Investigation and comparison of EU-wide regulations and rules concerning the commercialization of end-customers flexibility and building local energy market places/platforms

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EXECUTIVE SUMMARY

The transition towards a new era for energy and environment in the European Community, presents challenges unlike any the Grid has face in the past. Increasing energy demand creates concerns on environmental effects and energy bills, and the Grid stability is threatened by the injection of unpredicted energy volumes at various grid points, where distributed renewable energy resources are connected.

Under this prism, InterFlex commits to cross carrier energy system integration and flexibility, offered at the level of local energy systems and at distribution grid level. For demonstrating effective and scalable solutions, a clear understanding of the relevant regulatory framework is needed, to adapt to the relevant requirements and identify possible barriers that, at both European and national levels, need to be addressed in order to enhance the distribution grid flexibility.

In this context, the present work provides insights on the following two topics on a EU-wide scale as well as on national level for two example Member States, Sweden and Germany:

- Regulations and rules concerning local energy market places
- Regulations and rules concerning the commercialization of end-customers' flexibility

These topics are of major importance, as the transformation of the energy system requires the implementation of demand-side management approaches, with more emphasis on making end-users active players in the energy system. A number of regulatory barriers, for example the obligations from the Electricity Act in Germany that apply to prosumers who would like to form a local energy market, need to be removed, improved and adapted to successfully transform the energy system.

Concerning their flexibility, end-customers are currently seen as having great potential for helping with the integration of Renewable Energy Sources (RES), system balancing and postponing of investments in the grid.

On the other hand, Local Energy Markets are considered to function as a playing field for exploitation of such flexibility and reducing overall complexity of the grid. Because of above stated, regulations and rules and a national and EU-wide level are the main enablers of a transition of the grid towards high penetration of Renewable Energy Sources and in order to meet European Union's targets on climate protection and integration of renewables.

Currently, both concepts of local energy market and flexibility are not defined on a European level and have to be addressed in future legislation. With the new "Clean Energy for all Europeans" package, the roles and responsibilities of participants in local energy markets are defined, which is a first step on a European level towards establishing local energy markets and communities as well as for end-customers to commercialize their energy flexibility.

As a part of this "Clean Energy for all Europeans" package, the European Commission proposed an update to the Energy Efficiency Directive containing a new 30% energy efficiency target for 2030, and measures to ensure that the new target will be achieved. The topics covered in this paper are one of the enablers in meeting these challenging targets.

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LIST OF ACRONYMS

Acronym	Meaning
ACER	Agency for cooperation of energy regulators
BRP	Balance Responsible Party
BSP	Balancing Service Provider
CEER	Council of European Energy Regulators
CPP	Critical peak pricing
DSO	Distribution System Operator
Ei	Energy market inspectorate in Sweden
ENTSO-E	European network of transmission system operators for electricity
EURELECTRIC	The Union of Electricity Industry
GDPR	General Data Protection Regulation
ICER	International confederation of energy regulators
ICT	Information and communication technology
LEC	Local Energy Community
LEM	Local Energy Market
LES	Local Energy System
NRA	National regulatory authorities
P2P	Peer to peer
RES	Renewable energy source
RTP	Real-time pricing
ToU	Time-of-use
TSO	Transmission System Operator

1. INTRODUCTION

1.1. InterFlex project

The InterFlex project is part of the European Commission's Horizon 2020 framework program for research and technological development. This project addresses present challenges of the distribution system with respect to environmental and performance concerns. Environmental challenges are the member states' obligation to significantly reduce greenhouse gas emissions and to increase the share of energy generation from renewable energy sources. Additionally, the performance of distribution systems has to be improved since they play a vital role in handling the increasing complexity of the electricity system and because of their potential connections to other sectors, such as heat, transport, or gas.

These challenges primarily have to be approached by increasing the level of automation in order to handle more complex operations, and by aggregation of consumers/prosumers. In order to support the grid, flexibility is seen as a key enabler that has to be utilized through market signals sent by distribution system operators in order to nudge consumer/prosumers to exploit their generation or consumption capabilities.

Therefore, the overarching goal of the participating consortium in the InterFlex project is to demonstrate that combining network automation with the local generation and/or consumption flexibility can make local energy systems more reliable and more competitive. The three main directions of the project are improving smart grids via demand-response, energy storage, and cross carrier energy system integration.

This study in particular provides an overview of the current legislative framework on a European and national level dealing with the development of local energy markets (LEMs), and the commercialization of end-customers' energy flexibility.

1.2. Motivation

Buildings are responsible for 40% of the total energy consumption (European Union, 2010) and 36% of CO_2 emissions (European Commission, 2017) in the European Union (EU). The EU committed itself to the reduction of its greenhouse gas emissions of at least 80% below 1990 levels by 2050 (European Commission, 2017) (European Commission, 2011). This ambitious goal leads to new designs of existing regulations and new approaches to achieve it. This goal requires energy savings as well as an increased energy generation from renewable energy sources (RES).

RES mainly concerns fluctuating generation from wind and solar sources. In order to integrate a large share of such volatile generators, system flexibility is necessary. Such flexibility can for instance be generated through controlling loads of end-customers via demand side management or demand response schemes. In this manner, peak loads and stress on the grids can be reduced, resulting in reduced operating and grid investment costs as well as an increased integration of RES. However, from a distribution system operator's (DSO's) perspective, controlling end-customers' consumption patterns and flexibility is not yet clearly defined with regulations in current market schemes.

Since RES are usually connected to the distribution system, a high penetration of RES today already poses challenges to the existing grid infrastructure, in particular voltage increase and higher fault levels. It is expected that these challenges will increase in the future with higher capacities of RES. LEMs are a viable option for coping with these challenges. Additionally, LEMs allow for balancing sub-grids and reducing electricity flows from and to the distribution grid. The establishment of LEMs requires modern ICT infrastructure, allowing for a fast and bidirectional communication between consumers and generators allowing also supervision from DSO point of view. Such a marketplace for locally available energy or capacities could be established online through the Internet to overcome accessibility issues. This marketplace is widely considered in Smart Grid strategies and would serve as a platform for stakeholders to interact with each other (Federation of German Industries (BDI), 2010) (European Technology Platform SmartGrids, 2010).

Within LEMs, the consumption and generation capabilities of all participants can be combined, allowing for large energy flexibilities that could enable a better integration of RES. In this manner, the participants within a LEM can be bundled to Prosumer Virtual Power Plants (PVPP) that can adapt their consumption and generation patterns depending on the flexibility of the prosumers that constitute them (Karnouskos, Communityware SmartGrid, 2011) (Karnouskos, Crowdsourcing information via mobile devices as a migration enabler towards the SmartGrid, 2011). Such flexibilities are crucial for maintaining a cost-efficient high quality of electricity supply, a secure and stable grid, and to create a level playing field for innovative services in a cost-efficient, transparent and secure way (European Distribution System Operators for Smart Grids, 2014).

One concept of flexibility that has already been used is demand side management (DSM). DSM attempts to steer consumers to shift their flexible loads or generate electricity to support the grid, through methods such as financial incentives and education. The integration of large-scale DSM can be facilitated by aggregators that combine a group of participants and interact with them in real-time through modern ICT infrastructure. However, since these mechanisms have not been defined within a regulatory context yet, the full of potential of customers' flexibility has not entirely been exhausted, yet.

1.3. Document overview

The remainder of this document is structured as follows. The next chapter summarizes the historical developments of EU legislation regarding electricity markets.

Chapter 3 provides an overview of LEMs. First, a detailed introduction to LEMs is given, then EU regulations and directives regarding LEMs are presented, and barriers towards their successful implementation are discussed. Afterwards, national rules and regulations on LEMs for Sweden and Germany are described. Finally, chapter 3 closes with final conclusions on current regulations regarding LEMs on a European level.

Chapter 4 deals with the commercialization of end-customers' flexibility. This chapter starts with an introduction to energy flexibility, then regulations and laws on this topic as well as current barriers on a European level are described. Subsequently, the legal framework on energy flexibility in Sweden and Germany is analyzed.

Finally, chapter 5 summarizes this study and presents and outlook for future work.

2. HISTORICAL DEVELOPMENTS

From the 1990s, European Union agreed to move from monopoly markets to competitive "liberalised" energy markets. Via EU laws, the national energy markets have been progressively liberalised in the Member States. The objective is to achieve an internal energy market for the entire EU, which is competitive, secure and environmentally sustainable.

Internal energy market policy has gone through three different stages, now so called first, second, third energy policy package and the ongoing fourth so-called "Winter package" also referred to as "Clean Energy for All Europeans". The first energy package was adopted with 1996 Electricity and 1998 Gas directive as major outputs.

Article 15 of the Directive 96/92/EC concerning common rules for the internal market in electricity introduced requirements for separation of operations for vertical integration companies.

Article 15:

"1. Member States which designate as a single buyer a vertically integrated electricity undertaking or part of a vertically integrated electricity undertaking shall lay down provisions requiring the single buyer to operate separately from the generation and distribution activities of the integrated undertaking.

2. Member States shall ensure that there is no flow of information between the single buyer activities of vertically integrated electricity undertakings and their generation and distribution activities, except for the information necessary to conduct the single buyer responsibilities" (European Parliament, 1996).

The directive also set out key rules on unbundling – the idea that a supply company cannot also own an entity that operates a network – and rules for transmission system operators (TSOs) and distribution system operators (DSOs). Member states were required to designate whether the TSO or DSO would determine 'non-discriminatory access to networks'.

The second package was adopted in 2003 containing revised Electricity and Gas directive, as well as specific regulations to harmonized trade in across EU Member state borders.

Directive 96/92/EC and Directive 2003/54/EC have been the first directives aimed at defining common rules for an internal electricity market creating a level playing field for generation (as a part of first and second energy policy package). Both aimed at higher efficiencies, price reductions, increased competitiveness and non-discriminatory transmission and distribution tariffs.

Despite second energy package, from (Commission of the European Communities, 2007) can be seen that meaningful competition did not exist in many Member States. Often customers did not have any real possibility of opting for an alternative supplier. Even customers who had successfully changed supplier were often not satisfied with the range of offers they receive. In summary, stakeholders did not yet have a high degree of confidence in the internal market.

In 2009 the Renewables Directive set binding targets for all EU Member States, such that the EU will reach a 20% share of energy from renewable sources by 2020 and a 10% share of renewable energy specifically in the transport sector.

With the so-called Third Energy Package, passed in 2009, Directive 2003/54/EC was repealed by Directive 2009/72/EC liberalizing and opening energy markets, and strengthening consumer rights. Core elements include the ownership unbundling of companies' energy generation from energy transmission as well as the establishment of a network of transmission system operators. The three Regulations introduced were regarding access to the natural gas transmission networks (EC/715/2009), conditions for access to the networks to allow cross-border electricity exchange (EC/714/2009), and the establishment of ACER (EC/713/2009). Amongst its key provisions, the Third Energy Package reinforces:

- Consumer rights
- Powers and responsibilities of national regulatory authorities
- Independence of the non-competitive part of the market (network operation)
- Transparency and non-discrimination among market actors
- Harmonisation of wholesale market rules across the EU
- Cross-border collaboration and investment.

