which is likely to lead to sub-optimal reduction in congestion and RES curtailment. If the [energy storage system] is owned by a NO or SO, price based market clearing with the objective to maximize welfare may better improve market efficiency.”* (Hartwig and Kockar, 2016 p. 11)

An issue directly related to welfare losses is the threat of indirect subsidization or unequal share of benefits when only a limited number of consumers or prosumers profits from their flexible behavior at the cost of the grid socialized among all users. It is thus important to ensure that the new system does not benefit only flexibility providers and to bring in alignment the value for different actors and public interest. This critical point is particularly relevant for the protection vulnerable consumers and equal treatment of all consumers (E-Control, 2016b). Besides contention, this creates an additional case for incentivizing as many consumers as possible to adjust their consumption patterns and take up flexible technologies.

To be able to strike a balance between grid-oriented and market-oriented use coordinated action is crucial. Yet, it is bound to lead to more regulatory complexity. Such action needs to be based on clear contractual agreements between customers and market actors (such as suppliers or aggregators) and grid operators as well as between the latter two. Besides, new agreements are likely to be necessary among different market actors, especially to ensure balancing responsibility of each of them (see Sections 3 and 4.5) and avoid overlaps.

Unlike other markets, the functioning of electricity markets relies of the grid characterized by a number of inherent technical constraints, disregarding which may compromise the overall stability and quality of supply. Thus, in case of conflict of market incentives and needs of the grid, the latter should be given priority. On the other hand, although the use of a common resource creates conflicts of interests, this *per se*, is not enough of a reason to limit the use of flexibility to only one group of actors, for example, allowing grid operators to use available flexibility for the needs of the grid alone (see Section 5). Allowing several actors to procure flexibility and do so from multiple sources will help to exploit its full potential, develop new business models and create more value streams.

6.2.2. Optimal setups for flexibility provision: Ownership of storage systems

Particularly procurement of services from flexible technologies by DSOs is strictly regulated in the EU and in Austria where it is allowed to act as an infrastructure provider but not to own any facilities considered generation (see Section 5.1.2). Most contention revolves around storage systems due to their double nature rather than, for instance, demand response, which is already procured by DSOs although mainly from large industrial and commercial customers. As ENTSO-E (2014) pointed out, the question of ownership is far from being settled and *"should be addressed as high priority"*, according to DG ENER (n.d.).

Different existing setups in other EU Member States discussed in Section 5.1.2 sometimes allowing certain degree of control and ownership of storage by grid operators speaks for the recognition of their potential but difficulty in treatment from the regulatory point of view. Judging by the experience from Italy and the UK, the most cost-effective solution is prioritized independent of the fact whether it would imply DSO operation although such operation is subject to strict conditions. Ugarte et al. (2015 p. 66) also supported the idea of DSO-owned and operated storage but admits that *“[t]he operation of storage by third-party service companies can be a solution”* to overcome unbundling requirements. Such a solution is currently allowed in Austria and makes a case for market-driven provision of flexibility services.

According to DG ENER (n.d.) different ownership models create different business cases, revenue flows and varied degrees of incentive. In case a system operator owns flexible facilities, it could ensure equal sharing of benefits among end-users (i.e. even those grid users who cannot afford their own storage). For this case also speaks the fact that it would make it possible to choose an optimal location for storage in the grid, improve planning and incentivize DSOs’ preference for flexible technologies to capital-intensive grid reinforcement (see also Section 2.3.1).

The tradeoff for total control by a grid operator for ancillary and balancing services will be suboptimal operation and unrealized potential of storage since otherwise marketable capacities won’t be used. Thus, Ugarte et al. (2015) suggest that shared ownership and coordinated operation of storage facilities is more likely to provide more services and let various parties accommodate their interests.

Naturally, the preferred option for a DSO would be complete availability of a flexible component for the system services, which *per se* does not exclude the possibility of the use of the component by a third party for market participation. A DSO could agree with a third party on the specific time slots when it would use the components foreseeing when such a critical need would arise. An approach that would allow for determined flexible capacities to participate in the markets in times they are not required for the maintenance of grid stability thus seems to be sensible. It is in many ways similar to the approaches tested in the British SNS project discussed in Section 5.2 and Annex 1. Nonetheless, such an arrangement would be associated with a certain degree of uncertainty as definition of the time slots may turn out to be rather complicated (Bourwieg, 2014).

Other, more bold alternatives were put forward in several European projects such as platforms based on cloud computing that can be accessed by different actors (projects Green2store, MERGE, Flex4Energy in Annex 1) or the key role of an aggregator in facilitating connection between consumers and markets and selling active demand products to (de)regulated players (such as in project ADDRESS, Annex 1). However, these innovative approaches are likely to be difficult to implement in any foreseeable future in the current regulatory conditions and would need a comprehensive review of the whole system setup.

Central (connected to the distribution grid) or community storage options represent an attractive option as it is easier to implement, to keep track of for a DSO and to share the costs and benefits among all users on a fair basis. Community storage is furthermore not strictly prohibited by the Austrian regulation and would allow DSO's procurement of needed services as well as reduce grid losses and need for reinforcement.

Clarified ownership models for storage systems can indeed boost their value and improve incentives. A similar goal needs to be set for other flexible technologies as well, for example, with a wider implementation of EV infrastructure, to iron out inefficiencies and create a more favorable investment climate. Consequently, a holistic approach to the regulation of ownership and operation models is crucial.

6.2.3. Lack of appropriate incentives: insufficient incentives for DSOs to invest or make use of sources of flexibility

Avoidance or deferral or investment into grid reinforcement is one of the main reasons for DSOs to be interested in procuring flexibility. As discussed by several researchers (SWECO, 2015; EG3 Smart Grids Task Force, 2015), the CAPEX/OPEX breakdown of costs incurred by DSO requires revision to improve incentives. Procurement of flexibility from DER will imply higher OPEX for a DSO while grid reinforcement action is factored into CAPEX. SWECO (2015 p. 148) observes that *"solutions increasing OPEX may not be remunerated",* which understandably reduces DSOs' incentive to invest into flexible solution.

On of the suggested means of incentivizing DSOs (SWECO, 2015) could be authorizing DSOs to set up network tariffs, subject to the regulator's review, to tailor them most optimally to the needs of their respective grids. This would arguably allow them to make proper use of available information and suit grid-specific needs. The focus of the regulatory authority then would concentrate on *"on the overall revenue cap rather than individual prices/tariffs."* (SWECO, 2015 p. 158) This solution, however, is not feasible in Austria where E-Control has exclusive power to set tariffs. Besides, giving DSOs a free rein in tariff setting poses a threat of undermining the principle of equal and fair treatment of consumers irrespective of their position.

Another approach is then needed to optimally incentivize DSOs. For example, the existence of proper remuneration of OPEX incurred by DSOs may substantially improve the case for flexibility. For example, emphasis can be made on the total expenditure (TOTEX), the way it is currently done in Austria, instead of the separate treatment of the two categories. SWECO (2015 p. 149) suggests that *“regulators could for instance allow an increase in the OPEX allowance, if the DSO can demonstrate the CAPEX saving”*. A counterargument to consider is however an additional complication: OPEX increases would happen in the present while CAPEX reductions only later (likely not even in the same regulatory period).

Grid reinforcement is a much more straightforward but actually a short-term solution, “a low-hanging fruit”. More flexible consumption and generation and emergence of new structures, actors, technologies is already underway and stress on the beneficial use of flexibility will be instrumental in DSOs’ facing and dealing with these changes in the long term.

6.2.4. Lack of appropriate incentives: insufficient incentives encouraging consumer-driven flexibility

The energy system finds itself in profound transformation. One of its elements is an increasingly active role of consumers and the emergence of prosumers, which will be further facilitated by the availability of DER, demand response options and smart meters (see Section 2.3). Yet, other factors, such as “a lack of reward for active participation”, “insufficiently developed markets for residential energy services and demand response narrow consumers' choices”, “preventing consumers from self-generation and self-consumption” and “network tariffs [that] discourage demand response” are likely to nip incentives in the bud (European Commission, 2015a).

The European Commission deemed dynamic pricing an appropriate manner to “reward flexible consumption” based on positive experience from the Nordic countries, (European Commission, 2015a). Furthermore, market-oriented dynamic pricing is seen as a viable option to improve price signals reaching customers is supported in a number of discussions (EG3 Smart Grids Task Force, 2015; Ugarte et al., 2015).

On the other hand, E-Control (2016) sees such tariffs to be much more difficult to implement and questions their efficiency as long as end users can opt out of the installation of smart meters. Despite this concern, several projects in the United States and Nordic countries already proved the efficiency of this approach. In the latter case, an American electric utility ComEd launched its Residential Real Time Pricing program in order to promote more energy efficient behavior among consumers. They were provided with an automated control program and price alerts to steer their consumption and enable savings (O'Boyle, 2015). This type of pricing, however, will be efficient only in situations where this behavior-dependent part of the electricity price is not overshadowed by the share of taxes and changes as is currently often still the case.

In the future consumers and prosumers are likely to have different DER installed at their premises, which creates a greater case for *"measures tailored to the different groups of consumers to effectively enhance their participation",* for example through new types of contracts with different actors (EG3 Smart Grids Task Force, 2015 p. 69). Such tailored solutions might help to promote "grid-friendly" self-consumption and reduced electricity costs. In fact, the future development is highly likely to involve a more elaborate system of contractual agreements between regulated and deregulated actors and consumers providing flexibility. Hence, making information clear, comprehensive without overcomplicating it is one of the crucial and complex tasks.

6.2.5. Lack of appropriate incentives: insufficient or inadequate incentives for self-consumption by DER owners

Higher shares of self-consumption of energy by prosumers is one of the ways to optimize their consumption, use greater shares of energy from household-owned RES and reduce electricity bills. Self-consumption is one of the cornerstones of consumer empowerment. Thus, penalization of self-consumption through burdensome charges and other unfair measures runs against the priorities set in the EU policy.

Yet, a growing number of customer-owned PV and storage systems can conceivably lead to a redistribution of revenue flows and negatively affect certain types of consumers since grid costs are shared among all users. E-Control (2016b) and Ugarte et al. (2015) warn of a high probability of a vicious circle: with more consumers increasing their self-consumption, grid operators will be constrained to in crease network charges and thus incentivize even more consumers to follow suit and strive for a higher degree of autarky or so-called, load defection. Such a development has clear repercussions for DSOs and TSOs in the form of system stress and higher costs for all connected users.

However, the solution of dissuading prosumers from self-consumption, for example, through taxation in a way similar to a tax imposed on PV owners in Spain seems to be an inadequate one and runs contrary to the EU's overarching goals or to improving system efficiency.

An alternative way of encouraging efficiency-oriented self-consumption can be restructuring of the fees for electricity. Ugarte et al. (2015) explains that volumetric type of fee discourages higher levels of consumption while capacity tariffs, instead, may encourage provision of services from flexible resources, e.g. for peak shaving. Increasing the capacity-based component of the fee is also a solution supported by E-Control in its consultation paper *Tarife 2.0* (E-Control, 2016b).

6.2.6. Lack of appropriate incentives: unfavorable network charge and taxation regimes for distributed storage

The case for such flexible technologies as battery storage can be further complicated by the national taxation regime. In mentioned in the previous discussion (Section 4.4.2), storage facilities are capable of energy withdrawal and injection and thus, depending on the operation mode can be treated as energy producers or consumers. This results in double network charges levied on flexible storage facilities.

