Generalized Operational FLEXibility for Integrating Renewables in the Distribution Grid (GOFLEX)

D10.2 Demand Side Management, Opportunities and Restrictions in the European Market

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Executive Summary

The GOFLEX project aims to support the development of decentralised energy systems ("cellular" systems) based on (volatile) renewables. These energy systems must enable a maximum of flexibility by the utilisation of demand response, storage assets and controlled operation of generation.

Thus, this deliverable refers to FLEXIBILITY (instead of reducing it to the sub-issue of "demand response"), which is a more comprehensive term to understand the challenges and opportunities in a cellular energy system.

Decentralised flexibility can be provided by household appliances, industry processes and flexible generation. Batteries will play an essential role as source of flexibility in a decentralised energy system.

Flexibility needs to be considered as tradeable product separate from energy products. Today there are markets for flexibility for TSOs but not on local or regional level. GOFLEX aims to demonstrate a local flexibility trading system.

The future more decentralised energy system requires new market roles, functions and processes and as of today it is not clear which actors will carry them out. The relation between TSO and DSO will change, DSOs will have more resources in their grids and will carry more responsibility. On the other hand, DSOs are not permitted to get remuneration to avoid cost by using flexibility, which is a very limiting factor for the business models that are based on the DSO-centric use cases (avoiding costs for black-outs, grid congestion and grid expansion).

For BRPs the key factor is the cost comparison between the costs for requesting flexibility from the energy spot markets (not the framework barriers), which will be explored during the project time.

Generally speaking, the frameworks today do not support local cellular energy systems but often does not restrict them either: The issue how to utilise local flexibility locally is simply often not regulated. One could say, it is not prohibited to install these processes but it is very uncertain that the investment pays off for those who actively drive this development.

That very much applies to all countries where the trial sites are located and so all GOFLEX use cases can be implemented and will at least deliver a proof of concept.

The GOFLEX solution consists of building blocks with open interfaces which can be used individually and as a complete system. The core is the flexibility market application and the aggregation platform supported by a distribution grid monitoring system and energy management systems for households, buildings, e-cars, factories and grid storage.

Depending who in future will run these systems (DSOs, local energy suppliers, new service companies or the EEX) the GOFLEX solution can be used as full system or provide building blocks to complete the utilisation of local flexibility trading.

There are already a few companies on the market which provide commercial solution for managing decentralised energy system. Most of them aggregate local flexibility and offer it at the power reserve markets, or organise local energy communities as balance groups. None of them so far offer a solution for local flexibility trading.

The aim of GOFLEX is to join all actors supporting a decentralised energy system in the GOFLEX community to change the regulatory and market framework to push the local flexibility markets as a key component for decentralised energy systems based on renewable energies.

The results of the desktop research support the GOFLEX approach to demonstrate all GOFLEX system components and including all local market actors (real and emulated ones) and covering a wide range of possible business models. Utilising local flexibility trading is uncharted area from a market und regulatory perspective.

Document History

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List of Acronyms and Abbreviations

Abbreviation	Definition
ACER	Agency for the Cooperation of Energy Regulators
BEUC	The European Consumer Organisation
BRP	Balance Responsible Party
CEER	Council of European Energy Regulators
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
DoA	Description of Action
DSO	Distribution System Operator
EASE	The European Association for Storage of Energy
EASME	Executive Agency for SMEs
EDSO	European Distribution System Operators' Association for Smart Grids
EEGI	European Grids Initiative
EERA	Technology Platforms and the European Energy Re-search Alliance
EEX	European Energy Exchange
EIIs	European Industry Initiatives
ENTSO-E	European Network of Transmission System Operators for Electricity
ESMIG	European voice of smart energy solution providers
ETIP SNET	The European Technology and Innovation Platform "Smart Networks for the Energy Transition”
ETIPs	European Technology and Innovation Platforms
ETSI	European Telecommunications Standards Institute
EV	Electric Vehicle
GEODE	European independent distribution companies of gas and electricity
H2020	Horizon 2020
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISGAN	International Smart Grid Action Network
JRC	Joint Research Centre
LCE	Low-carbon energy (see H2020 competitive low carbon energy call)
RES	Renewable Energy Source
SCADA	Supervisory control and data acquisition
SEO	Search Engine Optimization
SET-Plan	European Strategic Energy Technology Plan
TRL	Technology Readiness Level
TSO	Transmission System Operator
VPP	Virtual Power Plant

1 Introduction

1.1 The Purpose of this deliverable

The deliverable "D10.2 : Demand side Management, Opportunities and Restrictions in the European Market" is a study based on desktop research and a report about the current discussion regarding the GOFLEX business models to be implemented or simulated by the GOFLEX trial sites during the project time and beyond.

The scope of the deliverable was extended from "demand side management" to "flexibility management" to get a more comprehensive view on the possibilities for actors in decentralised energy system based on renewables to respond to the challenges of the volatility of renewable generation. In GOFLEX flexibility provided by demand side management schemes, storage management schemes and generation management schemes compete on the GOFLEX flexibility market independent of its source of flexibility. This broader concept of flexibility provision was developed after the application phase of GOFLEX in the first 12 months.

The purpose is to get a clear picture about the supporting and hampering factors for the deployment of the GOFLEX flexibility use cases and the derived business models of the GOFLEX trial sites in Europe. It focuses on the market design, the regulation and the policies of several EU countries, indicating the countries with the best conditions for a roll-out of the solution.

The deliverable will give a brief overview about the planned functionality and the open architecture approach based on building blocks which provides the opportunity to collaborate with third parties and to integrate legacy systems which already exist. It will give a preliminary assessment of this approach regarding the chances to succeed in the European market.

It also explores successful business models and successful customer involvement strategies from other projects and companies which are already in place and discuss the partnership/competition aspects regarding the relationships that GOFLEX aims to build with these projects and companies.

It finally concludes with a possible roadmap for the implementation of GOFLEX flexibility business models during the project time

1.2 Related Documents

The deliverable D 10.2 has strong relations to

1. D6.2 "Integrated System Conceptual Architecture & Process Specification Description Business Processes" which has provided the underlying use cases implemented in the GOFLEX solution and

2. D7.2/D8.2/D9.2 "Business Model Design and KPI Definition" which provide information about supporting and hampering factors of the specific trial countries identified by the trial partners.

It is the preparation regarding structure and addressed issues for the upcoming deliverables D10.4 "Best Practice Results on Business and Pricing Models (trials + community), Implementation Guidelines and Recommendations for Regulators and Policy Makers" and D10.6 "Best Practice Implementations, Opportunities of the GOFLEX solution outside the Project and beyond the Project's Time".

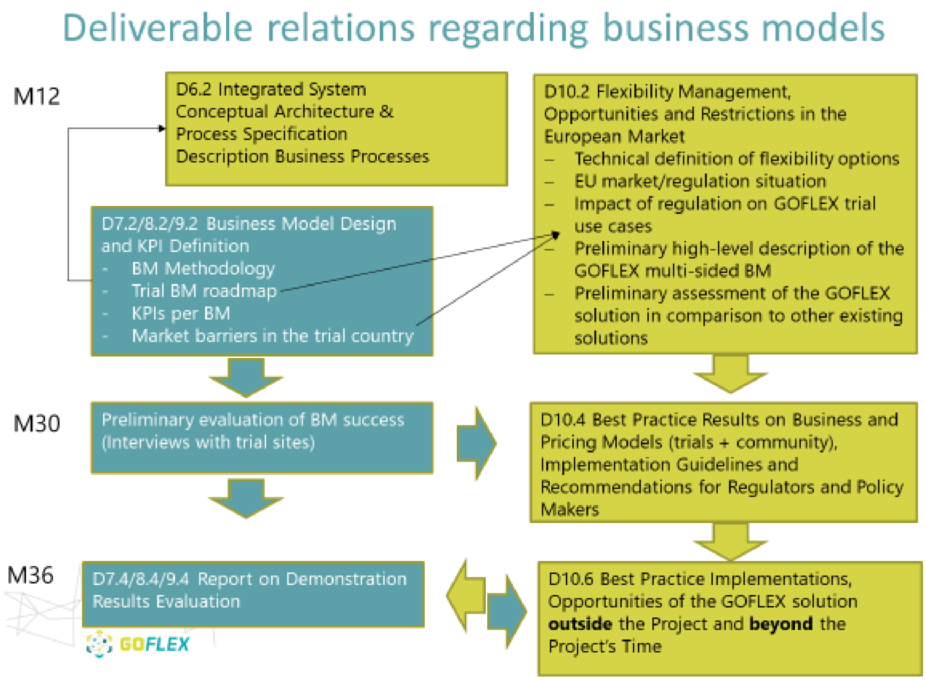

Figure 1 Related documents to deliverable D10.2

1.3 Document Structure

The documented is structured in five parts:

1. The first part is the formal introduction
2. The second part explores the technical and commercial utilisation of electricity flexibility and how it can be defined as a tradeable product.
3. The third part (main part) describes the EU market and regulation implications of flexibility trading. It describes the participating roles and actors.

4. The fourth part assesses the main GOFLEX use cases implemented in the GOFLEX trials regarding the implementation chances now and in the future. This chapter also assesses the market/regulation situation in the countries of the trial sites, indicating which countries could be easiest to start with.
5. The fifth chapter gives a short description about the market approach of the GOFLEX solution and its derived functionality and architecture based on building blocks. It assesses its chances in the current European market and describes European best practice business models which are already in place and commercially successful.
6. The fifth chapter concludes with a recommendation regarding the roadmap of the GOFLEX business model implementation.

2 Flexibility

Flexibility can be defined as the ability of the electricity system to respond to fluctuations of supply and demand while, at the same time, maintaining system reliability.

2.1 Flexibility as a technical term

The following sections introduce the concept of balancing power supply and demand in the distribution grid with the help of flexibilities in the electricity market. Based on the technical definition of flexibility, sources as well as owners of flexibilities are identified.

2.1.1 Technical definition of flexibility

Flexibility is 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. The parameters used to characterise flexibility include the amount of power modulation, the duration, the rate of change, the response time, the location, etc. (Eurelectric, 2014).

In order to balance power supply and demand in the distribution grid at all time, technical control capabilities are required on both the supply and the demand side. The capability to modify electricity generation within a distribution grid essentially depends on the availability of regional renewable power generation at a certain time, back-up power plants (e.g. gas, biomass, pumped storage) that serve peak load within the distribution grid, Power to X technologies in order to store energy surplus, and decentralised prosumer-owned power generation capacities. Intelligent and flexible use of electricity supply is one side of the coin; demand side flexibility is the other. Demand side flexibility, called demand response, allows consumers to adapt their energy usage to different energy prices throughout the day. This might mean receiving a payment for turning down the heating system in order to stabilise the grid during peak time. Alternatively, it might mean access to cheaper energy via dynamic price contracts and smart meters when wind farms and solar panels are producing plenty of electricity (Commission European, 2016).

2.1.2 Sources of flexibilities in the distribution grid

The section above already indicates technology-based flexibility solutions. The following remarks present flexibility options from a supply side, a demand side as well as a storage-based point of view.

Considering the possibilities of modifiable electricity supply available in the distribution grid, the following classification of flexibility options can be used:

Table 1 flexibility in power generation

Power plant technology	**Flexibility of electricity supply in terms of their possibility to modify power generation (base, intermediate, peak)**	**Feed-in on transmission grid level or distribution grid level**
run-of-river	base	transmission / distribution
nuclear	base / intermediate	transmission
lignite	base / intermediate	transmission / distribution
hard coal	base / intermediate	transmission / distribution
gas	peak	distribution
large cogeneration	peak	distribution
micro cogeneration	base	distribution
photovoltaic	base, if available	distribution
wind offshore	base, if available	transmission
wind onshore	base, if available	distribution
biomass	peak	distribution

Flexibility options on the demand side can be summed up as follows (Ecofys, 2014):

- Industrial Demand Response
- Small scale Demand Response
- Electric Vehicles
- Heat pumps
- Electric heating

In addition, further flexibility options can be identified in terms of storage technologies (Ecofys, 2014):

- Compressed air energy storage
- Pumped Hydro
- Flywheels
- Batteries
- Power to gas

In order to integrate fluctuating renewable energy sources in the distribution grid, the above listed technologies are subject to a mix of organisational, regulatory and technological measures of load or congestion management such as:

- feed-in management through peak load power plants, e.g. gas
- feed-in management through decentralised power generation by prosumers
- curtailment of renewable energy power plants
- regulatory incentives
- electricity storage through renewable power to gas

2.1.3 Owners of flexibility options

In this section, above listed flexibility options on the supply side, the demand side and in terms of storage technologies are assigned to the following energy market participants:

- energy suppliers
- industry
- trade and commerce
- public sector
- households

Table 2 Owners of flexibility options

flexibility options	owners of flexibility options: energy supp-liers	in-dustry	com-merce, trade and services	public sector	house-holds
fossil power plants	most likely	most likely	not likely	not likely	not likely
renewable energies (solar, wind)	most likely	most likely	most likely	most likely	most likely
biomass	most likely	most likely	not likely	not likely	not likely
Demand response	not likely	most likely	most likely	most likely	most likely
Electric Vehicles	most likely	most likely	most likely	most likely	most likely
Power to heat	most likely	most likely	most likely	most likely	most likely
Compressed air energy storage	most likely	most likely	not likely	not likely	not likely
Pumped Hydro	most likely	not likely	not likely	not likely	not likely
Batteries	most likely	most likely	most likely	most likely	most likely
Power to gas	most likely	most likely	not likely	not likely	not likely

not likely to be an owner of this flexibility option	(hatched)
most likely to be an owner of this flexibility option	(blue)

Experience shows that certain flexibility options do not reach a scale from which the transmission grid operator can directly benefit. This is why an additional market role, called flexibility aggregator, emerged during the last decade. Aggregators are new entities in the electricity market that act as mediators / brokers between users and utility operators. Aggregators have the technical possibilities to perform Demand Response and are responsible for the installation of the communication and control devices (i.e. smart meters) at end-user premises (Gkatzikis, 2013). Aggregation offers the opportunity to exploit the flexibility potential of smaller customers and thus allows them better market access.

All listed technologies compete with each other; however, they need each other to successfully tackle the challenge of integrating renewable energies in the energy market. In order to assess the potential of each technology to contribute, the following Figure 2 provides a first insight.

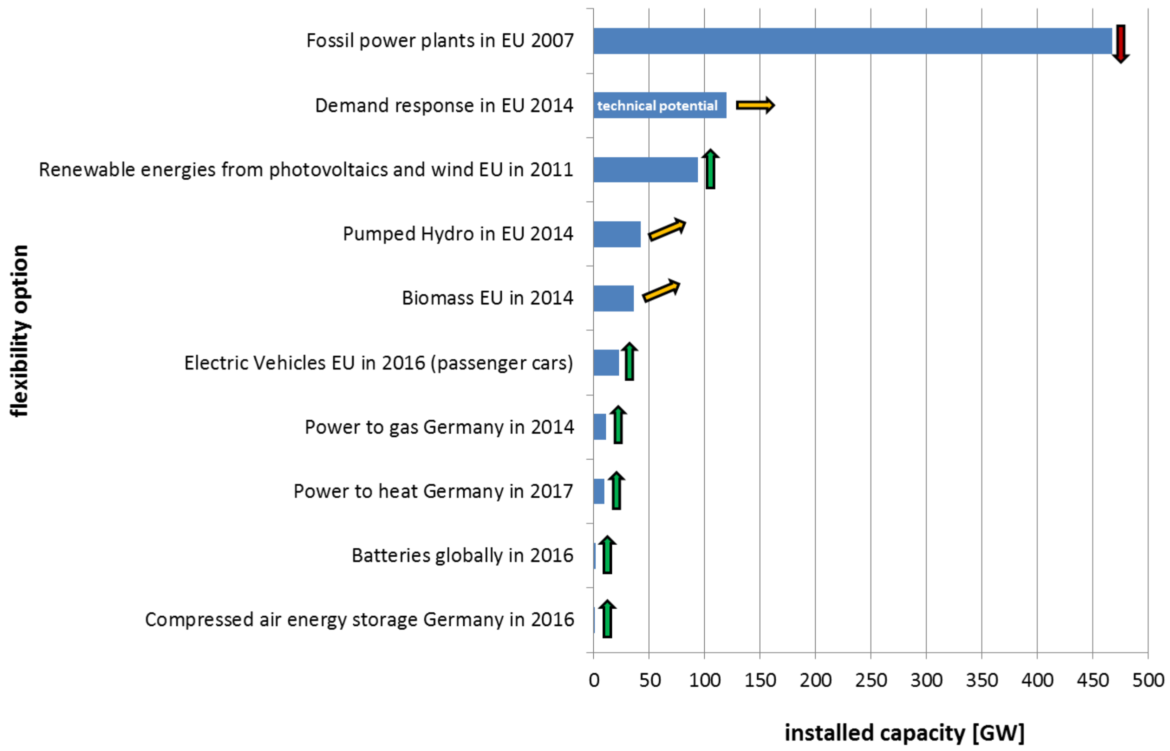

Figure 2 Potential of flexibility options

Source: Own figure based on (vdma Power Systems, 2010; Ecofys, 2014; Wissenschaftlicher Dienst des Bundestages, 2017; IWR online, 2016; Paschotta, 2017; Ludwig Bölkow Systemtechnik, 2014; european automobile manufactures association, 2017)

Figure 2 shows an overview of the capacity that each technology already provides or, in the case of demand response, will potentially be able to provide on the energy market. The arrows indicate whether the capacity of the flexibility option is likely to decrease or to increase. It is obvious that fossil power plants are currently responsible for the highest amount of flexibilities (vdma Power Systems, 2010). In order to avoid curtailment of renewable energies such as wind and photovoltaic, the indicated demand response potential needs to be exploited (Ecofys, 2014). In addition, there are high flexibility potentials in many technology options, which are not yet fully exploited, such as compressed air energy storage (Wissenschaftlicher Dienst des Bundestages, 2017), batteries (IWR online, 2016), power to heat (Paschotta, 2017), power to gas (Ludwig Bölkow Systemtechnik, 2014) and electric vehicles (european automobile manufactures association, 2017). Batteries, for instance, are expected to increase its global capacity from 1,5 gigawatts in 2016 to 14 gigawatts in 2020. Electric vehicles currently have a EU market share of motorised vehicles of only 1,2 % and thus there is enormous growth potential. Biomass and pumped hydro capacity are expected to increase slightly but not to the same extent as most of the other technologies.

2.2 Flexibility as a tradeable product

Flexibility is in GOFLEX seen as a product separate from energy consumption and provision and can also be traded separately on separate markets.

In the context of the GOFLEX automatic trading technology the following generalized techno-economical definition of flexibility can be given:

Energy flexibility is adaptation (increase or decrease) of energy consumption or production in given time interval that can be generated in a given response time when the incurred costs for generating the adaptation is lower than the benefit it brings. The adaptation is rep-resented by average power x time interval.

This definition of flexibility derives from the property of virtual energy reservoirs in processes, which are extracted by modifying the process dynamics; this adaptation can be essentially cost-free or it may incur costs in production or comfort: the amount of adaptation available depends on the income that can be obtained by the offering party. Price for flexibility is defined (calculated) by the offering party, so that no explicit negotiation phase is needed. The response time (assignment time, start before, start after) defines the time interval between the time when the flexibility has been contracted (assigned) and the time when it will be executed.

Energy is paid per kWh independent of the time when it is used with the time frame of an agreed supply contract (and with restricted peak loads).

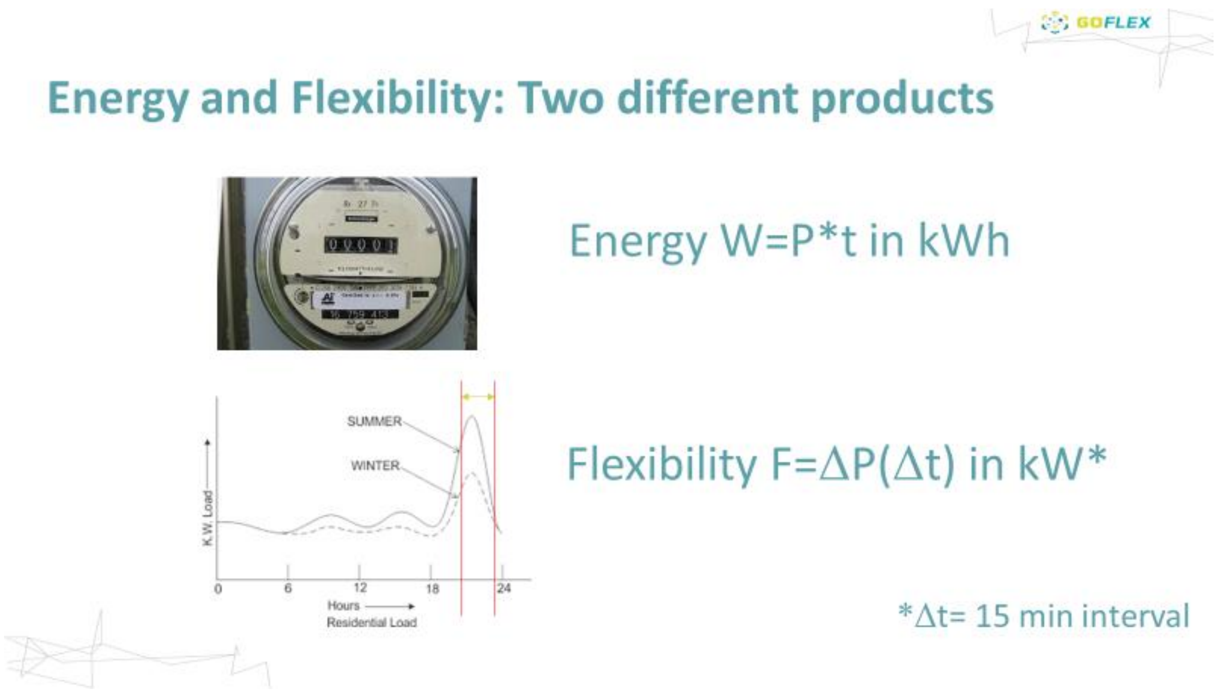

Figure 3 Flexibility as separate product

Flexibility is paid per average kW in defined (trading) time interval at a certain time. There is positive reserve power (increasing power supply or reducing power demand) or negative reserve power (decreasing power supply or increasing power demand)

On reserve market today, The average kW and the energy used/produced or not used/produced are generally remunerated separately.