During November 2016, the European Commission proposed a fourth package, entitled "Clean Energy For All Europeans" (also called "Winter Package") with the goals of putting energy efficiency first, achieving global leadership in renewable energies and providing a fair deal for consumers. The Clean Energy for All Europeans legislative proposals cover energy efficiency, renewable energy, the design of the electricity market, security of electricity supply and governance rules for the Energy Union. The package also includes actions to accelerate clean energy innovation and to renovate Europe's buildings. The European Commission, together with 14 EU countries (Croatia, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Malta, Portugal, Spain, and Sweden) have also signed a political declaration to launch the new 'Clean Energy for EU Islands' initiative on 18th May 2017. The proposals will improve the key legal acts that were part of the Third Energy Package. These include the Electricity Regulation (No 714/2009) and the Electricity Directive (No 2009/72/EC), alongside the Regulation establishing ACER (No 713/2009). Moreover, the "Winter package" includes a proposal for regulation on risk-preparedness in the electricity sector repealing Directive 2005/89/EC, a proposal for amending directive 2012/27/EU on energy efficiency, and a proposal for amending directive 2010/31/EU on the energy performance of buildings. In addition, the "Winter package" gives a Directive in the promotion of the use of energy from renewable sources. The package has shed some light on two key areas for LES. Firstly, it outlined a definition of a "local energy community", which for all intents and purposes, is a definition for an LES. Some regulations were also proposed around the running of LECs, including entitlement to autonomously manage networks, cost reflective charging and an assurance that participants can leave an LEC. Secondly, some promising new rules regarding flexibility have been set out.

3. REGULATIONS AND RULES CONCERNING BUILDING LOCAL ENERGY MARKET PLACES/PLATFORMS

European greenhouse gas emission reduction targets led to a significant development and installation of distributed energy resources, mainly from solar and wind energy. Such distributed generation offers several advantages compared to a traditional power system relying on centralized power generation: Firstly, micro-grid with distributed energy resources and energy storage have to potential to improve security of energy supply since sources are connected in close proximity to the consumers. Secondly, local generation may improve grid resilience and help mitigating large grid disturbances. Furthermore, since energy is generated closely to the customers, distribution losses can be significantly reduced.

However, such a distributed energy system relies on a large number of small-scale generation units, leading to a more complex power supply system. A possible approach to reduce system complexity is the introduction of LEMs.

The draft of the directive for the internal market in electricity (European Commission, 2017), in article 2 proposes a definition of a "Local Energy Community". This definition introduces the possibility that the local energy community acts as a LEM for the first time in the regulatory framework of the EU. It states: "'Local energy community' means: an association, a cooperative, a partnership, a non-profit organisation or other legal entity which is effectively controlled by local shareholders or members, generally value rather than profit-driven, involved in distributed generation and in performing activities of a distribution system operator, supplier or aggregator at local level, including across borders".

Such LEMs should allow for producers, consumers and prosumers (consumers who also produce energy on a small scale) to interact and trade energy or capacities with each other. This enables local power balancing and reduces the complexity of the total grid by balancing local units separately.

Furthermore, local energy markets can be an incentive for the stakeholders to actively collaborate in the energy sector. Participants are much more motivated to contribute to energy generation, adjustment of energy consumption or trading of energy, if they feel it to be close to them, e.g. if the local energy market is about their community, rather than some energy market where they interact with people they have never met, therefore being a much more abstract construct for the participants (Kotilainen, Mäkinen, & Järventausta, 2016).

LEMs could play a significant role in using the flexibility available in a local energy system through both generation and demand, in order to provide flexibility both system wide and locally, and for providing capacity to the system using both the generation and the potential demand reduction.

Lastly, LEMs are promising from an economic point of view. As the number of participants grows, more and more competition will arise. This benefits consumers as they have a multitude of energy providers to choose from. LEMs also tend to ease the barrier for small producers (or prosumers) to enter the energy sector. Furthermore, LEMs allow for new business models, such as offering flexibility or aggregator services combining a group of small-scale participants.

Figure 2.1 shows possible relations between the market roles. An aggregator is an entity acting as an intermediary among various consumers, prosumers and other players in the system. Its main function is to group large numbers of relatively small consumers to create economies of scale and simplify overall system operation. Some of these consumers may have storage and/or production capacity participants. Aggregators will be the main actors in the commercialization of end-customers flexibility. Market rules should be harmonized with the characteristics of aggregated demand response and generation (eurelectric, 2014).

The European network code on electricity balancing should provide a level playing field for all flexibility providers (European Commission, 2017).

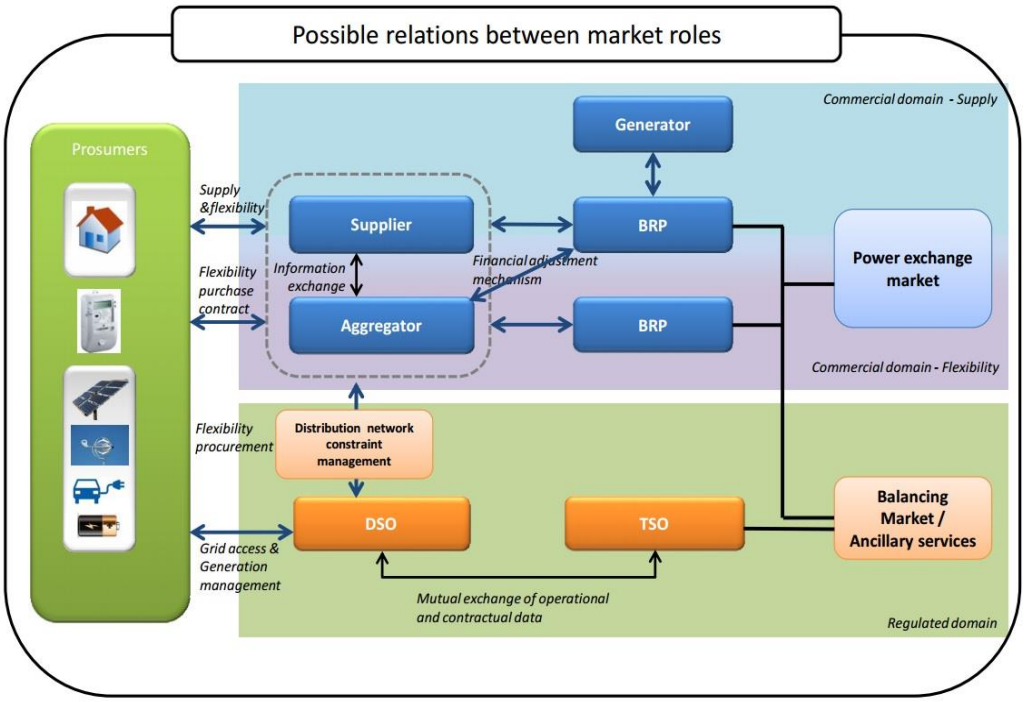

Figure 1. Possible relations between the market roles (Smart Grid Task Force, 2015, p. 8)

Stated above are the motivations for local energy markets, which in turn require local energy platforms. So far, we have outlined the purpose and aim of a local energy market. The following sections illustrate how local energy markets can be structured.

3.1. Roles of the actors in local energy market conditions

To enable a LEM market the roles and responsibilities should be clear, taking into consideration that one company can maybe fulfil more than one role. We should be able to incentivise consumers to participate on market and incentivise Balance Responsible Parties (BRPs), TSOs, DSOs and aggregators to use that opportunity. Robust pricing signals will ensure that balancing can be undertaken in the most efficient way and should try to ensure that the consumer receives the real market value for participation, so that benefits are properly shared amongst all network users (Smart Grid Task Force, 2015).

- Aggregator
  The aggregation service provider role can be taken by a third party aggregator or by a supplier (Smart Grid Task Force, 2015). For example in case of the Czech Republic, aggregation is already realized by retailers/suppliers (for consumption as well as for DERs). Usually, when the aggregator is a third party their contractual and legal relationship to other market actors is not covered by legislation in most Member States (Smart Grid Task Force, 2015). The consumer should have access to the best demand side flexibility offers available and to the service providers of their own choice. In the „Winter package" of the EU it is made a clear difference between aggregator and independent aggregator. While 'aggregator' means a market participant that combines multiple customer loads or generated electricity for sale, for purchase or auction in any organised energy market, ´independent aggregator´ means an aggregator that is not affiliated to a supplier or any other market participant.
- Balance Responsible Party (BRP) and Balancing Service Provider (BSP)
  From the proposal for a regulation on the internal market, electricity balance responsible party means a market participant or its chosen representative responsible for its imbalances in the electricity market (European Commission, 2017). All balancing service, energy and congestion management services need to be measured and there is need for no overlaps between market participants' responsibilities. Imbalances need to be fairly assigned (Smart Grid Task Force, 2015).The BRPs are core of European wholesales markets. Commonly, consumers suppliers are also and consumers BRP. If BRP is also an aggregator, much like a supplier, all the actions of the aggregator lead to an increase or decrease of the production or consumption of the BRP without requiring any direct intervention on the markets.
- Supplier
  A supplier is a company supplying electricity to end consumers. Suppliers should empower consumer flexibility with its incentives (dynamic prising for example). Dynamic pricing refers to retail electricity prices that concerns at least part of the wholesale price volatility to final end users. The EU definition of dynamic pricing should be extended to include time-of-use pricing (ToU), Critical peak pricing (CPP) and Real-time pricing (RTP) (euroelectric, 2017). The "dynamism" of these possibilities depends on the length of pricing interval and on how prices are set within each pricing interval (euroelectric, 2017).
- TSO
  Main role of TSOs is to ensure the overall system security and guarantee frequency system balancing and therefore TSOs have important role in enabling demand side flexibility to develop. The TSO (also DSO) acts as neutral market facilitators between aggregators, BRPs and suppliers, providing the communication and settlement services (Smart Grid Task Force, 2015). In a LEM, it will be important that TSOs and DSOs communicate and exchange relevant operational data.
- DSO
  For DSOs, local energy markets are important issue concerning optimization of investments and flexibility provided by customers that can be used for different purposes. DSOs should have the opportunity to use flexibility services where this provides a benefit to the network and hence to the consumer. Via proper regulation, DSO customers can benefit from new services, which can enhance competitive markets (Smart Grid Task Force, 2015). It is important to highlight that DSO could compare costs of asset investments with possible flexibility services, and compare

technical parameters such as the reliability level etc. DSO must have a right to decide whether to buy a flexibility or invest into its own asset.

About the topic of TSO-DSO platform and communication in the TSO-DSO data management report (CEDEC; EDSO; ENTSO-E; EUROELECTRIC; GEODE) as a tasks for TSOs and DSOs are pointed that:

- Data exchange must support efficient market functioning
  TSOs and DSOs should publish a service catalogue describing the different services they provide on data exchanges, data delivery and transparency.
- TSOs and DSOs will further develop data privacy and security standards
  TSOs and DSOs will further develop data privacy and security standards in a cost-effective manner.
- The level of data granularity should be defined depending on the task
  The defined roles and responsibilities approved by NRAs will set the level of detail needed for the delivered data.

The following should be addressed in the regulations: data from DSO to TSO, data from TSO to DSO, data from DSO to DSO and TSO to TSO, data from third parties to DSO and/or TSO and data commonly agreed-upon between the DSO and TSO (CEDEC; EDSO; ENTSO-E; EUROELECTRIC; GEODE). It is needed to first discuss and agree upon common principles for data management in general, and later define solutions.