In the Austrian regulatory framework, unfavorable charge and taxation regimes are applicable to distributed storage but in several cases not to PHSPs, which constitutes discriminatory treatment of the former if they are capable of providing the same kind of services. For instance, only new PHPS pursuant to the new amendment 2013 of ElWOG fall under a provision exempting them from use and losses charges (Section 4.4.1). Additionally, newly introduced reduced tariffs for providers of control reserve stipulated in the 2016 amendment of SNE-VO (see Section 4.4.2) exclude smaller providers connected to the low voltage network (< 1kV). Yet, distributed sources of flexibility have the potential to deliver control reserve in the future in a way similar to centralized generators, which makes it sensible to extend the provision to include all grid levels. Considering the fact that not only procurement of positive but also negative control power is included in the market code and SNE-VO, this opens up a clear opportunity for demand response and storage to participate in the market operations and obtain the same treatment as conventional PHSPs or gas-fired power plants.

Yet another example involves eligibility for a remuneration for relieving congestions. NEP-VO, as described in Section 4.4.4, applies this provision only to generation facilities connected to high-voltage levels. There is a potential for aggregated flexible sources at lower voltage levels to contribute to congestion management in a similar way, which would justify the extension of the remuneration provision to all network levels.

SWECO (2015 p. 15) finds double taxation *"counter-productive"* and explains that *"[i]f storage in the tax legislation is considered as end-consumption and subject to electricity tax it will create a wedge between the price paid for the electricity when charging the storage and the price received when discharging".* A similar situation may also affect electric vehicles in the future.

It is, however, important to differentiate between the cases when the stored energy is used for self-consumption or fed into the grid. Ugarte et al. (2015 p. 35) cites the case of Germany where *"the German Renewable Energy Sources Act (EEG) 2014 Sec. 60 exempts electricity storage facilities from the EEG levy (e.g. pumped storage power plants and battery storage facilities), if the stored electricity is exclusively fed back into the grid from which it is originally drawn."* Grid charge exemptions indeed seem sensible in the situations when storage provides services for the grid. In a similar vein, interruptible loads such as heat pumps are eligible for a lower network charge when they are used to serve the needs of the grid in Germany (Art. 14a, EnWG). Additionally, a transitional provision of the German Energy Industry Act (Energiewirtschaftsgesetz, EnWG) makes specific reference to technologies using chemical or mechanical storage, explicitly exempting them from system utilization charges (Art. 118 (a), EnWG, 2005).

Flexible DER that in the future will be able to provide a wide array of services should be placed on the same footing with traditional sources of flexibility. Exemptions from double charges on par with PHSPs and more a favorable taxation regime for distributed storage in case of grid-serving use is desirable. Finally, in order to avoid distortion of competition and create incentives for owners and operators of DER these and similar provisions have to be reviewed and amended to factor in the whole variety of the sources of flexibility.

6.2.7. Market access for flexibility owners and operators

The Internal Market in Electricity Directive stresses the importance of creating a level playing field and further promoting access to new market entrants. The Energy Efficiency Directive further stipulates that supply loads shouldn't be prioritized over consumer loads. But in reality, new actors face a number of obstacles related to market participation although their situation has been steadily improving.

Flexible loads and storage help to improve the integration of RES and can support secure grid functioning. With regard to wholesale electricity markets, membership fees for accessing organized markets and minimum bid sizes create additional obstacles for the participation of small volumes (SWECO, 2015). These observations make a stronger case for an aggregator able to pool smaller capacities to allow them to achieve an effect on par with larger units. In Austria, however, positive changes have already been underway, facilitating participation of flexible components in the wholesale markets with the introduction of 15-minute settlement periods (Section 4.5.2).

On both the EU and Austrian levels positive developments were identified with respect to balancing markets. *NC EB* allows for the possibility of flexible technologies and specifically storage to play a role in the provision of balancing energy and capacity and sets as one of the objectives of the balancing market *"facilitating the participation of Demand Side Response including aggregation facilities and energy storage"* (Art. 10, ENTSO-E NC EB, 2014). Quite obviously, in the future DER owners and operators are likely to act as Balancing Service Providers, including both positive and negative control power. Furthermore, in Austria pursuant to the new amendment of 2015 of the E-Control Market Rules, a new grid usage charge for balancing energy providers was introduced, creating an incentive for the provision of balancing services (Section 4.5.5).

Market mechanisms are one of the methods of exploiting the potential of flexibility. Other ways such as tendering for frequency control or bilateral agreement in case of provision of local services can be more efficient in achieving this goal. SWECO (2015 p.157) observes that these alternatives *"do not reveal the market value for the services provided, and should not be used more than necessary"*.

Equal market access is both technology- and actor-relevant. Technology-neutral treatment of flexible resources has to be safeguarded both in regulation and in practice to improve competition. Consumers, either on their own or through intermediaries, should be given a chance to profit from provision of flexibility by participating in the markets on equal terms with supply-side providers of flexibility. This has to be reflected both in pertinent network codes and market rules.

6.2.8. Need for new market roles in the energy system: Role of an aggregator

With the entry of new market participants to the balancing energy market, new models are underway (CEER, 2013). This, however, makes more evident the need for a general framework, which in the first place clearly defines the new roles, rights and responsibilities as well as their interaction (Section 3).

The future role of an aggregator, in turn, has been widely acknowledged on the EU and Austrian national levels. For example, in the Energy Efficiency Directive an aggregator is seen as a facilitator of demand service procurement and consumer participation (Arts. 2, 15, Directive 2012/27/EU). Yet, the extent of their activities and the actors assuming this role is subject to contention.

Theoretically, a DSO might be interested in carrying out the responsibility of an aggregator itself. But in the current regulatory conditions, this option is clearly prohibited due to DSOs' regulated nature. Besides, this would require a serious adjustment of the regulatory provisions, which does not seem commensurate with the benefits such an arrangement would bring.

On the other hand, when performed by a deregulated actor, the question about assigning their own balancing responsibility to aggregators remains open for debate. If performed by a supplier then balancing responsibility is clearly assigned but the business case is worse as they cannot access flexible loads from different balancing groups. For the sake of contrast, if independent actors act as aggregators outside of balancing groups, this can be more economically attractive but can lead to imbalances and penalties for other actors if no balancing responsibility is assigned.

Due to these concerns about aggregators' balancing responsibility, they necessarily have to enter contractual relations and *"standard communication procedures"* with suppliers and BRPs if acting independently (EG3 Smart Grids Task Force, 2015). These will ensure BRPs in whose balance group generation/consumption is located do not run into imbalance penalties due to aggregators' activities and aggregators bear strictly defined responsibility for their actions. That said, coordination between aggregators and BRPs will be necessary to track the bids aggregators are putting up at the balancing market through increasing or decreasing consumption and offering services to different BRPs. The choice as to whether aggregator functions are performed by an independent party or by a supplier should depend on local conditions and availability of a business case, thus, nether of the two option should be hampered in the corresponding regulation.

In case consumers can market their flexibility through internet-based platforms, this would not require aggregator action. In fact, such options were suggested in several of previously reviewed projects (see Annex 1). A platform-based approach, however, creates a new series of regulatory complications. That said, the role of an aggregator is more than that of a facilitator but also that of a coordinator between different liberalized and regulated actors and resources. SWECO (2015) supports the idea that access to the market to independent aggregators can boost innovation and competitiveness of flexible resources if provided a level playing field with other actors. Another argument is apparent success of aggregators in several Member States where *“independent aggregators are already witnessed on the market in several market regimes today (example Austria, Finland, Sweden) and are highly innovative and cost-effective”* (SWECO, 2015 p. 121).

Furthermore, in order to improve the business case for aggregators and promote a competitive regime, they have to be able to make use of multiple technologies working “in concert” and providing multiple services to different markets. Last but not least, the effectiveness of aggregators’ activities will be seriously compromised if not supported by adequate communication infrastructure.

6.3. Gap Analysis

Current situation	Gap / Inefficiency	Action plan	Achievable outcomes
1. **Optimal setups for flexibility provision**			
Different (regulated and unregulated) actors can make use of flexibility	Likely conflicts of interests: market vs. customer vs. network-driven use of flexibility	- combined, grid- and market-driven procurement of services from flexible resources - coordinated action between regulated and deregulated actors as well as consumers based on contractual agreements (see Section 6.2.1)	Higher rate of energy efficiency and resource conservation, Wider deployment of RES, Optimized market design, Decarbonization of the economy, Stable & resilient system, Increased shares of local generation and consumption
Regulated actors are not allowed to own or operate storage systems	Suboptimal deployment of storage systems	- allow mixed operation models with DSO operation strictly for grid purposes - promotion of community storage - inclusion of multiple technologies in ownership and operation models (see Section 6.2.2)	Optimized market design, Improved incentives, Cost-effectiveness, Secure and diverse energy supply
2. **Lack of appropriate incentives**			
DSOs largely prefer grid reinforcement to active grid management through flexibility	Insufficient incentives for DSOs to invest or make use of sources of flexibility for grid optimization and stability	- ensured cost recovery from investment in flexibility: e.g. through higher OPEX allowance authorized upon the proof of CAPEX savings (see Section 6.2.3)	Higher rate of energy efficiency and resource conservation, Wider deployment of RES, Improved incentives, Cost-effectiveness, Stable & resilient system, Secure and diverse energy supply

Few consumers are using DER	Insufficient incentives encouraging consumer-driven flexibility	- new tariff structures relying on dynamic pricing schemes - market-driven retail tariffs - improved access to information - contracts specifically tailored to the different groups of consumers (see Section 6.2.4)	Higher rate of energy efficiency and resource conservation, Wider deployment of RES , Consumer empowerment, Improved incentives, Cost-effectiveness, Increased shares of local generation and consumption
Self-consumption is not a widespread phenomenon	Lack of clear policy with respect to self-consumption despite an increasing tendency towards self-consumption	- avoidance of restrictive policy or burdensome charges for self-consumption and further promotion of energy-efficient behavior - tariff restructuring with an increased share of the capacity-based component to encourage provision of flexibility (see Section 6.2.5)	Wider deployment of RES, Higher rate of energy efficiency and resource conservation, Decarbonization of the economy, Improved incentives, Increased shares of local generation and consumption
Storage facilities are subject to double charges	Insufficient business case for the deployment of distributed storage through unfavorable network charge and taxation regimes	- removal of double charges for storage - reduced taxes in case of provision of grid services - provision of equal treatment for distributed storage systems and PHSPs - extension of provisions beneficial to PHSPs to all grid levels, including low-voltage level (see Section 6.2.6)	Improved incentives, Cost-effectiveness, Stable & resilient system, Increased shares of local generation and consumption, Secure and diverse energy supply

3. **Market access for flexibility owners and operators irrespective of scale**			
Market access guaranteed for traditional actors on the supply side	Equal market access for flexibility owners and providers irrespective of scale and position in the grid needs streamlining	- allow for aggregation of sources of flexibility for their market participation - further support pooling requirements - reduce minimum bid size requirements in balancing markets - ensure equal treatment of large-scale generation as well as distributed sources of flexibility (see Section 6.2.7)	Wider deployment of RES , Optimized market design, Decarbonization of the economy, Improved incentives, Stable & resilient system, Secure and diverse energy supply
4. **Increasing complexity and need for new market roles in the energy system**			
Likely emergence of new actors due to changing grid reality	Role of an aggregator not sufficiently clarified	- allow for the role of an aggregator to be performed either by a supplier or an independent party depending on local conditions - provide for assured balancing responsibility of aggregators or contractual agreements and “standardized communication patterns” with suppliers and BRPs to avoid imbalances (see Section 6.2.8)	Optimized market design, Improved incentives, Cost-effectiveness, Secure and diverse energy supply, Increased shares of local generation and consumption,

7. Conclusion

The electricity system is changing due to ever more expansive deployment of RES. Distributed sources of flexibility coupled with smart metering have been shown to be instrumental in enabling such deployment and creating new value chains. Nevertheless, this research has identified multiple barriers and “grey areas” in the legal and regulatory framework in Austria and the EU with respect to the treatment of flexible technologies in legal and regulatory documents, access of new providers of flexibility to the markets irrespective of scale and network tariff schemes. It furthermore revealed a higher and more complex degree of interaction between existing and new actors. When it comes to creating optimal arrangements for exploiting the full potential of distributed flexible resources, different technologies need to operate “in concert” for the benefit of consumers, the grid and the markets. In this setting, coordinated action of various actors is crucial. Finally, different approaches to incentivizing provision and procurement of flexibility from DER were evaluated and plans for action related to the identified critical points were proposed.