Reserve market today also gives a clear indication how flexibility bids ("Flex-Offers") could look like also on local flexibility markets (Tennet definition of bids www.tennet.org) :
"The volume calculation is based on:

- *The size of the bid in MW (for a given time interval)*
- *The direction (+/ -) of the bid:*
    - *to adjust upward (+): the supplier wants to produce more, or consume less*
    - *to adjust downward (-): the supplier wants to produce less (or consume more)*
        - *nature of the bid*
- *Reserve capacity:*
    - *dispatched according to demand*
    - *volume calculated on the basis of the dispatch time offered*
- *Regulating capacity:*
    - *continuously controlled through national load frequency control*
    - *volume determined on the basis of a control signal*

TenneT TSO activates bids for each direction according to the demand and in bid price order."

2.3 The utilisation of flexibility in a cellular energy system

GOFLEX supports a new concept of the energy system which is based on two major influences:

1. the "cellular approach" as it was described by the E-Energy project "moma (Modellstadt Mannheim)" and
2. the energy system consisting of "vertically nested fractal-parental energy sub-systems" based on the Harmonized Model as it was described in the FP7 Mirabel project.

Apart from the discriminations in terms and definitions both approaches describe an energy system which is built bottom-up (for convenience reasons we will use the term "cellular"), which can be described as follows:

GOFLEX enables trading of energy flexibility between parties connected to the grid. This trading occurs through processes carried out by roles. In GOFLEX, these roles and processes are based on the Harmonized Electricity Market model in Europe.

ENTSO (2015) identifies 37 distinct roles in the Harmonized Model including roles such as "Producer", "System Operator", and "Market Operator". Traditionally, these roles act at the highest levels of an energy system that delivers power through physical grids cascading from high to medium to low voltage. Energy produced at centralized facilities enters the system at high voltage. A market operator receives and settles bids to produce or consume energy. The system operator imposes some constraints to ensure stability of the system.

The energy system is undergoing a transformation wherein meaningful energy production is occurring at lower levels of the grid. This transformation presents an opportunity for other roles of the harmonized model to act at lower levels of the grid. The introduction of roles such as "producer" and "market operator" at the lower, indeed, the lowest levels of the grid means that each level may possess most of the functions present other levels. Each portion of a system that contains a minimal set of roles may be called a cell. In the future energy system, such cells may very well sit within other cells in a manner similar to nesting dolls.

This cellular approach to arranging the energy system is well suited to incorporating distributed sources of renewable energy. A group of actors capable of meeting their own energy needs can make good trading partners.

The cellular system is built bottom-up:

The smallest cells (subsystems) are commercial and residential buildings, houses and industry plants (e.g. performing as microgrids). The next level of cells are the distribution grids and the third levels of cells are the transmission grids.

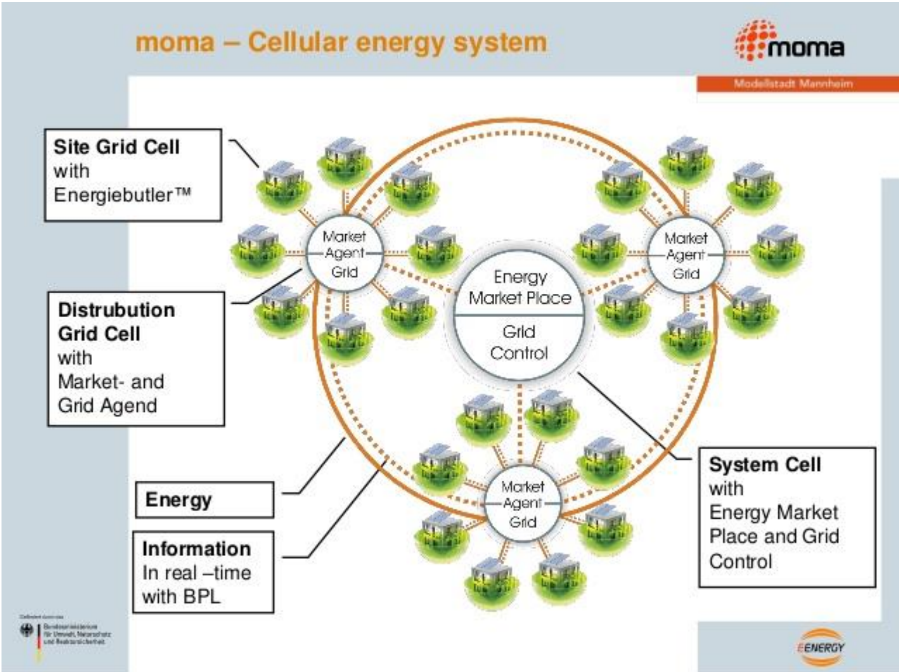

Figure 4 Cellular energy systems according to the moma project (E-Energy 2013)

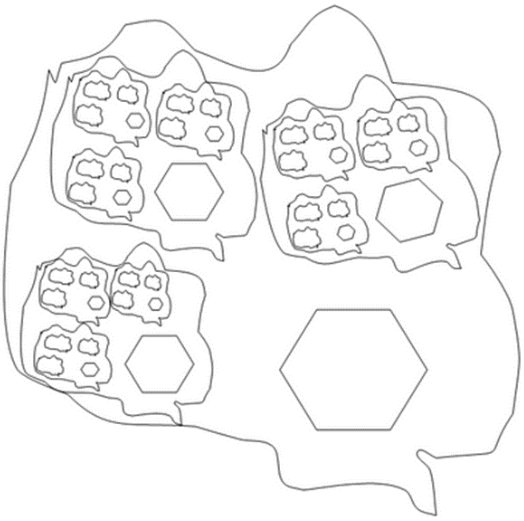

Figure 5: Schematic representation of vertical and horizontal decomposition of electrical grid system into nested subsystems (Mirabel 2013)

Each cell aims to generate enough (renewable) energy to be self-sufficient and to balance generation and consumption. As of today, the transmission grid operator is responsible to monitor the system but not the lower levels, on which GOFLEX focuses on.

In the cellular system all cells provide services to the neighbouring cells and to the cells on the next levels.

One special ability of the cells in a cellular system is the controlled islanding mode (again on all levels). In energy systems with a high penetration of volatile renewables and digital infrastructure which is vulnerable to attacks this ability makes the energy system more resilient. To perform this mode, enough flexibility in the cell must be available.

All in all, there are a lot of potential benefits which the cellular approach could provide:

- Renewable generation and distributed storage mainly is connected to the distribution grid or becomes an integral component of buildings (consumers become prosumers), so the cellular approach supports much better the integration of renewables then the top-down energy system of today which organises the transmission of big power plants.
- The cellular approach encourages and supports many participants in the energy system to get active. Less central generation is required and less transmission assets.
- The system creates added value through energy generation in the area where the energy is used.
- The system is more resilient due to the ability to perform islanding mode.

However, there are challenges to make this system work.

The first main challenge in this model is to build enough generation capacity based on renewables per cell and the second main challenge is to balance the volatile generation with the consumption which needs to be flexible.

The smaller the cell, the more emphasis is on the flexibility of the consumption to attain energy balance. Flexibility becomes the decisive enabler of the cellular approach. A distribution grid which is committed to develop such a system needs to facilitate local generation and local flexibility (e.g. by supporting the creation of flexible consumers and prosumers)

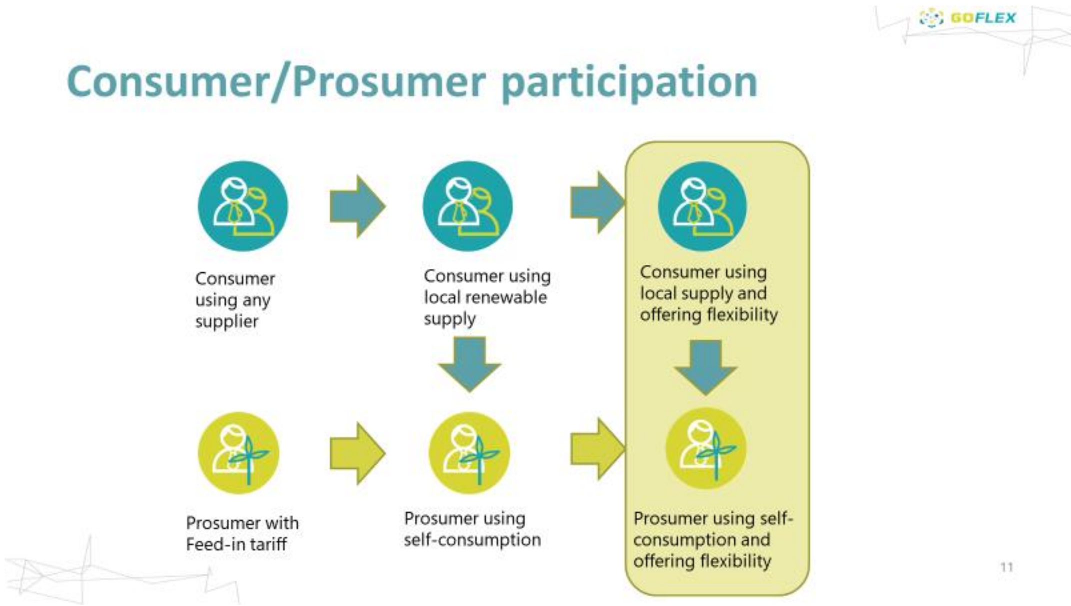

Figure 6 Consumers and Prosumers become active participants of the energy system

GOFLEX aims to provide the necessary tools, the appropriate business models and the necessary strategies to involve consumers and prosumers to make this happen and will be explained in chapter 5.1

3 Regulation on flexibilities in the EU energy market

The success of the business models of the GOFLEX trials and depending on that the success of the GOLFEX solution very much depend on the regulatory framework, since the energy system is a highly regulated system.

For a better understanding of the relevant aspects which influence the facilitation of flexibility utilisation the illustration in Figure 7 is used.

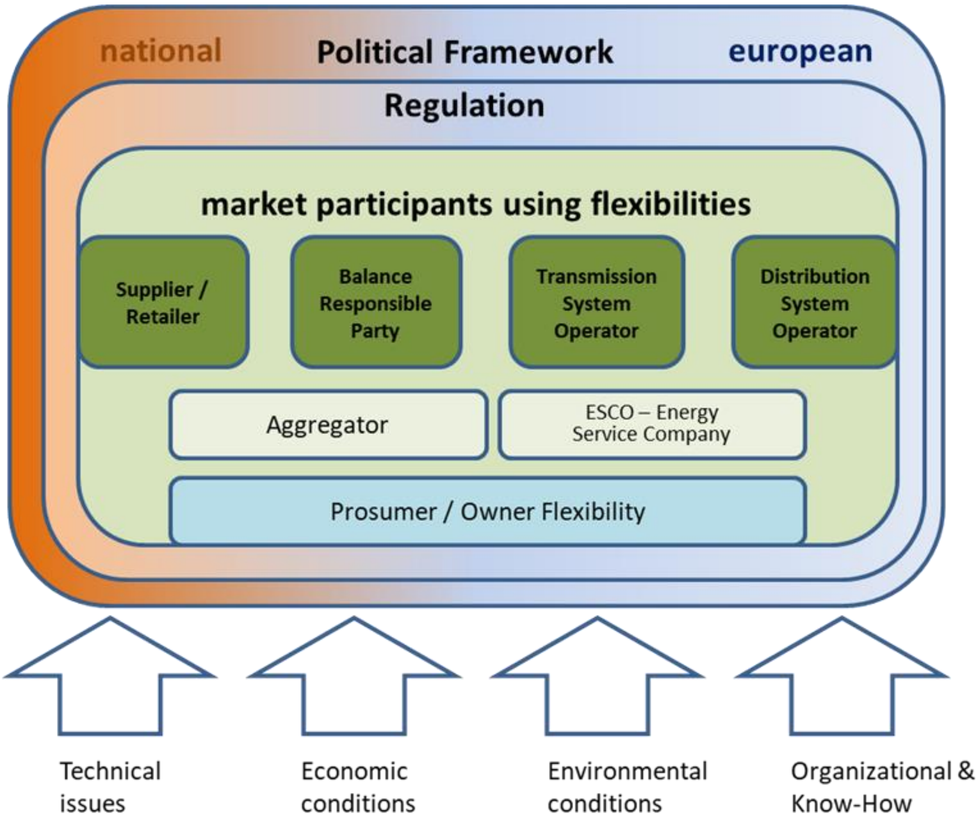

Figure 7: structuring external factor and political frameworks on the markets for flexibility

External factor (shown as the arrows on the bottom) are megatrends, which affect the whole energy system and do not change in a short period of time.

Examples:

If technical developments in a certain area (e.g. battery storage) make great progress for example, costs can drop significantly. This would be a good opportunity fostering the use of flexibility as the costs for implementation would go down.

If economic conditions change e.g. the price for imported fuels will rise, it will have a direct impact on the prices for electricity coming from fossil fuelled power plants and supports the installation of local renewable generation plants, which has an impact on the grid and puts the role DSO under pressure.

The climate change caused by CO_2 emissions is another external factor which could make the politics act on it, e.g. by allocating the costs caused by climate change to the polluters, which would also have a huge impact on the existing energy system, like the massive expansion of renewables on all grid levels with the known impact on the grid.

This chapter focuses on the relationship between regulation and policy, the current market design and the description of the interaction of roles being potentially involved with flexibility trading.

The aim of the GOFLEX community is to improve the regulation to implement local energy systems and local flexibility trading easier. This chapter provides a first overview about the critical aspects.

3.1 Political Framework

The political framework sets the directions and the laws which are manifested in the regulation. It is important to understand, that there is a European perspective and the national one resulting in different regulation and market rules in most of the Member States.

The energy market and it´s submarkets constitute of the market players as it is generally described in the harmonized role model (ENTSO-E, 2015). Although some roles – in the first place the one of the aggregators - are not finally defined yet, they are important when analysing the opportunities and restriction in the market.

The political framework can be further divided into different categories on how politicians aim to achieve their goals and affect the energy market especially regarding the use of flexibility. Many studies focus on on Demand Side Management (DSM) only and have to be expanded to meet the broader definition of flexibility to include storage devices and virtual power plants offering flexibility from different sorts of generation.

Nevertheless, the DSM study approach can be applied to the GOFLEX situation.

"Existing DSM policies can be classified into: 'Policy Type', 'Policy Category', and 'Specific Policy', with each level becoming more detailed (Warren, 2014)." To understand the different approaches, some examples at the 'Specific Policy' level are given in brackets:

Market-based policies are:

- Incentive payment-based demand response (e.g. interruptible/curtailment programmes)
- Price-based demand response (e.g. time-of-use pricing, critical peak pricing tariffs)
- Market transformations (e.g. removal of market barriers, market stimulation programmes)

Regulatory:

- Infrastructure rollouts (e.g. smart meter rollouts, energy display monitor rollouts)
- Utility obligations (e.g. energy efficiency resource standards, white certificate schemes)

- Labelling (e.g. appliance energy efficiency labelling, building labelling)
- Performance standards (e.g. equipment energy efficiency standards, building codes)

Fiscal:

- Loans and subsidies (e.g. tax incentives, grants, low-interest loans)
- Utility business models (e.g. decoupling policies, integrated resource planning)
- Research and development programmes (e.g. funding for deployment programmes)

Information-based:

- Information campaigns (e.g. energy audits, training programmes, education campaigns)

Voluntary:

- Voluntary programmes (e.g. industrial voluntary agreements, large commercial agreements)

It is difficult to judge which type of policy serves best to achieve the goals. Evaluation on energy policies has been done by a few scientists and most of the times with a specific national focus. One who evaluated policies in a more general way is Peter Warren who analysed DSM policies and focused on the failure factor. He pointed out "that across policies and countries/states, **lack of monitoring** (inadequate – comprehensive- evaluation during and after the policy period to monitor policy performance) **and technical issues** (programme management issues, technological performance problems, and a lack of required technical skills) **are the two most important failure factors**."

In his research he also concluded for the effective creation of rules, that "individual DSM policies appear to perform better than DSM policy packages" (Peter Warren, 2015), which means that policy should concentrate on individual measure to meet concrete challenges rather than creating complex solution packages whose impact cannot be tracked.

3.2 Market design

3.2.1 Status Quo

The EU internal energy market is built on established principles, such as the right of access for third parties to electricity grids, free choice of suppliers for consumers, robust unbundling rules, the removal of barriers to cross-border trade, market supervision by independent energy regulators, and the EU-wide cooperation of regulators and grid operators within the Agency for the Cooperation of Energy Regulators (ACER) and the European Network of Transmission System Operators (ENTSO).

But, the existing market concept dates from an era in which large-scale, centralized power plants, largely fuelled by fossil fuels, had the key aim of supplying every home and business in a limited area with as much electricity as it wanted, and in which consumers — households, businesses, and industry — were perceived as passive. But, "today, the number of players involved is increasing and existing market roles are changing. The electricity market needs to adapt to this new reality (…)." (USEF, 2016).

A key role comes to the use of flexibility to compensate the variability rising as more renewable energy resources participate in the system. There are a lot of studies showing deficits for the use of flexibility (SEDC, 2015; EASME, 2017; dena, 2016). Depending on their perspective and the interest group behind those studies, different barriers for the use of flexibility are being stressed.

Flexibility in most terms refers to demand side management and often focusses on rather large generation or loads as they are found in the industry sector. But they all come to a similar conclusion: adjustments to regulation are required for improved use of flexibility - at least in most Member States.

For example, only in five Member States (MS) the aggregation of flexible volumes is allowed. Market development is not only hampered by the fact that the identification of flexible loads and the assessment of the exact potentials remain difficult and require high efforts and costs due to the necessary audit process." (Delnooz et al, 2012) There are further barriers regarding regulations to achieve the desired development as well.

"Due to the lack of an appropriate regulatory framework in the larger part of Europe, the business model of aggregators is not yet mature. Some experts representing the demand side and research pointed out that generation overcapacities in some national electricity markets presently block the 'sense of urgency' for integration of flexibility in the market. Business models for demand-side participation are especially complex, since access to a large number of household devices is needed before the residential DR business model becomes interesting." (EASME, 2016. p.16)

SEDC research shows that six European countries already provide a regulatory framework allowing for the development of Demand Response services: Ireland, Great Britain, Belgium, France, Switzerland and Finland. (SEDC, 2016) Although there are remaining regulatory issues Explicit (incentive-based) Demand Response is a commercially viable product offering. Among this group, France and Switzerland stand out due to fact that they have restructured the roles and responsibilities of market participants specifically in order to enable independent aggregation.

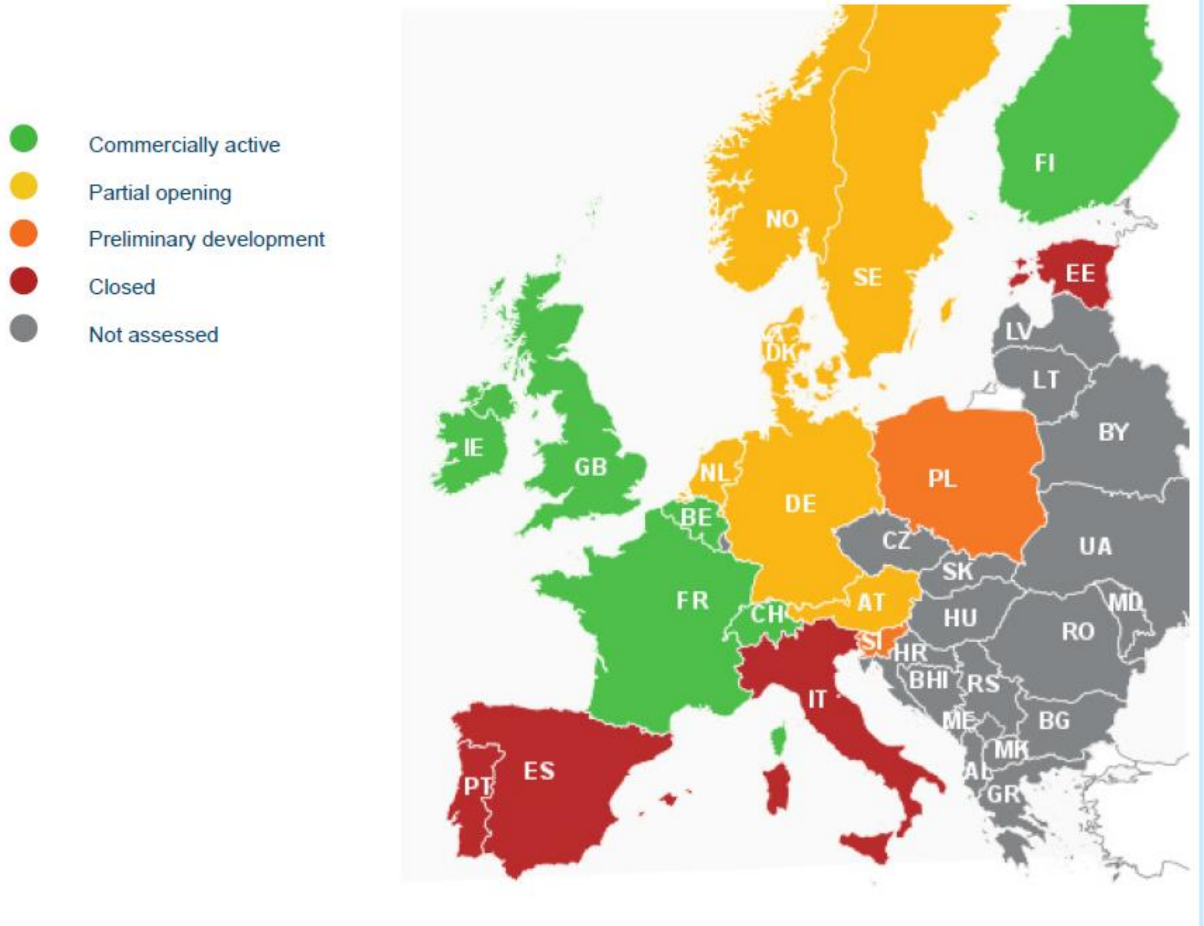

Figure 8 SECC: Map of Explicit Demand Response development in Europe today (2017)

The SEDC report concludes (SEDC, 2015):

"Overall main regulatory barriers found repeatedly across Member States include

- *Demand Response may not be accepted as a resource in wholesale, balancing, or capacity markets when it is being aggregated, which is in direct contradiction to the Energy Efficiency Directive, Article 15.8.*
- *Inadequate and/or non-standardised baselines lead to uncertainty about measuring the flexibilities accurately.*
- *Technology biased programme requirements: Consumers may be blocked by historical programme participation requirements.*
- *Aggregation services are not fully enabled: Prequalification, registration and measurement may still be conducted at the individual consumer level rather than on the pooled load collected by the aggregator,*

blocking participation by placing heavy administrative and legal burdens on the individual consumer.