A local energy market either has to provide a means for producers to offer their generation capacities and for consumers to retrieve these offers, or for consumers to make bids for energy and for producers to respond to these bids. An ideal market enables both options, making the market flexible for both producers and consumers. Since such a transparent platform requires the publication and sharing of large amounts of personal data, mainly consumption patterns, LEMs have to be regulated to guarantee data privacy and data protection. Regulations should however, ensure on one hand the balance of consumer protection and an option to anonymize personal data where appropriate and on the other hand the interests of energy producers and suppliers and at the same time make it feasible for small participants to join the market.

As a result of everything above mentioned about LEMs, there should be some consideration as to how these markets are designed and to explore suitable market designs for a Local Energy System (LES) proposition, which will lead to a transparent market. It is also important to understand any regulatory environment around the provision these services in order to identify any possible barriers and potential implementation strategies to overcome barriers.

In several members states there is a tendency for restriction of numbers of offers retailers are allowed to propose to the customers (euroelectric, 2014). This can have a great influence on prices and thus influence on market competitiveness.

Markets should facilitate transparency with:

- Standardized products
- Auction based procurement
- A single trading platform with visible offered/accepted prices
- Minimum standards of data provided by market participants

In LEMs, we should take care that these requirements are fulfilled. Peer to peer (P2P) energy trading could be an important part of an LES, as it gives members of the LES the ability to interact with each other and could contribute to the LES self-managing itself. There are a few different definitions of what peer to peer trading actually is, not all of which are straight forward from a regulatory point of view. The different types and the associated challenges are shown below.

- Prosumer as a supplier
  Peer to peer in its truest form is where a prosumer is able to directly supply consumers with their exported energy. The main problem with this form of peer to peer is that there currently seems to be no way of the prosumer actually acting as a supplier, specifically when it comes to attributing and paying associated system costs. In this case, the prosumer should fulfil all legal requirements as retailer/supplier. The electricity supplied by prosumer to nearby consumers is distributed through distribution grid, so the distribution tariff for electricity consumed by consumers have to be paid.
- Supplier as a P2P facilitator (reservation of generation)
  Another way by which a form of P2P could be achieved is where a supplier acts as a facilitator of a pseudo peer to peer transaction. What is meant by this is that a prosumer can market their energy on some sort of web interface, whilst consumers wanting to participate in P2P can reserve this capacity.
- Peer to Community
  A peer to community system, where prosumers provide their excess energy for the community as a whole to use, would be a more simple way of achieving a sort of peer-to-peer offering whilst maintaining much of the benefits of a true peer-to-peer system such as using locally produced energy near to the source.

Two groups were set up with the intent of supporting the European Union and the market participants. The European Regulators' Group for Electricity and Gas was the first one and was established in 2003. Its responsibilities comprise ensuring cooperation between national regulators and proper application of the internal market directives within the Member States (European Commission, 2003). The second one was the European Agency for the Cooperation of Energy Regulators (ACER), which was established in 2010 (European Commission, 2009). Both have an advisory role to the European Commission and the Agency acts as a supervisor (European Parliament, 2017).

In the following we will investigate rules and regulations concerning local energy markets in the entire European Union, as well as a closer investigation of rules and regulations in Sweden and Germany, as those are the countries that are relevant for this work package of the InterFlex project.

3.2. Regulations and Rules in the European Union

With the Third Energy Package, the European Union took a step into the direction of promoting competitiveness. One major task was the unbundling of generation and transmission. Another major aim for the Third Energy Package was to improve customer protection. In this context, for example, it was decided, that consumers have to have the possibility to switch energy supplier without cost in three weeks, therefore strengthening consumer rights (European Union, 2009).

For (establishing) local energy markets as a special case of energy markets in the European Union, several aspects have to be considered:

- Regulations on energy business and trading.
- Regulations on consumer protection.
- Regulations on data protection.

Table 1 provides an overview of the relevant regulatory framework.

Table 1. Overview of European regulations and directives regarding local energy markets

Document	Description	Relevant Articles
Directive 2009/72/EC	Internal Energy Market Directive	
Regulation (EC) 765/2008	Setting out the requirements for accreditation and market surveillance relating to the marketing of products and repealing Regulation (EEC) No 339/93	Art 19: Market surveillance measures
Regulation EU 2016/679	European General Data Protection Regulation. Harmonizes rules for data processing of personal data by businesses and public entities. Valid starting May 2018; repeals Directive 95/46/EC	Art 5: Principles relating to handling personal data Art 6: Criteria for making data processing legitimate Art 12: Transparent information, communication and modalities for the exercise of the rights of the data subject Art 13 and 14: The data controller has to provide the data subject with several information Art 15: Right of access by the data subject Art 16: Data subject's right to rectification Art 17: Data subject's right to be forgotten Art 18: Data subject's right to restriction of processing Art 24: Responsibilities of the data controller

		Art 25: Data protection by design and by default Art 32: Security of processing Art 33 and 34: Behavior in case of security breach
Directive 95/46/EC	Protection of individuals with regard to the processing of personal data and on the free movement of such data. Valid until May 2018; repealed by Regulation EU 2016/679	Art 6: Principles relating to personal data Art 7: Lawfulness of data handling Art 10+11: Information to be provided to the data subject Art 12: Right of access by the data subject Art 14: Right of objection by the data subject Art 16: Confidentiality of data handling Art 17: Security mechanisms for processing data Art 18: Responsibilities in case of security breach
Regulation EU 2016/631	Establishing a network code on requirements for grid connection of generators	
Regulation 2016/1388	Establishing a Network Code on Demand Connection	
Regulation 2016/1952	Establishing a common framework for the development, production and dissemination of comparable European statistics on tariffs for household and final non-household customers	Art. 3: Data sources: Statistical surveys, administrative sources Art. 4: Coverage Annex II: Methodology for collecting and compiling data on electricity prices
Regulation 2013/543	Disclosure obligations apply to data relating to generation, transportation and consumption of electricity	Art 2: Definitions Art 4: Submission and publication of data

		Art 6: Information on total load Art 7: Information relating to the unavailability of consumption units Art 8: Year-ahead forecast margin Art 12: Information relating to the use of cross zonal capacities Art 14: Forecast generation Art 15: Information relating to the unavailability of generation and production units Art 16: Actual generation Art 18: Liability
Directive 2002/58/EC	Concerning the processing of personal data and the protection of privacy in the electronic communications sector (Directive on privacy and electronic communications)	Article 6: Traffic data Article 9: Location data other than traffic data

Regarding energy business and trading, **Directive 2009/72/EC** (European Union, 2009) is the only regulatory document identified to be relevant to energy markets. However, this directive does not specify local energy markets and the interaction of consumers and producers in such a market. According to (European Union, 2009) "the rules for organization of the sector are aimed at developing a competitive, secure and environmentally sustainable market in electricity".

It shall promote competitiveness, open up the market and ensure non-discrimination between all participants. For this reason, it demands that energy suppliers must be unbundled from network operators. Furthermore, not only from the supplier side the competitiveness shall be promoted not only from the supplier side but consumers shall also be enabled to compare the different suppliers better and participate in the market. Therefore, energy suppliers have to inform customers about the contribution of different energy sources. Non-household customers have the right to contract simultaneously with several suppliers. It further clarifies competition requirements. This, however, is only in the form of how the network should work and not how a marketplace should work. The directive moreover aims at increasing transparency in retail markets in order to benefit customers. For this reason, member states must organize a system of third party access to both the transmission and the distribution system. Tariffs based on this system have to be published increasing transparency.

Directive 2009/72/EC is also the relevant directive to address consumer protection in the energy sector. According to it, the national legislation in each member state of the European Union has to guarantee the energy consumer the following rights:

- Each user is provided an electricity connection and is therefore able to receive energy.
- EU countries have to ensure that customers have the right to choose their electricity supplier.
- Switching of suppliers must be fast and easy. To be more specific, users have the right to switch suppliers within three weeks without cost.
- Energy consumers have to be provided with sufficient contract information. They also have the right of withdrawal from contracts.
- The consumers have the right to receive accurate information about the energy consumer's consumption and billing based on it. They also have the right to information on how to use energy more efficiently.
- In case of complaints and disputes, consumers have the right of an easy resolution.

This Directive introduces and insists too the unbundling principle between producers, suppliers and transmission system operators:

"(12) Any system for unbundling should be effective in removing any conflict of interests between producers, suppliers and transmission system operators, in order to create incentives for the necessary investments and guarantee the access of new market entrants under a transparent and efficient regulatory regime and should not create an overly onerous regulatory regime for national regulatory authorities" (European Union, 2009).

However, in the directive, rules specific to local energy markets are not included.

Regulation (EC) 765/2008 (European Commission, 2008) provides a framework for market surveillance of products to ensure that those products fulfil requirements providing a high level of protection of public interests. In article 19 is written that Market surveillance authorities shall respond appropriately to alert users within their territories within an adequate timeframe of hazards they have identified relating to any product to reduce risk of injury or other damage. In the case of LEM injury can be unappropriated usage of data of the customer. Market surveillance authority is authority of Member State responsible for carrying out market surveillance on its territory. Therefore, from perspective of customer we need to have a party for dealing with the customer's privacy and security.

The aspect that EU regulations are most specific about is "data protection". It is addressed by the **European General Data Protection Regulation EU 2016/679** (European Commission, 2016). The reason a local energy market is affected by this regulation is straightforward. It is because the local energy market will be exposed to users' (personal) data. The General Data Protection Regulation (GDPR) (Regulation (EU) 2016/679) is a regulation which intention is to strengthen and unify data protection for all individuals within the European Union (EU). It also addresses the export of personal data outside the EU. The primary objectives of this regulation are to give control back to citizens and residents over their personal data and to simplify the regulatory environment for international business by unifying the regulation within the EU (unlike a directive, regulations do not require any

enabling legislation to be passed by national governments). This regulation have also a great social impact as it deals with personal data of citizens.

GDPR addresses the tasks, rights and responsibilities of and the interactions between the following roles:

- Data subject
- Controller
- Processor
- Recipient of data (whether a third party or not)
- Data protection officer
- Supervisory authority

"(7) 'controller' means the natural or legal person, public authority, agency or other body which, alone or jointly with others, determines the purposes and means of the processing of personal data; where the purposes and means of such processing are determined by Union or Member State law, the controller or the specific criteria for its nomination may be provided for by Union or Member State law;

(8) 'processor' means a natural or legal person, public authority, agency or other body which processes personal data on behalf of the controller;

(9) 'recipient' means a natural or legal person, public authority, agency or another body, to which the personal data are disclosed, whether a third party or not. However, public authorities which may receive personal data in the 4.5.2016 EN Official Journal of the European Union L 119/33 framework of a particular inquiry in accordance with Union or Member State law shall not be regarded as recipients; the processing of those data by those public authorities shall be in compliance with the applicable data protection rules according to the purposes of the processing;

(10) 'third party' means a natural or legal person, public authority, agency or body other than the data subject, controller, processor and persons who, under the direct authority of the controller or processor, are authorised to process personal data" (European Commission, 2016).

From regulation:

"The processing of personal data should be designed to serve mankind. The right to the protection of personal data is not an absolute right; it must be considered in relation to its function in society and be balanced against other fundamental rights, in accordance with the principle of proportionality." (European Commission, 2016).