The discussion presented in this Master’s Thesis has shown that the identified critical points are tightly interconnected and addressing some of the gaps or inefficiencies will have indirect effects on other issues. These, therefore, should be reviewed and treated in holistic way to avoid unnecessarily lengthy adaptation processes and future clashes or overlapping rules. At the same time, positive developments on the national and EU levels were determined revealing future support for distributed flexible resources. Adaptation of current regulatory and legal documents is thus necessary and unavoidable to optimally align the current environment to the evolving specifics of the energy system and reduce its high complexity.

Bibliography

AB VN Oö. 2014. General conditions and conditions for the access to the distribution network of Netz Oberösterreich GmbH (In Ger. Allgemeine Bedingungen für den Zugang zum Verteilernetz der Netz Oberösterreich GmbH). [Accessed 23 January 2016]. Available from: http://strom.netzgmbh.at/eag_at/resources/2840948356076319291028631756552887790_4K7KgkNN.pdf.

AB VN Stmk. 2014. General terms and conditions for the access to the distribution network of Styrian network operators 2014 (In Ger. Allgemeine Bedingungen für den Zugang zum Verteilernetz der steirischen Netzbetreiber 2014). [Accessed 23 January 2016]. Available from: https://www.e-control.at/documents/20903/26585/steirische-weiterverteiler-allgemeine-verteilernetzbedingungen-270614.pdf/7196a5c8-f5b0-4d7f-8dc2-41b2f5382f4a.

AB VN Szb. 2014. General conditions and conditions for the access to the distribution network of Salzburg Netz GmbH (In Ger. Allgemeine Bedingungen für den Zugang zum Verteilernetz der Salzburg Netz GmbH). [Accessed 23 January 2016]. Available from: https://www.e-control.at/documents/20903/26585/AB-VN_Strom_Salzburg_20140519.pdf/e6cb7c3a-bdd0-44c4-bafa-7939decd99da.

AIT 2015. Energieforschungsprogramm - Präsentation des Projektes auf der KLI.EN Homepage / publizierbare Kurzfassung, internal report. [Accessed 9 November 2015]. Available from: http://mmenergies.at/wa_files/Leafs_KF_engl.pdf

Allen, E. and Seaman, C. 2007. Likert Scales and Data Analyses. [Online]. American Society for Quality. [Accessed 9 May 2016]. Available from: http://asq.org/quality- progress/2007/07/statistics/likert-scales-and-data-analyses.html.

Aphram, S. and Glotzbach, L. 2016. Rechte und Pflichten der Akteure an regionalen Flexibilitätsmärkten unter Berücksichtigung der Transformation der Energieversorgung. Presented at *the 14th Energy Innovation Symposium. Graz, 10.02.2016.* [Accessed 29 April 2016]. Available from: https://www.tugraz.at/fileadmin/user_upload/Events/Eninnov2016/files/lf/Session_A3/LF_Glotzbach_Aphram.pdf.

Boone, H.N. and Boone, D.A. 2012. Analyzing Likert Data. *Journal of Extension*. **50**(2),p.6.

Brauner, G. 2012. Wege zur Nachhaltigen Energieversorgung – Herausforderungen an Speicher und thermische Kraftwerke. Paper presented at *the 12th Energy Innovation Symposium. Graz, 15.02.2016.* [Accessed 15 November 2015]. Available from: www.ea.tuwien.ac.at.

Bremer Energie Institut Forschungsinstitut für Regulierungsökonomie an der Wirtschaftsuniversität Wien 2014. *Handlungsfelder zur Weiterentwicklung des Institutionellen Rahmens für Smart Grids in Österreich* [Online]. Vienna: Bundesministerium für Verkehr, Innovation und Technologie. [Accessed 5 May 2016]. Available from: http://www.nachhaltigwirtschaften.at/e2050/e2050_pdf/reports/201407_aktionspapier_institutioneller_rahmen_von_smart_grids_in_oesterreich.pdf.

Brunner, H. 2015. Transmission and Distribution System Interaction. Presented at the *Joint PVSP and ISGAN Workshop.* Vienna, 18.05.2015. [Accessed 9 November 2015]. Available from: http://iea-pvps.org/fileadmin/dam/public/report/technical/04_-_Brunner_-_keynote_2.pdf.

de Bruyn, K., Kollman, A., Bartos, B., Markl, B., Schwarz, M. and Hauer, A. 2012. *Smart Grids - Rechtliche Aspekte von Intelligenten Stromnetzen in Österreich.* Linz: Bundesministerium für Verkehr, Innovation und Technologie.

de Bruyn, K. and Markl, B. 2013. *Smart Grids in Österreich aus rechtlicher Sicht* [Online]. Linz: Energieinstitut an der Johannes Kepler Universität Linz. [Accessed 9 February 2016]. Available from: http://eeg.tuwien.ac.at/eeg.tuwien.ac.at_pages/events/iewt/iewt2013/uploads/fullpaper/P_24_de_Bruyn_Kathrin__30-Jan-2013_16:59.pdf.

B-VG 1930. Constitution of Austria (In Ger. Bundes-Verfassungsgesetz). BGBl. Nr. 1/1930 idF BGBl. I Nr. 102/2014.

CEER 2012. *CEER Benchmarking Report on Meter Data Management Case Studies* [Online]. Brussels: Council of European Energy Regulators ASBL. [Accessed 5 May 2016]. Available from: http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Customers/Tab3/C12-RMF-46-05_BR_MDM_07Nov2012.pdf.

CEER 2013. *Regulatory and Market Aspects of Demand-Side Flexibility. A CEER Public Consultation Document. Ref: C13-SDE-38-03. 8 November 2013* [Online]. Brussels: Council of European Energy Regulators. [Accessed 26 January 2016]. Available from: http://www.ceer.eu/portal/page/portal/EER_HOME/EER_CONSULT/CLOSED%20PUBLIC%20CONSULTATIONS/ELECTRICITY/Demand-side_flexibility/CD/C13-PC-71_C13-SDE-38-03_SF_PC_2013-11-04.pdf.

Commission Regulation 2016/631. Commission Regulation (EU) of 14 April 2016 establishing a network code on requirements for grid connection of generators, OJ L 112, 27.4.2016, p. 1–68. [Accessed 20 April 2016]. Available from: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:JOL_2016_112_R_0001.

Covrig, C.F., Ardelean, M., Vasiljevska, J., Mengolini, A., Fulli, G. and Amoiralis, E. 2014. *Smart Grid Projects Outlook 2014* [Online]. Joint Research Centre of the European Commission - Institute for Energy. [Accessed 4 May 2016]. Available from: https://www.researchgate.net/profile/Eleftherios_Amoiralis/publication/269763242_Smart_Grid_Projects_Outlook_2014/links/5495ab8c0cf29b94482411d5.pdf.

Deutsche Energie-Agentur 2012. *dena-Verteilnetzstudie. Ausbau und Innovationsbedarf der Stromverteilnetze in Deutschland bis 2030.* Berlin: Deutsche Energie-Agentur GmbH (dena).

DG ENER n.d. *The Future Role and Challenges for Energy Storage* [Online]. Brussels: European Commission Directorate-General for Energy. [Accessed 18 February 2016]. Available from: https://ec.europa.eu/energy/sites/ener/files/energy_storage.pdf.

Directive 95/46/EC. Directive of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data. OJ L 281, 23.11.1995, p. 31–50.

Directive 2009/28/EC. Directive of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. OJ L 140, 5.6.2009, p. 16–62.

Directive 2009/72/EC. Directive 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.

Directive 2012/27/EU. Directive of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC. OJ L 315, 14.11.2012, p. 1–56.

Dragoon, K. and Papaefthymiou, G. 2015. *Power System Flexibility Strategic Roadmap. Preparing power systems to supply reliable power from variable energy resources*. Berlin: ECOFYS.

ECOFYS 2011. *Potenziale der Wärmepumpe zum Lastmanagement im Strom und zur Netzintegration erneuerbarer Energien.* [Online]. Berlin: Bundesministerium für Wirtschaft & Technologie. [Accessed 3 January 2016]. Available from: http://www.bmwi.de/BMWi/Redaktion/PDF/Publikationen/potenziale-der-waermepumpe.pdf.

E-Control 2015b. Market Code for Electricity. Chapter 1. Definitions (In Ger. Sonstige Marktregeln Strom. Kapitel 1. Begriffsbestimmungen). [Accessed 26 January 2016]. Available from: https://www.e-control.at/documents/20903/-/-/f355228c-ba0b-4a97-a2a5-b3458a804b27.

E-Control 2015c. Market Code for Electricity. chapter 3. Schedules. (In Ger. Sonstige Marktregeln Strom. Kapitel 3. Fahrpläne).

E-Control 2012. Market Code for Electricity. Chapter 6. Meter readings, file formats and standardized load profiles (In Ger. Sonstige Marktregeln Strom. Kapitel 6. Zählwerte, Datenformate und standardisierte Lastprofile). [Accessed 26 January 2016]. Available from: https://www.e-control.at/documents/20903/-/-/af765977-0df4-4281-9086-8cf8073b48c3.

E-Control 2016a. Technical and organizational rules for users and operators of networks, Part D: Special technical rules, main section D4: parallel operation of generating plants with distribution networks (In Ger. Technische und organisatorische Regeln für Betreiber und Benutzer von Netzen, Teil D: Besondere technische Regeln, Hauptabschnitt D4: Parallelbetrieb von Erzeugungsanlagen mit Verteilernetzen). Version 2.2 of 22.2.2016). [Accessed 26 February 2016]. Available from: http://www.e-control.at/documents/20903/388512/TOR_D4_V2-2.pdf/3124c79f-0dc3-4a1a-99da-1cc1eb129653.

E-Control 2016b. *Weiterentwicklung der Netzentgeltstruktur für den Stromnetzbereich („Tarife 2.0“). Konsultationsfassung* [Online]. Vienna: E-Control Austria.

[Accessed 20 May 2016]. Available from: http://www.e-control.at/documents/20903/388512/Konsultationsentwurf_Tarife+2-0_Strom.pdf/58d5d1e5-f44b-40f4-a897-53616f931fb1.

EEGI 2014. *European Electricity Grid Initiative Implementation Plan 2015-2017* [Online]. Brussels: European Commission. [Accessed 3 May 2016]. Available from: http://www.gridplus.eu/Documents/EEGI%20Implementation%20Plan%202015-2017.pdf.

EG2 Smart Grids Task Force 2011. *Essential Regulatory Requirements and Recommendations for Data Handling, Data Safety, and Consumer Protection. Recommendation to the European Commission* [Online]. Brussels: European Commission. [Accessed 4 May 2016]. Available from: https://ec.europa.eu/energy/sites/ener/files/documents/Recommendations%20regulatory%20requirements%20v1_0_clean%20%282%29.pdf.