- *Lack of standardised processes between the BRP (Balance Responsible Party) and Aggregator: without these processes in place, consumers cannot freely choose their service provider, and market competition around consumer services is severely hampered.*"

To proof that there is an overarching understanding to this problem, the position from the "regulators" ACER and CEER is mentioned as well: "European Energy Regulators recognise the benefits of introducing independent aggregation and propose that Member States enable independent aggregation, unless a national implementation assessment suggests an alternative that better serves system efficiency and can be implemented effectively. Such an assessment might be supported by an analysis of the state of competition in MSs' retail markets. This reflects a focus on the facilitation of aggregation (the activity), rather than aggregator type (the agent)." (CEER, 2017)

3.2.1.1 Regulation on energy storage

A particular aspect that is gaining importance is the use of storage devices in the energy system. In the EASME project experts were interviewed on the future of smart grid and a central aspect was storage. "It is generally claimed that the regulatory framework has not yet evolved to support cost-efficient deployment of energy storage. The interviewed experts stated that it is not possible to regulate storage without having a definition of what storage is or the role it plays within the energy system. For instance, the lack of a definition of energy storage at EU level leads to uncertainty about how energy storage devices should be treated under current regulations (EASE/EERA, 2016 and EUROBAT, 2016). A specific European Storage Framework is envisaged (ENTSO-E, 2016) to clarify the role of storage in the different Smart Grid layers (equipment, communication, information, functions/services and business scenarios). The proposals in the Winter Package clearly aim at creating an open and competitive market for storage, although the concrete support mechanisms are yet to be determined." (EASME, 2017)

3.2.2 The vision of the Clean Energy Package

According to the proposals included in the Clean Energy Package (EC, 2016), consumers should be able to freely choose and change suppliers or aggregators and to engage in demand response, self-generation and self-consumption of electricity, so every consumer is entitled to request a smart meter equipped with a minimum set of functionalities.

The Clean Energy Package (EC, 2016) defines a 'demand response' as the change of electricity load by final customers from their normal or current consumption patterns in response to market signals, including time-variable electricity prices or incentive payments, or in response to acceptance of the final customer's bid, alone or through aggregation, to sell demand reduction or increase at a price in organized markets as defined in Commission Implementing Regulation (EU) No 1348/2014

The present electricity market design initiative thus aims to adapt the current market rules to new market realities, by allowing electricity to move freely to where it is most needed when it is most needed via undistorted price signals, whilst empowering consumers, reaping maximum benefits for society from cross-border competition and providing the right signals and incentives to drive the necessary investments to decarbonize our energy system.

3.3 Market participants

The existing market participants have been described in the harmonized role model. This Role Model has been developed in order to facilitate the dialogue between the market participants from different countries through the designation of a single name for each role and domain that are prevalent within the electricity market. It is an ongoing process because new roles evolving and they need to be integrated and the latest version (ENTSO-E, 2015) should be used.

In the following those roles relevant to the defined use cases are listed and supplemented by new roles such as the aggregator. To each role the potential use of flexibility is mentioned based on a functional perspective – not on existing business models.

3.3.1 Transmission System Operator (TSO)

Definition in the Harmonized role model, called *System Operator*: "A party that is responsible for a stable power system operation (including the organization of physical balance) through a transmission grid in a geographical area. The System Operator will also determine and be responsible for cross border capacity and exchanges. If necessary he may reduce allocated capacity to ensure operational stability".

Transmission system operators (TSOs) must ensure that sufficient network transmission capacity is available for energy to flow freely between its producers and its end users, while maintaining system balance. The TSO safeguards the system's long-term ability to meet electricity transmission demands. The TSO is responsible for keeping the system in balance by deploying regulating capacity, reserve capacity, and incidental emergency capacity.

3.3.1.1 **Ancillary services**

Ancillary services according to the ACER's Framework Guidelines on Electricity System Operation (ACER, 2011) mean services necessary to support transmission of electric power between generation and load, maintaining a satisfactory level of operational security and with a satisfactory quality of supply.

The main elements of ancillary services include active power reserves and reactive power reserves for balancing power and voltage control.

Directive 2009/72/EC defines ancillary service as 'a service necessary for the operation of a transmission or distribution system.'

The EU Network Code on System Operation in Article 55(c) lists ancillary services among services provided by third parties, through procurement when applicable, that each Transmission System Operator (TSO) uses for ensuring the operational security of its control area. Typical ancillary services procured by TSOs to ensure the management of the system divide into:

- frequency ancillary services (balancing of the system), and

- non-frequency ancillary services (voltage control and black-start capability).

Legislative Proposal for a Directive of the European Parliament and of the Council on the internal market for electricity (recast) on common rules for the internal market in electricity (recast) of 30.11.2016 (COM(2016) 864 final 2016/0380 (COD)) in Article 2(37) adds to the existing legal definition from the Directive 2009/72/EC the following words: 'including balancing and non-frequency ancillary services but not congestion management.'

The Proposal for the Directive of 30 November 2016 also provides for the rule forbidding transmission system operators to own assets that provide ancillary services save under the conditions set out in Article 54. ENTSO-E replies, that today TSOs own or operate facilities which de facto provide ancillary services, either as main purpose or as a by-product of their operations (ENTSO-E, 2017)

3.3.1.2 **Balancing capacity**

Balancing Capacity is a type of Balancing Services where the reserve capacity is contracted (see, in particular, Frequency Containment Reserve, Frequency Restoration Reserve, Replacement Reserve).

The so-called 'Winter Package' defined Balancing Capacity as a volume of capacity that a Balancing Service Provider (BSP) has agreed to hold to and in respect to which the BSP has agreed to submit bids for a corresponding volume of Balancing Energy to the Transmission System Operator (TSO) for the duration of the contract [1].

The ACER's Report of November 2015 observes in a majority of EU Member States the largest share of balancing costs is made up by the procurement costs of Balancing Capacity. These are not charged directly to Balance Responsible Parties (BRPs) through Imbalance Prices, but are normally socialised, typically through the network tariffs.

Primary control

TSOs have a long history using flexibility, but most of the times it is provided by large-scale generation units. Traditionally, only rotating equipment has supplied primary control, but several types of Prosumer loads can supply this service as well. So there are no technical restrictions. In the context of GOFLEX the perspective changes whether the aggregation of different (smaller) units offering flexibility is possible and to which conditions.

Primary control or frequency containment reserves (FCR) are the first line of defense against frequency deviations in the grid. Primary reserves respond within seconds. They aim to maintain the grid frequency at 50 Hz (in Europe). Legal definition of the 'Frequency Containment Reserves' is contained in Article 3(2)(6) of the EU Network Code on System Operation where the FCR denotes "the active power reserves available to contain system frequency after the occurrence of an imbalance".

Provisions regulating Frequency Containment Reserve are stipulated in the Network Code on System Operation: Articles 153 Dimensioning – Articles 154 FCR technical minimum requirements – Articles 155 FCR prequalification process – Articles 156 FCR provision.

The Austrian, Switzerland, Dutch, Belgian, and German TSOs currently procure their FCR in a common market[2]. Extension towards France has been realized in mid January 2017 and extension towards Denmark is currently foreseen. The cooperation is organized with a TSO-TSO-model[3], where the FCR is procured through a common merit order list where all TSOs pool the

[1] (Article 2(2)(l) of the Proposal for a Regulation of the European Parliament and of the Council on the internal market for electricity (recast), 30.11.2016, COM(2016) 861 final 2016/0379 (COD))

[2] In Belgium and the Netherlands, a part of FCR balancing capacity is currently procured through a national tender. In Denmark, a part of FCR balancing capacity is procured through a long term contract with Norway.

[3] Currently there are two role models related to cross-border procurement of Balancing Capacity and Balancing Energy: TSO-BSP Model and a TSO-TSO Model. Also see " Guideline on Electricity Balancing"

https://ec.europa.eu/energy/en/topics/wholesale-market/electricity-network-codes offers they received. The interaction with Balancing Service Providers[4] (BSPs) and the contracts between the TSOs and BSPs are handled on a national basis.

Changes in the market design are an ongoing process and actual reports[5] reflect the new requirements for example are leading to new auction frequencies, product duration, bid designs and TSO-BSP settlements and further more.

Secondary control

Secondary control or frequency restoration reserves are used to relieve the primary control from its duty and allow it to return to a normal operational state. Secondary control aims to reduce imbalance within one imbalance settlement period. Secondary control is generally supplied to the TSO based on public bidding (on the imbalance market) and dispatched based on a merit order. Depending on national regulations, aggregated loads can also bid in to provide secondary control. This category includes operating reserves with an activation time typically up to 15 minutes (depending on the specific requirements of the synchronous area).

Provisions regulating Frequency Containment Reserve are stipulated in Articles 157 - 159 of the Network Code on System Operation.

Operating reserves of this category are typically activated centrally and can be activated automatically or manually. In application of parameters of Balancing Capacity Standard Products the different categories of Balancing Capacity will have at least central common characteristics like minimum or maximum delivery periods or on pricing mechanisms.

Tertiary control / replacement reserve

Tertiary control resembles secondary control, but it responds more slowly and can be sustained for a longer time period: it includes operating reserves with activation time from 15 minutes (in Continental Europe) up to hours. It relieves the secondary control from its duty. As with secondary control, aggregated loads can also supply this service, based on national regulations.

Provisions regulating Frequency Replacement Reserve are stipulated in Articles 160 - 162 of the Network Code on System Operation.

[4] Balancing Service Provider (BSP) in the European Union Internal Electricty Market is a market participant providing Balancing Services to its Connecting TSO, or in case of the TSO-BSP Model, to its Contracting TSO.

[5] https://www.entsoe.eu/Documents/Consultations/20170601_FCR_Consultation_Report.pdf

3.3.1.3 Capacity market

National capacity markets (including strategic reserves) aim to increase the security of supply by organizing sufficient long-term peak and non-peak capacity. Typically, an increase in solar and wind generation requires greater supporting capacity to compensate for daily and seasonal fluctuations and during prolonged periods of solar and wind absence.

Depending on national regulations, load flexibility can be aggregated and supplied to capacity markets. Although some national capacity markets and strategic reserves are already active in the EU, it is not yet clear how many capacity markets will be created in the long term and whether the TSO will manage this market.

In July 2015, the BMWi published a White Paper[6] announcing the decision that Germany will not introduce a capacity market, but instead will further develop the energy-only market and complement it with a capacity reserve for the transition period ahead. This capacity reserve is open for generation only, with no access for the demand side, and initially will encompass 2.7 GW of lignite coal power plants. The legislative process with final design proposals is scheduled for autumn/winter 2015.

A capacity market for Switzerland alone is not being considered, as it would bring high administrative costs, inadequate liquidity and insufficient competition between individual power generators. Alternatively Switzerland will continue to work more closely with its neighbours.

3.3.1.4 Potential flexibility services7 for the TSO

Congestion management and grid capacity management in the transmission grid are basically the same as congestion management and grid capacity management in the distribution grid, though the size of the congestion and the applicable regulations will differ. Aggregated load flexibility is a feasible service for both. With the GOFLEX solution the focus is on the DSO level and no service requirement result from the use cases to develop a product for the TSO Level.

Controlled Islanding in the transmission grid is essentially the same as in the distribution grid, though the size of the region that operates in island mode and the applicable regulations will differ. Again GOFLEX will focus on the DSO situation.

Redundancy (n-1) support refers to the supply of emergency power and black-start capability. Depending on national regulations, these services are contracted out or provided by the TSO itself. Emergency power in particular is a viable market for (aggregated) load shedding.

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[6] http://www.bmwi.de/DE/Mediathek/publikationen,did=718200.html

[7] quoting in major parts the USEF Framework explained

3.3.2 Balance Responsible Party (BRP)

The so-called 'Winter Energy Package' defines a 'Balance Responsible Party' (BRP) as a market participant or its chosen representative responsible for its imbalances in the electricity market (EC, 2016)

The role of BRPs in a liberalised European Union electricity market is comprehensively described in the ENTSO-E Supporting Document for the Network Code on Electricity Balancing of 23 December 2013.

Given that the market players have an implicit responsibility to balance the electricity system, the BRPs are financially responsible for keeping their own position (sum of their injections, withdrawals and trades) balanced over a given timeframe (the Imbalance Settlement Period). The remaining short and long energy positions in real-time are described as the BRPs' negative and positive imbalances respectively. Depending on the state of the system, an imbalance charge is imposed per Imbalance Settlement Period on the BRPs that are not in balance.

This defines the imbalance settlement, which is a core element of balancing markets. It typically aims at recovering the costs of balancing the system and may include incentives for the market to reduce imbalances – e.g. with references to the wholesale market design – while transferring the financial risk of imbalances to BRPs.

3.3.2.1 **Interaction of the BRP with the TSO**

ENTSOE - Role of Balance Responsible Parties

"In order to be balanced or help the system to be balanced according to the provision defined by the terms and conditions of each TSO, each Balance Responsible Party (BRP) shall be entitled to change its Position in the Intraday timeframe until the Intraday Cross Zonal Gate Closure Time basing on rules and criteria defined by its Connecting TSO. In this case each BRP is obliged to respect specific rules and criteria as defined in terms and conditions of each TSO. Any modification of the Position declared by the BRP shall be submitted to the Connecting TSO if specified in accordance with the terms and conditions by each TSO. TSOs shall not be obliged to accept a change of Position by a BRP after the Intraday Cross Zonal Gate Closure Time.

Some market designs rely on BRPs Positions being frozen prior to delivery; others allow for notifying intra-zonal trades after delivery which may help intermittent generation and Demand Side Response to participate in short time (bilateral) markets. TSOs that do not allow for ex-post notification are not obliged to do so and can continue current practice and those

TSOs that do allow for ex-post notification are also allowed to continue current practice, even if it is not an obligation.

A BRP is financially responsible for the residual imbalances of its perimeter (portfolio) after the process explained above concerning the modification of Position.

TSOs are entitled to require BRPs to have a balanced Position after the day ahead process and this requirement would be included in the terms and conditions related to Balancing. This possibility is particular important for TSOs interacting with BRPs that only trade (i.e. have no portfolio of physical injections or withdrawals and hence no Allocated Volume). For those BRP's a balanced Position means that in their commercial trade schedules sales equal purchase. Without this requirement there would be volumes of energy unaccounted for in the system at this stage." (ENTSO-E, 2013)

3.3.2.2 Potential use of flexibility

The Balance Responsible Party (BRP) naturally aims to avoid imbalance charges. Flexibility whether in terms of demand-side flexibility from Prosumers within the BRP's client base or from flexible generations can be used to optimize its portfolio. The time availability of the flexibility is of particular importance since an optimization can take place both before the delivery date, exactly at the time of the delivery, but also under certain conditions after the delivery date.

Self-balancing is the reduction of imbalance by the BRP within its portfolio to avoid imbalance charges.

From a TSO's point of view, further value can be created through **passive balancing**. In passive balancing, the TSO remunerates a BRP that support the reduction of the system imbalance by deviating the balance position of its own portfolio in the right direction. If this contributes to reducing the total imbalance, the BRP may receive remuneration for its passive contribution, depending on market design

The BRP does not actively bid on the imbalance market using its load flexibility, but uses it within its own portfolio. There are risks involved in this strategy, related to the predictability of the total imbalance. Generally, an online signal for the total imbalance is required, provided by the TSO or other means.

Production responsible party (is part of BRP):

Generation optimization refers to optimizing the behaviour of central production units as they prepare for their next hourly planned production volume. Because the control speed of conventional power units is limited, they start ramping up or ramping down minutes before the hour. To avoid imbalance, some overshoot or undershoot in output is necessary, which may reduce these units' lifetime and increase their fuel consumption. This over- or undershoot can be avoided by using demand-side flexibility. The trade-off between the cost of flexibility and increased generator cost determines the feasibility of this service.

3.3.3 Distribution System Operator – Distribution network operator

Distribution System Operators (DSOs) in the European Union Internal Electricity Market are responsible for providing and operating low, medium and high voltage networks for regional distribution of electricity as well as for supply of lower-level distribution systems and directly connected customers (EC, 2009)

According to Article 2(6) of the Directive 2009/72/EC, 'Distribution System Operator' is 'a natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity.'

This definition is left unchanged by the so-called 'Winter Energy Package' proposed by the European Commission in December 2016.

Besides the regional distribution and supply task it is also the DSOs' responsibility to ensure the security of their networks with a high level of reliability and quality.

3.3.3.1 Closed Distribution System Operators

A sub-set of the DSOs' generic category are Closed Distribution System Operators (CDSOs). Closed Distribution Network means a network classified as Closed Distribution Network pursuant to Article 28(1) of Directive 2009/72/EC at national level. Article 28 of Directive 2009/72/EC defines such a network as a system which distributes electricity within a geographically confined, industrial, commercial or shared services site and does not (without prejudice to a small number of households located within the area served by the system and with employment or similar associations with the owner of the system) supply households customers.

The Closed Distribution Network will either have its operations or the production process of the users of the system integrated for specific or technical reasons or distribute electricity primarily to the owner or operator of the Closed Distribution Network or their related undertakings.

Winter Energy Package adds paragraph 5 to Article 28 of the Directive 2009/72/EC (renumbered Article 38 of the Proposal for a Directive of the European Parliament and of the Council on the internal market for electricity (recast) on common rules for the internal market in electricity (recast), 30.11.2016, COM(2016) 864 final 2016/0380 (COD)) with the following wording:

"Closed distribution systems shall be considered as distribution systems for the purpose of the Directive".

3.3.3.2 Potential flexibility services

Cost for balancing capacity are not charged directly to Balance Responsible Parties (BRPs) through Imbalance Prices, but are normally socialised, typically through the network tariffs.

Distribution System Operator uses flexibility for local grid management - Congestion management and voltage control. The costs belong to their operational costs and are typically transferred to the network tariffs as well. Business opportunities evolve when existing cost can be avoided – in Operations but also in Investments for grid enforcements.

USEF identifies the following services an aggregator of flexibility might propose to the DSO:

Congestion management refers to avoiding the thermal overload of system components by reducing peak loads. In contrast with grid capacity management, this is a situation where failure due to overloading may occur. It is a short-term problem (with respect to the duration of a grid reinforcement project) for the DSO that requires a relatively swift response. The conventional solution is grid reinforcement (e.g., cables, transformers). The alternative (load flexibility) may defer or even avoid the necessity of grid investments.

Voltage problems typically occur when solar PV systems generate significant amounts of electricity. This will “push up” the voltage level in the grid. Using load flexibility by increasing the load or decreasing generation is an option to avoid exceeding the voltage limits. This mechanism can reduce the need for grid investments (such as automatic tap changers) or prevent generation curtailment.

Grid capacity management aims to use load flexibility primarily to optimize operational performance and asset dispatch by reducing peak loads, extending component lifetimes, distributing loads evenly, and so forth. An added benefit may be the reduction of grid losses.

Controlled islanding aims to prevent supply interruption in a given grid section when a fault occurs in a section of the grid feeding into it.

Redundancy (n-1) support refers to actions that help reduce the frequency and duration of outages. An example is supplying emergency power (or shedding loads) in the event of a severe power shortage, or supplying backup power during grid maintenance activities.

Another potential usage of flexibility for a DSO is the support of **power quality**. Power quality issues are rapid phenomena that occur in the sub-minute to millisecond range (e.g., harmonics, flicker, dips). Power quality support requires fast devices and local control loops. Some equipment on Prosumer premises (especially inverter-based equipment) might be technically capable of improving the grid's local power quality.

3.3.4 Supplier (Trade Responsible Party)

Suppliers buy energy in the wholesale market and sell it on to customers. Suppliers work in a competitive market and customers can choose any supplier to provide them with gas and electricity.

Definition in the Harmonised role model: Trade Responsible Party: A party who can be brought to rights, legally and financially, for any imbalance between energy nominated and consumed for all associated Accounting Points.

3.3.4.1 Potential use of flexibility

Suppliers will need to optimize their generation assets. This means they can use flexibility to reduce peak loads based on the end user's demand profile and hence prevent the dispatch of less efficient generation units. They can reduce their active and passive balancing costs by continuously optimizing their client portfolios and hence the complete set of all generation assets, including their customers' demand-response assets.

Suppliers can use their customers' flexibility to adapt their consumption profiles to the availability of renewable energy sources such as the wind and sun. This prevents the load curtailment of these generation units, significantly improving the business case for wind and solar power.

Day-ahead portfolio optimization aims to shift loads from a high-price time interval to a low-price time interval on a day-ahead basis or longer. It enables the BRP to reduce its overall electricity purchase costs.

Intraday portfolio optimization closely resembles day-ahead optimization, but the time frame is constrained after closing of the day-ahead market. Depending on national regulations, the electricity program can be changed one to a few hours before the actual time period it refers to. This enables intraday trading and load flexibility can be used to create value on this market, equivalent to the day-ahead and long-term markets.

3.3.5 Consumer / prosumer

Definition in the Harmonised role model: Party connected to the grid: a party that contracts for the right to consume or produce electricity at an “Accounting Point”. Certain types of party are a Consumer or a Producer.

For users who both produce and consume, the term prosumer has become established in the language usage.

Generally speaking the number of prosumers is rising and they are a supplier for flexibility as well as a target group to service providers – such as aggregators – using flexibility. The existing market structures allows only larger prosumers to directly participate in the energy market, which is why the aggregation of flexibility is an enabler to give market access to them.

3.3.5.1 Potential flexibility services offered by an aggregator to prosumers

Time-of-use (ToU) optimization is based on load shifting from high-price intervals to low-price intervals or even complete load shedding during periods with high prices. This optimization requires that tariff schedules are known in advance (e.g., day-ahead) and will lower the Prosumer’s energy bill.

Control of the maximum load is based on reducing the maximum load (peak shaving) that the Prosumer consumes within a predefined duration (e.g., month, year), either through load shifting or shedding. Current tariff schemes, especially for C&I customers, often include a tariff component that is based on the Prosumer’s maximum load (kWmax). By reducing this maximum load, the Prosumer can save on tariff costs. For the DSO, this kWmax component is a rudimentary form of demand-side management.

Self-balancing is typical for Prosumers who also generate electricity (for example, through solar PV or CHP systems). Value is created through the difference in the prices of buying, generating, and selling electricity (including taxation if applicable). Note that solar PV self-balancing is not meaningful where national regulations allow for administrative balancing of net load and net generation.

3.3.6 Aggregator

Aggregator is a new market role that can be taken by existing market parties and new entrants. Aggregators accumulate the flexibility they obtain from the (demand-response) resources owned by a set of industrial, commercial, and residential end users. This pool of flexibility is then turned into products to serve the needs of the various stakeholders.