In GDPR (General Data Protection Regulation-Regulation (EU) 2016/679) (European Commission, 2016), we can see the definition of personal data:

"'personal data' means any information relating to an identified or identifiable natural person ('data subject'); an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person".

Data are anonymised if characteristic factors are the same for several individuals and if any particular individual cannot be identified with reasonable effort. The assessment of how identifiable the data of a dataset are and how they can be anonymised is always done on a case-by-case basis. There are no anonymisation methods that would be suitable for all types of data.

The most explicit reference to anonymisation in European data protection law is in Recital 26 of the European Data Protection Directive (95/46/EC) which:

- makes it clear that the principles of data protection shall not apply to data rendered anonymous in such a way that the data subject is no longer identifiable;
- recognises that a code of conduct, such as this one, can be a useful means of guidance as to how personal data can be rendered anonymous; and
- is particularly important because it indicates clearly that the anonymisation of personal data is to be considered possible and that it can be used to provide important privacy safeguards for individuals.

Recital 26 signifies that to anonymise any data, the data must be stripped of sufficient elements such that the data subject can no longer be identified (The Working Party on the Protection of Individuals with Regard to the Processing of Personal Data, 2014).

The e-Privacy Directive (**Directive 2002/58/EC**) also refers to "anonymisation" and "anonymous data" very much in the same regard. Recital 26 states that:

"Traffic data used for marketing communications services or for the provision of value added services should also be erased or made anonymous after the provision of the service" (European Parliament and the Council, 2002).

Accordingly, Article 6(1) states that:

"Traffic data relating to subscribers and users processed and stored by the provider of a public communications network or publicly available electronic communications service must be erased or made anonymous when it is no longer needed for the purpose of the transmission of a communication without prejudice to paragraphs 2, 3 and 5 of this Article and Article 15(1). (European Parliament and the Council, 2002)"

Under Article 9(1), moreover:

"Where location data other than traffic data, relating to users or subscribers of public communications networks or publicly available electronic communications services, can be processed, such data may only be processed when they are made anonymous, or with the consent of the users or subscribers to the extent and for the duration necessary for the provision of a value added service. (European Parliament and the Council, 2002)"

Data controllers should consider that an anonymised data set can still present risks to data subjects and reassessing anonymization is needed as anonymisation and re-identification are on-going fields of research and even anonymised data can be used to find existing profiles of individuals and creating new data protection issues (The Working Party on the Protection of Individuals with Regard to the Processing of Personal Data, 2014).

In (European Smart Grids Task Force, Expert Group 1 - Standards and Interoperability, 2016), are considered some implementation issues which will most likely arise with roll put of smart meters and explores data management in the field of energy distribution, to identify possible obstacles. The focus of report is My Energy Data services to domestic/residential consumers, where My Energy Data is the term adopted in the report as a generic description of services to offer customers the possibility of downloading their energy consumption information and granting access to third parties to that information to enable service providers to offer analytical and other services to customers. Report stresses that within the specific scope of the GDPR, data subject has the right of access to his/her data and be able to control the (third) parties with whom the data is shared and that access and control should be defined via authentication and consent mechanisms (European Smart Grids Task Force, Expert Group 1 - Standards and Interoperability, 2016). The Task Force proposes the business related roles represented in following figure. The Data subject can access the information regarding any third parties he shares or has shared data with according to the GDPR Articles 13 and 14 including:

i) Name or category of third party;

ii) Start and end dates of the data sharing process;

iii) Legitimate interests pursued by a third party.

This is extremely important transparency and data security issue.

Report “My Energy Data” rises many questions and implementation issues concerning data management-customer rights, authentication of the customer, cyber security challenges, interoperability, costs etc. It also points that several Member States have implemented different mechanisms to provide energy data to their end energy clients in a different data formats/standards and arguments from stakeholders on the reasons why certain formats and information models are used.

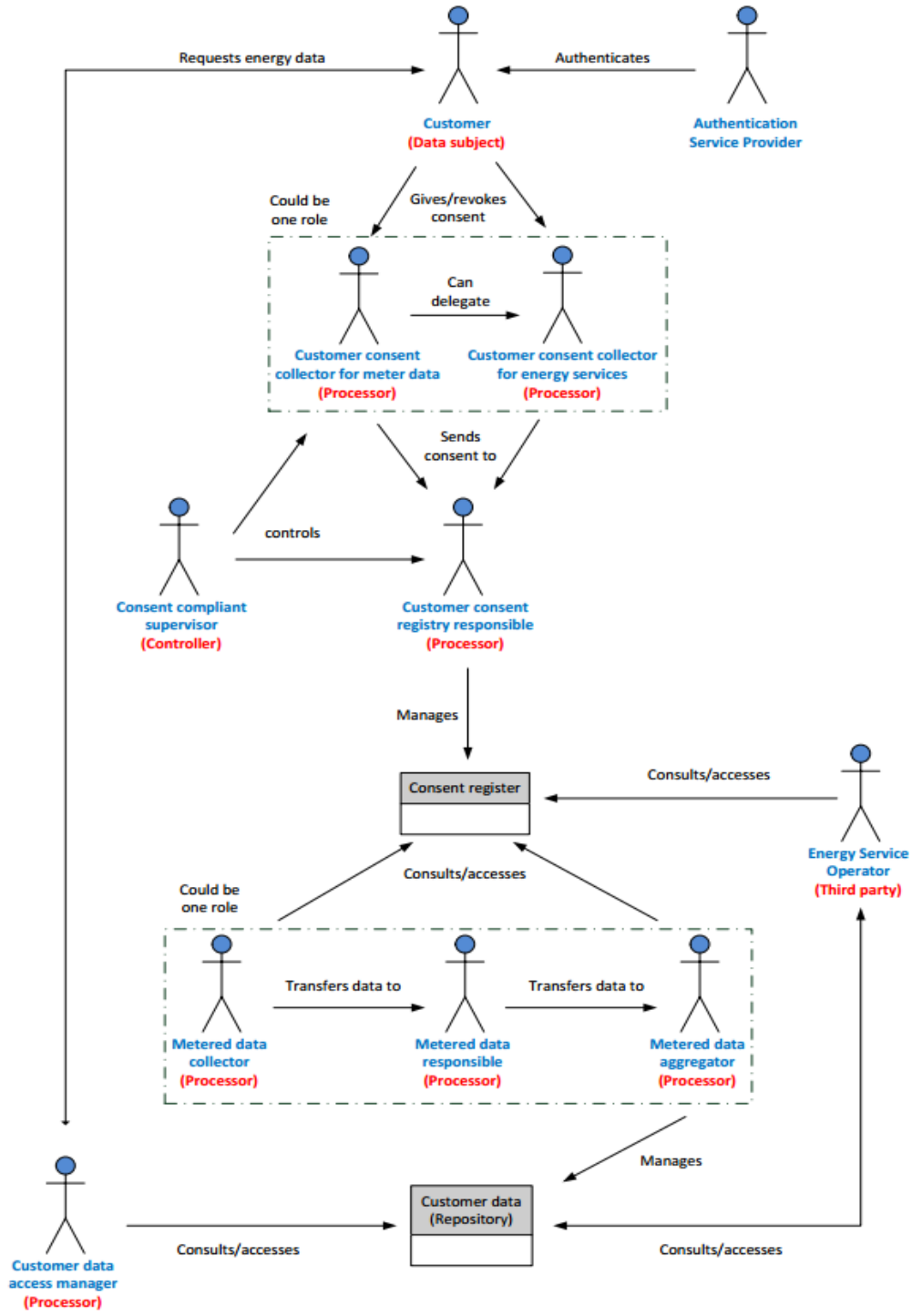

Figure 2. Comprehensive roles model related to "My Energy Data" services (European Smart Grids Task Force, Expert Group 1 - Standards and Interoperability, 2016, p. 13)

For the case of a local energy market, the following aspects are important:

Directive 95/46/EC (European Commission, 1995) describes the protection of personal data. Regulation EU 2016/679 will apply as of May 25th 2018 and builds upon Directive 95/46/EC. In the context of this regulation, “data controllers” are persons or entities who collect and process personal data. They determine the purpose and the means of the processing of

personal data. It is important to stress the fact that all roles outlined in the GDPR have to be mapped on the LEC/LEM organization. Data controllers have to respect the privacy and data protection rights of those whose data they are entrusted with, in the following called data subjects. For this, they must:

- Only collect and process data when it is legally permitted. Two circumstances that justify data collection and processing to be legal and that are relevant for our case are:
  - The concerned individual has unambiguously given his or her consent after being adequately informed.
  - The data processing is necessary for a contract.
- Adhere to obligations while processing personal data. The data controller must handle the data according to the following rules:
  - Lawfulness, fairness and transparency: Personal data must be processed lawfully, fairly and transparently.
  - Purpose limitation: The data has to be collected for explicit and legitimate purpose and used accordingly.
  - Data minimization: The collection must be adequate, relevant and not excessive in relation to the purposes for which it is collected and processed.
  - Accuracy: The data must be accurate and kept up to date if necessary. Data controllers further have to take every reasonable step to ensure that personal data that is inaccurate regarding their purpose is erased or rectified without delay
  - Storage limitation: Data controllers have to ensure that data is kept in the form that data permits identification no longer than is necessary for the purpose. Subjects have to be able to rectify, remove or block incorrect data about themselves.
- Integrity and confidentiality: Data controllers are required to protect personal data against accidental or unlawful destruction, loss, alteration and disclosure, particularly when processing involves data transmission over networks. This protection has to ensure a level of protection appropriate to the data.
- Handle complaints about breaches of data protection rules in a suitable way.

This means that a data subject can send a complaint to the data controller if he/she is of the opinion that his/her data has been compromised. In the case that the data controller's handling of the complaint is not satisfactory, he/she can file a complaint to the respective national supervisory data protection authority. The data controller should cooperate with the supervisory body. In case the concerned data is found to be inaccurate or unlawfully obtained, the data subject has the right to demand that it be corrected, blocked or erased.

The data collector has to provide the data subject at the time when personal data are obtained with the certain information, including the purpose of the collection/processing and the entities to contact, i.e. the data collector.

The data controller has to delete the subject's data and stop using it if either the subject revokes his consent or the data is not necessary anymore for the purpose that they were collected or processed for. In case of a security breach, the data collector has to inform the person whose data privacy has been violated by a third party.

In 2009/72/EC can be seen definition of processor as natural or legal person, public authority, agency or other body incl. his representative which processes personal data on behalf of the controller, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction.

For the technical aspect of the data protection the following privacy enhancing techniques are to be employed:

- Pseudonymisation: identifiers within data records are to be replaced by artificial records
- Encryption: data shall be handled in a way such that the information can only be accessed by authorised parties.
- The employed measures for data protection have to be evaluated regularly on a methodological basis.
- Data protection has to be implemented by design and by default: data protection safeguards have to be built into products and services from the earliest stage of development.

In Commission recommendation on preparations for roll-out of smart metering systems, (European Commission, 2012) are given recommendations on data protection. It distinguishes:

- "'data protection by design' requires to implement, having regard to the state of the art and the cost of implementation, both at the time of the determination of the means for processing and at the time of the processing itself, appropriate technical and organisational measures and procedures in such a way that the processing will meet the requirements of Directive 95/46/EC and ensure the protection of the rights of the data subject;" (European Commission, 2012) and
- "'data protection by default' requires to implement mechanisms for ensuring that, by default, only those personal data are processed which are necessary for each specific purpose of the processing and are especially not collected or retained beyond the minimum necessary for those purposes, both in terms of the amount of the data and the time of their storage;" (European Commission, 2012).