EG3 Smart Grids Task Force 2013. *EG3 First Year Report: Options on handling Smart Grids Data* [Online]. Brussels: European Commission. [Accessed 5 May 2016]. Available from: https://ec.europa.eu/energy/sites/ener/files/documents/xpert_group3_first_year_report.pdf.

EG3 Smart Grids Task Force 2015. *Regulatory Recommendations for the Deployment of Flexibility* [Online]. Brussels: European Commission. [Accessed 26 January 2016]. Available from: http://ec.europa.eu/energy/sites/ener/files/documents/EG3%20Final%20-%20January%202015.pdf.

Electricity (Class Exemptions from the Requirement for a Licence) Order 2001. Statutory Instrument 2001/3270. [Accessed 28 March 2016]. Available from: http://www.legislation.gov.uk/uksi/2001/3270/pdfs/uksi_20013270_en.pdf.

Electricity Tax Act 1996 (In Ger. Bundesgesetz, mit dem eine Abgabe auf die Lieferung und den Verbrauch elektrischer Energie eingeführt wird). BGBl. Nr. 201/1996 idF BGBl. I Nr. 64/2014.

ElWOG 2010. Electricity Industry and Organization Act 2010 (In Ger. Elektrizitätswirtschafts- und –organisationsgesetz 2010, Bundesgesetz, mit dem die Organisation auf dem Gebiet der Elektrizitätswirtschaft neu geregelt wird). BGBl. I Nr. 110/2010 idF BGBl. I Nr. 174/2013.

EnBW 2015. *Endbericht Modellversuch „Flexibler Wärmestrom“* [Online]. Karlsruhe: Energie Baden-Württemberg AG. [Accessed 30 April 2016]. Available from: https://www.haw-hamburg.de/fileadmin/user_upload/Forschung/CC4E/Newsletter/Content/BK_ergebnisbericht-modellversuch_final.pdf.

ENTSO-E 2014. *Ten-Year Network Development Plan 2014* [Online]. Brussels: European Network of Transmission System Operators for Electricity (ENTSO-E). [Accessed 17 February 2016]. Available from: https://www.entsoe.eu/Documents/TYNDP%20documents/TYNDP%202014/141031%20TYNDP%202014%20Report_.pdf.

ENTSO-E NC DCC 2012. ENTSO-E Network Code on Demand Connection 21 December 2012. [Accessed 5 January 2016]. Available from: https://www.entsoe.eu/fileadmin/user_upload/_library/resources/DCC/ENTSO-E_finalises_DCC/121221_final_Network_Code_on_Demand_Connection.pdf.

ENTSO-E NC EB 2014. ENTSO-E Network Code on Electricity Balancing. Version 3.0, 06 August 2014. [Accessed 3 February 2016]. Available from: http://networkcodes.entsoe.eu/market-codes/electricity-balancing/nc-eb-timeline/.

EnWG 2005. Electricity and Gas Supply Act 2005 (In Ger. Gesetz über die Elektrizitäts- und Gasversorgung (Energiewirtschaftsgesetz)). BGBl. I S. 1970, 3621 idF BGBl. I S. 2016, 254.

EPEXSPOT 2015. *15-minute contracts on Austrian Intraday market launched with success. 108.75 MWh of power traded on first day.* [Online]. Paris/Vienna: EPEXSPOT, APG Austrian Power Grid. [Accessed 2 February 2016]. Available from: https://www.epexspot.com/document/33352/2015-10-02_EPEX%20SPOT_15-minute%20contracts%20in%20Austria%20successfully%20launched.pdf.

Esterl, T., Spreitzhofer, J., Friedl, W., Bletterie, B. and Kathan, J. 2015. *Rechtliche und Regulatorische Rahmenbedingungen für Speicher im Stromnetz.* Internal report. Vienna: AIT Austrian Institute of Technology.

EURELECTRIC 2014. *Flexibility and Aggregation. Requirements for their interaction in the market.* [Online]. Brussels: EURELECTRIC [Accessed 31 January 2016]. Available from: http://www.eurelectric.org/media/115877/tf_bal-agr_report_final_je_as-2014-030-0026-01-e.pdf.

European Commission 2015a. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Delivering a New Deal for Energy Consumers.* COM(2015) 339 final. [Online]. Brussels: European Commission. [Accessed 3 May 2016]. Available from: https://ec.europa.eu/energy/sites/ener/files/documents/1_EN_ACT_part1_v8.pdf.

European Commission 2013. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Energy Technologies and Innovation.* COM(2013) 253 final. [Online]. Brussels: European Commission. [Accessed 3 May 2016]. Available from: http://ec.europa.eu/energy/sites/ener/files/comm_2013_0253_en.pdf.

European Commission 2015b. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Launching the public consultation process on a new energy market design.* COM(2015) 340 final. [Online]. Brussels: European Commission. [Accessed 3 May 2016]. Available from: https://ec.europa.eu/energy/sites/ener/files/publication/web_1_EN_ACT_part1_v11_en.pdf.

European Commission 2015c. *Energy Union Package. Communication from the Commission to the European Parliament, the Council, the European Economic* *and Social Committee and the Committee of the Regions. A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy*. COM(2015) 80 final. [Online]. Brussels: European Commission. [Accessed 3 May 2016]. Available from: http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1431711858167&uri=CELEX:52015DC0080.

Georges, E., Masy, G., Verhelst, C., Lemort, V. and André, P. 2014. Smart Grid Energy Flexible Buildings Through The Use Of Heat Pumps In The Belgian Context. *In*: International High Performance Buildings Conference. Purdue University [Accessed 3 January 2016]. Available from: http://docs.lib.purdue.edu/ihpbc/114.

Giordano, V., Fulli, G., Sánchez Jiménez, M. and Gangale, F. 2011. *Smart Grid projects in Europe: lessons learned and current developments* [Online]. Luxembourg: Joint Research Centre of the European Commission - Institute for Energy. [Accessed 4 May 2016]. Available from: http://ses.jrc.ec.europa.eu/sites/ses/files/documents/smart_grid_projects_in_europe_lessons_learned_and_current_developments.pdf.

Görtz, S. 2015. *Battery energy storage for intermittent renewable electricity production. A review and demonstration of energy storage applications permitting higher penetration of renewables* [Online]. Umea: Umea Universitet. [Accessed 4 October 2016]. Available from: https://www.diva-portal.org/smash/get/diva2:818683/FULLTEXT01.pdf.

green2store 2014. Die Energy Storage Cloud schafft virtuelle Energiespeicherkapazitäten, die erneuerbare Energien effizient in die Energieversorgung integrieren. [Accessed 3 May 2016]. Available from: http://www.green2store.de.

GWG 2011. Gas Management Act 2011 (In Ger. Gaswirtschaftsgesetz 2011, Bundesgesetz, mit dem Neuregelungen auf dem Gebiet der Erdgaswirtschaft erlassen werden). BGBl. I Nr. 107/2011 idF BGBl. II Nr. 226/2015.

Hartwig, K. and Kockar, I. 2016. Impact of Strategic Behavior and Ownership of Energy Storage on Provision of Flexibility. *IEEE Transactions on Sustainable Energy*. **7**(2),p.11.

Hatziargyriou, N., Abel Pecas Lopes, J., Strunz, K., Raab, A.F., Gómez San Román, T., Gonzalez Bordagaray, A., Karfopoulos, E., Walsh, A., Kanellopoulos, K., Sanchez Tejerina, C., Díaz-Guerra Calderón, B., Hartmann, N., Momber, I. and Rivier, M. 2012. *Mobile Energy Resources in Grids of Electricity. Final Recommendations* [Online]. Brussels: AVERE European Association for Battery, Hybrid and Fuel Cell Electric Vehicles. [Accessed 29 April 2016]. Available from: http://www.avere.org/www/Images/files/MERGE%20doc%20A5%20def.pdf.

Havranek, F. 2012. Pumpspeicherkraftwerke als zentraler Baustein der Energiewende: Eine Wirtschaftlichkeitsanalyse für das deutsche und österreichische Marktgebiet. DI Thesis, Vienna University of Natural Resources and Life Sciences

Hayling, J. 2014. *Smarter Network Storage - Business Model Consultation Responses* [Online]. UK Power Networks (Operations) Limited. [Accessed 3 May 2016]. Available from:

http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-2-projects/Smarter-Network-Storage-(SNS)/Project-Documents/SNS4+12_Business-Model-Consultation-Responses_v1+0.pdf.

Hinterberger, R. and Hinrichsen, J. 2015. *Errichtung und Betrieb von Power-To-Heat Anlagen in städtischen Ballungsgebieten der D-A-CH Region - Demonstrationsanlage der BTB in Berlin Adlershof* [Online]. [Accessed 8 February 2016]. Available from: http://eeg.tuwien.ac.at/eeg.tuwien.ac.at_pages/events/iewt/iewt2015/uploads/fullpaper/P_18_Hinterberger_Robert_30-Jan-2015_18:25.pdf.

Hollinger, R., Willie-Haussmann, B., Erge, T., Sönnichsen, J., Stillahn, T. and Kreifels, N. 2013. *Kurzgutachten zur Abschätzung und Einordnung energiewirtschaftlicher, ökonomischer und anderer Effekte bei Förderung von objektgebunden elektrochemischen Speichern.* München: Fraunhofer-Insitut für Solare Energiesysteme ISE.

IEA-ETSAP and IRENA 2015. *Renewable Energy Integration in Power Grids. Technology Brief* [Online]. IEA Energy Technology Systems Analysis Programme and International Renewable Energy Agency. [Accessed 12 December 2015]. Available from: http://www.irena.org/DocumentDownloads/Publications/IRENA-ETSAP_Tech_Brief_Power_Grid_Integration_2015.pdf.

IRENA 2015. *Battery Storage for Renewables: Market Status and Technology Outlook*. Abu Dhabi: International Renewable Energy Agency.

JRC 2014. *Strategic Energy Technology (SET) Plan. Towards an Integrated Roadmap: Research & Innovation Challenges and Needs of the EU Energy System* [Online]. Brussels: Joint Research Centre of the European Commission. [Accessed 3 May 2016]. Available from: https://setis.ec.europa.eu/system/files/Towards%20an%20Integrated%20Roadmap_0.pdf.

Kabinger, A., Knaus, K. and Süßenbacher, W. 2014. *Short-Term Physical Electricity Trading in Austria. Marketing Opportunities, Market Concentration and Market Functioning* [Online]. Vienna: E-Control Austria. [Accessed 6 February 2016]. Available from: https://www.e-control.at/documents/20903/443907/Working+Paper+-+Short-Term+Physical+Electricity+Trading+in+Austria.pdf/f9ee8f0b-8adf-4f41-af4f-6a6def4f2dda.

Kempener, R., Komor, P. and Hoke, A. 2013. *Smart Grids and Renewables: A Guide for Effective Deployment* [Online]. Abu Dhabi: International Renewable Energy Agency. [Accessed 3 November 2015]. Available from: http://www.irena.org/documentdownloads/publications/smart_grids.pdf.

Kollau, M. and Vögel, S. 2014. *Demand Response im Österreichischen Regelenergiemarkt im Kontext der Energieeffizienzrichtlinie 2012/27/EU - Analyse anhand internationaler Erfahrungen* [Online]. Graz: TU Graz. [Accessed 26 January 2016]. Available from: http://www.tugraz.at/fileadmin/user_upload/Events/Eninnov2014/files/lf/LF_Kollau.pdf.

KWK-Gesetz 2008. Combined Heat and Power Act 2008 (In Ger. Bundesgesetz, mit dem Bestimmungen auf dem Gebiet der Kraft-Wärme-Kopplung neu erlassen werden). BGBl. I Nr. 111/2008 idF BGBl. I Nr. 27/2015.