According to Article 2(14) of the Proposal for a Directive of the European Parliament and of the Council on the internal market for electricity (recast) on common rules for the internal market in electricity (recast), 30.11.2016, COM(2016) 864 final 2016/0380 (COD), being part of the European Commission's Winter Energy Package, ‘aggregator’ means "a market participant that combines multiple customer loads or generated electricity for sale, for purchase or auction in any organised energy market".

In turn, Article 2(15) of the said Proposal for a Directive of 30 November 2016 defines an 'independent aggregator' as "an aggregator that is not affiliated to a supplier or any other market participant".

The following aspects help to characterize the role:

- Number of units: A pool can consist of only a few power generation units, movable loads or storage units, or can link several thousand units together.
- Unit performance: The overall performance of the units assembled in the pool is of great importance for the energy system.
- Number of different plant types: Pooling can take place in the form of swarms, that is, that a large number of similar plants are combined into one pool. At the same time, however, a pool can also be set up in a diversified manner, for example, by linking different production facilities (eg solar, wind, biogas) to different consumption systems and storage types.
- Spatial dissemination of the units: Pooling solutions can, in principle, occur either locally or regionally as well as with a wider range at national or European level.

Although the role of an aggregator is described in a comprehensible manner and there are regulations which require involvement in the energy system by the actors involved, the desired result does not appear in each country (see chapter Status Quo).

3.3.7 Conflicts between market roles

Whenever changes are occurring, established roles have to be adapted and the resulting resistances occur. The market participants have business processes relying on the established regulation and some changes might threaten their business. For this reason, interpretation spaces in regulation are interpreted in their own favour and sometimes need more clarification.

The aforementioned Proposal for a Directive of 30 November 2016 literally expresses the rule that transmission system operators and distribution system operators when procuring ancillary services, must treat demand response providers, including independent aggregators, in a non-discriminatory manner, on the basis of their technical capabilities (Article 17).

It is further developed in Article 40 of the said Proposal (Article 40(3) and (4)), which envisions that in performing the tasks of procuring ancillary services from market participants the transmission system operator must:

1. take into account the functions performed by the regional operational centres and cooperate as necessary with neighbouring transmission system operators, and

2. ensure that the procurement of balancing services and, unless justified by a cost-benefit analysis, non-frequency ancillary services, is

(a) transparent, non-discriminatory and market-based;

(b) ensures effective participation of all market participants including renewable energy sources, demand response, energy storage facilities and aggregators, in particular by requiring regulatory authorities or transmission system operators in close cooperation with all market participants, to define technical modalities for participation in these markets on the basis of the technical requirements of these markets and the capabilities of all market participants.

However, role conflicts cannot be reduced only to the ancillary services for the TSO - to which the above-mentioned rules refer - but also to the cooperation of the different actors in the energy system. Much of this is concentrated in the role of the aggregator and how it interacts with the BRP and the customers.

3.3.7.1 Design of the role of the aggregator

The following chapter is based on the USEF ideas of developing an independent aggregator role, which can serve different market roles. (De Heer et al.,2016), representing USEF, propose the definition of an Aggregator Implementation Model (AIM), which describes the relation of the aggregator with the supplier and BRP and how balance responsibility, transfer of energy and information exchange are organized. This kind of model could help to eliminate some concerns about aggregation.

There are three leading criteria to classify the existing variations of interaction between the roles:

a) Aggregator needs to assign its own BRP - There is a clear distinction between single-BRP and dual-BRP models. In general, a dual-BRP model complicates the allocation process: synthetic profiles are needed on connection level to separate the two perimeters. However a single-BRP model restricts the aggregator in the type of flex-products and markets he can develop/access.

b) Aggregator needs a contract with the supplier's BRP - Models that are based on a contractual relationship require less regulation, as most (if not all) aspects can be arranged bilaterally. However, if all allowed models require a contract with the BRP of the supplier this may affect the level playing field for Aggregators.

c) Energy transfer method - Dual-BRP models are further classified on the energy transfer method, defining if, and how energy volumes are transferred between the BRP of the aggregator and the BRP of the supplier. Possible methods are: Prosumer, Central, Bilateral, Central/socialized and None.

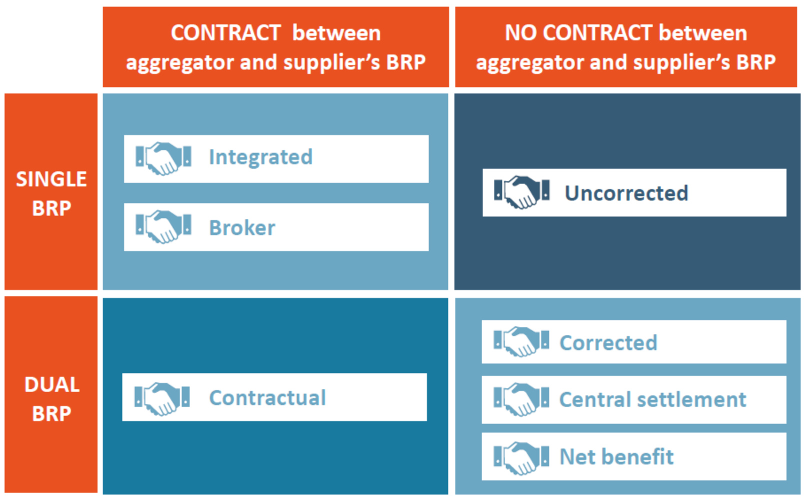

Figure 9 USEF Classification of different models for the role of the aggregator

This leads to seven different implementation models that are partly active in the EU energy market.

Integrated model

In the integrated model the roles of supplier and aggregator are combined in one market party. Compensation for imbalances and the open supply position are not necessary.

Broker model

In the broker model, the aggregator transfers the balance responsibility to the BRP of the supplier. Compensation for the open supply position and the caused imbalance is settled bilaterally based on contractual arrangements.

Contractual model

In the contractual model, the aggregator associates with his own BRP. Balancing parameters are corrected through a hub-deal (ex-post) between Aggregators BRP and the BRP of the supplier, transfer prices are based on contractual arrangements.

Uncorrected model

In the uncorrected model, no perimeter correction is performed and no volume transfers occur between the BRPs of the Aggregator und the Supplier. The activated volume is settled through the regular balancing mechanism.

Corrected model

In the corrected model, the Prosumer's meter readings are modified, based on the amount of flexibility that has been activated by the aggregator. The transfer of energy takes place through the Prosumer, based on retail prices. The aggregator associates with his own BRP.

Central settlement model

In the central settlement model, the aggregator associates with his own BRP. A central entity (e.g. TSO) corrects the balancing perimeters following a Demand Response (DR) activation. Compensation for the open supply position is also settled by this central entity, based on a pre-defined price formula.

Net benefit model

The net benefit model is similar to the central settlement model, yet the cost of neutralizing the Suppliers BRP not born by the aggregator but socialized. Socialization may be limited to situations where DR brings energy savings.

3.4 Conclusion for GOFLEX

The discussion about the development of the future market framework and the new market role and the change of existing market roles is very relevant for the success of the GOFLEX trial use cases and the GOFLEX solution, especially all discussions around the enabling of flexibility.

The key question is, which of the described market actors will take on the systematic roles of GOFLEX? Chapter 5 will further elaborate on this question.

And which regulatory changes need this new role to fully deploy its business models?

The strategy to influence the legal and regulatory process will be done by the GOFLEX community:

The GOFLEX community will promote concrete measures in one of the addressed fields (market-based policy, regulatory policy etc.) rather than promoting complex systematic changes.

The upcoming deliverable D10.4 "Best Practice Results on Business and Pricing Models (trials + community), Implementation Guidelines and Recommendations for Regulators and Policy Makers" will provide a list of concrete changes to be implemented in all national regulations.

Are there any conclusions regarding on which market to start?

According to SEDC the most promising countries regarding market and regulatory framework for Demand Side Management and Flexibility Management in Europe are Great Britain, Ireland, Belgium, France, Finland and Switzerland (SEDC, 2017).

According to the structure of the energy system, the most decentralised structures in Europe have Switzerland, Germany and Austria.

Since Switzerland is top in both categories, it is the most promising country in Europe regarding the GOFLEX approach.

4 Regulatory impacts on GOFLEX trial use cases

This chapter describes which regulatory hurdles for implementation exist from the perspective of the GOFLEX trial use cases. This chapter is focused on the use cases that will be implemented by all trial sites.

4.1 Ancillary services to the TSO

4.1.1 Use Case description

Players - roles, processes and relations (based on Harmonized model)

The active roles and trading relations between them are depicted in red.

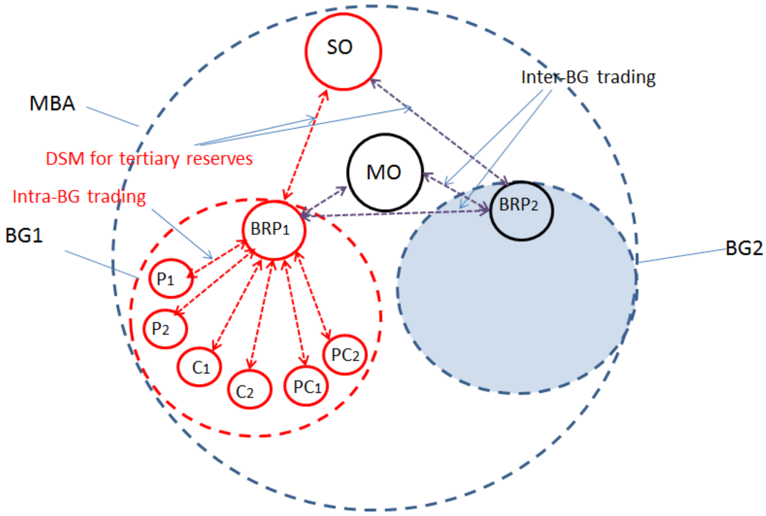

Figure 10: Schematic representation of Use Case 1

The use case involves offering energy flexibilities for tertiary reserves as ancillary services for TSO: It stems from basic Harmonized market model. This UC does not focus on distribution grid, but it can be interesting as interim UC for DSO & BRP coupling, as it can be immediately operational.

<u>Targeted project characteristics:</u>

Project is carried out in the aggregate of companies of one Balance group, several DSO distribution companies and several (city) communities, and is not tied up to a geographical location. For pilot demonstration case, the project should consist of at least 10 large industrial prosumers within one BG, offering tertiary reserve of at least 5 MW. TSO participates as project partner with the purpose of collaboration in defining the system ancillary services for tertiary reserve of TSO.

<u>Business Cases:</u>

Business Case 1: The basic business case is provision of energy flexibility (positive and negative) vs peaker station (with 10-15 min start up time to full operation).

Business Case 2: Additional potential business case is provision of energy flexibility vs dedicated measures for secondary reserves (1-10 min start up time

<u>Involved active roles:</u>

- **TSO**
- **BRP (in the role of an aggregator)**
- Prosumers

The driving role for business models is BRP (in the role of an aggregator); the user of energy flexibility is TSO.

The trading process: is manual (individual long term closed contract between TSO and BRP).

4.1.2 Regulation: General considerations

From the perspective of regulation, two main areas need to be looked upon. One is referring to the requirements to participate in the balancing capacity market in the category tertiary reserve. They are harmonized to a certain extend and provisions are stipulated in Articles 160 - 162 of the Network Code on System Operation. ENTSO-E uses the terminology Frequency Replacement Reserve - (manual) FRR. Nevertheless, there are large differences for implementing the use cases at the trial sites.

The other aspect regards the regulation on building a Virtual Power Plant System (VPS). The leading question is, under what conditions the party connected to the grid (Prosumer, Consumer, Generation) can participate in the virtual power plant. If one assumes that the VPS consists of aggregated flexibility, the question can also be formulated as to how the role of the aggregator is defined. Is it an independent aggregator or associated with the BRP supplying the customer?

4.1.3 Germany

The national legal framework deals with questions on the topic complex of balancing energy, not only in the specialized electricity network access regulation (StromNZV), but also directly in the Energy Industry Act (EnWG). In addition to general principles for the system responsibility of the transmission system operators, specific requirements for the market-based procurement and provision of compensation services, in particular regulating energy, are also defined. This regulation, emphasized in relation to other system services, emphasizes the importance of power-frequency regulation. On this basis, the electricity NZV complies with more detailed provisions for the procurement, provision and allocation of this system service. The Renewable Energy Sources Act (EEG) also regulates the participation of power generation plants based on renewable energies in control energy markets.

4.1.3.1 Programme requirements for tertiary reserves:

Programme requirements act as a barrier for the development of Demand Response in Germany (SEDC, 2015)

Tertiary reserve in Germany is called Minute reserves. They are tendered on a daily basis for positive and negative regulation in 6 four-hour time windows for the following day. The minimum bid size is 5 MW and the notification time is 15 minutes. The activation runs automatically by the Merit Order List Server and flexibilities are triggered up to several times per day. Tertiary reserve programme provides availability and utilisation payments. Bids are accepted following the merit order list of availability prices. During activation, the merit order list of utilisation prices applies. All payments are issued pay-as-bid.

4.1.3.2 **Conditions** in conjunction with participation

Bid size - the minimum bid size has been downsized in 2011 and 2012 to 5MW with significant effect on the broader range of offers now available and prices decreasing. Still it remains a hurdle to integrate small flexibilities especially in combination with the pre-qualification process.

Tariffs - Consumers participating in Minute Reserve risk potential increases in grid tariffs for deviations from their normal (flat) energy consumption profile, which constitutes a significant financial disincentive for offering their flexibility in this market.

Regarding renewable energy sources, in Germany the majority installations is based on Feed-in-Tariffs – EEG, which guaranties a certain government-set feed-in tariff for 20 years, dependant on the technology and size of project.

Installations, which were put into operation from January 1, 2016 on, must directly market their electricity when the installed power is larger than 100 kW (§21 EEG 2017, previously §37 EEG 2014). In addition, the remote controllability of the systems is mandatory. A switch to flexible production is often not financially attractive. But, there is the possibility to switch back to the usual remuneration model monthly, while maintaining the right to the previous fixed feed-in tariff.

Pre-Qualification - Several pre-qualification tests are required at an individual asset level: a significant barrier to consumer participation as each small consumer site is treated as if they were a 500 MW generation unit. This is significantly limiting participation, as many loads/assets that would provide valuable contributions to a pool through their specific capabilities, cannot pass the pre-qualification stage on their own.

Pre-qualification also has to be done with each of the 4 German TSOs separately (depending on the location of the units), increasing the cost and time required.

Required activation period

Reserve power requires the ability to be activated for duration of 4 hours for Minute Reserves and 12 hours for Secondary Reserves (up to 60 hours over the weekend) whereas the service is normally only required for much shorter periods.

4.1.3.3 **Role of the aggregator**

Third-party aggregation is currently very difficult in Germany, due to regulatory barriers that require independent service providers (e.g. aggregators) to ask the bilateral permission of multiple parties – including the consumer's BRP, a potential competitor – prior to offering a consumer's flexibility into the market. In total, an aggregator operating in Germany has to negotiate and sign five different contracts:

• Consumer (agreement on participation)

• TSO (prequalification (PQ), supply of reserve energy)

• DSO (agreement, report of non-availability, confirmation for PQ)

• Consumer's BRP (agreement on schedule exchange, BRP-approval for PQ)

• Consumer's supplier (agreement on payments)

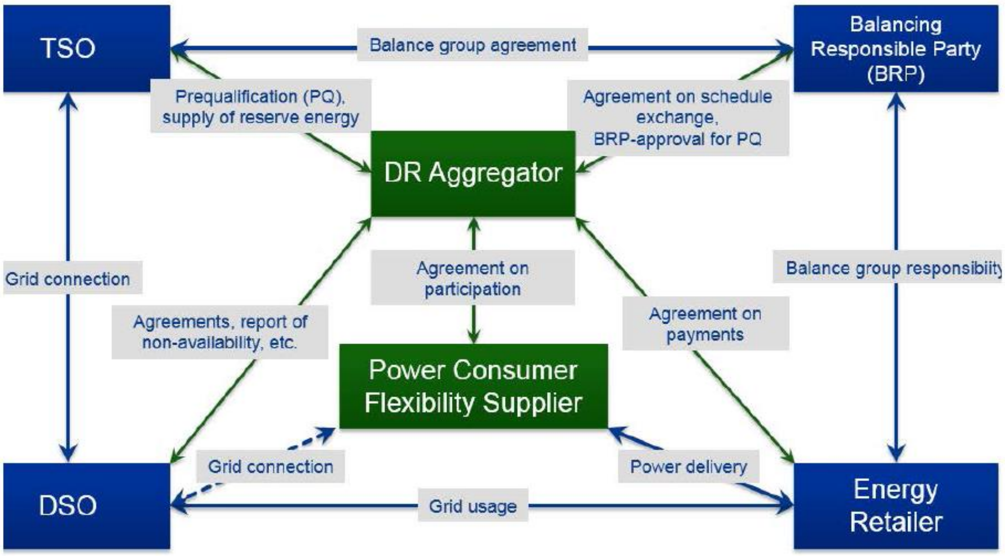

Figure 11 EnerNOC on contracts needed in the DR market in Germany

A particular difficulty is the requirement to reach a bilateral agreement on schedule exchange and compensation payments with the consumer's BRP and supplier. There are no standards for this, and the BRP and supplier often have no interest in working with the aggregator to reach such an agreement. The reason for this is that BRPs/suppliers usually see the aggregator as competitor: someone who is approaching their customer to offer services the BRP/supplier may not yet be able to offer. The aggregator's dependency on the approval of a potential competitor is the single largest barrier for competition between service providers in Germany.

One way to escape from these difficulties is for the service provider (aggregator) to work for and within a supplier. In this case the aggregator is pooling loads in one supplier's balancing group. This constellation is named contractual model when using the definition USEF suggest for the different implementation models. In the contractual model, the aggregator associates with his own BRP. Balancing parameters are corrected through a hub-deal (ex-post) between BRPagr and BRPsup and transfer prices are based on contractual arrangements.

This will be the case for implementing the GOFLEX solution in the trail side at SWW.

4.1.3.4 **Imbalance settlement after load curtailment**

In case of a third-party aggregator participating in the tertiary reserve market, the process for load curtailment is handled as follows:

1. The aggregator sends information to the BRP, on the basis of the bilateral agreement.
2. The balancing group settlement is processed through a “day-after” schedule exchange.
3. The aggregator sells the curtailed energy to the TSO (as positive balancing energy).

The consumer’s BRP sells the same amount of energy to the aggregator in order to correct both its own and the aggregator’s balancing perimeter.

The aggregator must pay the BRP/supplier for the energy curtailed during a Demand Response event, on the basis of their commercial agreement. There is no standard or regulatory oversight of such agreements, so the supplier and BRP set the prices.

4.1.3.5 **BRP-aggregator adjustment mechanism**

Retail and Demand Response aggregation activities are bundled by the market model. There are no standardised mechanisms with aspects like baseline methodologies, clearing and correction, compensation of rebound effects, transparent but still confidential information exchange. The adjustment addressing the open energy position faced by the Supplier/BRP when flexibility is used by a third-party aggregator is not clear.

4.1.3.6 **Outlook**

According to SEDC report an unofficial baseline definition is agreed bilaterally between the aggregator and all 4 TSOs, although this information does not appear to be public and is not equally available to all Demand Response providers.

The definition should become a standard across Germany and be published in a transparent manner. This will require further effort on the part of the regulatory bodies, in particular the BNetzA. Currently not only is the baseline not standardised between the BRP and Demand Response provider but also among the different BRPs or between them and the TSO. This results in costly duplication of data exchange operations, which could be simplified or even centralised by the TSO, as it is the case in Switzerland.

Interest groups published in December 2016 a Guideline (BNetzA, 2016) addressing the problems when 3rd party aggregators participate in the balancing market and suggest solutions to the following issues: prequalification, standardizing exchange on change information and data, Quantification and balance sheet correction, data formats, handling ramps, plausibility checks by the TSO, clearing and correction. But, by the time of this desktop research the suggested solutions were not official regulation yet.

4.1.4 Switzerland

Swissgrid is responsible for the secure, reliable operation of the Swiss transmission system and for connections to the transmission systems of foreign operators. To this end swissgrid coordinates operation of the systems with neighbouring transmission system operators and supervises the Swiss control area, for which purpose swissgrid needs ancillary services. System services in the electricity supply area are defined as services essential for the functioning of the system. Such services are delivered by grid operators to customers in addition to the transmission and distribution of electricity and hence determine the quality of the electricity supply.

In accordance with Article 22 of the Electricity Supply Ordinance, from 1 January 2009 Swissgrid is required to purchase system services in accordance with a transparent, non-discriminatory and market-based procedure. It does this in accordance with the technical specifications of the European Network of Transmission System Operators for Electricity ENTSO-E (UCTE1).

The details of ancillary service provision are being drawn up by swissgrid. The contract scenario envisages signing a framework agreement with service providers following a technical and operational appraisal (prequalification) of providers and their power stations. On this basis, providers are then eligible to bid for the ancillary service in question.

As a result of the regulatory developments which took place in 2013, Demand Response and aggregation have access to most of Swiss ancillary services: including Primary, Secondary and Tertiary Control Power (positive and negative). Main regulatory barriers have been removed and aggregators can bid into these programmes.

The national network is instructed to use electricity from renewable energy as a priority for the collection of control energy.

4.1.4.1 Programme requirements

Monthly tenders that existed at the start have been replaced by weekly and daily tenders. This increased liquidity by enabling power plants that were unavailable for several days a month due to maintenance to also make bids. At the same time, bidders' risks were reduced and entry for smaller bidders simplified

Tertiary control can be tendered for asymmetrically, with minimum bids of 5MW and a total volume of 100MW. There are either 6 blocks of 4 hours opened every day or weekly tenders (00:00 Monday – 24:00 Sunday). The blocks of tenders and the asymmetrical bidding requirement both support the participation of consumers through providing the required flexibility in timing and up or down bids.

4.1.4.2 Conditions in conjunction with participation

In the balancing markets, the aggregator (in the Swiss-Documents called Balancing Service Provider, BSP) does not have any contracts with the Balance Responsible Parties of the areas where it operates**.** The BSP contracts directly with Swissgrid (the Swiss TSO) to access the market**.** BSP can aggregate load from anywhere in the country. Neither the BRP nor the BSP are charged for the imbalance caused by the load curtailment. Swissgrid corrects each BRP's balance group the day after the operation, taking into account all the operations that took place in its respective area.