Other regulations that are loosely related to local energy markets are listed below. These, however, are not regulations about (local) energy markets, but regulations on preconditions that participants of the power network have to fulfill. Therefore, they are not of a special interest at this point for establishing local energy markets. One of these is **regulation 2016/631** (European Commission, 2016) establishing a network code on requirements for grid connection of generators. This Regulation establishes requirements for grid connection of power-generating facilities, synchronous power-generating modules, power park modules and offshore power park modules, to the interconnected system. Regulation ensure fair conditions of competition in the internal electricity market, security, integration of renewable electricity sources, and facilitate Union-wide trade in electricity. This regulation also lays down the obligations for ensuring that system operators make appropriate use of the power generating facilities' capabilities in a transparent and non-discriminatory manner to provide a level playing field throughout the Union.

In the commission **regulation 2016/1388** (European Commission, 2016) of 17 August 2016 establishing a Network Code on Demand connection we can see in article two a few definitions that are important for us, especially:

"(19) 'demand aggregation' means a set of demand facilities or closed distribution systems which can operate as a single facility or closed distribution system for the purposes of offering one or more demand response services";

(20) 'demand response system frequency control' means demand within a demand facility or closed distribution system that is available for reduction or increase in response to frequency fluctuations, made by an autonomous response from the demand facility or closed distribution system to diminish these fluctuations;

(21) 'demand response very fast active power control' means demand within a demand facility or closed distribution system that can be modulated very fast in response to a frequency deviation, which results in a very fast active power modification;".

This Regulation establishes a network code which lays down the requirements for grid connection of:

- transmission-connected demand facilities;
- transmission-connected distribution facilities;
- distribution systems, including closed distribution systems; This seems to be most specific to LES/LEM and should be opened towards supply of domestic customers.
- demand units, used by a demand facility or a closed distribution system to provide demand response services to relevant system operators and relevant TSOs.

Transparency in wholesale energy markets has been a major focus of Commission Regulations in the past, where **Regulation (EU) 543/2013** (European Commission, 2009) targeted especially the submission and publication of data in electricity markets. The disclosure obligations apply to data relating to generation, transportation and consumption of electricity. Regulation 543/2013 specifies the entity subject under disclosure obligation as "the primary owner of the data" which is defined as "entity which creates the data". The nature of the data specifies the primary owner as follows:

- In most cases the TSOs are regarded as primary owners of the data.
- Generation units and DSO must provide information on the total load and information required to calculate the year-ahead forecast margin for each bidding zone.
- Generation and production units must provide information on:
    - actual generation
    - unavailability
    - forecast of generation
- Cross-zonal capacity information must be provided by power exchanges and transmission capacity allocators.

The above-specified information is submitted to the TSO or to a central information transparency platform. The data must subsequently be delivered to the ENTSO-E with sufficient time so that it can meet its obligations. This regulation was implemented by the date of 1 January 2015. It can be summarized that this regulation clearly aims towards the

Transmission level and cross border power exchanges at Transmission level, although it establishes information flows with clear roles and responsibilities (primary data owner, data provider, central information transparency platform) which allows an overall assessment of market functioning fundamentals. Part of these mechanisms could be extended towards local energy system markets to help facilitate them.

Additionally, **Regulation (EU) 2016/1952** (European Commission) facilitates European statistics on natural gas and electricity prices for residential and non-residential customers. Such statistics are required to compare prices for drafting energy union policy and monitor energy markets in the Member States. Furthermore, these data shall increase transparency and therefore competition as it allows for customers to assess their energy bills in a broad context.

Annex I and II of this regulation describe in detail the methodologies for collection and compilation of data on natural gas and electricity prices for household and non-household customers. Customers are grouped into different consumption bands. According to these annexes, prices have to display generation costs, network costs, taxes and other expenses. In addition, the obtained consumption volumes have to be reported.

Similar to Regulation 543/2013, Regulation 2016/1952 therefore improves transparency on a large scale. Extending these regulations or parts of these regulations towards local energy markets could tremendously improve transparency on a local scale and help establishing functioning local markets.

None of those regulations, however, addresses issues for local energy markets, but issues somehow related to them.

3.3. Implementations of EU directives in Sweden

Before 1996, the Swedish energy market was regulated and was characterized by vertically integrated monopolies active in local markets. These local monopolies were active in all parts of the energy market, producing electric power, selling electricity to customers, and running the distribution network. The Swedish electricity market was deregulated in 1996 and a new regulating authority, the Swedish Energy Agency (STEM) was established in 1998 (Johan & Bertling, 2010). The 1996 electricity market reform gave the customers the possibility to lower their costs by actively choosing a suitable contract among competing retailers. The Energy Agency is also responsible for part of the electricity market directive (2009/72/EC) and gas market directive (2009/73/EC) (THEMA Consulting Group, 2014). As a network authority, the Swedish Energy Agency is responsible for monitoring network operations. It monitors compliance by various market players with the requirements of the **Electricity Act (1997:857)** (Sveriges Riksdag, 2017), except for the requirements of electrical safety and system responsibility. Electricity Act provides regulations concerning power installations, concerning trade in electrical power in certain cases and concerning electrical safety.

The Ministry of the Environment and Energy is responsible for the Government's environmental, energy and climate policy. They are putting as a main objective more sustainable society. The Swedish Government has launched the Fossil Free Sweden initiative, where Swedish actors are given the opportunity to call attention to how they are contributing to climate change work. Sweden is country which highly promotes share of RES. Sweden

promotes renewable electricity through a quota system, tax regulation mechanisms and a subsidy scheme. Tax exemptions are the main incentives to support renewable heating for example. The grid operator is obliged to connect electricity generation systems to the grid, transmit electricity and expand the grid. Renewable energy is not given priority (DG Energy, 2013).

The Swedish transmission system operator ("TSO") Svenska kraftnät has warned of a risk of a shortage of electricity in the coming years if Sweden fails to introduce new baseload energy production or a mechanism where the customers would have to bear the full price effects of the imbalance between supply and demand during peak usage times (Winström, Hanqvist, & Olsson, 2015). Indeed, in January 2016, there was a shortage of electricity in Sweden and a need to import electricity.

In the concluded framework agreement on Swedish energy policy, Sweden's energy policy should build on the same three pillars as energy cooperation in the EU. The policy therefore aims to combine ecological sustainability, competitiveness and security of supply.

The framework agreement includes the following three targets:

- By 2045, Sweden is to have no net emissions of greenhouse gases into the atmosphere and should thereafter achieve negative emissions.
- The target by 2040 is 100% renewable electricity production.
- An energy-efficiency target for the period 2020 to 2030 will be produced and adopted no later than 2017.

Legislation for the implementation of Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure has been introduced and became effective on 18 November 2016. The legislative package provides some regulatory privileges to suppliers of electricity for transport.

In **regulation (2007:1118)** (Ministry of the Environment and Energy, Sweden, 2007) with Instructions for the energy markets inspectorate we can see that Ei (Energy market inspectorate) is responsible for tasks arising from:

- European Parliament and Council Directive 2005/89/EC of the 18 January 2006 concerning measures to safeguard security of electricity supply and infrastructure investments,
- European Parliament and Council Regulation (EC) no 713/2009 of 13 July 2009 establishing an agency for the cooperation of energy regulators,
- European Parliament and Council Regulation (EC) no 714/2009 of 13 July 2009 on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003,
- European Parliament and Council Regulation (EC) no 715/2009 of 13 July 2009 on conditions for access to the natural gas transmission networks and repealing Regulation (EC) No 1775/2005,
- European Parliament and Council directive 2009/72/EC of the 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC,

- European Parliament and Council directive 2009/73/EC of the 13 July 2009 concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC, and
- European Parliament and Council Regulation (EU) no 1227/2011 of 25 October 2011 on the integrity and transparency of wholesale markets for energy.

From regulation (2007:1118) that the Inspectorate's tasks is to be responsible for monitoring, issuing regulations and licensing under the **Electricity Act (1997:857)**, the **Natural Gas Act (2005:403)** and the **Act (1978:160)** on certain pipelines, and for the supervision and the regulatory process under the **District Heating Act (2008:263)** and for the supervision according to the **Act (2013:385)** for action against market when trading in wholesale energy products.

Act on control of wholesale of energy products (2013:385) contains provisions implementing EU regulations with regard to the prohibition of trade in energy products by implementing control and reporting actions. Penalties for non-compliance are in adherence to EU regulations with imprisonment of a minimum of 6 months to a maximum of 4 years. Supervisory authorities shall be appointed by the Government. Regulatory authority's decision under this Act may be appealed to the public Administrative Court.

Electricity certificate program has been in place in Sweden since 2003. Electricity producers receive one electricity certificate unit (in electronic form) from the Swedish state for each megawatt-hour (MWh) of electricity that they produce from renewable energy sources or from peat. Norway has a similar system and two countries developed of a market for electricity certificates. **Act No. 2011:1200** (**Act on Electricity certificates**) (Swedish Energy Agency, 2012) obliges electricity suppliers, certain electricity consumers and energy-intensive companies to annually acquire renewable energy certificates in due proportion to their electricity sales and their consumption by a set date (Chapter 4 §§ 1 and 4 Act No. 2011:1200). The purpose of this Act is to introduce the trade of certificates and a quota system; obliging electricity suppliers to purchase certificates. Furthermore, the Act stipulates the conditions in which owners of renewable energy generation plants may acquire electricity certificates (Chapter 2 §§ 1-13 Act No. 2011:1200) (DG Energy, 2013).
Every producer that supplies electricity on a non-commercial basis is eligible for tax exemption (Chapter 11 § 2 **Act No. 1994:1776**) (DG Energy, 2013).

Electrical Safety Act (2016: 732) (Ministry of the Environment and Energy, 2016) aims to promote high electrical safety and reduce risks for electricity causing personal injury or property damage. Special provisions concerning electromagnetic compatibility in the **Act (1992: 1512)** (Ministry of the Environment and Energy, Sweden, 1992) on electromagnetic compatibility.

In the Act No. 1994:1776 on tax on energy, Sweden levies a tax on the consumption of electricity. The persons liable to this tax are commercial electricity producers and suppliers (Chapters 11 §§ 1, 5 Act No. 1994:1776). Wind energy is not subject to this tax if it was generated by a non-commercial producer/ delivered by a non-commercial supplier (Chapter 11 § 2 No. 1 Act No. 1994:1776) (DG Energy, 2013).

Customers with low electricity consumption usually have fewer tariff options than customers with high electricity consumption, while most electricity network companies only offer one

tariff type, known as flat rate tariff, to customers with low consumption (Swedish Energy Market Inspectorate, 2015).

With reference to the many consumer complaints about shortcomings in information from electricity suppliers and electricity network companies, Ei started an extensive supervisory initiative in 2015. This supervision covered consumers' rights to accurate contract information, how consumers should proceed if they want to make a complaint and information regarding power cut compensation (Swedish Energy Market Inspectorate, 2015). With this, Ei protects consumer´s rights and empowering customers. Consumers on the Swedish electricity market are guaranteed access to their consumption data as the network companies need to report meter values to the consumer before the time of billing (Swedish Energy Market Inspectorate, 2015). If an electricity or gas company does not follow the regulations in the Swedish Electricity Act or Natural Gas Act, consumers can report them. As the regulator, Ei should investigate it (Swedish Energy Market Inspectorate, 2015).