LEG 1999. Electricity Act of the Federal State of Salzburg 1999 (Salzburger Landeselektrizitätsgesetz 1999). LGBl Nr 75/1999 idF LGBl Nr 107/2015.

Losi, A., Mancarella, P., Mander, S., Valtorta, G., Linares, P., Horch, A., Dolce, F. and Belhomme, R. 2013. *ADDRESS. Recommendations for standard committees, regulators, stakeholders groups, future R&D.* [Online]. ADDRESS Interactive Energy. [Accessed 30 April 2016]. Available from: http://www.addressfp7.org/config/files/ADD-WP7-T72-DEL-CASSINO-D7.5-Recommendations.pdf.

Lund, P., Nyeng, P., Duban Grandal, R., Sorensen, S.H., Bendtsen, M.F., le Ray, G., Mahler Larsen, E., Mastop, J., Judex, F., Leimgruber, F., Kok, K.J. and Mac Dougall, P.A. 2016. *EcoGrid EU – A Prototype for European Smart Grids. Deliverable D6.7. Overall evaluation and conclusion*. Copenhagen: Energinet.dk.

Mair, E. 2015. Auf der Suche nach dem flexiblen Stromkunden. Die Bedeutung von verbraucherseitigen Flexibilisierungsmaßnahmen im Stromsystem. Presented at the *Energy Talks*. Vienna.

Meeus, L. and Hadush, S. 2016. The emerging regulatory practice for new businesses related to distribution grids. *FSR - Policy Brief*. [Online]. (2016/02). [Accessed 21 April 2016]. Available from: http://fsr.eui.eu/publications/emerging-regulatory-practice-new-businesses-related-distribution-grids/.

NEP-VO 2008. Network Congestion Charge Ordinance 2008 (In Ger. Netzengpassentgelt-Verordnung 2008, Verordnung der Enegie-Control Kommission, mit der das Verfahren zur Ermittlung des angemessenen Entgelts für die Leistungen der Erzeuger zur Beseitigung von Netzengpässen im Übertragungsnetz festgelegt wird). Amtsblatt zur Wiener Zeitung Nr. 077, 17. April 2008.

O'Boyle, M. 2015. *Who Should Own and Operate Distributed Energy Resources? Adaptive Approaches to their Deployment* [Online]. Energy Innovation Policy and Technology LLC. [Accessed 20 May 2016]. Available from: http://sepa51.org/phaseII/OBoyle_51stState_Addendum.pdf.

Ökostromförderbeitragsverordnung 2015. Green Electricity Support Ordinance 2015 (Verordnung des Bundesministers für Wissenschaft, Forschung und Wirtschaft, mit der der Förderbeitrag für Ökostrom für das Kalenderjahr 2016 bestimmt wird). BGBl. II Nr. 458/2015.

Ökostrompauschale-Verordnung 2015. Green Electricity Flat Rate Ordinance 2015 (In Ger. Verordnung des Bundesministers für Wissenschaft, Forschung und Wirtschaft, mit der die Ökostrompauschale für die Kalenderjahre 2015 bis 2017 bestimmt wird). BGBl. II Nr. 359/2014.

van den Oosterkamp, P., Koutstaal, P., van der Welle, A., de Joode, J., Lenstra, J., van Hussen, K. and Haffner, R. 2014. *The role of DSOs in a Smart Grid environment*. Asterdam/Rotterdam: ECORYS, ECN.

ÖSG 2011. Green Electricity Act 2012 (In Ger. Ökostromgesetz 2012, Bundesgesetz über die Förderung der Elektrizitätserzeugung aus erneuerbaren Energieträgern). BGBl. I Nr. 75/2011 idF BGBl. I Nr. 11/2012.

Papaefthymiou, G., Grave, K. and Dragoon, K. 2014. *Flexibility options in electricity systems* [Online]. Berlin: ECOFYS. [Accessed 17 December 2015]. Available from: http://www.ecofys.com/files/files/ecofys-eci-2014-flexibility-options-in-electricity-systems.

Papapetrou, M., Maidonis, T., Garde, R. and García, G. 2013. *European Regulatory and Market Framework for Electricity Storage Infrastructure. Analysis and recommendations for improvements based on a stakeholder consultation. stoRE Project.* WIP, CENER.

Parliament of Lower Austria 2014. Antrag der Abgeordneten Mag. Schneeberger, Edlinger, Mag. Hackl, Dr. Michalitsch, Bader und Ing. Rennhofer betreffend 'Keine Elektrizitätsabgabe auf Ökostrom-Eigenverbrauch' (Ltg.-386/A-1/25-2014). [Accessed 2 October 2016]. Available from: http://www.landtag-noe.at/service/politik/landtag/LVXVIII/03/386/386A.pdf.

PÖYRY 2014a. *Smarter Network Storage Low Carbon Network Fund Electricity storage in GB: SNS4.13 – Interim Report on the Regulatory and Legal Framework* [Online]. London: UK Power Networks (Operations) Limited. [Accessed 4 December 2016]. Available from: http://poyry.co.uk/sites/www.poyry.co.uk/files/smarter-network-storage-lcnf-interim-report-regulatory-legal-framework.pdf.

PÖYRY 2014b. *Smarter Network Storage Low Carbon Network Fund: SDRC 9.3 – Commercial Arrangements for Integrated Use of Flexibility* [Online]. London: UK Power Networks (Operations) Limited. [Accessed 29 April 2016]. Available from: http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-2-projects/Smarter-Network-Storage-(SNS)/Project-Documents/SNS4.6_SDRC+9.3+-+CA+for+IU+of+Flexibility_v1.0.pdf.

Regulation (EC) 714/2009. Regulation (EC) of the European Parliament and of the Council of 13 July 2009 on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003. OJ L 211/15, 14.8.2009. [Accessed 20 April 2016]. Available from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0015:0035:EN:PDF.

Riese, C., Schulte-Beckhausen, S., Asmus Nebel, J., Schneider, C. and Kirch, T. 2014. *Rechtsgutachten im Rahmen der Trilateralen Vereinbarung vom 2. Mai 2012 zwischen Deutschland, Österreich und der Schweiz zu Pumpspeicherkraftwerken.* [Online]. Vienna: GÖRG Partnerschaft von Rechtsanwälten mbB. [Accessed 11 February 2016]. Available from: http://www.bmwfw.gv.at/EnergieUndBergbau/Energieversorgung/Documents/Rechtliche%20Aspekte.pdf.

Robbins, N. and Heiberger, R. 2011. Plotting Likert and Other Rating Scales. Presented at *Joint Statistical Meetings*. Chicago. [Accessed 10 May 2016]. Available from: http://www.amstat.org/sections/srms/proceedings/y2011/files/300784_64164.pdf.

SEDC 2015. *Mapping Demand Response in Europe Today 2015.* Brussels: Smart Energy Demand Coalition (SEDC).

SNE-VO 2012. Electricity System Charges Ordinance 2012 (In Ger. Systemnutzungsentgelte-Verordnung 2012, Verordnung der Regulierungskommission der E-Control, mit der die Entgelte für die Systemnutzung bestimmt werden). BGBl. II Nr. 440/2011 idF BGBl. II Nr. 428/2015.

Steber, D., Bazan, P. and German 2016. SWARM – Primärregelleistungserbringung mit ver- teilten Batteriespeichern in Haushalten. Presented at the *14th Energy Innovation Symposium.* 12.02.2016, Graz. [Accessed 3 May 2016]. Available from: https://www.tugraz.at/fileadmin/user_upload/Events/Eninnov2016/files/lf/Session_C3/LF_Steber.pdf.

Stmk. ElWOG 2005. Electricity Industry and Organization Act of the Federal State of Styria 2005 (In Ger. Steiermärkisches Elektrizitätswirtschafts- und -organisationsgesetz 2005, Gesetz vom 19. April 2005, mit dem die Organisation auf dem Gebiet der Elektrizitätswirtschaft im Land Steiermark geregelt wird). LGBl. Nr. 70/2005 idF LGBl. Nr. 45/2014.

Stromkennzeichnungsverordnung 2011. Electricity Labeling Ordinance (In Ger. Verordnung der E-Control über die Regelungen zur Stromkennzeichnung und zur Ausweisung der Herkunft nach Primärenergieträgern), BGBl. II Nr. 310/2011 idF BGBl. II Nr. 467/2013.

SWECO 2015. *Study on the effective integration of Distributed Energy Resources for providing flexibility to the electricity system.* [Online]. Stockholm: SWECO, ECOFYS, Tractebel Engineering, pwc. [Accessed 10 December 2015]. Available from: https://ec.europa.eu/energy/sites/ener/files/documents/5469759000%20Effective%20integration%20of%20DER%20Final%20ver%202_6%20April%202015.pdf.

TFEU 2012. The Treaty on the Functioning of the European Union, signed on 13 December 2007. OJ C 326, 26/10/2012.

Thomann, R., Schubert, M., Pickford, G. and Natour, A. 2015. *Strombank. Innovatives Betreibermodell für Quartierspeicher* [Online]. Karlsruhe: MVV Enegie AG. [Accessed 2 May 2016]. Available from: http://www.fachdokumente.lubw.baden-wuerttemberg.de/servlet/is/115026/bwe13017_13020.pdf?command=downloadContent&filename=bwe13017_13020.pdf&FIS=203.

Ugarte, S., Larkin, J., van der Ree, B., Swinkels, V., Voogt, M., Friedrichsen, N., Michaelis, J., Thielmann, A., Wietschel, M. and Villafáfila, R. 2015. *Energy Storage: Which Market Designs and Regulatory Incentives Are Needed?* [Online]. Brussels: European Parliament. DG for Internal Policies. Policy Department A: Economic and Scientific Policy. [Accessed 15 February 2016]. Available from: http://www.europarl.europa.eu/studies.

Vasconcelos, J., Ruester, S., He, X., Chong, E. and Glachant, J.-M. 2012. *Electricity Storage: How to Facilitate its Deployment and Operation in the EU.* [Online]. European University Institute. [Accessed 25 October 2015]. Available from:

http://www.eui.eu/Projects/THINK/Documents/Thinktopic/THINKTopic8online.pdf.

www.apg.at 2016. Austrian Power Grid - Market Information - Balancing. [online]. [Accessed 15 February 2016]. Available from: http://www.apg.at/en/market/balancing.

List of tables

List of figures

Annexes

Annex 1. Overview of a selection of relevant European projects

Smart Network Storage (SNS)

The Smart Network Storage (SNS) project developed by the UK Power Networks explores a synergy of multiple applications of bulk 6MW/10MWh battery storage connected to the substation at the distribution level. It is meant to support the grid, participate in the balancing market and provide ancillary services. In this project storage is used primarily for peak shaving to help avoid grid reinforcement alongside with voltage and reactive power support. However, it is not a *"pure distribution asset"* but rather *"operat[es] on a commercial shared use basis"* (PÖYRY, 2014b p. 12). The storage unit can be leased to a supplier company against a fee (so-called "Tolling Agreement") to be used at the wholesale market for arbitrage purposes or for solving imbalances (PÖYRY, 2014b). Thus, the supplier plays the key role in flexibility provision for the market. However, the network operator retains the right to override the Agreement and access storage in case of the system stress compensating the supplier (PÖYRY, 2014b).

Following an official consultation, Hayling (2014) singled out the two most promising business models. These are "DNO[19] Contracted" and "Contracted Services" within the SNS project. In both cases, storage provides services to the system and the market while commercial control of the asset is allowed within time slots specified in long-term contracts between the DNO and a supplier. The difference is that in the DNO Contracted model, the DNO is the one owning and fully controlling the unit and sets up an auction for third parties while in Contracted Services model that is the prerogative of a third party that provides grid services to the DNO against a fixed annual fee. Such a model implies a tradeoff between lower commercial risk for a DSO and lower operational security. Both models are seen as advantageous to a third party, providing for aggregation, increasing value streams and scalability (Hayling, 2014). Despite the fact that DNOs are not allowed to own generation units, both models are deemed feasible in the UK context (see Section 5.1.2).