If the BSP fails to deliver the agreed curtailment, the penalty corresponds to the imbalance price of electricity. If the BSP has not reserved the power as planned in the bid and is directly responsible for it, the penalty is 10 times the price established in the bid.

Bid size

The minimum size for tenders has been reduced, allowing the operators of smaller generating units to also participate in the market. The minimum bid size for tertiary reserve is 5MW, but there is no minimum size and no technical requirements for a single unit. Virtual generation units appear as single feed-in/out node for the TSO.

Tariffs

The regulatory authority Swiss Federal Electricity Commission (EICom) serves as a price monitor and checks the tariffs billed by the Swissgrid. It shall in particular decide on disputes regarding network access and monitor network usage tariffs and electricity tariffs.

Since 2009, consumers with a consumption of more than 100,000 kWh / year have been free to choose their electricity suppliers. You can negotiate the electricity price on an individual basis with the electricity supplier. Consumers can, however, also decide not to go into the free market and to purchase the electricity at regulated prices from the local network operator. They remain just like the consumers with a consumption of less than 100 000 kWh / year so-called "firm customers".

For "fixed customers", the energy tariff is based on the production costs and long-term contracts of the distribution grid operator (see Art. 4 StromVV). Whether or not the current market prices are reflected in the energy prices for fixed customers thus strongly depends on the procurement strategy of the electricity supplier.

The customers pay a working tariff (cents/kWh) and a power tariff (CHF/MW). In many cases there are categories with the predefined maximum power consumption in the different voltage levels. A rise in the total maximum need for power might lead to sorting the company in another category which would also increase their energy bill.

Producers whose installations are fed electricity based on Article 7 or 7a EnG and who sell the physically supplied electricity or a part there of to the national grid as a control power will not receive any additional compensation for this electricity pursuant (Der Schweizerische Bundesrat, 2008).

Pre-qualification[8]

The consumer/prosumer (or VPP) unit has to fulfil requirements as an aggregate. This simplifies the prequalification requirements, as it allows the aggregator to stand in the place of the consumer.

The application for prequalification is submitted to the Swissgrid, the documents will be examined and possibly tests carried out. After successful prequalification, the relevant framework contract is concluded. The prequalification and the signing of the framework contract are necessary to be accepted for tendering by SDL.

Within the documents the provider must indicate the nature of the EZE (Erzeugungseinheit – energy source) for each EZE participating in the Tertiary Scheme published by Swissgrid. The following two declarations are possible: Conventional EZE or Virtual EZE. If the EZE is of a virtual nature, the provider provides a list of all sub-installations.

For each EZE, which is to participate in the tertiary control, the provider must name the point of entry (network nodes). For virtual EZEs that requirement is waived, provided that evidence indicates the necessary information on the feed location is not obtainable.

Tertiary energy retrieval is carried out by means of the Swissgrid call signal. The supplier must be technically able to receive, evaluate and assign the EZEs to the required tertiary control performance.

The aggregator monitors and regulates its pool at its own costs (including installation and maintenance) and provides the monitoring data to Swissgrid. The prequalification process is usually completed within 2-3 months.

Required activation period

The dynamic requirement for the provision of tertiary control performance is different for positive and negative tertiary control performance. The detailed foundations can be found in the document "Basic Systems Service Products" (published at www.swissgrid.ch). The provider must state the necessary lead time for a tertiary call.

4.1.4.3 **Role of the aggregator**

Following the USEF definition of the integration models, in Switzerland there is the central settlement model established. In this model, the aggregator associates with his own BRP. A central entity (the TSO) corrects the balancing perimeters following a Demand Response (DR) activation. Compensation for the open supply position is also settled by this central entity, based on a pre-defined price formula.

4.1.4.4 **Imbalance settlement**

In the balancing market, Swissgrid corrects each BRP’s balance group the day after the operation, taking into account all the operations that took place in its respective area.

The schedule-based processing of tertiary control performance calls for a system service provider is based on the 15-minute schedule grid. The timetable will be postponed by Swissgrid on the working day after the call. The part of the call-off, which takes place within the commenced schedule quarter hour, is averaged by Swissgrid over the entire quarter hour, so that no balancing energy is incurred by the provider for this reason.

The baseline is defined as the measured value of the load before being influenced by the aggregator. Its measurement is then set at the pre-qualifications stage.

4.1.4.5 BRP-AGG adjustment mechanism

According to the framework agreement on aggregated loads, the added value, caused by the provision of balancing services, is handed to the aggregator. However, the aggregator is obliged to compensate the BRP for the difference in consumed energy with a payment that is determined by the quarter-hourly day-ahead spot price of the Swiss Electricity Index (SwissIX). This regulatory structure and clarity will be critical for the long-term stability and growth of Demand Response in Europe. However it should be noted that if the spot price is used for payment this will block Demand Response from participating in the spot market now and in future. The use of this price rather than a more complex but accurate sourcing price is questionable.

4.1.4.6 Outlook

To understand the ongoing development a look back to the fulfilled changes in the past is helpful.

The Swiss control area joined the first module of the German Grid Control Cooperation: The imbalance of all participating countries will be balanced out before control power is activated and shared out proportionately in order to reduce requests for control power and lower costs in Switzerland.

The price for balance energy from balance groups has been increased, resulting in balance groups delivering more accurate consumption and generation forecasts in order to avoid balance energy costs. This in turn has led to a reduction in control power provision, since deviations registered in the grid are no longer as high.

Swissgrid has developed a prognosis system to apply the tertiary control power efficiently and relieve the pressure on secondary control.

The switch from threshold pricing to bidding meant that every bidder is now paid the price that he bids. This contrasts with the beginning when the threshold price, i.e. the price of the last successful bid, was used as the remuneration basis for all bids. But this might change in the future due to standardisation at the European level following ENTSO-E's requirements, which are 'pay as cleared.

4.1.5 Cyprus

The "Trading and Settlement Rules" (Market Rules) were officially published and placed into force on 30 January 2009 (CEER, 2016). In general, the Trading and Settlement Rules enable the TSO to fulfil its obligations under the Law, regulate the means by which Participants may trade Energy, allow the calculation and settlement of payments in respect of Energy and specify the way in which settlement and billing shall be carried out. The Trading and Settlement Rules provide all necessary information concerning the operation of the electricity market in the country. The balancing arrangements are also described in these.

Currently the system applied in Cyprus is based on Bilateral Agreements between producers and their customers, who must nominate their productions to the TSO 24hrs ahead of their planned production. Their production must balance within ±10% of their customers' demand. The difference between total supply and total demand is settled through the balancing market. Gate closure is applied at midnight – as provided by Trading and Settlement Rules. Settlement of imbalances will be arranged on a monthly basis. It should be noted that the balancing interval is 30min. Participants acknowledge the following principles governing System Balance:

Energy Contracts are for delivery of total Energy over a Settlement Period. However, for particular minutes within a Settlement Period, the system may be long or short of Energy even when, in aggregate for the Settlement Period, the system is in balance. The TSO will need to contract to buy and sell Energy to achieve minute-by-minute Energy Balance within the Settlement Period.

In addition to achieving Energy Balance, the TSO will contract for other services to manage system constraints, voltage control and frequency control. However, the market is not yet operating in practise since there is only one Supplier/Power Producer, namely the EAC. The TSO purchases and pays for the ancillary services from EAC Generation and the TSO then bills and receives payment from EAC Supply for those services.

But the foundations have been laid, that third parties provide these ancillary services and participate in a market. It is required of the TSO and the Distribution System Operator during the fulfilment of the demands for the balancing of the market and for the ancillary services, to treat response suppliers of energy demand, objectively and based on their technical capabilities. To be able to act this way, TSO and the Distribution System Operator are defining in co-operation with all relevant parties and stakeholders technical modalities for participation in these markets. CERA ensures that the operators of high efficiency cogeneration can offer balancing services and other ancillary services at the level of TSO or the Distribution System Operator, where it is both technically and economically feasible within the high efficiency cogeneration installation.

Outlook

CERA published a study titled “The New Electricity Market Arrangements in Cyprus” concerning the detailed design of the Electricity Market in Cyprus and published the Regulatory Decision 01/2015. The Regulatory Decision proposes a design regarding the new electricity market arrangements in Cyprus based on the decision for implementing a Net-Pool Model as being the most appropriate trading arrangement approach for the Cyprus electricity market.

The proposed design allows bilateral, Over the Counter (OTC), contracting on a forward basis while at the day-ahead stage a central market is organised. CERA should regulate the minimum participation of the Dominant Participant in the Day Ahead Market (DAM) with a view to enforcing adequate liquidity. Specifically, under the proposed net pool design, bilateral physical forward contracts are notified and corresponding schedules are nominated to the Market Operator (MO) by OTC market gate closure on the day ahead. Suppliers and generators provide bid curves to a DAM on a half hourly basis. Orders in the DAM are unit based in the case of generators. Suppliers submit orders based on individually forecast demand. Orders in the DAM should correspond to quantities not already covered by bilateral contracts and take into account any Replacement Reserve of type 2 commitments. The DAM is centrally managed by a MO.

The MO runs a process of matching bid curves to optimise dispatch of residual volumes at the day ahead. Contracts resulting from the DAM are between market participants and the MO at the DAM clearing price. An Integrated Scheduling Process with a real time Balancing Mechanism and later a continuous intra-day trading platform will be organized to further support market operations.

Besides the ongoing (long term) development of the system towards a net-pool model with all the above-mentioned requirements regarding the use of flexibilities, there are concrete adjustments to the tariffs and their structure. In October 2016 a document called "Design and development of wholesale and retail electricity tariffs" was published as a tariff submission in accordance with CERA Regulatory Decision No 02/2015. In the suggested tariff structures, the end use supply tariff is composed of different parts under which the wholesale charges are dominant. The tariffs for ancillary services and system operation are straight cost pass-throughs and integral part of the wholesale charges. Tariff charge and structure: HV: €¢ 0.65/kWh MV: €¢ 0.66/kWh LV: €¢ 0.67/kWh To derive the unit charge, they have used the allowed revenue from ancillary services of the EAC Generation business, being the only provider of such services.

4.2 Microgrid Optimisation

4.2.1 Use Case description

Players - roles, processes and relations (based on Harmonized model)

The active roles and trading relations between them are depicted in red.

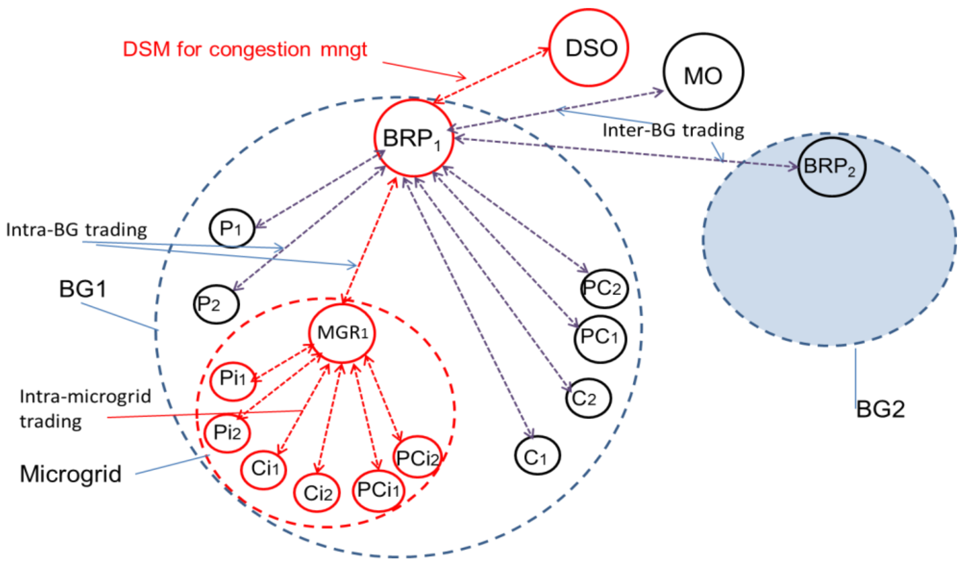

Figure 12: Schematic representation of Microgrid optimisation

The use case is one of the new GOFLEX use cases and implies further structuring of the Harmonized Electricity market model and cellular structuring of the electricity grid system.

Targeted project characteristics:

Projects are carried out on the aggregate of companies in one BG, and in several distribution companies and (city) communities and is not be tied to any geographical territory or location within selected BG. It will comprise variable consumers, prosumers and producers of Renewables, with RES systems, business and industrial prosumers, public and residential buildings and including a network system of electrical vehicle charging stations.

Business Cases:

Business Case 1: Energy flexibilities (positive and negative) vs open contracts supply & vs. System Operator penalties for not keeping the schedules. The driving role and the user of flexibilities is the Microgrid Responsible Party.

BC2.2 Additional business cases: energy flexibilities offered to the DSO (congestion management): vs. incremental investment into Distribution grid capacity. The driving role and the user of flexibilities in these cases is the DSO

Involved active roles:

- DSO
- BRP
- Micro-grid responsible party (MRP)
- Prosumers

The trading process in the local community microgrid (intra-microgrid) is 1:many the microgrid external trading is between Microgrid Responsible Party and Balance Responsible Party .

4.2.2 Regulation: General considerations

As it is described in Use Case 2, a virtual power system (VPS) based on DSM for optimising the operation of microgrid.

The understanding of a microgrid system at this point is a single party connected to the grid with a variety of assets which can be used to affect the energy consumption and production as well. Optimisation of the energy usage within the microgrid can follow different reasons. Typically it aims to reduce energy cost, to increase self-consumption when it is helpful or to serve the DSO to support grid management activities'.

Another term used in the context of microgrids is "Closed Distribution Networks. This means a network pursuant to Article 28(1) of Directive 2009/72/EC at national level. This article defines such a network as a system which distributes electricity within a geographically confined, industrial, commercial or shared services site and does not (without prejudice to a small number of households located within the area served by the system and with employment or similar associations with the owner of the system) supply households customers.

Core functions in the above mentioned use case are: different assets consuming and generating energy offer flexibility (as a single resource or aggregated) to the entity that manages the area with all connected facilities.

It must be differentiated between optimisation on the balance sheet level (normal case and the role of the microgrid manager is similar to the one of a BRP) and the system operator with responsibility to managing the grid quality in this area (when the role is similar to the one of a DSO).

Either way, there are no new roles, which need to be formed. From a regulatory perspective, the conditions under which these roles are executed are interesting.

4.2.3 Germany

The optimisation of energy consumption and generation using flexibility is an established business model in the industry or companies with high energy consumption. There are in-house solutions with energy management systems as well as companies specialized in this service. In addition to the classical strategy of energy saving, the possibility of energy shifts – using flexibilities - is also used. For energy cost optimization it is important to know the supply contracts. The included network fees are designed to incentivise a flat consumption pattern.

An increasingly popular optimization is the increase in **self-consumption**. This is very frequently in conjunction with the remuneration for renewable energies, which are funded under the EEG. Self-consumption of solar power means that the current generated by solar panels themselves used locally and is not fed into the public grid. Whereas the supply of self-generated solar power to the public grid has so far been the norm, self-consumption is gaining in importance given the falling feed-in tariff. The consumption can be increased by intelligent electricity consumption, if consumers are switched on during the day or even at particularly sunny times. Likewise, by using battery storages, the time offset between power generation and power consumption can be buffered and thus the own consumption share can be increased.

In order to settle the private consumption with the energy supplier, the electricity meters included in the PV system must, on the one hand, record electricity generation, on the other hand the purchase of public electricity and the feed into the public grid. The self-consumption is calculated from the difference between the generated (PV) counter and the fed-in energy (feed-in counter). On the basis of the feed-in and self-consumption values, the network operator creates a credit memo, on the basis of which the advance payments are charged to the PV system operators.

In addition to the production costs for electricity, economic efficiency depends in particular on the feed-in tariff for the renewable energy system.

Special cases: **Closed distribution networks** can be exempted from certain regulations of the energy industry law upon request, or do not fall under the rules for network operators because they are classified as "customer installations".

This is especially true for the incentive-based regulation (“Anreizregulierung”) and the price approval for the network tariffs. Nevertheless a central prerequisite for the classification as a closed distribution network is, if no consumers (Letztverbraucher = end consumer) (...) are supplied via the grid. Other prerequisites make these exemptions only realistic to a limited of industrially or commercially used areas.

Microgrid as local energy community - A special case occurs when the energy is generated (and consumed) within a home network or in (almost) direct connection to the generation units. For example in a multi-party house or building complex, electricity is shared with the tenants, neighbors or other parties. To a certain extend some fees and regulations are reduced or do not need to be applied. This opens business opportunities for the supply with renewable energy to competitive costs.

Pre-requirements on the generation units result primarily from the EEG, the technical definitions of the used units and the grid connection requirements. Typically the installed power of the power generation system will not exceed 100 kW, the annual grid supply should not exceed 100,000 kWh to act flexible.

In this case, the Microgrid-Manager - typically the owner of the RES – has similar tasks like the classical energy supply companies, which means optimizing generation and consumptions, but without the tasks of a system operator because only the “private” home network is used.

4.2.4 Switzerland

In the trial side in Switzerland there will be no microgrid management when implementing the GOFLEX solution. But, there will be services offered to prosumers and industrial customers, whom can be defined as microgrid managers. The services aim to maximize self-consumption or optimise energy prices. The customers (producers and end-users) concluded energy supply contracts, which regulate the modalities of supply. But, as they are basic end users, the supply of energy is done by the distribution network operator (Article 6 para. 1 StromVG). This leads to the situation that the partner ESR is the supplier and the DSO as well with whom the customers have the grid usage contract.

For these planned services ESR will have additional contracts depending on the value proposition. From the perspective of regulation there are no hurdles identified, as such services are already in the market established.

Outlook - Principles from the Revised Energy Act regarding the aspects of self-consumption can be interpreted positively to the GOFLEX solution and the development of decentralised markets for flexibility.

The **self-consumption** scheme was anchored in 2013 in the Energy Act (EnG). With the first package of measures for the energy strategy 2050, the Energy Act will be completely revised on January 1, 2018, which also affects the self-consumption regulation (articles 16-18). With the publication of the new manual to self-consumption regulation can be expected in the second quarter of 2018.

Anyone who produces electricity himself should be allowed to consume it or (and this is new in the law) to sell it wholly or partly at the place of production. The owners of the property can join together for their own consumption if the production output at the point of production is considerable in relation to the connected output at the measuring point of the private consumers. The owners of the distribution network are responsible to the distribution network operators, which is why the concept of self-consumption is not used in the law.

Owners can also set up their own consumption for their tenants. They are allowed to opt for or against participation in the establishment of their own consumption. They (and also the subsequent tenants) can only return to the basic supply by the local network operator after an entry if the owners do not fulfill their obligations. The right to market access remains. The owner must bear the costs for setting up the own consumption and must not distribute it to the tenant or tenant.

As a result of the new legislation, several end consumers, for the purpose of joint self-consumption, are considered as end consumers at the point of production for all aspects of energy supply. Thus, for example, the individual consumption points within this Community need not necessarily be measured by the distribution network operator. The aggregate consumption of market access is also assessed for the whole transaction. Thus the owner of a multi-family house in his own consumption for his tenants can buy the whole electrical energy in the free market (pooling).

4.2.5 Cyprus

The University of Cyprus (UCY) with its campus will be the microgrid. Energy management systems (EMS) of each building on the UCY campus as well as RES on the campus will be the assets for the centralised energy system. The Campus is connected as one single party to the (MV) Grid. The central energy management system takes the role to manage the assets like managing a virtual power system. Consequently there are no regulations on how to manage “private” assets. The role of the university campus will change from a passive energy consumer to a controllable microgrid. Relevant for this use case are the condition to which the UCY is connected to the grid and supplied with energy so far.A special aspect are the renewable energy sources (RES). RES producers have priority dispatch over conventional ones. According to the Trading and Settlement Rules generators are self-dispatched. Existing RES generators (currently only RES energy sold to EAC by the feed-in tariff regime, is injected to the system) provide their forecast to the TSO on the day-ahead on a half hour basis, and are not liable for any imbalances. Curtailments of RES generation either at the day-ahead stage or later are not compensated.

Outlook:

According to the New Market Model to be implemented in the coming years, contracts of RES generators under the Support Scheme are transferred from EAC to the TSO, acting as the RES Agent; while respective contracts of the RES generators with the RES Fund remain otherwise unaffected. The RES Agent bids the forecasted RES capacity into the DAM, where it is handled as must run. As currently practiced, curtailments of RES generation under the Support Scheme either at the day-ahead stage or later are not compensated. Existing arrangements imposing forecasting penalties are applied.

The RES Agent is liable for imbalances of RES generators in the Support Scheme. The imbalance cost or benefit from the operation of the RES under the Support Scheme is fed to a special account and then through the TSO allocated to all customers as a system cost or as a PSO. To minimise the imbalance exposure of the RES Agent, it may bid the RES output on a national portfolio basis rather than a per unit basis. Other RES generators (along with conventional generators and suppliers) may enter into bilateral contracts and/or participate to the DAM. Such RES operators are subject to imbalance settlement.

4.3 Balance Group Optimisation

4.3.1 Use Case description

Players - roles, processes and relations (based on harmonized model)

The active roles and trading relations between them are depicted in red.

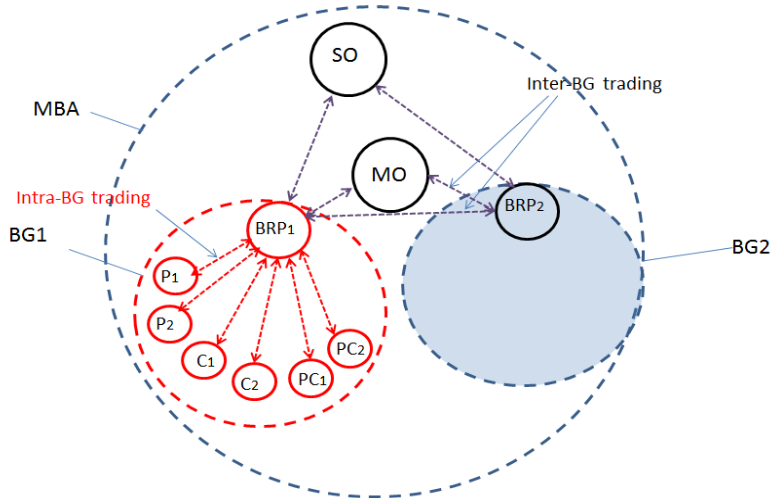

Figure 13: Schematic representation of Balance Group Optimisation

The use case concerns intra-Balance Group trading of energy flexibilities in closed contracts between BRP and parties connected to the grid (producers, consumers, prosumers). It stems from basic Harmonized market model.