The aim of the regulations is to ensure that the electricity network companies will, through preventative work, decrease the vulnerability of the electricity network and contribute to fulfilling the functional requirement of the Electricity Act which states that power cuts may not last longer than 24 hours (Swedish Energy Market Inspectorate, 2015).

When making decisions which are affected by the electricity market directive (2009/72/EC Article 39), Ei must specify that the decision may be altered or annulled at the request of the European Commission.

3.4. German national laws and EU directives' implementations in Germany

The primary objective of German energy regulation is the supply of electricity (and natural gas) for society as a whole that is as secure, affordable, consumer-friendly, efficient and environmentally sustainable as possible. To that end, the regulation of the energy supply networks aims to ensure effective and undistorted competition in the supply of energy and at securing a long-term efficient and reliable operation of energy supply networks. Furthermore, in order to protect the climate and the environment, as well as to conserve fossil fuels, German energy policy promotes the generation of electricity from renewable energy sources.

In Germany there exist no single codification of an energy law. Instead, it can be found in various provisions, ordinances and statutes. These are subject to constant modifications and amendments. The key regulations are summarized in the following table. The main pieces of legislation are the **Energy Industry Act** (*Energiewirtschaftsgesetz* (EnWG)) and the **Renewable Energies Act** (*Erneuerbare-Energien-Gesetz* (EEG)):

Table 2. Key regulatory references in Germany for local energy markets

Regulation	**Regulation in German**	**German abbreviation**
German Energy Industry Act	Energiewirtschatsgesetz	EnWG
Electricity Grid Charges Ordinance	Stromnetzentgeldverordnung	StromNEV
Ordinance on General Terms Regulating Universal Service for Household Customers and Replacement Supply via the Low Voltage Network	Stromgrundversorgungsverordnung	StromGVV
German Measurement and Verification Act	Mess- und Eichgesetz	
Electricity Grid Access Ordinance	Stromnetzzugangsverordnung	StromNZV
German Federal Data Protection Act	Bundesdatenschutzgesetz	BDSG
Renewable Energy Sources Act	Erneuerbare-Energien-Gesetz	EEG
Low Voltage Terminal Ordinance	Niederspannungsanschlussverordnung	NAV
Distribution Code	Regeln für den Zugang zu Verteilungsnetzen	
Electricity Market Act	Strommarktgesetz	
Act on Digitization of the Energy Transition	Digitalisierung der Energiewende	
Act on Measuring point operation	Messstellenbetriebsgesetz und intelligente Messsysteme	MsbG

The legal basis for core provisions of German energy law are contained in the **German Energy Act** of 7 July 2005 (Gesetz über die Elektrizitäts- und Gasversorgung – Energiewirtschaftsgesetz – EnWG) (Gesetz über die Elektrizitäts- und Gasversorgung, 2017) which implements the Directive 2009/72/EC (European Union, 2009).

The text consists of 119 articles divided into 10 parts as follows:

1. General provisions
2. Use of information
3. Regulation of the net
4. Supply of energy to consumers
5. Planning
6. Safety and reliability of energy supply
7. Administration
8. Process and legal protection at overlong lawsuits
9. Other regulations
10. Evaluation

Its main objectives are laid down in § 1 EnWG. The law aims at ensuring a safe, cost-effective, consumer-friendly, efficient and environmentally-friendly supply of power and gas as well as efficient and unrestricted competition and the safeguarding of an effective and reliable operation of power grids. Especially Section 1a states that flexibility in supply and demand should be promoted. A competition between efficient and flexible generation plants, electrical energy and load storage facilities should take place. The efficient coupling of the heat and transport sectors with the electricity sector and the integration of the charging infrastructure for electric vehicles into the electricity supply system are designed to reduce the costs of energy supply. The transformation should be made environmentally compatible, reliable and affordable energy supply system and ensure supply security.

The **Federal Network Agency** (Bundesnetzagentur) was assigned with the task of regulating Germany's electricity market based on the legal framework of the EnWG (Bundesnetzagentur, 2017) (Gesetz über die Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen, 2016). The liberalization of the energy markets is one of the aims of the Bundesnetzagentur.

It is the Bundesnetzagentur's central task to create the prerequisites for functioning competition on the upstream and downstream markets by unbundling and regulating the power and gas supply grids. The regulatory task of the Bundesnetzagentur covers ensuring non-discriminatory network access and the control of the network usage rates levied by the power supply companies. The Bundesnetzagentur's range of tasks also includes the supervision of anti-competitive practices and the monitoring of the regulations concerning the unbundling of network areas and the system responsibility of the supply network operators.

Based on the EnWG, several additional ordinances have been enacted. The **Electricity Grid Access Ordinance** (Stromnetzzugangsverordnung – StromNZV) regulates access to the grid (Verordnung über den Zugang zu Elektrizitätsversorgungsnetzen, 2016), and the **Electricity Grid Charges Ordinance** (Stromnetzentgeltverordnung – StromNEV) regulates the grid fees (Verordnung über die Entgelte für den Zugang zu Elektrizitätsversorgungsnetzen, 2016). By setting rules for an unbundling of vertically integrated utilities (6), EnWG further promotes

competition. The StromNZV regulates the conditions for supplying electrical energy to feed points of the electricity supply networks and the simultaneous withdrawal of electrical energy at remote points of the electricity supply networks. The provisions of the ordinance are final pursuant to section § 111 section 2 no. 2 of the Energy Industry Act.

The **Electricity Grid Charges Ordinance** (Verordnung über die Entgelte für den Zugang zu Elektrizitätsversorgungsnetzen, 2016), a German regulation on charges for access to electricity supply networks, regulates the use of grid usage charges in the liberalized energy market for the transmission of electricity through networks of electricity grid operators to consumers.

The **Electricity Supply Ordinance** (StromGVV) (Verordnung über Allgemeine Bedingungen für die Grundversorgung von Haushaltskunden und die Ersatzversorgung mit Elektrizität aus dem Niederspannungsnetz, 2016) is a German ordinance regulating the conditions under which household customers are to be supplied with electricity by the electricity supply companies within the scope of the basic supply according to § 36 Energiewirtschaftsgesetz (EnWG). The regulation regulates citizens' right to electricity supply after the electricity market had been reformed in 2005 by the Energy Industry Act. The regulation defines the terms customer and end user as well as the basic supply and determines the basic provider and regulates its obligations and rights.

The **German Federal Data Protection Act** (Bundesdatenschutzgesetz (BDSG)) (Federal Data Protection Act, 2009) defines legal norms. They are intended to protect the privacy of the citizen against unauthorized access. The law applies to all data processing, collection, transmission, storage, modification, deletion, blocking and finally use of personal data by the public authorities of the Federation. For the private sector, the BDSG is relevant only if the data are used for commercial or professional purposes. The main statement of the BDSG is the prohibition of any use of personal data. It is only when a legal provision provides for the processing of the data or has the written consent given to the person concerned that this general prohibition does not apply. All data stored via a person must also be accessible to them. Every citizen has the right to receive information. Furthermore, it must be possible for everyone to correct incorrect data or to request the deletion of stored data, to obtain their blocking. There s also a right of objection to the use of data for advertising or market research purposes.

The purpose of the **Renewable Energy Source Act** (EEG) (Gesetz für den Ausbau erneuerbarer Energien, 2017) is contained in article 1 of the Act of 21 July 2004 (BGBl. 1918) revising the legislation of renewable electricity energy. In particular, in compliance with the provisions laid down in Directive 2001/77/EC (European Commission, 2001) of 27 September 2001, the purpose of the present Act is to promote an increase in the contribution of renewable energy sources to electricity production in the internal market for electricity. “Renewable energy sources” are defined as renewable non-fossil energy sources, i.e. wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogas.

The **Low Voltage Terminal Ordinance** (NAV) (Verordnung über Allgemeine Bedingungen für den Netzanschluss und dessen Nutzung für die Elektrizitätsversorgung in Niederspannung, 2016) regulates the relationship between the utility company (RU) and the consumers of

electricity from the general public. This means the so-called tariff customers, in contrast to so-called special customers.

In Germany the grid usage is carried out according to the system of the regulated grid Network access. The present Distribution Code 2007 (Verband der Netzbetreiber, 2007) was developed as a set of rules for access to the distribution networks based on EnWG and the Network Access and Grid Regulation (StromNZV, StromNEV) and the Low Voltage Terminal Regulation (NAV). Herein the task of the distribution network operators is to ensure the technical safety and reliability as well as the technical quality of the power supply and to guarantee non-discriminatory access to their distribution networks and their use in accordance with § 14 EnWG. This task can only be fulfilled if technical minimum requirements and procedural rules for access and use of the networks are complied with. The aim is to ensure trouble-free operation and the control of possible accidents. The VNB is responsible for the entire distribution network. Network connections can have an impact on the rest of the supply network, so that the network operator must, in particular, have the possibility to have a legally unlimited access to and access to the event of any faults. The Distribution Code grants each distribution system operator the option of specifying the rules further. The Distribution Code cannot replace rules coming from the ordinances and laws.

The **Act for the further development of the electricity market** (Strommarktgesetz) (Gesetz zur Weiterentwicklung des Strommarktes, 2016) was adopted by the Bundestag on 8 July 2016 and entered into force on 30 July 2016. Some parts of the Act have already been applied retroactively as of 1 January 2016. This was preceded by an extensive consultation process, which resulted from an electricity market discussion in Germany. This debate involved the fact that the economic views of the electricity-producing companies developed in such a disadvantageous way as a result of the prevailing market situation in Germany. These doubts were mainly related to the long-term supply of electricity. Another reason for this is the enormous expansion of renewable energies to see more CO_2 emissions in the "Energiewende-Paradox" (Agora Energiewende, 2014).

In response to this, the Federal Ministry of Economics and Technology, in the subsequent consultation process for the redesign and redesign of the German electricity market in October 2014, presented the "Green Paper" for public discussion. On the one hand, this had as its object the presentation of potential market arrangements for the future electricity market. On the other hand, this included "anyway measures. These are intended to ensure a safe, cost-efficient and environmentally compatible electricity market and must be implemented in any case. In essence, the "green book" was concerned with the basic decision for a capacity market or a further developed so-called electricity market 2.0 (Schneider, 2016).

In July 2015 followed the publication of the "White Book" (Bundesministerium für Wirtschaft und Energie, 2015). In this case, the Federal Government's basic decision contained the idea that a capacity market, in which it would be possible for operators of controllable, conventional "safety power stations" to gain additional profits due to the mere provision, is not introduced for the time being. The Federal Ministry for Economic Affairs and Energy rejects a capacity market and is committed to the liberalized, European electricity market. Rather, the current electricity market is to be further developed. The necessary capacities in the electricity market 2.0 can be remunerated via the market mechanisms.

Free pricing on the electricity market is anchored in the Energy Industry Act. At the same time, market players get stronger incentives to meet their supply commitments. These measures strengthen the existing market mechanisms. As a consequence, the electricity market is able to remunerate the necessary capacities. A number of further measures ensure a flexible and efficient electricity system. These include new fields of cooperation for the European electricity markets, the further development of balancing markets and the design of the grid fees in order to allow for more market-based demand-side management. The "White Paper" included 20 precise measures for the realization of the electricity market 2.0, for example "measure 8 opening special grid charges for more load flexibility" (Bundesministerium für Wirtschaft und Energie, 2015, p. 32).