EcoGrid

The Danish-led project EcoGrid tested smart-grid prototypes on the island of Bornholm and focused on the market-based use of demand response from households

---

[19] Distribution Network Operator

(predominantly from thermal storage devices such as heat pumps and electric heating) and industrial customers with the help of the Internet-connected Home Energy Management Systems (EMS) and smart meters. In the development of the market concept it was established that the real-time market would be necessary to exploit DR potential and enable small-scale DER to react to next-to-real-time electricity prices (update every 5 minutes) (Lund et al., 2016). Besides, even though customers are provided with all the tools to control their flexible units and access information (on-line or through an app), the results have shown that automated control systems at customers' premises (as opposed to customers' manual control of smart loads) were crucial to ensuring customer participation. In this concept, a TSO as the actor in charge of managing imbalances may assume the role of the "Real-Time Market Operator (RTMO)" (Lund et al., 2016). The results show that the real-time market will support and be interconnected with the balancing market. Participating customers are expected to sign a real-time market contract. At the same time, it predicts the emergence of different types of contracts available from retailers. The project, however, does not review the interaction between the DER-owning customers and DSOs or how customers' behavior can affect the grid.

ADDRESS

The Pan-European project ADDRESS jointly developed by 11 participating EU Member States focuses on the residential and small commercial consumers' active demand and involves them in provision of flexibility services in the market through an aggregator in return for savings. It employs various distributed flexible technologies, DG, appliances and PV-connected storage. An aggregator in this case is defined as either a separate deregulated actor or a retailer performing additional functions. The Energy Box is installed at consumers' premises and acts as a controller that can be accessed by the aggregator that "*sends price and volume signals to the EBox of the consumers in the active consumers portfolio. The signals are specifically designed to produce the needed aggregated consumption modification."* (Losi et al., 2013 p. 18) The settings of the EBox such as user comfort preferences, flexibility, interruption and thermal control are determined by the consumer. In the proposed architecture, DSO doesn't have direct control of flexible resources. Instead, it is the aggregator that plays the key role in controlling loads, facilitating connection between consumers and markets and selling active demand products to regulated and deregulated players (Losi et al., 2013).

Green2store

In the German pilot project Green2store*,* launched in 2012, the new approach to distributed storage systems for improved integration of renewables and overall grid stability is being tested. Cloud technology has been implemented in the electricity system to bundle up these systems into a single virtual storage. This technology allows to centrally manage several storage facilities, local network, home, campus storage units as well as an area storage unit connected to a residential complex (green2store, 2014). Storage capacity can be used by different actors irrespective of the actual position of the units in the system. It allows for dynamic operation through a so-called "Energy Storage Cloud", a platform, which communicates with storage and is accessed by generators, network operators, traders and commercial as well as domestic customers. In this project, the crucial role is that of a "Cloud Manager" who supervises the system and leases capacities to users, deciding at each point, which specific units have to allocated – thereby preventing any of the actors from getting direct access to storage units (green2store, 2014). According to the project developers, such a setup allows optimal use of storage capacities not only at the local level and greater potential for scalability (green2store, 2014). The use of the platform by multiple actors creates a number of legal and regulatory issues that were examined within the framework of the project.

SWARM

In a similar manner, the objective of a recent German-French project, SWARM*,* is to integrate 60 to 100 home battery storage units to form a 1MW virtual storage system. In this way, local balancing energy mechanisms help to relieve the transmission network, namely by providing primary control reserve. Notably, the minimum bid size is 1MW, which would enable virtual storage units to participate in the tender. Thus, the so-called "swarm[20] operation" delivers benefits for both consumers (higher share of self-consumption from PV as well as beneficial rent conditions and savings) and retailers providing balancing service to the TSO (Steber et al., 2016).

Flex4Energy

The Flexibility Management System (FMS) is the pivotal point for the project Flex4Energy*.* Deployment of flexibility is meant to facilitate cost-efficient grid development. The trade platform for distribution-level flexibility can also be used for the benefit of the grid. Under this concept, the grid is divided into multiple grid cells, which

---

[20] Swarm is defined as a "network of multiple smart energy stroage systems" (Steber et al., 2016)

include customers, prosumers and storage and can be viewed together in a FMS of each cell. The aggregator brings the required flexibility onto the market through a new Flexibility Platform, which would allow provision of flexibility not only on the global system but also on the local level. The products provided through the Platform are subdivided according to whether they can be forecasted into “schedule products” (for instance, settling imbalances among grid cells) and “adaptive products” (for instance, voltage control) (Aphram and Glotzbach, 2016). In the flexibility market envisaged in the project, its providers (consumers, generators, storage) can offer their services on their own or through an aggregator to flexibility users, DSOs, suppliers or BRPs. The aggregator’s role can be performed by a trader, supplier or a third party which creates standard marketable flexible capacities out of flexible DER. The project foresees the new role of the platform operator whose main task is to ensure universal access, market transparency and matching for a fixed fee. Aggregators have free choice of Platform (or Platforms) and thus of a platform operator. The latter is either an independent party or an additional function of a DSO, overseen by the regulator (Aphram and Glotzbach, 2016). The latter option, however, runs into a regulatory barrier since DSOs are not allowed to be involved in energy sales.

StromBank

German StromBank project (Thomann et al., 2015) focusing on community storage proposes an innovative operational solution to optimize the use of PV-produced energy based on an Energy Cloud. It uses the analogy of a traditional bank, replacing electricity for money. The participants include both industrial and private PV-owning customers as well as several CHP facilities. The Energy Cloud operated by a DSO communicates with two smart meters installed at each participant’s premises. Prosumers (consumers also producing their own electricity) are provided with an app similar to online banking displaying different accounts and services that they can use storage for. These potential applications include self-consumption, market participation through aggregation, energy trade and balancing services. So far, simulations have shown that such a model allows prosumers to boost their self-consumption from 33% to up to 62% (Thomann et al., 2015).

Flexibler Wärmestrom

The flexibility potential of heat storage, namely heat pumps and storage heating, for grid- and market-efficient load management was tested in a German pilot project Flexibler Wärmestrom in Baden-Wüttemberg, and implemented by EnBW, German energy supplier (EnBW, 2015). Controllers were installed to enable management of the flexible components – for example in situations when output surpasses local load – as a single virtual power plant (VPP). This management succeeded in fully utilizing the storage capacity of thermal controllable loads, guaranteeing network stability, avoidance of grid reinforcement and facilitated load management in the presence of a high share of renewable DG. Since consumer-owned thermal storage units can act as a buffer for VRES, the project foresees the need for special tariffs for these consumers to encourage provision of flexibility and reduce electricity costs. A supplier can also potentially use the available capacity in the day-ahead market (EnBW, 2015).

MERGE (Mobile Energy Resources in Grids of Electricity)

Other interruptible loads, EVs, were tested in the EU-wide project MERGE. Mobile DER require separate consideration and an advanced control model, which in this case includes a local (on-site) controller and an "upper level control" communicating with the charging points. A new entity, the EVs supplier/aggregator, is envisaged to carry out upper level control, managing a network of EV batteries and interacting both with the regulated and deregulated players as well as participating in the balancing markets. At the same time, Hatziargyriou et al. (2012) deem DSOs as the most adequate charging infrastructure developers. It is important to differentiate between the different uses of EVs. One is to operate with regard only to one's own charging needs (so-called "Dumb Charging"). This use would often coincide with the use of other appliances, driving peak load up and is thus likely to destabilize the grid and complicate its management. In contrast "Smart Charging" strategy would allow for external control and use of the EV during valley times for the sake of the grid (frequency and voltage control) and would help avoid voltage imbalances and grid infrastructure update (Hatziargyriou et al., 2012). Another new deregulated actor is a Charging Point Manager that owns and operates charging point(s) and is "allowed to resell energy for EV charging is it wishes to" and acts as a link between EV owners and electricity suppliers (Hatziargyriou et al., 2012). Smart meters are also seen as enablers of wider use of EVs through allowing Time of Use (ToU) tariffs.

Annex 2. Survey of Expert Opinion

Project LEAFS

Task 4.3 “Realization in the current legal and regulatory framework”

Introduction

Flexible generation, consumption and storage are considered to be promising ways of boosting the integration of generation from variable renewable energy sources and customer involvement. Provision of flexibility at all network levels bears potential benefits both for the grid and the market. However, for its successful deployment multiple aspects, technical, economical and regulatory, require further analysis.

The aim of the Task 4.3 project LEAFS is to assess the implementability of the proposed control approaches and identify potential barriers to the provision of services from flexible resources in the Austrian and European regulatory framework. To enable and incentivize wide deployment of distributed flexibility it is crucial to clarify regulatory issues, which are the focus of this survey.

The goal of this survey is thus to collect and analyze the opinions of project stakeholders with regard to areas pertinent to the research including grid and market services as well as ownership of flexible components and data management, incentives and the role of aggregators. This will help us determine possible arrangements for the deployment of flexibility, assess views on disputable questions from different perspectives and address the concerns expressed.

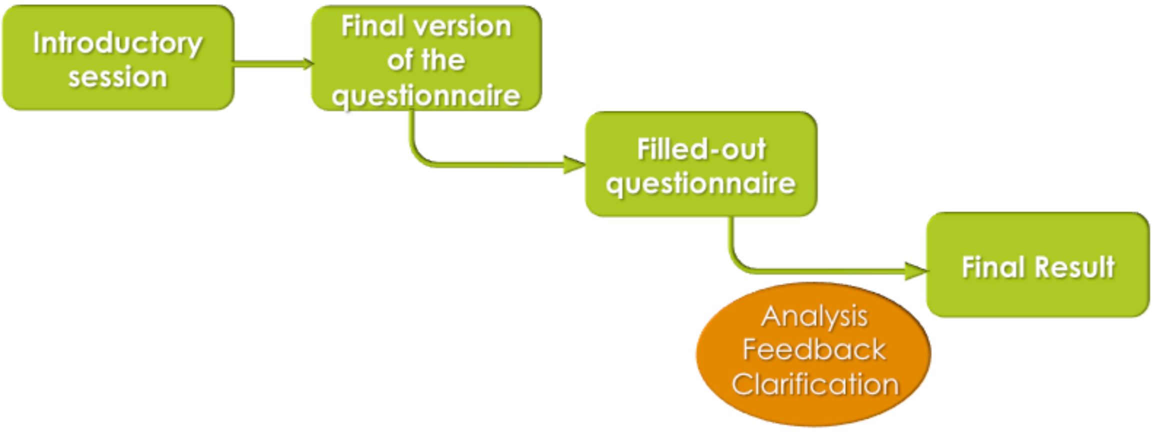
Expected outcome

This survey is meant to provide an insight into possible ways of deploying flexibility in a legally practicable and commercially attractive ways. Clarifying the questions below will not only be helpful for the case of project LEAFS but will also help to identify ways to facilitate its implementability in “real-life” conditions and transferability to other, national and European, settings.

Structure of the survey

The present survey is organized in several stages.

Following the introductory session, the participants are requested to fill out the agreed-upon, finalized version of the questionnaire below. Further on, the results will be analyzed revealing the degree of consensus within the group on different aspects of flexibility provision. Finally, the experts will be provided with the feedback on the group outcome and will be able to be able to elaborate on their choices with regard to the identified critical points, share their comments and potentially review their original position.