Targeted project characteristics for Balance Group Optimisation:

Projects are carried out on the aggregate of companies in one BG, and in several distribution companies and (city) communities and is not be tied to any geographical territory or location within selected BG. It will comprise variable consumers, prosumers and producers of EE, with RES systems, business and industrial prosumers, public and residential buildings and including a network system of electrical vehicle charging stations.

Business cases:

BC3: The business cases are energy flexibility (positive and negative) vs open contracts supply & vs. TSO penalties for not keeping the schedules.

The driving role for business models is BRP, who is also the user of energy flexibility.

The trading process: is 1: many automatic by BRP.

4.3.2 Regulation: General considerations

Core function: The BRP uses the flexibility to correct deviations from its prognosis, thus avoiding penalties in the form of imbalance charges.

The European Code for Electricity Balancing (EB) of ENTSO-E is the European guideline for the organization of balance group management.

4.3.3 Germany

Balancing group settlement must be in accordance with market rules for the implementation of balancing group accounts for electricity (MaBiS).

In order to prove to the TSO that its own balancing group is balanced, the BRP must draw up a daily load forecast for all feed and removal points assigned to its balancing group. On the basis of the forecast, he is obliged to report all withdrawals, feeds and deliveries to and from his balancing group on a quarterly basis to the transmission network operator. For the energy consumers and energy feeders assigned to the balancing group without a registered power measurement, reports and balancing of the balancing group are made on the basis of standard load profiles.

The unpredictable fluctuations in consumption or in the feed-in of the balancing group occurring during the period (quarter-hour for electricity) are balanced by the transmission system operator with positive or negative compensation energy ("Ausgleichsenergie"). Since numerous balancing groups exist and positive and negative balance sheet deviations of the individual balancing groups occur at the same time, this partial compensation is compensated for. The underfunding of a balancing group can thus be compensated by the overlap of another balancing group.
Only the deviations of the withdrawals from the feeds / generators for the entire area must be compensated by the control power. In the case of a balancing group, the compensation energy is always applied when the balancing group is not balanced, even if another balancing group compensates for this. The quantities of balancing energy balanced exceed the actually required control energy by a large number.

The BRP has different opportunities depending on the point of time, when a deviation from his prognosis becomes likely or has occurred. He can either become active at the intraday market and buy or sell the estimated amount of energy shortly before the point of delivery. Another option to avoid imbalances for the BRP would be if he can access with a remote-control system his generation and consumption units and uses their flexibilities to adjust the energy used to his forecast.

Finally, the BRP might not react and simply accept any compensation energy costs - which however is contrary to the market rules (§ 4 Abs. 2 StromNZV and No. 5.2 of the standard balance sheet contract).

This leads to two ways of using flexibility with the GOFLEX solution:

1) active DSM within the BRP balance group
2) Participating at the Wholesale market with pooled or single flexible units

For the purpose of BG optimisation an integrated model as the suitable market design seems to fit or be at least the simplest way to integrate flexibility in these processes. In this design, the roles of supplier and aggregator are combined in one market party. Compensation for imbalances and the open supply position are not necessary.

Further on it can be differentiated between two refinements. One is called *Variable supply price model* by the entso-e. In this model, the consumer pays the supplier a variable supply price. The possible variations of the supply price are set contractually, and the consumer can adapt its consumption in response to price variations. Supply price indexation on market prices makes the price signal more accurate, but also more risky and complex to manage for consumers. The supplier anticipates the behaviour of the consumer in response to the price signal. This information is used by the BRP to balance its portfolio. This model represents a large share of existing DSR in Europe, notably for small consumers equipped with smart meters. Depending on the price gap between wholesale prices and the retail prices and additionally on the time perspective of the deviation from the forecast (“how urgent and to what extend adjustments are necessary), it might not be efficient to meet the requirement of the BRP to avoid imbalance charges.

For a situation rather urgent, the *Supplier load control model* might be more suitable. The flexibility clause in a supply contract can provide for direct supplier load control in specific situations. In such cases, the consumer is expected to curtail its load of a predefined volume at the request of the supplier, which can then be used by the BRP source to take part in balancing markets, self-balance its portfolio or benefit from high market price situations. This type of integrated supply and flexibility typically targets industrial consumers.

Aspect 2) participating at the Wholesale market is difficult for aggregated flexibilities.

German electricity is being traded at the European Energy Exchange EEX in Leipzig (forward market) and the EPEX SPOT in Paris (day ahead and intraday market). It has so far been operated as a so-called energy-only market. This means that energy supplies are traded here, whereby payments are only made for actually delivered energy quantities. Typically only very large consumers participate on the spot market, and as intraday trade for Demand Response is still closed, the participation of demand-side aggregators is practically non-existing.

In contrast, 3rd party aggregation of distributed generation assets, e.g. wind, biomass and biogas is a viable business opportunity, as the distributed renewable energy unit chooses a BRP to market its generation. VPP (Virtual Power Plant) providers have started to participate.

Because in the trial side at SWW such a “Direktvermarkter” is involved, it would be obvious to integrate or build on the existing processes. But, as this provider has its own BRP responsibilities the efficient use of flexibilities in generation assets might not be fitting to the requirements of the BRP from SWW.

The regulations governing the electricity trade have further considerable influence on the use of flexibility. Two factors are particularly relevant here: the duration of the accounting period and the related design of the trading products as well as the length of the period between the closing date and the delivery date.

In the day-ahead market the majority of hourly products are traded. Hourly products are, however, an obstacle to the participation of flexibility options with time constants of less than one hour, as they have to assure that they are able to supply electricity continuously for one hour or to continually reduce their consumption. For the participation of flexibility options with lower time constants, therefore, the intraday market is of great importance, where quarter-hour products are traded.

4.3.4 Switzerland

The procedure for the BRP in correspondence with the TSO are pretty much the same as in Germany.

Currently there is no Demand Response participation on the EPEX spot market from Switzerland, although in principle Virtual Power Plants (VPP), including demand-side flexibility, could already participate in the day-ahead market. The contractual situation to enable the offering of independently aggregated demand-side flexibility on the day-ahead market has yet to be regulated (EPEX, 2015).

4.3.5 Cyprus

There is only one Balancing Area (the whole island) and a single BRP at transmission level, that is the TSO. When flexibilities at the University of Cyprus are aggregated, they are offered to the BRP which is the use case of congestion management.

4.4 Congestion Management

4.4.1 Use Case Description

The active roles and trading relations between them are depicted in red.

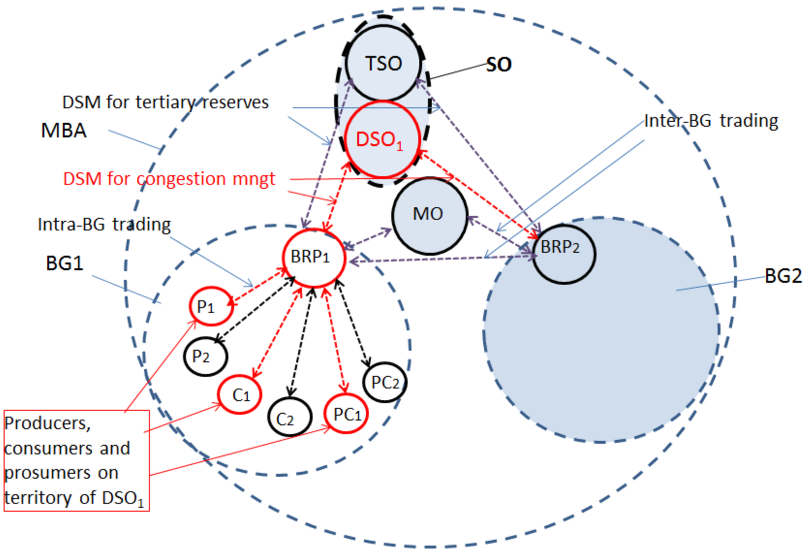

Figure 14: Schematic representation of Use case 4

The use case is the basic case for local balancing of energy disbalances on the distribution grid, using the local resources closest to the point of disbalance. The congestion management is thus done by reducing the energy flows rather than increasing the capacity of the grids. This a new use case possible by introducing cellular structure in the electricity grid system. To carry it out, new business model for DSO vs. TSO is implied.

<u>Targeted project characteristics for:</u>

Projects will be carried out in the frame of suitable locations with variable available prosumers and producers of EE, including with RES systems, business and industrial prosumers, public and residential buildings and including a network system of electrical vehicle charging stations. The project locations will be on the geographical territory of the DSO distribution company where the selected local community is situated.

The projects will typically be carried out on the same or similar location and aggregate as for Use case 2. The DSO distribution company will be project partner for collaboration for defining the system ancillary services for congestion management at DN level and the network fee (or bonus) as function of local DN conditions.

<u>Business Cases</u>

BC1: Business cases are based on avoided costs of balancing the local grid by local balancing as opposed to balancing regionally by TSO. There are two main contributors:

- reduction of energy transport costs (grid capacity and operation)
- reduction of costs of balancing energy through intensive use of energy flexibilities (positive and negative). This means that the investments into dedicated peaker stations are avoided or largely reduced, as the energy flexibilities are supplied by prosumers with installed process equipment; the investment is reduced to control and management systems and adaptation of environment

BC2 = energy flexibilities vs. incremental increase in distribution network capacities for transferring sufficient amount of energy + increased investment and operation of peaker stations.

The business case driver is DSO or sub-DSO as the sole user of energy flexibilities.

Involved active roles

- DSO or sub-DSO (in particular when coupled with UC2 or UC5)
- BRP or equivalent (SRP)
- Prosumers

The trading process is automatic 1:many, with BRP playing the role of Market operator

4.4.2 General considerations

Core function: DSO uses flexibility in his network for congestion management

Congestion management refers to avoiding the thermal overload of system components by reducing peak loads. In contrast with grid capacity management, this is a situation where failure due to overloading may occur. It is a short-term problem (with respect to the duration of a grid reinforcement project) for the DSO that requires a relatively swift response. The conventional solution is grid reinforcement (e.g., cables, transformers). The alternative (load flexibility) may defer or even avoid the necessity of grid investments.

With any form of congestion management by the distribution system operator a correct recognition of the changed amounts of energy is essential. If a distribution network operator uses flexibility as part of the congestion management, the question arises as to who is responsible for balancing these measures. In contrast to the redispatch with the TSO, a simultaneous ramp-up and shutdown of plants for balancing the measures is frequently not possible.

If and to what extent network relevant flexibility will be used is also depending on what voltage level as well as to the generation and load situation in a given network area and whether the responsibility of the transmission and distribution system operator is affected.

4.4.3 Germany

The targeted use of network-based flexibility to increase the network capacity has not been established in practice. The distribution network is known historically only for the charging of night-storage heaters to the specific use of network-oriented flexibility. These are traditionally loaded by a control signal from the network operator and receive a reduced fee for this. The supplier supplies a standard load profile (SLP). Otherwise the network capacity would already be insufficient to enable active demand-side management of night-storage heaters at any time on the network side.

In the framework of the electricity market law adopted in July 2016, the concept of peak load cutting was defined by the legislature. The concept provides that DSOs for planning their grid enforcement may assume reducing the connected renewable generation in their network up to 3 percent. By this the principle that power lines are not to be expanded for (rare) special production or trading peaks is operationalised and also used in the framework of the distribution network expansion.

This approach is new and deviates from the previous target direction of a network expansion aimed at the complete implementation of the market result on the distribution network level. Furthermore, the concept has an influence on the economic considerations of a solution that wants to highlight network-specific flexibility. If alternatives to grid expansion are more cost-effective solutions, the system of incentive regulation (“Anreizregulierung”) must reward them, which is not extensively established. This is partly due to the fact that the incentive regulation favours CAPEX over OPEX, hence it is better from a DSO perspective to expand its network (and thus increase its capital base) than to contract with a Demand Response provider.

At the moment, the feed-in management of the renewable energies is in any case more attractive than market-related measures. The incentives from the “Anreizregulierung” are currently countering the possibilities for congestion management according to § 13 EnWG and are thus an obstacle to an efficiency-oriented network operation. If the network operator will be more frequently in the situation where congestion management becomes necessary, the regulatory unequal treatment of comparably effective network-related flexibility is of critical relevance.

To understand the situation in Germany regarding congestion management, the network traffic light “Netzampel” concept must be explained. The Netzampel is intended as an illustration of upcoming network bottlenecks and the possible countermeasures by the network operator within the framework of network operation management. The following legal classification was made according to the provisions of § 13 EnWG:

Green: In the green phase, all market participants can realize their plans. There are no restrictions on the network operator. This is the optimal condition that should be striven for.

Yellow: If a network operator is confronted with network problems, which he can no longer solve by using his own resources, he leaves the green phase. It now enters into the yellow phase and takes effect on so-called market-related measures (§ 13 para. 1 no. 2 EnWG). These include, for example, the raising and lowering of conventional power plants (redispatch) or the contractually agreed use of disconnectable and switchable loads, the contracting of which is permitted under current conditions only under certain conditions.

Red: If the threat or disturbance caused by the measures pursuant to section 13 para. 1 no. 2 EnWG can not be remedied and the market measures available are exhausted, network operators must take measures pursuant to section 13 para. 2 EnWG. In this "red traffic light phase" conventional production plants, loads and also renewable systems can be switched off (or driven up) without prior agreement or agreement and without a compensation payment.

In the case of EEG and CHP plants, § 13 (2) EnWG i.V.m. § 14 EEG (feed-in management, or "Einsman") is applied. This means that they are also switched off or reduced, but they are subordinated to conventional plants and with a legally stipulated compensation (§ 15 EEG).

As stated above and also in most European countries, possibilities for DSOs to invest in Demand Response (flexibility options) are limited. Nevertheless, this possibility is being discussed within the energy industry associations and the regulator (BNetzA) is considering various models for a (near) future incentive regulation (BNetzA, 2017).

Regarding the **requirements for energy and balance-sheet balance**, there are two approaches conceivable. Either a balancing by the distribution network operator or by the owner of the flexibility: On the one hand, market participants, which offer flexibility to the network operator, could be held responsible for the management of their balancing groups. The cost of an unbalanced balancing group would then have to be borne by the respective supplier via the use of compensation energy. Since an active congestion management by the grid operator with the support of market participants could only take place with a corresponding lead time, the balancing should be possible without major problems. Compensation could be achieved both by acting on the intraday market and by adapting a suitable approach for systems that are allocated to the corresponding balancing group.

On the other hand, the responsibility for the balancing of the measures could also be settled with the distribution network operator. However, this would have the effect that distribution network operators would have to take a more active role as a "energy trader". Except for the management of the loss-power and difference-balancing circle, however, this is not discriminatory-free from the perspective of unbundling and is therefore not desirable.

Further there are different approaches on how the **interaction of the distribution network operator with the providers** of network-oriented flexibility should be designed.

a) Classical approach

The actors would have to adjust their behaviour in the event of network congestion at the instigation of the distribution network operator. The shifted quantities would have to be balanced in terms of energy and balance. The instructed installations would have to receive a financial compensation for an economic loss.

b) Interaction of the network operator with providers of network flexibility

As an alternative to the classical approach, the DSO can in future be used as a demander of network-based Flexibility. For this purpose, the network operator will interact with providers of network flexibility, loads and storages that can be switched off and on and are connected in their grid. Within the scope of this interaction the Flex-Owner gives the network operator (direct as well as indirect) a certain control possibility to eliminate the congestion. Among providers of network flexibility, which most effectively impacts the congestions, it should be the most economical option.

In this model, the network operator bilaterally negotiates a contract-based remuneration for behavioral change with the providers of network-based flexibility. This agreement includes the possibility of control of the network flexibility by the distribution network operator at time x for a change in performance of y and a corresponding remuneration to the provider of the network-oriented flexibility.

As a detailed technical and contractual design of the interaction between the network operator and the provider of network-based flexibility is the responsibility of the network operator, clear requirements must be placed on the bilateral contracts in order to limit the misuse potential of the network operator. Therefore, the bilateral treaties must be discriminatory-free and in compliance with the applicable unbundling regulations in order to prevent associated business sectors from being favored.

If the number of potential providers is high enough, organized platforms could also be a way of interacting. Section 13 (6) sentence 2 EnWG provides for a common Internet platform as a prerequisite for the contracting of loads that can be switched off by transmission system operators. Section 14 (1) EnWG also extends the possibility of platform-based contracting of loadable and switchable loads to at least de jure also to the distribution network area. Implementing the GOFLEX platform at the trial side will be such a way, although the regulator

BNetzA does not see enough (local) potential for such platforms for the purpose of congestion management at DSO level.

Another critical issue is the **remuneration of the flexibilities** used for congestion management by the DSO. Both above mentioned approaches have different advantages and disadvantages. Either the network operator pays "prices" that are bilaterally negotiated or determined in other procedures, or he can only pay "compensation" based on the costs or disadvantages of the Providers through the access of the network operator.

Established procedures are the use of compensation. According to the amendments to § 13 ff of the EnWG (German Electricity Act), electricity producers continue to receive "only" compensation, which merely compensates for the disadvantages that the producers incur due to the intervention of the grid operator. Also, according to § 15 para. 1 EEG, plant operators whose supply of electricity from renewable energies or cogeneration is reduced because of a network congestion, have to be compensated as if they generation would have run through.

In the area of adjustable loads, the legal assessment is less clear. These can be equivalent in the technical effect to the control of generation. However, the regulations are different. A central disadvantage of a "pure cost replacement" consists in this difficulty to determine the costs (of load curtailment) in a particular case. Business models offering network flexibility are unattractive when the pure cost replacement is applied. It must be assumed that in such a case the compensation payment would not lead to more alternative offers or products. Profitable business models will not be established in this constellation.

But, one advantage of the compensation model is that neither the generating facilities nor the loads or storages have an incentive to promote a continuity of the congestion by their behavior. In addition, this administrative approach can also work under non-competitive, very small-scale conditions with limited flexibility. Especially in rural areas with a lot of EE generation and only a small load would be an advantage.

Another option in line with the GOFLEX solution would be a compensation based on bilateral contracts. The performance (granting of a network-related control possibility of the plant) and consideration (remuneration) is negotiated and contractually fixed between providers of the network-oriented flexibility and the distribution network operator. This interaction must be non-discriminatory, suitable for unbundling and transparent. In a platform-based organization, the amount of remuneration would be determined by the incoming bids.

Negotiating the remuneration would have the advantage that the providers of network-oriented flexibility themselves make an assessment of the resulting cost positions. This means free price formation, accompanied by a regulatory framework. The compensation payment for renewable energy plants as a "last resort" measure would constitute the ceiling for compensation. Assuming sufficient competition would result in an efficient price for network-based flexibility. If this is missing, market distortions are possible. If, for example, the liquidity of network flexibility is very limited locally, this may lead to too much market power for individual market participants.

Regardless of these two model variants, it is an open discussion whether a work-related or a performance-related remuneration should be carried out. In this respect, BNetzA votes for a work-oriented remuneration. Their argument is, that this has the advantage that it is not possible for flexibility providers to gain economic advantages by maintaining their performance and to permanently interpret their business model for a possible retrieval of network-specific flexibility in the event of a congestion. As a result, no capacities for network services are bound, which would then no longer react to the price signals of the EOM.

4.4.4 Switzerland

The distribution code regulates the technical regulations for the connection, operation and use of the distribution network.

Congestion management is of central importance to Swissgrid (TSO) in fulfilling the statutory responsibility of secure grid operation. The Electricity Supply Act (StromVG) provides, inter alia, that in the case of congestion in the transnational transmission network, the network capacities are allocated according to market-oriented allocation procedures (auctions). The auction rules describe the rules and conditions for the allocation of available transport capacities of the CWE region, CSE region and Switzerland. The valid version of the auction rules is on the JAO S.A. Website (JAO S.A. Webseite).

But, on the DSO Level there are only pilot programmes.

4.4.5 Cyprus

The incumbent Electricity Authority of Cyprus (EAC) owns both the transmission and the distribution system. The TSO is legally but not functionally unbundled from EAC, since all its staff is seconded from EAC. The obligation of ownership unbundling of the TSO does not apply, since Cyprus has obtained a derogation from Article 9 of the 2009/72/EC Directive. The DSO is responsible for managing, operating and developing the network, safeguarding access to the distribution network and equal treatment for all users. EAC has unbundled the accounts of the DSO.

In UC2 (island-wide) the EAC (DSO) will function as an aggregator and also both as a BRP and DSO procuring congestion management services from the GOFLEX market. In this use case, the identified grid congestion will be relieved by activating the flexibility offers. The DSO will analyse the parameters of the system through the GOFLEX platform (DOMS) in order to identify any possible grid congestion issue. Then, the DSO will send the flexibility offers to the Aggregator / BRP in order to activate the trading with the respective nodes and resolve the congestion issue.

CERA will monitor the congestion management of the national electricity systems including interconnectors, and the implementation of congestion management rules, which form part of the Transmission and Distribution Rules and/or the Electricity Market Rules. To that end, the Transmission System Operator shall submit the congestion management rules, including capacity allocation, to CERA. CERA may request amendments to those rules;

Basis for ongoing development of regulation: where the Distribution System Operator is responsible for balancing the distribution system, the rules it shall make for this purpose, including the rules for charging their network users due to lack of energy balance, shall be objective, transparent and impartial. The terms and conditions, including the tariff rules for the provision of such services on behalf of the Distribution System Operator shall be set out in accordance with clause (7) of Article 25 in an impartial manner reflecting the cost, and shall be published.

4.5 Conclusion for GOFLEX

The GOFLEX approach is to demonstrate innovative use cases and business models or at least to emulate them to deliver a proof of concept. All GOFLEX use cases can be implemented taking this into consideration.

It is noticeable that the provision of ancillary services to the TSO is possible in all countries, so there is a first commercial business case possible to set up the infrastructure for decentralised flexibilities for all trial sites.

The other use cases can be implemented only partly and possibly don't have a positive business case yet due to regulation issues but will be used as proof of concept to define requirements to national regulation.

5 Preliminary Assessment of the GOFLEX Solution in comparison to other solutions

GOFLEX as a project integrates and demonstrates several individual software and hardware tools into one solution. The goal of the project is to provide a commercial solution and a business plan by the end of the project. In this chapter a preliminary concept of the project consortium is outlined including a first assessment of the solution in relation to the EU market model and possible competitors/partners.