The Electricity Market Act, which entered into force on 30 July 2016, does not in itself contain separate regulations. Rather, this existing law is amended. In this case, too, a framework legislation is mentioned (Schneider, 2016).

The law does not focus on distribution grids but has rather as focus the transmission system operator, where flexibility is mentioned in the context of control energy, furthermore the Demand Side Management in the “White Book” (Bundesministerium für Wirtschaft und Energie, 2015) is geared towards industrial customers and nowhere a special attention is given towards local energy markets.

The German legislator has the opinion that the electricity market design will guarantee the security of supply and low-cost electricity even when a large share of the electricity is derived from renewable energy sources. In addition, the **Act on the Digitization of the Energy Transition** creates the key prerequisites for a sustainable grid infrastructure (Gesetz über den Messstellenbetrieb und die Datenkommunikation in intelligenten Energienetzen, 2016).

With the Act on Digitization of the Energy Transition in Germany there is for the first time a legally binding obligation for the broad installation of so-called modern measuring devices (digital current meters). It also marks the way when and how smart measuring systems (also known as smart meters) are introduced into the market. The legislator understands the extension of the meters by a communication module (smart meter gateway). A control box with which, for example renewable systems or large loads, can be integrated if necessary.

Implementation of smart meters according to this law will start during the first quarter of 2017. The law covers metering data, market communication, contractual arrangements related to metering, electricity/gas heating/district heating.

The Act on Digitization of the Energy Transition is based on the following directives coming for the European Union where it already established initial approaches with the Directive on Energy Efficiency 2012/27/EU of 25 October 2012 (European Union, 2012).

In accordance with Article 9 (1) of this directive, the Member States are obliged to provide, as far as technically feasible, financially justifiable and proportionate to the potential energy savings, end customers with smart metering devices. Member States shall ensure that all end individual counters are obtained at competitive prices and are reflecting the actual energy consumption of the end user and the actual time of use.

According to Article 9 (1b) of the regulation, an exchange is already required as soon as new buildings are equipped with connections or if buildings undergo major renovations as defined in Directive 2010/31/EU (European Union, 2010). In addition, the billing is intended to provide the end user with suitable information that provides him with a comprehensive picture of current energy costs. Billing based on actual consumption is so often carried out that customers are able to control their own energy consumption (European Union, 2012). The aim was to create a better information exchange between end users and the electricity supply market.

With the European Energy Market Directive 2009/72/EC (European Union, 2009), the European Union has given its Member States further important guidelines. In accordance with Annex 2 of the Energy Market Directive 2009/72/EC, Member States shall ensure that smart metering systems are implemented to support the active participation of consumers in the electricity supply market. The introduction of these measuring systems can be subject to an economic evaluation, which examines all long-term costs and advantages for the market and the individual consumers, as well as the type of intelligent measurement that is economically justifiable and cost-effective.

The new **MsbG** (Gesetz über den Messstellenbetrieb und die Datenkommunikation in intelligenten Energienetzen, 2016) replaced the former **MessZV** (Verordnung über Rahmenbedingungen für den Messstellenbetrieb und die Messung im Bereich der leitungsgebundenen Elektrizitäts- und Gasversorgung, 2013). It changed certain market roles; for example, the measuring point operation is no longer an original task of the network operator. According to (§ 21b EnWG), the distribution network operators are responsible for the measuring point operation. Pursuant to Section 3 (1) on the Act of Measuring Point Operation (MsbG), the ground-measuring site operators are now responsible for the installation and distribution of the new measuring infrastructure. According to §§ 41-45 MsbG (Gesetz über den Messstellenbetrieb und die Datenkommunikation in intelligenten Energienetzen, 2016), this can, however, transfer its basic jurisdiction to another network operator or measuring point operator. A prerequisite for this is that the transferring actor has an authorization to include the basic jurisdiction according to § 4 MsbG. The transmission applies exclusively to basic control with regard to modern measuring devices and intelligent measuring systems.

It has to be clarified that the Act does not contain any references to Smart Home Application or Local Energy Markets. However, the smart meter gateway can act as a secure communication infrastructure and therefore can be used as a standard solution in this area.

Summarizing for Germany it can be said that local electricity models and P2P trading depend on a de-bureaucratization, in particular the role of sellers. Without adapting the regulatory framework, it will hardly be possible to create a pilot project in real life or even to think about a local energy market. Especially prosumers have to fulfill all the obligations from the EnWG, which is still written for the "old energy industry" with large central production capacities and multi-level energy supply and transaction systems. The resulting requirements for contracts, invoices and advertising material can only be fulfilled by means of specialized service providers. The resulting costs may destroy all profitability. For local energy markets to succeed the prosumers must therefore be freed as far as possible from the disproportionate EnWG obligations for suppliers. The same applies in principle to the reporting and transparency obligations under the EEG. In this context, the Winter Package offers promising hope for consumers, or as the EEX in this regard concludes: “The Winter

package can become a success if the European internal power market actually benefits the consumers throughout Europe in the future. This includes more renewable energies at costs, which are as low as possible and the highest possible security of supply. Consumers should, in particular, be able to decide freely whether they want to procure their power from a certain supplier or want to actively operate as producers – i.e. as so-called prosumers" (European Energy Exchange (EEX), 2017, p. 4). This will hopefully materialize in new German legislation.

3.5. Summary

Local energy markets can significantly support the integration of renewable energy sources and therefore help meeting EU 2050 visions. The EU strongly drives regulatory frameworks in direction of more sharing of RES in the energy system and the biggest challenge in the new energy ecosystem is how to deal with the intermittency of renewables.

On EU level, the existing regulatory framework describes concepts such as free energy markets and distributed generation. However, a local energy market has not yet been defined. With the Third Energy Package, the European Union took a step into the direction of market competitiveness but without clearly defining the role and position of local energy markets in the already existing framework. Future systems can be subject to operations of some of the actors due to personal interest and may mislead market allocation of income if roles are not clearly defined. Free energy market principles demand that energy suppliers must be unbundled from network operators and therefore special attention must be put on clear TSO-DSO relation and DSO-prosumer relation.

Sweden has set itself the target of achieving 100% renewable electricity production by 2040, so LEM will clearly support this decision in Sweden, and probably be necessary. Taking into consideration that roll-out of smart meters in Sweden has been completely finished, Sweden already has a good background to achieve this goal faster than other countries.

Germany is due to the Energiewende one of the forerunners in expanding the renewable energy production. However, until this point, there is no clear motivation for promoting LEMs in Germany. Instead, the discussion is focused on possible Smart Markets that enable the reduction of network congestions, which are targeted towards the TSOs.

In EU regulations, consumer's rights are clearly defined and addressed such as that energy consumers have to be provided with sufficient contract information and that they also have the right of withdrawal from contracts. Data security needs to be addresses in new regulations concerning local energy markets, especially with the threat of cyber or terrorist attacks.

The concept of local energy markets is not yet defined on a European level but with the new EU legislation package "Clean Energy for all Europeans" this concept has been introduced and therefore with right implementation might benefit the whole energy system. "Clean Energy for all Europeans" makes immense progress on aspects of market participation such as trading flexibility, but the improvement is not equally met for gas.

However, the organization of LEMs is still not defined within a legal context. Also, it is not yet clear what kind of information systems would be needed and how data privacy concerns might be affected, regarding information flows, availability and security. Furthermore, there are still unresolved regulatory questions related to the security and supply of electricity, financial security, and grid load balancing. LEMs are entirely new concepts from a regulatory perspective.

4. REGULATIONS AND RULES CONCERNING THE COMMERCIALIZATION OF END-CUSTOMERS' FLEXIBILITY

This chapter describes the commercialization of end-customers' flexibility and starts with motivating and defining flexibility. Afterwards, regulations and rules on a European and national level are discussed and barriers for commercializing flexibility are presented. Finally, this chapter closes with a short summary of the presented contents.

4.1. Flexibility

The increasing installation of fluctuating renewable energy sources such as photovoltaics and wind energy has led to a paradigm shift. Previously, electricity generation has been controlled to meet the customers' demands. However, with growing generation from volatile sources like photovoltaics and wind, the demand side also has to be operated flexibly for balancing generation and supply.

Energy flexibility can be defined as the "modification of generation injection and/or consumption patterns, on an individual or aggregated level, in reaction to an external signal (price signal/network tariff/activation) in order to provide a service within the energy system. The parameters used to characterize flexibility include the amount of power modulation, the duration, the rate of change, the response time, the location etc." (eurelectric, 2014, p. 5)

Since buildings account for nearly 40% of the final energy consumption in the EU (European Commission, 2011) (European Union, 2010), their flexible operation is indispensable for integrating renewable energies and ensuring a stable, high quality power supply. The IEA EBC Annex 67 project on "Energy Flexible Buildings" (International Energy Agency, 2017), therefore specifically defines energy flexibility of buildings, particularly addressing potential interaction with energy grids (Danish Technological Institute, 2017).

> *The Energy Flexibility of a building is the ability to manage its energy demand and generation according to local climate conditions, user needs and grid requirements. Energy Flexibility of buildings will thus allow for demand side management and load control and thereby demand response based on the requirements of the surrounding grids.*

Energy flexibility can be obtained through different options, such as storage, shiftable loads and controllable local generation. Flexibility options for individual energy carriers are

thermal storage tanks used to buffer heat or electrical storages, such as battery units, for storing electricity. Interactions between different energy carriers can, for example, be achieved through heat pumps or combined heat and power units. Heat pumps can convert electricity to thermal energy that can either be used directly for heating purposes or stored within a thermal storage tank or the building's construction mass. In this manner, surplus electricity, e.g. from local renewable generation, can be used as heat during a later point in time. Similarly, combined heat and power units can be operated flexibly to provide electricity and heat during peak demands. The simultaneously generated heat can also be stored in buildings and used when required. Flexibility can also arise from shiftable electrical loads, such as dishwashers, washing machines and laundry driers, as well as charging and discharging strategies for electric vehicles. Additionally, to a certain extent, industry processes can be operated flexibly, allowing for shifting loads in multiple sectors and different types of locations. In contrast to domestic customers, industry processes can often provide large amounts of flexibility in the range of several megawatts.

This flexibility can for example be used for balancing renewables during times of high solar or wind availability or for grid frequency control through demand response (DR). DR is defined as "a tariff or program established to motivate changes in electric use by end-use customers in response to changes in the price of electricity over time, or to give incentive payments designed to induce lower electricity use at times of high market prices or when grid reliability is jeopardized" (U.S. Department of Energy, 2006, p. V). Figure 3 illustrates this behaviour graphically. A high demand during morning hours is shifting to noon in order to profit from available solar energy.