Part 1 – Information about the participant

Please provide your name___________________________

Please provide your email address____

In what capacity are you completing this questionnaire

- On behalf of a distribution network operator
- On behalf of a technology provider
- On behalf of a research center
- Other:_____________________________________

__ My contribution has to be used anonymously. *(Please select if applicable)*

Part 2 – Context-setting

1. Provision of flexibility has to be managed on:
    - the transmission system level
    - the distribution system level
    - the distribution system level and much as on the transmission system level

2. In terms of their access to the market, distributed flexible resources should be placed on the same footing with the traditional sources of flexibility such as pumped hydro storage and gas turbines.

1 – absolutely agree	2	3	4	5	6 – completely disagree

3. DSOs should be able to procure flexibility:
    - directly from generators/loads (without intermediation of the aggregators)
    - only through aggregators/third parties
    - Other:_____________________________

4. Use of flexible technologies (active grid management) is preferable to grid reinforcement.

1 – completely disagree	2	3	4	5	6 – absolutely agree

5. Real-time decentralized flexibility offers a viable alternative to load or generation curtailment in case of congestions.

1 – completely disagree	2	3	4	5	6 – absolutely agree

6. As distribution network becomes more ‘active’ the range of responsibilities of the DSO will be expanded significantly.
Yes _____ Rather yes_______ Rather not________ No_______

7. In the future, network operators’ activities will rather be focused on providing energy services rather than managing assets.

1 – completely disagree	2	3	4	5	6 – absolutely agree

Part 3 – Operation Strategies

8. Please select the actors that, in your view, **should be legally responsible** for the listed operation strategies (in the context of project LEAFS):

Actor / Strategy	Grid operator	Supplier	Generator	Balance responsible party	Independent third party	Aggregator	Consumer/ Prosumer
Increased own consumption							
Reduction of electricity procurement costs							
Reduction of peak load							
Provision of reactive power							
Reduction of balancing energy costs							
Provision of control power (primary, secondary, tertiary)							
Arbitrage							
Islanding							
Virtual inertia							
Black start capacity							
Power quality (Symmetrierung)							

9. In the absence of regulatory constraints, which of the following actors, in your view, **would implement** the listed operation strategies **in the most cost-efficient way?**

Actor / Strategy	Grid operator	Supplier	Generator	Balance responsible party	Independent third party	Aggregator	Consumer/ Prosumer
Increased own consumption							
Reduction of electricity procurement costs							
Reduction of peak load							
Provision of reactive power							
Reduction of balancing energy costs							
Provision of control power (primary, secondary, tertiary)							
Arbitrage							
Islanding							
Virtual inertia							
Black start capacity							
Power quality (Symmetrierung)							

Part 4 – Market

10. Flexible distributed resources should be facilitated access to the electricity markets.

	1 – definitely	2	3	4	5	6 – under no circumstances
0-5kW						
5-20kW						
20-100kW						
100-200kW						
200kW-1MV						
1-5MW						
>5MW						

11. Procurement of the following services from flexible components has to be based on:

Type of procurement / Strategy	Market-driven	Mandatory provision	Bilateral contracts	Tendering	Other
Increased own consumption					
Reduction of electricity procurement costs					
Reduction of peak load					
Provision of reactive power					
Reduction of balancing energy costs					
Provision of control power (primary, secondary, tertiary)					
Arbitrage					
Islanding					
Virtual inertia					
Black start capacity					
Power quality (Symmetrierung)					

12. An organized ancillary services market (including at least some of the listed strategies) is likely to emerge in the future if equal access is granted to all potential market players (demand, supply; small and big providers).

1 – completely disagree	2	3	4	5	6 – absolutely agree

13. With respect to strategies such as peak shaving, the implementation of a capacity mechanism and activation fees in Austria would help to promote adequate valorization of demand response and other flexibility measures.
Yes ______ Rather yes_______ Rather not________ No_______
Other: ______________________________

14. Commercial actors should have a possibility to supply flexibility services to a DSO for grid management.

1 – absolutely agree	2	3	4	5	6 – completely disagree

15. In case of conflict of market incentives and needs of the grid, the latter should be given priority.
Yes ______ Rather yes________ Rather not_________ No________
Other: _______________________________

Part 5 – Future arrangements and incentives

16. Regulation of flexibility provision is associated with a number of grey areas. In order to facilitate the deployment of flexible resources, these grey areas have to be addressed:
    - on the EU level
    - on the level of Member States
    - Other (e.g. on the level of individual utilities): ______________________________

17. Differences on the European / national level / the level of federal states in the treatment of flexible technologies hinders their deployment and investment decisions and needs to be addressed:

1 – very urgently	**2**	**3**	**4**	**5**	**6 – not at all important**

18. Procurement of flexibility from distributed resources will be facilitated most efficiently through the following mechanisms *(please choose the applicable one(s)):*
    - new tariffs structures
    - markets
    - tendering
    - grid code
    - direct bilateral contracts

19. Incentives for the provision of flexibility should be harmonized at the EU level.

1 – completely disagree	**2**	**3**	**4**	**5**	**6 – absolutely agree**

20. Provision of flexibility by a small group of consumers leads to unequal benefit allocation among grid users and creates a negative impact of the rest of the consumers (indirect subsidization).

1 – absolutely agree	**2**	**3**	**4**	**5**	**6 – completely disagree**

21. Differentiation of network charges according to different types of network user profiles is required to avoid favoring certain groups of grid users and higher cost socialization.

1 – absolutely agree	2	3	4	5	6 – completely disagree

22. Network users should have a possibility to adapt their behavior in terms of load/feed-in of electricity, including self-consumption, according to their incentives regardless of the planning criteria of the network.

under no circumstances	probably not	probably	quite likely	definitely

23. In the future grid users should be able to profit from their behavior (as consumer / producer) even if these come at the cost of the network paid jointly by all network users.

under no circumstances	probably not	probably	quite likely	definitely

24. Regulated end-user prices should be abandoned. Instead, market information on the value of flexibility has to be passed through (directly) to customers/ prosumers to improve incentives.

1 – completely disagree	2	3	4	5	6 – absolutely agree

25. New tariff structures are necessary to promote the uptake of flexible technologies by customers.

1 – very important	2	3	4	5	6 – unimportant

26. Self-consumption should be encouraged and not negatively affected by excessive taxes or charges or discouraged through provisions forcing the sale of self-produced energy.

1 – absolutely agree	2	3	4	5	6 – completely disagree

27. Owners of distributed energy resources (DER) have to be rewarded for providing curtailing services to DSOs in case of risks of congestion.

1 – completely disagree	2	3	4	5	6 – absolutely agree

28. Stronger regulatory support of inclusion of demand response in energy and balancing markets in Austria would help to exploit its potential for the grid.
Yes _____ Rather yes_______ Rather not________ No_______
Other: ____________________________

29. Improved price signals for customers will enable their active participation in demand response schemes and stimulate uptake of smart appliances by consumers.

1 – completely disagree	2	3	4	5	6 – absolutely agree

30. Same conditions have to be applicable to storage systems irrespective of the size (Compare: pumped hydro storage and battery storage systems).
Yes _____ Rather yes_______ Rather not________ No_______
Other: ____________________________

31. Current regulation treats storage systems on par with generation, which effectively prohibits network operators from managing such systems due to the unbundling requirement. Would it be necessary to assign storage systems their own category as a special type of assets separate from generation?
Yes _____ Rather yes_______ Rather not________ No_______
Other: ____________________________

32. In order to improve their business case, storage systems should be exempted from double taxes and charges.
Yes _____ Rather yes_______ Rather not________ No_______
Other: ____________________________

Part 6 – Ownership and control

33. Within the pilot project LEAFS several control approaches listed below are being tested. Which of these have, in your view, the greatest potential to be deployed in the "real-life" context outside the project?
    - DSO's direct control of central flexible components where components belong to the system operators,
    - DSO's direct access to decentralized components;
    - DSO's indirect access to decentralized components through a customer energy management system, where components belong to the customer.

Please, clarify your choice:_________________________________
____

34. A network operator has to be allowed …… a flexible unit to suit the needs of the grid. *(please select multiple options if applicable)*

Strategy / Technology	Own	Operate	Other (e.g. contract)
Battery storage systems			
Power-to-heat			
Appliances involved in demand response			
Electric vehicle charging infrastructure			

35. Variable distributed generation (such as PV) has to be able to be controlled remotely by the network operator (smart inverter).
Yes ______ Rather yes________ Rather not_________ No________
Other: ________________________________

36. Large number of prosumers and owners of flexible components will disrupt the revenue flows of grid operators and traditional generators.
Yes ______ Rather yes________ Rather not_________ No________
Other: ________________________________

Part 7 – Aggregator

37. The new "smartening" grid will need a new actor – aggregator - to aggregate distributed generation and flexible loads.
Yes ______ Rather yes________ Rather not_________ No________
Other: ________________________________

38. The role of an aggregator should be performed by:
    - a retailer
    - a telecommunications entity
    - a DSO
    - a completely new entity
    - Other:_______________________________________

39. An aggregator has to be (recognized as) an independent service provider with a single function of participating in the electricity markets.

1 – absolutely agree	2	3	4	5	6 – completely disagree

40. An aggregator has to have balancing responsibility in order to avoid conflict of interests with BRPs.

1 – absolutely agree	2	3	4	5	6 – completely disagree

Part 8 – Data management

41. Data handling should lie within the area of responsibility of:
    - metering company
    - ICT company
    - DSO
    - aggregator
    - Other:___________________________________

42. DSO should be able to obtain information about how the way customer behavior changes following market signals.

1 – absolutely agree	2	3	4	5	6 – completely disagree

43. Smart metering equipment should be controlled by
    - the DSO
    - retailer
    - Other:____________________________

44. In terms of market facilitation, the role of a data hub operator has to be assigned to:
    - a DSO
    - a TSO
    - a third party
    - a joint venture of the above actors
    - Other:_______________________________

Annex 3. Results of the survey of expert opinion

Number of participating experts: 23

Part 1 - Context setting

1. Provision of flexibility has to be managed on:

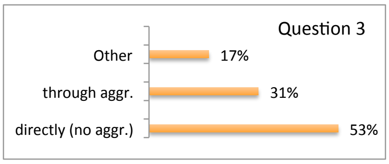
TN level	DN level	both
	3	20

2. In terms of their access to the market, distributed flexible resources should be placed on the same footing with the traditional sources of flexibility such as pumped hydro storage and gas turbines.

1 -c. disagree	2	3	4	5	6 - abs. agree
		2	4	7	10

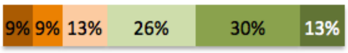
3. DSOs should be able to procure flexibility:

directly (no aggr.)	through aggr.	Other
19	11	6



4. Use of flexible technologies (active grid management) is preferable to grid reinforcement.

1 -c. disagree	2	3	4	5	6 - abs. agree
2	2	3	6	7	3



5. Real-time decentralized flexibility offers a viable alternative to load or generation curtailment in case of congestions.

1 -c. disagree	2	3	4	5	6 - abs. agree
1	2	1	4	11	4

6. As distribution network becomes more ‘active’ the range of responsibilities of the DSO will be expanded significantly.

No	Rather not	Rather yes	Yes
	1	10	12

7. In the future, network operators’ activities will rather be focused on providing energy services rather than managing assets.