5.1 The GOFLEX application approach: a toolbox based on building blocks with open interfaces

5.1.1 The GOFLEX process: Utilisation of local flexibility via Flex Offers

GOFLEX supports a bottom-up approach for the future energy system (see chapter 2.3). As a consequence, flexibility as a product is also offered bottom up. The mechanism is called "Automated training of Flex Offers". Local Owners of flexibility (Prosumers, active consumers, producers or storage operators) offer their energy flexibilities (available positive or negative power within a certain time interval) either directly on a local flexibility market or to an aggregator. The prices are dynamic depending on the decision of the flexibility suppliers but in relation to the value of flexibility to the user of flexibility at particular time and circum-stances. The underlying principle is that the value of flexibility depends on the principle of avoided costs to the user. Typical such case, when the user of flexibility is DSO, is to prevent congestion or off-normal operating modes on the grid by local balancing of energy flows.

Possible users of local flexibilities (DSO, TSO or BRPs; but also, the new downsized cellular roles SRP – Subgroup Responsible Party, MRP – Microgrid Responsible Party, LSE-Local supplier of energy) have direct access to the flexibility market platform (FMAR) and closed usage contracts which will be carried out automatically.

The software/hardware module enabling the trading and the automated execution of Flex Offers is the Flex-Offer Agent (FOA) which directly links the Energy Management System of the Flexibility Owner to the GOFLEX flexibility market platform; this enables trading of individual FOAs with their individual prices ("direct GOFLEX trading"); or to the GOFLEX flexibility management platform for aggregators which aggregates the FOAs and assigns an aggregate price to them ("delegated GOFLEX training").

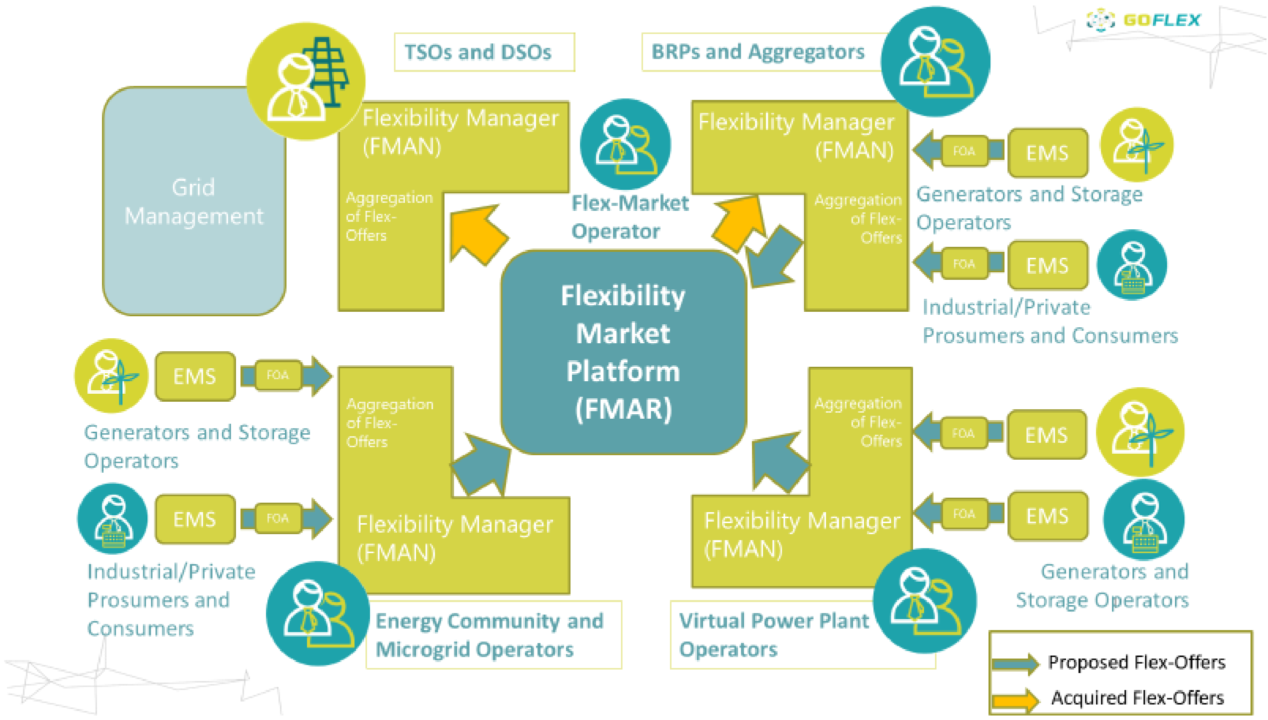

Figure 15 The GOFLEX flexibility trading process

The Flex-Offer process step by step:

Energy flexibilities are offered by prosumers using Flex Offers they will be aggregated, scheduled and auctioned, contracted, disaggregated and executed.

1. Planning
   - planning adaptation potential in production and consumption processes
2. Trading
   - offering: formulating and issuing Flex-Offer for selling energy flexibility (positive or negative) for direct GOFLEX trading, includes price. Several Flex offers with different prices can be formulated and issued
   - offering: formulating and issuing flex offer for selling energy flexibility (positive or negative) for delegated GOFLEX trading, without price.
   - aggregation of Flex-Offers for delegated GOFLEX trading and assigning price
   - scheduling of Flex-Offers
   - auctioning (marketplace trading)
   - assigning

    - de-aggregation (if required)
3. Billing
    - Billing will be executed in separate systems

5.1.2 The GOFLEX toolbox based on building blocks

All GOFLEX partners agree to prefer a GOFLEX platform approach to exceed the impact of their solutions, if it was only provided in an isolated way. GOFLEX is a family of solutions, an assembly of software and hardware with individual interfaces to each other, but mainly independent of each other and open to connection with other building block solutions.

All applications are sold in two business models:

- Integrally as part of Integrated GOFLEX system
- individually according to the pricing model of the app supplier. The focus is on the interfaces, all software and hardware blocks are supposed to be integrated in an easy way.

It is also decided that the solution is open to other software and hardware suppliers, e.g. other aggregation platforms, other EMS and Car-charging solutions, other grid monitoring tools etc.

The aim is to create a "GOFLEX compatible" certificate and offer open specifications for the interfaces rather than offering a closed software solution.

The GOFLEX software will be offered as cloud solution, the future users will have no installation or additional hardware costs.

Here is a complete list of the GOFLEX building blocks:

- The **GOFLEX Flexibility Market Platform (FMAR)** allows trading of energy flexibilities, based on the two-sided pool concept, where FLEX Requests and FLEX Offers are constantly matched via flex-offer management algorithms.
- The **GOFLEX Flexibility Management Platform (FMAN)** collects and aggregates Flex-Offers from a large number of prosumers and acts as a seller on the flexibility market, in two variants – for direct GOFLEX trading and for delegated GOFLEX trading. It is a sub-system for Aggregators, BRPs, MGRs, which allows managing (potentially large) collections of flexible loads in the Flex-Offer form. It integrates advanced Flex-Offer aggregation and disaggregation functionalities, optimization, as well as GUI, which allows its users effectively and efficiently analysing, trading, and shaping available flexibility in near real-time.

- The **GOFLEX Flex Offer Agent (FOA)** is a family of intelligent trading interfaces that enable all owners of flexibility to participate in the local flexibility market. FOA extracts and trades flexibility with next level of GOFLEX integrated system in standardized format (”Flex-Offers”).
- The **GOFLEX Factory Management System (FEMS)** offers an advanced peak demand management functionality for use by industrial prosumers, creating virtual energy storage in processes based on cost-benefit considerations.
- The **GOFLEX Home Energy Management System (HEMS)** is designed to provide best matching of the strategy imposed by its owners. This is done through management of prosumers behaviour, demand side management, and energy flow control by knowing the users' strategy and behaviour, local production (for example PV), local consumption, and environmental parameters.
- The **GOFLEX Charging Energy Management Solution (CEMS)** provides dedicated energy management system and communication interfaces for Charging stations for EVs as active consumers.
- The **GOFLEX Charging Discharging Energy Management Solution (CDEMS)** provides dedicated energy management system and communication interfaces for new generation of Charging stations for EVs with the batteries with charging & discharging functionality, as part of the EMS or as active prosumers.
- The **GOFLEX Distribution Observability Management System (DOMS)** offers demand and supply forecasting services to the DSO. A particular focus is on forecasting demand at disaggregated levels (e.g., distribution substations, MV/LV transformers), accounting for distributed generation, photo-voltaic forecasting, utilizing high-resolution weather forecasts and quantifying uncertainty associated with demand forecasts.
- **The GOFLEX Service Platform – (SP)** is a cloud based collection of services, made available through defined APIs. Logically SP offers services to different GOFLEX building blocks. SP will provide single point of connection for different services, such as Metering service, Weather prediction services, as well as DOMS sub-services, such as Energy transfer cost (ETC) calculator.

5.2 Considerations of a future GOFLEX business strategy

The GOFLEX solution is a comprehensive solution to enable local flexibilities. However, the individual building blocks will be operated by different stakeholders. Many of the GOFLEX building blocks are state-of-the art components, like FEMS, HEMS and CEMS. Others are new but already in competition to existing solutions like the flexibility management platform for aggregators (FMAN). The Flexibility market (FMAR) is a building block for a market which does not exist yet. This chapter will start discussing mainly the possible business strategies for FMAR und FMAN.

5.2.1 Who will run the GOFLEX flexibility market platform?

GOFLEX offers a complete system to enable and utilise local flexibilities with the Flexibility Market Platform at the heart of the system.

During the project time the main actor carrying out the flexibility use cases are local energy suppliers/utilities and smaller DSOs. They take all roles in the new system, they become the aggregators, the flexibility market operators and the users of flexibilities. They also equip the prosumers with necessary devices and organise the infrastructure for car charging. But who will be in future in charge of the heart of the system, the flexibility market platform? And how will they start their business?

Here is a list possible scenarios, how a local flexibility market can start and a short assessment about chances that GOFLEX can become the software provider in this context.

5.2.1.1 **DSOs will create their own local flexibility market**

Today the TSOs run their own power reserve markets and the DSOs could implement local power reserve markets following this model. Since DSOs are highly regulated, and the use of flexibility is in most cases not remunerated and not considered by many DSOs as an asset to manage the distribution grid, it is very unlikely that this situation will take place. Unless the regulation changes and the DSOs are obliged to run local flexibility markets (like the TSOs in the past were obliged to open “markets for ancillary services for TSOs”). If that happens, the software to carry this out will be possibly tendered with strong requirements and GOFLEX could be one of the vendors bidding for it.

5.2.1.2 **BRPs will create their own local flexibility market**

To avoid to be obliged balancing energy from the TSO, already today some BRPs tender flexibility. However, the more common way is to buy or sell energy at the spot markets (Day-ahead or Intraday). So, the business case of a local flex market needs to beat the business case of the spot market trading, the flex-offers need to be cheaper than the prices at the spot markets. It is one of the cases that the GOFLEX project will explore:

GOFLEX can offer an opportunity for a BRP that mainly trades (volatile) local renewable energy and sells it to a local community: GOFLEX offers an application to forecast and monitor generation and consumption and can quickly respond to short-term weather changes (e.g. shades on PV plants) by utilising flex offers from the local flexibility market, quicker than the BRP can place orders on the spot market.

However, since this is a very new approach, there must be pilots in place delivering a proof of concept for this idea for BRPs to get interested. Also, the concept of "local" energy and "local energy communities" is supported only by a few companies and needs more market perseverance to offer a real business opportunity for application providers like GOFLEX.

5.2.1.3 A service company will run the local flexibility market (and scale it up)

It is very likely that DSOs and BRPs (or regional suppliers) will not create flexibility markets themselves. They will rather outsource such an activity to a service company. Such a service company could establish local flexibility markets in other areas and offer flexibility trading to DSOs, BRPs and regional suppliers.

This scenario is very likely to happen. In this case GOFLEX must team up with this new business unit and develop the business together (first steps are taken in the GOFLEX project).

5.2.1.4 An Aggregator will extend its business scope and develop into a flexibility market operator

Aggregators today mainly offer flexibility on the power reserve markets and They either classify as BRP, have direct relationships to BRPs (usually acting as an outsourced function of a BRP) or having the permission to offer demand-response to BRP's clients. The flexibility is usually taken from big industry plants or storage plants (especially hydro pump stations or big battery plants), there also applications using demand response from office buildings and households.

The aggregators could extend their business scope and offer their flexibility to more parties, especially in a local context. As soon as there is a working business model for such an application, it is very likely that aggregators will use this opportunity.

The challenge for GOFLEX is that aggregators usually have a high ICT competence themselves and have their own applications running since there is no "standard" aggregation application available. The opportunity would be to develop such an application together with a *new* local aggregator at a very early stage (e.g. a spin-off of the local energy supplier). Ideally the aggregator would start with the GOFLEX aggregation platform.

5.2.1.5 The EEX AG will run a network of local flexibility markets

The EEX (European Energy Exchange) obviously considers this scenario, EEX and EPEX Spot (European Power Exchange, 51% owned by EEX) are project partners in the SINTEG project ENERA in Germany together with the regional utility EWE, the regional DSO EWE Netz, the TSO Tennet and the aggregators Younicos. It is very likely that EEX will extend its scope and create a platform or a network of homogenous platforms for local flexibilities.

For the GOFLEX solution this will turn out to be a strong competition since EEX will probably develop their own applications. However, the collaboration with this development in a very early stage should be considered. There is a possibility that local DSOs and local BRPs want to have direct control about their own local flexibilities and prefer local independent solutions. In the end it could be a network of local flexibility markets with open interfaces which is not dominated by one company or organisation. This is what GOFLEX should support.

5.2.1.6 The GOFLEX consortium will run a network of local flexibility markets

The GOFLEX consortium could become flexibility market operators itself. A lot of new energy service providers (aggregators, energy community operators etc.) have a strong root in the ICT sector. The DSOs and local energy providers of the trial sites today could become the first customers on the platform without the need to run the platform themselves.

5.2.2 The Challenges for a multi-sided flexibility market platform

The GOFLEX solution can be considered as a multi-sided platform. According to the Osterwalder definition, multi-sided platforms bring together two or more distinct but interdependent groups of one group of customers only if the other groups create value by facilitating interactions between grows in value to the extent that it attracts more users, a phenomenon known as the network elect. (Osterwalder, 2010)

The GOFLEX platform link flexibility provider and flexibility users. GOFLEX creates value as intermediaries by connecting these groups. The key is that the GOFLEX must attract and serve all groups simultaneously in order to create value. The platform's value for flexibility users depends substantially on the number of providers of flexibility and vice versa. It must create a win-win-win situation.

Hence the GOFLEX multi-sided platform faces a "chicken and egg" dilemma.

One way multi-sided platforms solve this problem is by subsidising a Customer Segment. Though a platform operator incurs costs by serving all customer groups, it often decides to lure one segment to the platform with an inexpensive or free Value Proposition in order to subsequently attract users of the platform's "other side." One difficulty multi-sided platform operators face is understanding which side to subsidize and how to price correctly to attract customers.

In the GOFLEX case this could be implemented by subsidising the necessary equipment to participate in the flex market (Energy Management System, Flex-Offer agent). For this the flexibility market operator must be identical with the local aggregator or the local energy supplier or must work closely with them. There are a variety of possibilities to subsidise customers offering flexibilities, e.g. they could be offered flat fees for equipment like they are offered for mobile phone contracts (which in reality are leasing contracts).

These strategies will be tested with the participating prosumers during the project.

5.2.3 : The strategy for new aggregators with a local focus: from power reserve market offers to local trading

The GOFLEX FMAN aggregator platform can possibly not compete with existing platforms that are already run by the aggregators, since they are usually developed and maintained by the aggregators themselves.

But GOFLEX can support existing BRPs and local suppliers to become aggregators or spin off an aggregator company. Since GOFLEX provides a complete toolbox to enable flexibility trading and provides a future vision how to run a local energy system as an interdependent cell, there is a good chance to convince these companies to use the GOFLEX toolbox for their purposes.

The GOFLEX trial sites play in this scenario an important role, because they will appear as the best practise cases for exactly this development.

Since the market for local flexibilities does not exist today apart from aggregating local flexibilities for the reserve power market, the power reserve market should be considered as a bridging till the local and regional markets for flexibility are fully functional. In this phase the complete equipment for prosumers can be rolled out and all aggregation functionalities can be deployed and there is a good chance that the income from the reserve market pays off the investments.

This approach will be explored in detail during the project time.

5.2.4 GOFLEX advantages and challenges

Based on the insights of the previous chapters, a preliminary analysis of strength and weaknesses of the GOFLEX solution was carried out:

5.2.4.1 GOFLEX advantages

- Bringing in demand response process all groups of prosumers, from largest to smallest

- Automatic trading technology which opens up fast reaction to transients and supply of energy flexibilities close to real time
- Aggregation of local energy flexibilities close to the place of use: copes with energy disbalances where they appear – directly supports dispersed energy production as opposed to centralized energy production
- Dynamic prices of energy flexibilities in closed contacts based on the value of flexibility in terms of local conditions - potentially avoided costs for DSOs (cheaper than alternative in terms of long term and short term marginal costs)
- Based on dynamic prices of energy flexibility engaging full flexibility potential in prosumers – thus potentially reducing the costs of balancing for DSOs and BRPs.

5.2.4.2 GOFLEX challenges

- Regulatory change/resistance: To achieve full effect in market penetration it needs further harmonization of electricity market – making DSO cellular role subordinated to TSO – this means that DSO is responsible for energy balancing of its grid and entailed to power reserves market for ancillary services. This can be achieved by sufficient mass of lobbying this idea.
- Market resistance: the bottom up approach is not supported and certainly not pushed forward by established actors that are part of the paradigm of concentrated/centralized energy supply. New actors have to materialize or move in, existing actors need to take on new roles and functions. This takes time, in particular because the process needs time to generate sufficient mass of interest. GOFLEX community is the one dissemination and deployment concept planned to stimulate and accelerate this process.

5.3 GOFLEX community: Collaboration with existing best practice examples in the European market

The energy market is in a transition. The integration of renewable energies with their volatile and distributed character change the rules of the market. Flexibility becomes more and more important though currently the trading of flexibility is very limited to specific business models.

The focus of flexibility trading is still on bigger loads, big storage solutions and demand response with big industry plants. There a lot of companies throughout Europe which deliver this service, depending very much on the price development of power reserve and capacity markets.

However, there are two kinds of energy companies on the market whose business models have a local focus that are similar to the GOFLEX trial site approach. Some of them are small but already successful on the energy market:

1. Aggregators of local flexibilities (from households and small enterprises) and
2. Operators of local energy communities.

Since the European market for local energy and flexibility trading is very small, GOFLEX aims to partner up with these companies to develop the market and share experiences (e.g. by organising workshops for specific issues similar to the GOFLEX has established the GOFLEX community website to showcase this business approach (www.GOFLEX-community.eu).

The GOFLEX community will also involve demonstration projects, which explore business models for decentralised energy systems and aim to commercialise their solutions (like GOFLEX), but this chapter will focus on already commercial solutions, since there is a significant difference in the maturity of the business models between a company who took the risk and invested money compared to the assumed business models of a publicly funded innovation project.

5.3.1 Aggregating flexibility and offering it at the power reserve/ ancillary service market

5.3.1.1 Kiwi power (UK)

Self-Description

"KiWi Power is the UK's leading demand response aggregator and has been a key player in the UK energy market since 2009. We are passionate about driving innovation in technology to create efficiencies, generate commercial opportunities and promote a green agenda.

We work confidently with policy makers, System Operators and network operators to help evolve the energy landscape. As a result, KiWi Power has been instrumental in setting up new demand response programmes in the UK and around the world.

Delivering significant commercial returns and sustainability benefits to large consumers of electricity, utilities and grid operators, we provide our clients with robust, best in class proprietary technology and unrivalled expertise.

KiWi Power is the only demand response provider to offer a full suite of grid balancing services. Our award winning software and hardware surpasses competitors and we continually innovate for the future. We offer our clients unrivalled industry expertise and more experience of complex site implementation than any other."

Services

KIWI power is specialised in aggregating and utilising flexibility from small and medium business energy consumers via demand response. They trade flexibility at the UK capacity reserve market, at the frequency response market and utilise it for network constraint management.

It is one of the biggest aggregators at the UK market.

Prosumer Acquisition Strategy

On the website KIWI promotes the financial benefits for flexible commercial consumers and prosumers in without giving numbers. They explain the several markets in an easy-to-understand way. There are testimonials of KIWI clients to attract the attention and give the impression that it is normal and easy to participate. It is a classical B-to-B approach.

Figure 16 Main business model of KIWI power (source: website)

Assessment

KIWI power is already a very established company in and established market. It is very unlikely that they will use GOFLEX solutions to run their business. However, if their scope enhances in the direction of local use of flexibility (and their participation in the EU H2020 project "Flexiciency" indicates it), there is an opportunity to collaborate and cross-breed technology via the GOFLEX community.

5.3.1.2 **Tiko (Swisscom Energy Solutions CH)**

https://tiko.ch/page/energy/

Self-Description

"Tiko has been managing tens of thousands of residential loads to provide ancillary services to the European grid since 2012.

We connect prosumers to a unique network to deliver energy management, smart-solar and micro-grid management. We analyse per-second information across the network to provide tailored solutions to energy industry actors and behind the meter value through the Tiko app."

Figure 17 Tiko management of residential loads (source website)

Services

Tiko offers a full service to (private) prosumers and consumers (optimising self-consumption, data management etc.) which includes utilising flexibility for ancillary grid services. The software solution is used as "white label" product by other energy service providers like Sonnen AG and EKS Energie.

Tiko is currently active at the European market.

Prosumer Acquisition Strategy

On the website Tiko offers a standard way to become part of the Tiko storage network. A price calculator is on the website, a web shop is included. It appears to be an easy way to buy the products and services. The marketing is a mixture of contributing to the environment and gain also personal benefits together with a strong partner for the welfare of Switzerland. They offer power supply with digital control or a prosumer starter set with PV and battery and digital components. The strategy is very similar to what the GOFLEX trial sites want to achieve.

Assessment

The interesting part with Tiko is the business model for the local flexibility provision of ancillary service to the grid. Usually the investment into equipment for private prosumers does not pay off regarding the expected revenue. This needs further exploration. It would be also interesting to discuss how local flexibility markets could fit in the business model of Tiko. Regarding learning from others it is the top candidate in this assessment and it is a candidate for the GOFLEX community.

5.3.2 Local energy supply and energy community management as cloud solution

5.3.2.1 Sonnen AG/SonnenCommunity (GE)

https://www.sonnenbatterie.de/en/sonnenCommunity

Self-Description

"The sonnenCommunity is a community of sonnenBatterie owners who are committed to a cleaner and fairer energy future. As a member you can share your self-produced energy with other members of the sonnenCommunity. Since you are exclusively using energy from the community, there is no need for a conventional energy provider anymore."