1 -c. disagree	2	3	4	5	6 - abs. agree
1	1	3	3	13	2

Part 2 - Operation strategies

8. Please select the actors that, in your view, should be legally responsible for the listed operation strategies (in the context of project LEAFS):

Actor / Strategy	Grid operator	Supplier	Generator	Balance responsible party	Independent third party	Aggregator	Consumer/ Prosumer
Increased own consumption		3		3	6	7	22
Reduction of electricity procurement costs	5	9	2	4	5	6	9
Reduction of peak load	11	2	4	3	2	7	16
Provision of reactive power	14	1	13	3		4	9
Reduction of balancing energy costs	6	5	3	16	1	6	3
Provision of control power (primary, secondary, tertiary)	8	5	15	4	4	13	13
Arbitrage	1	9	3	1	6	7	6
Islanding	10	2	4			2	11
Virtual inertia	9	5	11	3	4	8	7
Black start capacity	18	2	12	1		1	6
Power quality (Symmetrierung)	20		11		1	3	9

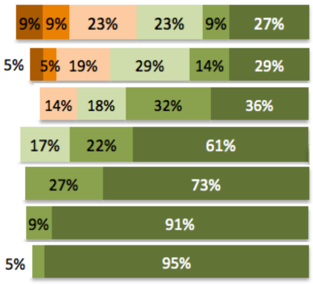
9. In the absence of regulatory constraints, which of the following actors, in your view, would implement the listed operation strategies in the most cost-efficient way?

Actor / Strategy	Grid operator	Supplier	Generator	Balance responsible party	Independent third party	Aggregator	Consumer/ Prosumer
Increased own consumption	3		1		6	9	15
Reduction of electricity procurement costs	3	12	4	2	4	6	9
Reduction of peak load	12	2	2	1	3	5	8
Provision of reactive power	11	1	13			3	7
Reduction of balancing energy costs	2	6	4	14	2	6	3
Provision of control power (primary, secondary, tertiary)	6	2	12	3	2	8	3
Arbitrage	1	10	1	1	3	5	3
Islanding	12		6			1	7
Virtual inertia	3	1	12	1	2	4	4
Black start capacity	13	1	13				4
Power quality (Symmetrierung)	12	1	9	1	1	2	5

Part 3 - Market

10. Flexible distributed resources should be facilitated access to the electricity markets.

	6 – under no circumstances	5	4	3	2	1 - definitely
0-5kW	2	2	5	5	2	6
5-20kW	1	1	4	6	3	6
20-100kW			3	4	7	8
100-200kW				4	5	14
200kW-1MV					6	16
1-5MW					2	20
>5MW					1	21



11. Procurement of the following services from flexible components has to be based on:

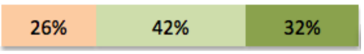
Actor / Strategy	Market-driven	Mandatory provision	Bilateral contracts	Tendering	Other
Increased own consumption	16	3	7	3	3
Reduction of electricity procurement costs	16	2	7	3	
Reduction of peak load	8	14	10	6	
Provision of reactive power	5	16	4	3	
Reduction of balancing energy costs	16	2	6	4	
Provision of control power (primary, secondary, tertiary)	15	2	8	11	
Arbitrage	16	2	2	3	
Islanding	1	9	9	7	3
Virtual inertia	3	11	9	10	
Black start capacity	1	15	10	6	
Power quality (Symmetrierung)	5	17	5	4	

12. An organized ancillary services market (including at least some of the listed strategies) is likely to emerge in the future if equal access is granted to all potential market players (demand, supply; small and big providers).

1 -c. disagree	2	3	4	5	6 - abs. agree
	2	1	4	13	3

13. With respect to strategies such as peak shaving, the implementation of a capacity mechanism and activation fees in Austria would help to promote adequate valorization of demand response and other flexibility measures.

No	Rather not	Rather yes	Yes	Other
	5	8	6	2

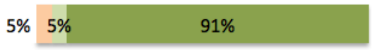


14. Commercial actors should have a possibility to supply flexibility services to a DSO for grid management.

1 -c. disagree	2	3	4	5	6 - abs. agree
1	1		5	5	14

15. In case of conflict of market incentives and needs of the grid, the latter should be given priority.

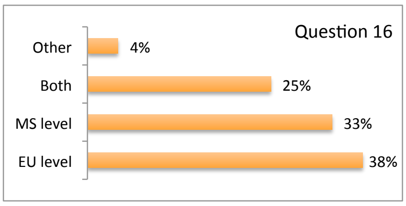
No	Rather not	Rather yes	Yes	Other
	1	1	20	1



Part 4 - Future arrangements and incentives

16. Regulation of flexibility provision is associated with a number of grey areas. In order to facilitate the deployment of flexible resources, these grey areas have to be addressed:

EU level	MS level	Both	Other
9	8	6	1

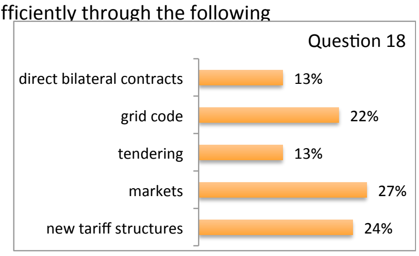


17. Differences on the European / national level / the level of federal states in the treatment of flexible technologies hinders their deployment and investment decisions and needs to be addressed:

6-unimportant	5	4	3	2	1- v.urgently
	3	1	8	7	3

18. Procurement of flexibility from distributed resources will be facilitated most efficiently through the following mechanisms (please choose the applicable one(s)):

new tariff structures	markets	tendering	grid code	direct bilateral contracts
11	12	6	10	6



19. Incentives for the provision of flexibility should be harmonized at the EU level.

1 -c. disagree	2	3	4	5	6 - abs. agree
	6	2	7	7	1

20. Provision of flexibility by a small group of consumers leads to unequal benefit allocation among grid users and creates a negative impact of the rest of the consumers (indirect subsidization).

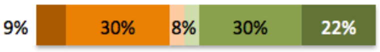
1 -c. disagree	2	3	4	5	6 - abs. agree
1	5	5	7	4	1

21. Differentiation of network charges according to different types of network user profiles is required to avoid favoring certain groups of grid users and higher cost socialization.

1 -c. disagree	2	3	4	5	6 - abs. agree
	1	3	7	6	5

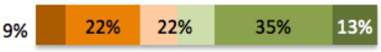
22. Network users should have a possibility to adapt their behavior in terms of load/feed-in of electricity, including self-consumption, according to their incentives regardless of the planning criteria of the network.

under no circumst.	probably not	probably	quite likely	definitely
2	7	2	7	5



23. In the future grid users should be able to profit from their behavior (as consumer / producer) even if these come at the cost of the network paid jointly by all network users.

under no circumst.	probably not	probably	quite likely	definitely
2	5	5	8	3



24. Regulated end-user prices should be abandoned. Instead, market information on the value of flexibility has to be passed through (directly) to customers/ prosumers to improve incentives.

1 -c. disagree	2	3	4	5	6 - abs. agree
	6	1	3	8	5

25. New tariff structures are necessary to promote the uptake of flexible technologies by customers.

6-unimportant	2	3	4	5	1 -v.important
1	2		3	11	6

26. Self-consumption should be encouraged and not negatively affected by excessive taxes or charges or discouraged through provisions forcing the sale of self-produced energy.

1 -c. disagree	2	3	4	5	6 - abs. agree
		4	2	5	12

27. Owners of distributed energy resources (DER) have to be rewarded for providing curtailing services to DSOs in case of risks of congestion.

1 -c. disagree	2	3	4	5	6 - abs. agree
3	2	4	6	5	2

28. Stronger regulatory support of inclusion of demand response in energy and balancing markets in Austria would help to exploit its potential for the grid.

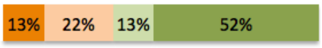
No	Rather not	Rather yes	Yes	Other
	3	10	9	1

29. Improved price signals for customers will enable their active participation in demand response schemes and stimulate uptake of smart appliances by consumers.

1 -c. disagree	2	3	4	5	6 - abs. agree
	5	3	3	7	5

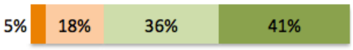
30. Same conditions have to be applicable to storage systems irrespective of the size (Compare: pumped hydro storage and battery storage systems).

No	Rather not	Rather yes	Yes	Other
3	5	3	12	



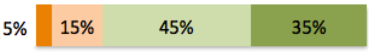
31. Would it be necessary to assign storage systems their own category as a special type of assets separate from generation?

No	Rather not	Rather yes	Yes	Other
1	4	8	9	1



32. In order to improve their business case, storage systems should be exempted from double taxes and charges.

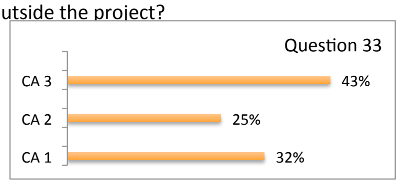
No	Rather not	Rather yes	Yes	Other
1	3	9	7	2



Part 5 - Ownership and control

33. Within the pilot project LEAFS several control approaches (CA) listed below are being tested. Which of these have, in your view, the greatest potential to be deployed in the "real-life" context outside the project?

CA 1	CA 2	CA 3
9	7	12



34. A network operator has to be allowed …… a flexible unit to suit the needs of the grid. (please select multiple options if applicable)

Technology	Own	Operate	Other (e.g. contract)
Battery storage systems	13	13	16
Power-to-heat	6	9	18
Appliances involved in DR	3	10	18
EV charging infrastructure	8	11	19

35. Variable distributed generation (such as PV) has to be able to be controlled remotely by the network operator (smart inverter).

No	Rather not	Rather yes	Yes	Other
1	3	10	8	2

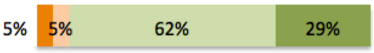
36. Large number of prosumers and owners of flexible components will disrupt the revenue flows of grid operators and traditional generators.

No	Rather not	Rather yes	Yes	Other
2	4	11	5	1

Part 6 - Aggregator

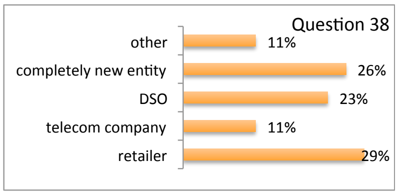
37. The new "smartening" grid will need a new actor – aggregator - to aggregate distributed generation and flexible loads.

No	Rather not	Rather yes	Yes	Other
1	1	13	6	1



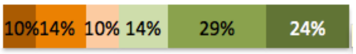
38. The role of an aggregator should be performed by:

retailer	telecom company	DSO	completely new entity	other
10	4	8	9	4



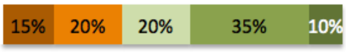
39. An aggregator has to be (recognized as) an independent service provider with a single function of participating in the electricity markets.

1 -c. disagree	2	3	4	5	6 - abs. agree
2	3	2	3	6	5



40. An aggregator has to have balancing responsibility in order to avoid conflict of interests with BRPs.

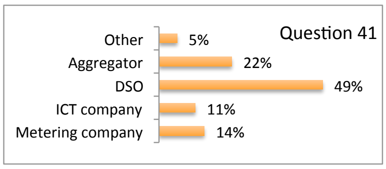
1 -c. disagree	2	3	4	5	6 - abs. agree
3	4		4	7	2



Part 7 - Data Management

41. Data handling should lie within the area of responsibility of:

Metering company	ICT company	DSO	Aggregator	Other
5	4	18	8	2

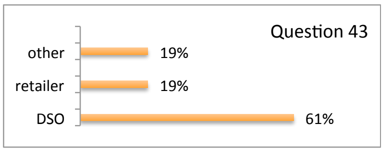


42. DSO should be able to obtain information about how the way customer behavior changes following market signals.

1 -c. disagree	2	3	4	5	6 - abs. agree
1			6	7	9

43. Smart metering equipment should be controlled by:

DSO	retailer	other
19	6	6



44. In terms of market facilitation, the role of a data hub operator has to be assigned to:

DSO	TSO	third party	a joint venture of the above	other
9	2	5	12	1