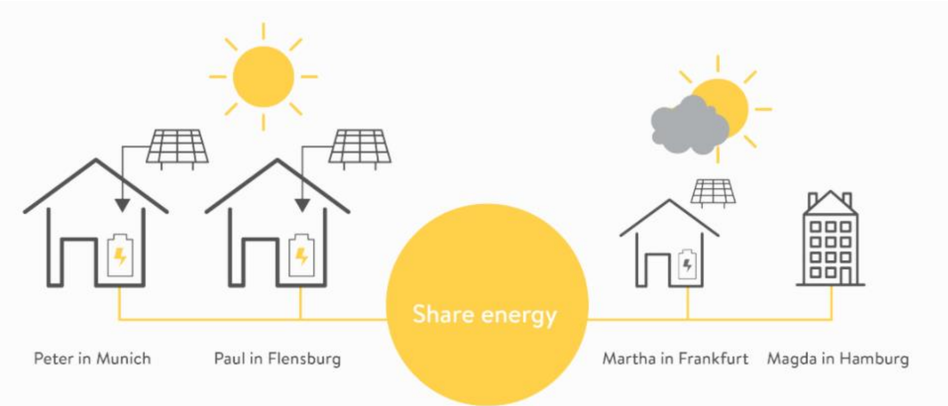

Figure 18 sonnenCommunity (source: website)

Services

Sonnen had started as home battery dealer for prosumers and developed into a utility service provider. They offer utility services for prosumers (purchasing energy surplus and supplying energy in times when the there is no self-generated energy available). They do act as a BRP and balance their group with Biogas plants and only purchase from the spot market in an emergency case. They also offer to aggregate the available battery storage of the community and trade it at the power reserve market. They currently tested it via a Blockchain application. Sonnen is currently active in Germany.

Prosumer Acquisition Strategy

The strategy of Sonnen for prosumers is based on two elements: Being self-sufficient and being part of a community. All facts are presented in an easy-to-understand way, there are many tools available on the website to calculate tariffs vs using PV and battery. The website is actually a web shop for prosumer devices and gadgets.

Sonnen also has an ambassador system in place to acquire new customers.

Assessment

Sonnen is a very innovative company testing various business models. They consider their community "national", the customers are spread all over Germany. They have partly the same prosumer business model as the GOFLEX trial sites and are competitors. However, there is a great possibility to learn from Sonnen and they are a candidate for the GOFLEX community.

They might be also interested to sell their flexibility at local and regional flexibility markets, so they will be collaboration partners when GOFLEX flexibility markets platforms are in place.

5.3.2.2 Open Utility (UK)

https://www.openutility.com/

Self-Description

Open Utility is an ambitious software company based in London.

In 2015 Open Utility launched their flagship Piclo® peer-to-peer energy marketplace for UK business customers with their first partner Good Energy. In 2017 Open Utility is expanding the Piclo® service in selected international markets and is running a residential customer trial.

Open Utility has secured £1.5million of funding, including grants from DECC and private investment from Ian Marchant, former CEO of SSE. Open Utility has been named by Bloomberg as one of the UK's top 50 Business Innovators and won Startup of the Year at European Utility Week.

"Peer-to-peer and local flexibility trading are becoming important pillars of the decentralised energy system." James Johnston, CEO Open Utility

Services

Peer-to-peer energy matching (Pico): Service for energy retailers who want to build a new customer proposition around local energy. Smart meter data is used match customers with local renewable generators. Transparency and choice leads to increased customer loyalty.

The peer-to-peer market platform is trialled with a Dutch and an Italian supplier of renewable energy.

Local flexibility trading: Service for DSOs who want to tender for customer flexibility as an alternative to reinforcing networks in congested areas. Service lowers barriers to entry for the long tail of flex providers. Resource optimisation algorithms can handle multiple buyers and sellers at scale.

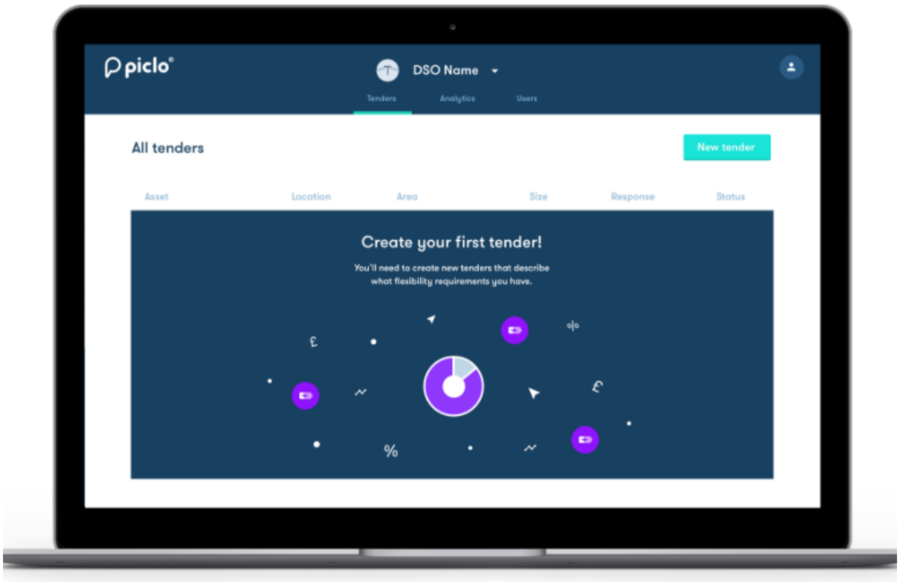

Figure 19 Open Utility local flexibility trading interface (source: website)

Open utility is currently active in the UK, in Belgium and Italy

Prosumer Acquisition Strategy

No direct prosumer acquisition, Open utility addresses retailers, aggregators and DSOs.

Assessment

Open utility offers specific services which are partly very similar to the GOFLEX approach.

The peer-to-peer matching of energy exceeds the scope of GOFLEX today but could be an option for the near future

The local flexibility trading supports the approach that the DSO could establish a local flexibility market for its own purposes, which is permitted and supported in the UK regulation. According to the website the service is currently under development.

The company is a start-up and really worth monitoring regarding their success in the market, especially after the launch of the flexibility trading platform in the UK.

5.3.2.3 **Lumenaza (GE)**

https://www.lumenaza.de/

Self-description

"Lumenaza is the software supplier for the new decentral and digital energy transition. The software is able to offer the whole range of functionalities which are required in the energy market in a modular "utility in box". We are able to operate renewable power plants, to include

electricity from big and small power plants, manage balance groups and provide real-time energy management data for all market actors. The green electricity can be directly sold to the customers. We make it possible to connect all participants of the new energy world on one digital market place and to operate the system in an intelligent way and thus address all suppliers, new actors and generators. Lumenaza makes a peer-to-peer energy market available."

Figure 20 Modules of the Lumenaza software (source: website)

Services

Lumenaza mainly supports the idea of "regional power", it combines the local renewable generation of a utility and the local utility sells it to their customers as local product. Lumenaza manages the balance group but could also appear as software provider offering the software as a "white label" product to the utility. The utility SWW Wunsiedel is currently a Lumenaza customer for their product "Fichtelgebirgsstrom". Lumenaza is currently only active in Germany.

Prosumer Acquisition Strategy

No direct prosumer acquisition, Lumenaza addresses mainly local and regional utilities, generators and energy communities.

Assessment

Since Lumenaza is already a service provider for our trial site in Wunsiedel, it would make sense to discuss with them, how the future local energy system in Wunsiedel could look like taking into consideration the Lumenaza BRP services and the GOFLEX flexibility tool box. It could be an excellent opportunity to demonstrate a fully decentralised local energy system. Lumenaza is in any way a strong candidate for the GOFLEX community.

5.3.2.4 BUZZN (GE)

Self-description

Since 2009 buzzn has connected energy providers and energy user. Today the community comprises a few thousand people, many of them organised in energy communities.

Buzzn is a toolbox for the ecological and social transformation of our energy system. The movement, that drives this transformation we call People Power.

The central BUZZN tool is the energy community ("Energiegruppe"), a new form of self-sufficient energy supply. An energy community is a container for exchanging electricity, money and information among people who share common targets of a real energy transition, sufficiency, autarky and local supply.

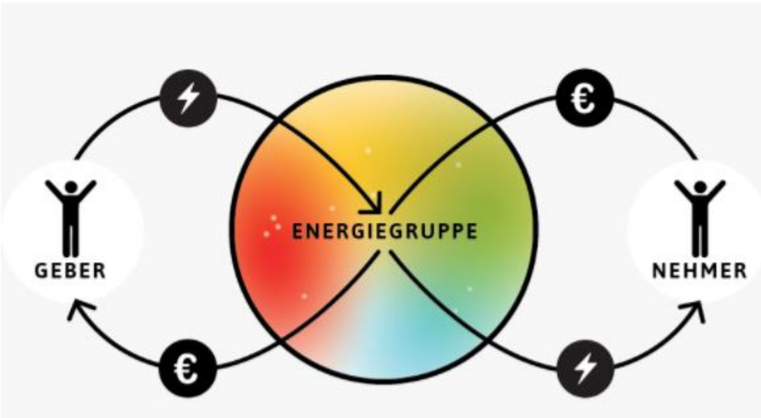

Figure 21 BUZZN energy community (source: website)

Services

BUZZN organises energy communities between local renewable energy generators/ prosumers and consumers. BUZZN acts as an energy retailer, but not as BRP, the BRP services are outsourced. BUZZN also operates microgrids in residential buildings ("Mieterstrom"= Tenant electricity). BUZZN is active in Germany.

Prosumer Acquisition Strategy

On its website BUZZN offers a comprehensive description of its community approach which is clearly designed for prosumers with green values who want to support regional renewables (including the vegan movement, PV on factory farms are not welcome). The approach is clearly anti-establishment. Besides the website BUZZN acquires customers by recommendation of BUZZN community members in an unstructured way, mouth-to-mouth. Apart from the website , the company has no marketing activities.

Assessment

BUZZN supports the local energy approach and fits into the GOFLEX philosophy. They are also competitors to local utilities (like SWW) since they target prosumers all over Germany.

They manage their business with their own software and hardware. However, they do not have an approach for local flexibility, the BRP management is done by a service company probably using the spot market to balance its balance group.

If BUZZN aims to manage its communities as balance groups, the GOFLEX solutions could be a suitable approach.

5.3.2.5 Good Energy, Selectricity(UK)

https://www.goodenergy.co.uk/selectricity/

Self-description

"20 years ago, people in the UK had little choice about where their energy came from. 98% of UK energy was generated from fossil fuels – and with the growing threat of climate change, we desperately needed alternative and more sustainable options.

Good Energy was set up to give people the choice to do something about climate change by choosing renewable energy for their homes and businesses – and we've been doing just that ever since."

Services

Selectricity is a special service portal of „Good energy" Besides other services it offers to "Select from your nearest sustainable electricity generator - show your support for the local economy and the community you work in."

It is supporting generators and businesses (no private consumers) to match supply with demand and helps raising awareness of the local renewable energy market place.

Good Energy is active in the UK.

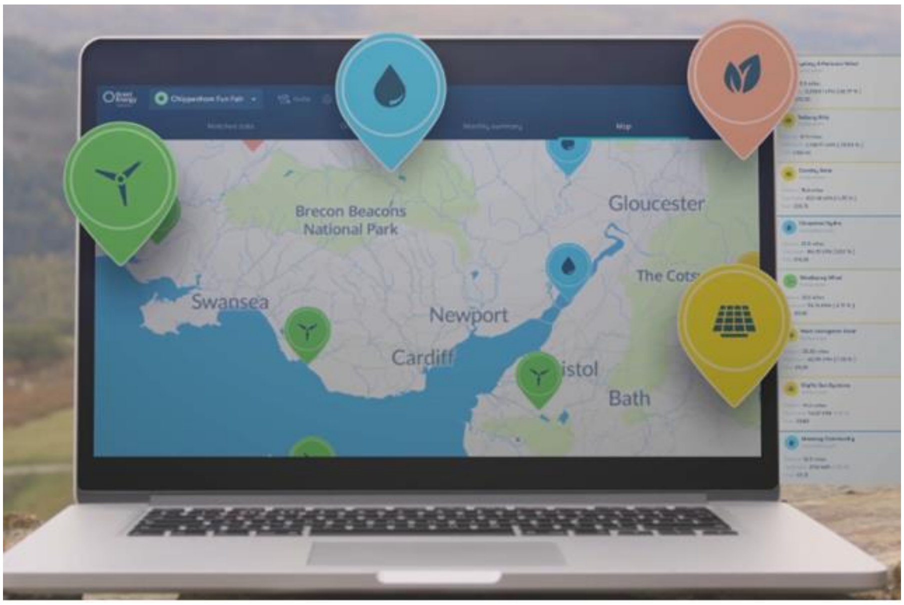

Figure 22 Good Energy Selectricity service (source: website)

Prosumer Acquisition Strategy

Good Energy is mainly an eco power provider. The Selectricity service is to find among other business services. Generators are addressed separately. There is no community approach in the marketing, no acquisition of prosumers, the company appears as green utility.

Assessment

Very similar to Lumenaza and buzzn, Good Energy provides (commercial) consumers the possibility to buy directly from local energy providers. It is not clear if Good Energy is a BRP (like Lumenaza) or uses the services of a BRP (like BUZZN). For Selectricity, Good Energy collaborates with Open Utility which has an approach similar to GOFLEX. Good Energy is a candidate for the GOFLEX Community for experience exchange.

5.3.2.6 StromDAO (GE)

www.stromdao.de

Self-description

"The StromDAO uses the blockchain technology to coordinate concrete actions decentrally and to develop an innovative electricity product with the cooperation of the consumers.

DAO is an acronym for "Decentral Autonomous Organisation"

STROMDAO
digital energy infrastructure for tomorrow.

Figure 23 StromDAO claim (source: website)

Services

StromDAO offers power to end consumers based on blockchain technology as energy retailer.

It is also able to support peer-to-peer networks or local energy markets technically. Utilities can use this open source software to create new energy products. The emphasis of the technology approach is on the consensus about a closed energy contract within a certain timeframe and the recorded transaction in 15min intervals.

A reference application is the billing within a residential building operated as microgrid with power feed-in from the roof PV combined with the supply of the local energy supplier. Due to the billing via blockchain each source of energy and money is replicable.

Prosumer Acquisition Strategy

Very basic and technical website. No references to renewables or green energy or other services for customers. This portal is for blockchain fans.

Assessment

It is very difficult to say, what the impact of this technology will be and how StromDAO will perform at the energy market. The chances are high that it will revolutionise the energy market and build the base for future peer-to-peer market transactions. The GOFLEX consortium will monitor the developments in this area and assess the areas of the energy market where Blockchain technology in future is useful or even absolutely required. Definitely a candidate for the GOFLEX community.

6 Conclusion: A possible roadmap for GOFLEX business model development

The use of volatile and decentral renewable energies will change the energy system. There is still a lot of debate though how it will finally evolve.

One development can be predicted: the use of decentralised power generation will increase and this will automatically demand a more decentralised structure of the energy system, that considers local generation, local consumption and the needs of the local grid.

It is also very certain that flexibility in energy supply and demand will play a key role in this upcoming energy system and flexibility will be considered as a complementary product to energy and traded separately (as it is seen already today at the only open flexibility market- the power reserve market).

Another aspect of the increased share of renewables are the increased challenges to the distribution grid. The requirements of the grid operation need more and more to be coordinated with the process of the energy markets, if the investments costs in the “copper plate” shall be limited. The most significant use case showing this challenge is the islanding mode of a distribution grid, when the whole system, generation, consumption and the physical requirements of the grid need to be balanced.

The GOFLEX toolbox offers a lot of solutions to the emerging decentral system and the approach that was taken to collaborate with smaller local utilities to test and demonstrate all building blocks of the solution and to support them to implement all possible business models seems to be a good way to go. It is also a good strategy to get the first revenue streams from established TSO-centric services like the provision of reserve power, but this can only be the start.

GOFLEX works with state-of-the art components with one big exception: The local flexibility market based on local Flex-Offers. The advantage of a local flexibility market and Flex-Offer strategy need to be proven and demonstrated during the project time.

It is very difficult to predict the “ideal” way to implement the GOFLEX toolbox into the market, when the demonstration was successful and the project is finished.

It is certainly a good idea to team up with the other players today (which might turn into future competitors) pursuing a decentralised energy market and join forces to change thinking paradigms, market models and regulation:

Today locally produced renewable energy has no commercial advantage compared to centrally produced energy though it uses less grid resources. Additionally, fossil energy does not pay the costs of the climate change and nuclear power pay only a small share of the nuclear waste costs. But that might change in future and will boost the business models of local energy communities and local virtual power plants based on renewable energy.

Today the DSOs are not in the driver seat for their grids. The grid paradigm today is still the “copper plate” where the grid is capable to connect generators and consumers wherever they are located in Europe and the whole system is managed by the TSOs.

The DSO in most countries today is not remunerated for avoiding costs regarding black-outs, congestions and grid expansion, not to mention a remuneration for being able to perform islanding mode. But these “avoided costs” cases are the backbone for the GOFLEX business models.

There is still a lot of change needed in market, regulation and in the energy paradigms.

To move forward, it is certainly a good idea to find during the project time further small and medium-sized utilities who are interested to use their consumer base to turn it into a prosumer base and/or utilise their local potential of local generation and integrate it into a local energy system. That is the main target group of the GOFLEX community.

Smaller utilities have a good predisposition to survive in a transition to decentral local energy system: They have always been local, they don't need to acquire this credibility.

In a more decentralised energy system they need to take this role fully and balance energy supply and demand and the needs of the local grid with their own resources and the support of their local citizens. With the GOFLEX tools they can start to develop in this direction.

GOFLEX will have the tools and the partners from the GOFLEX community in place to make this happen.

When we look at the individual situation of the countries in Europe regarding market and regulation framework, Switzerland is the most promising country in Europe followed by France, Belgium, Great Britain, Ireland and Finland.

7 References

ACER (2011) ACER's Framework Guidelines on Electricity System Operation

BNetzA (2017) Flexibilität im Stromversorgungssystem. Bestandsaufnahme, Hemmnisse und Ansätze zur verbesserten Erschließung von Flexibilität. Diskussionspapier BnetzA; April2017

BNetzA (2016) Branchenleitfaden Regelleistungserbringung durch Drittpartei-Aggregatoren gem. § 26a StromNZV (Berlin, den 05.12.2016)

CEER (2017) European Energy Regulators' White Paper # 3 Facilitating flexibility Relevant to European Commission's Clean Energy Proposals 22 May 2017

CEER (2016) National report Cyprus 2016 to the European Commission

De Heer et al., (2016) USEF: WORK STREAM ON AGGREGATOR IMPLEMENTATION MODELS

Delnooz et al., (2012) e-Harbours Identification and analysis of barrier_VPP

Dena (2017) Netzflexstudie, Optimierter Einsatz von Speichern für Netz- und Marktanwendungen in der Stromversorgung

Der Schweizerische Bundesrat (2008) StromVV. Art. 26 Control and compensation energy; https://www.admin.ch/opc/de/classified-compilation/20071266/index.html#a22

drip-project (2015) Activity B4 - - Demand Response in Industrial Production https://www.drip-project.eu/project/workplan/action-b4.html

EASME (2017) Smart Grids report

Ecofys (2014), Flexibility options in electricity systems.

ENTSO-E (2015): The Harmonized Electricity Market Role Model, version 2015-01

ENTSO-E, (2017) Clean Energy Package: Promising market proposals, but some issues to be solved

ENTSO-E (2013). Supporting Document for the Network Code on Electricity Balancing of 23 December 2013

EPEX (2015): Press release, available at: https://www.epexspot.com/document/30189/2015-01-13_EPEX%20SPOT_2014_Annual%20Press%20Release+.pdf (retrieved on 11th October 2017)

Eurelectric (2014). Flexibility and Aggregation Requirements for their interaction in the market. [Online] http://iet.jrc.ec.europa.eu/energyefficiency/esco.

European automobile manufacturers Association (2017). Statistics. [Online] http://www.acea.be/statistics/article/trends-in-fuel-type-of-new-cars-between-2015-and-2016-by-country.

European Commission (2016). Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources (recast). Article 2(16) on common rules for the internal market in electricity (recast), 30.11.2016, COM(2016) 864 final 2016/0380 (COD)

European Commission (2016). Clean energy for all Europeans ("winter package")

European Commission (2009). Articles 2 and 25 of 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

Gkatzikis, I., Koutsopoulos, I., and Salonidiset, T (2013). The Role of Aggregators in Smart Grid Demand Response Markets. IEEE Journal on Selected Areas in Communications. 31, 2013, 7, S. 1247-1257.

IEA (2014) – the power of transformation

IWR online (2016). IWR News. [Online] . http://www.iwr.de/news.php?id=31960.

Ludwig Bölkow Systemtechnik (2014). Bundesverband Erneuerbare Energien e.V. [Online] 2014. https://www.bee-ev.de/fileadmin/Publikationen/Pr%C3%A4sentationen/Hannover_Messe_2014/20140409_Power_to_gas_Matthias_Altmann.pdf.

Osterwalder, Pigneur (2010), Business Model Generation. ISBN: 978-0470-87641-1

Paschotta. (2017). RP-Energie-Lexikon. [Online] 2017. https://www.energie-lexikon.info/power_to_heat.html.

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

Smart Energy Demand Coalition (2017) Explicit Demand Response in Europe Mapping the Markets 2017

Swissgrid (2017) https://www.swissgrid.ch/swissgrid/de/home/experts/topics/ancillary_services/prequalification.html

vdma Power Systems. (2010). elektrotechnik & automation. [Online] 2010. http://www.etz.de/files/vdma+ps_strommix_ausblick_final.pdf.

Warren, Peter (2015). Demand-Side Management Policy: Mechanisms for Success and Failure. August 2015. PhD thesis submitted in fulfilment of the degree of Doctor of Philosophy in Energy Policy; UCL Energy Institute. University College London (UCL)

Warren, Peter (2014). Demand-Side Management Policy: Failure and Transferability, University College London

Wissenschaftlicher Dienst des Bundestages (2017). Entwicklung der Stromspeicherkapazitäten in Deutschland von 2010 bis 2016. 2017.

Mirabel (2013): Miracle, Micro-Request-Based Aggregation, Forecasting and Scheduling of Energy Demand, Supply and Distribution, Specific Targeted Research Project: 248195