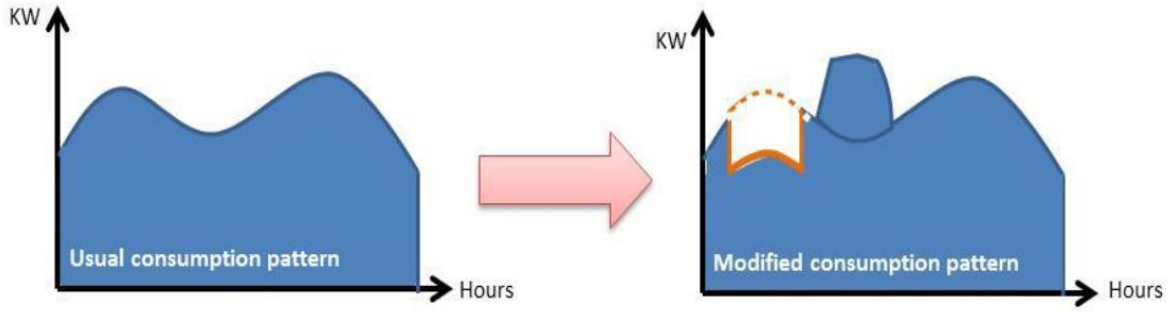

Figure 3. Simplified overview of demand response (eurelectric, 2015, p. 7)

Different stakeholders in the energy market consider flexibility beneficial for multiple purposes. Energy suppliers, aggregators and ancillary service providers can trade generation and load capacities on markets for profit maximization. System operators, such as TSOs and DSOs can benefit from flexible generators and consumers in order to reduce their costs for grid planning and operational efficiency maximization. In France, for instance, the annual peak load has been reduced by 3% due to DR mechanisms (Deutsche Energie-Agentur, 2013).

Potential service providers are active participants who are able to modify their feed-in and consumption behaviour. These stakeholders comprise (aggregated) small industrial and commercial sites, (aggregated) household customers as well as (aggregated) distributed energy resources (DER). Such pooling of multiple participants through dedicated aggregators allows for complexity reduction and improves controllability on a local scale, leading to a

better integration of locally generated electricity. Some studies even describe that aggregators are essentially needed for capturing flexibility of a multitude of small-scale flexibility sources (Sweco Energuide AB, 2015). Aggregator services can be provided by energy suppliers, retailers, telecommunication companies, or specialised new businesses.

Small industrial and commercial users can offer services using electricity-intensive machinery, electric vehicles or using electricity for heating or cooling purposes, such as air conditioning, water heaters, boilers, freezers, or refrigeration units, mainly exploiting thermal inertia. Household customers could be an important source of flexibility for network operators, but flexibility services of single households hardly affect the network system. Hence, household customers could potentially be grouped to larger units, contributing flexibility through their energy supplier or an aggregator. A number of different DERs could be used to provide flexibility. Whereas large DER units could act individually in flexibility markets, small units (e.g. domestic storage units), would have to be represented by an aggregator to provide services. According to Navigant Research (Navigant Research, 2014) (Navigant Research, 2014), DR will be a significant market in future energy systems. It is expected that revenues generated from residential DR and commercial as well as industrial (C&I) DR will reach $2.3 billion and $38 billion worldwide by 2023.

4.2. Regulations and Rules in the European Union

This chapter describes the regulations, directives and rules proposed in the European Union that are related to the commercialization of end-customers' flexibility. Since customers can be both, electricity providers as well as electricity consumers, this analysis also covers both aspects.

4.2.1. Overview of relevant European regulations and directives

First, an overview of relevant regulatory texts that are currently in force is presented. Afterwards, the implications of these legislative texts are analyzed. The identified relevant regulations, guidelines and directives are listed in Table .

Table 3. European regulations, guidelines and directives on commercialization of end-customer´s flexibility

Document	Description	Relevant Articles
Directive 2009/72/EC	Common rules for the internal market in electricity	Art. 3: Public service obligations, customer participation and protection Art. 5: Technical rules for demand and generation connection Art. 7: Authorisation procedure for new capacity Art. 25: Tasks of distribution system operators Art. 33: Market opening and reciprocity

		Art. 36: General objectives of the regulatory authority Art. 41: Access to retail markets
Regulation 2016/631	Network code on requirements for grid connection of generators	Art. 13: General requirements for small-scale generators
Regulation 2016/1388	Network code on requirements for grid connection of consumers	Annex I: Frequency ranges and operation time periods for demand connection
Directive 2012/27/EU	Energy efficiency	Art. 9: Roll out of smart meters Art. 15: Energy transformation, transmission and distribution Annex XI: Energy efficiency criteria for energy network regulation and for electricity network tariffs
Directive 2009/28/EC	Promotion of the use of energy from renewable sources	Art. 16: Access to and operation of the grids
Directive 2005/89/EC	Measures to safeguard security of electricity supply and infrastructure investment	Art. 3: General provisions Art. 5: Maintaining balance between supply and demand
Communication 2014/C 200/01	Guidelines on State aid for environmental protection and energy 2014-2020	3.9: Aid for generation adequacy

The **internal electricity market directive (2009/72/EC)** (European Union, 2009) defines common rules for the generation, transmission, distribution and supply of electricity, as well as consumer protection provisions. This directive aims at improving and integrating competitive electricity markets in the European Union. The directive is based on free markets ensuring the Treaties on European Union and on the Functioning of the European Union in respect of free provision of services (European Union, 2016).

Article 3 of the internal electricity market directive considers energy efficiency and demand side management measures to combat climate change and ensure security of electricity supply. The directive in this manner strongly recommends the optimization of electricity usage, for example by means of third party access, energy management services, smart grids and smart metering systems as well as innovative pricing models.

Article 3, paragraph 3 furthermore states that nothing in this directive shall prevent Member States from strengthening the market position of household, small and medium-sized consumers by promoting the possibilities of voluntary aggregation of representation for that

class of consumers. As a result, customers are allowed to aggregate themselves. The aggregation of final customers is also mentioned in the introduction of this directive, for facilitating the participation in reserve and balancing markets, however the concept of aggregators is not further elaborated in this directive.

Article 5 requires technical rules that allow for interoperability between systems and that these rules shall be objective and non-discriminatory. This article is also supported through different EU mandates, such as mandate 441 (European Commission, 2009) on utility meters and mandate 490 on smart grids (European Commission, 2011). Furthermore, this article ensures that technical safety criteria are defined and that technical rules establishing the minimum technical design and operational requirements for the connection to the system of generating installations, distribution systems, directly connected consumers' equipment, interconnector circuits and direct lines are developed and made public. Therefore, this article sets non-discriminatory rules that are equal for all participants.

However, in order to promote the development of distributed generation systems, small-scale and distributed generation facilities shall have simpler authorization procedures due to their limited size and potential impact (article 7).

In chapter 6 of the directive, the roles and responsibilities of distribution system operators (DSOs) are described. The tasks of DSOs are defined in article 25. The DSOs must not discriminate between system users, they shall provide system users with the information required for efficient access to and usage of the system. Furthermore, DSOs shall procure the energy they use to cover energy losses and reserve capacity in their system according to transparent, non-discriminatory and market based procedures. When planning the development of the distribution network, energy efficiency and demand side management measures or distributed generation that might supplant the need to upgrade or replace electricity capacity shall be considered by the distribution system operator. The concept of customer integration through demand side management is therefore explicitly recognized as a benefactor for grid developments. However, this section lacks concrete requirements and rules regarding demand side management and customer integration.

Article 33 states a full market opening for all customers, which means that every customer can purchase electricity from the supplier of his or her choice. In this manner, customers are already allowed to flexibly choose a supplier and are not bound to a specific energy provider.

According to article 36, regulatory authorities help to achieve, in the most cost-effective way, the development of secure, reliable and efficient non-discriminatory systems that are consumer oriented, and promote system adequacy as well as energy efficiency and the integration of large and small-scale production of electricity from renewable energy sources and distributed generation in transmission and distribution networks. Furthermore, the regulatory authorities facilitate access to the grid for new generation capacities by removing barriers for new market entrants and electricity from renewable energy sources. This article attempts to ensure consumer protection and consumer oriented markets, however, it lacks a recognition of end-customers' ability to support the grid through variable loads or as prosumers.

Furthermore, Article 41 aims to facilitate customers' and suppliers' access to networks. This article also allows large non-household customers to have multiple energy suppliers, strengthening the competition in the market.

The **network codes regulation (2016/631/EU)** (European Commission, 2016) establishes a network code, which lays down the requirements for grid connection of power-generating facilities to the interconnected system. It helps to ensure fair conditions of competition in the internal electricity market, to ensure system security and the integration of renewable electricity sources, and to facilitate Union-wide trade in electricity.

Article 13 of the network codes regulation describes general requirements for small-scale generators, such as minimum time periods these generating modules have to be capable of operating on different frequencies in different regions in the European Union. These requirements have to be fulfilled by all generating units with nominal capacities between 0.8 kW and 100-1500 kW (100 kW in Ireland and Northern Ireland, 500 kW in the Baltic States, 1000 kW in Continental Europe and the United Kingdom, and 1500 kW in Scandinavia). Therefore, this regulation is also relevant to end-customers offering generation capabilities in the range of a few kilowatts.

According to 2016/631/EU, article 13.6, such small-scale generators have to be equipped with an external input port that enables system operators to cease active power output within five seconds. Therefore, due to this regulation, all connected generation modules have to be able to provide flexibility per se.

Analogously, the **EU regulation 2016/1388** (European Commission, 2016) of August 17th, 2016 establishes a network code on demand connection. This regulation is relevant for large-scale customers directly connected to a transmission system, but it also applies to any customer offering demand response services for grid operators. Annex I of this regulation describes the frequency ranges and time period for operation in different regions of the European Union that the demand facility has to comply with.

The **energy efficiency directive (2012/27/EU)** (European Union, 2012) establishes a common framework of measures for the promotion of energy efficiency within the European Union. It lays down rules designed to remove barriers in the energy market and overcome market failures that impede efficiency in the supply and use of energy, and provides for the establishment of indicative national energy efficiency targets for 2020. Furthermore, demand response is explicitly named as a cornerstone for improving energy efficiency.

In order to enable these measures, the energy efficiency directive establishes the need to equip customers with smart meters that reflect information on the actual time of usage for electricity, gas, domestic hot water as well as district heating and cooling. This can be seen as a first step towards customers' integration and market participation via demand response.

Smart meters are defined as "instrument[s] for measuring, memorizing and displaying the consumption of a commodity that also offer additional functionalities, one of which is data communication" (CEN-CENELEC, 2011, pp. 10,f.).

Article 15 requires Member States to ensure that network operators are incentivized to improve efficiency in infrastructure with the goal of improving consumer participation via demand response. This article explicitly includes aggregators for grouping multiple

customers and enabling impactful demand response measures. Furthermore, this article obliges Member states to encourage demand response and participation of consumers alongside supply in wholesale and retail markets. It promotes access to and participation of demand response in balancing, reserve and other ancillary markets. However, the technical modalities for such a participation shall be defined on a local level. Therefore, this directive can lead to reduced balancing costs, which currently differ strongly across the EU Member States, requiring tailored incentives for introduction of local energy markets and prosumers' flexibility on national levels (Agency for the Cooperation of Energy Regulators (ACER), Council of European Energy Regulators (CEER), 2015).

Annex XI of this directive allows network operators and energy retailers to provide system services for demand response measures, demand management and distributed generation on organized electricity markets. These comprise load shifting from peak to off-peak times by final customers, energy savings from demand response of distributed consumers through energy aggregators, demand reduction from energy efficiency measures, generation at lower voltage levels (typically) in close proximity to the consumption, and the storage of energy. Hereby, organized electricity markets include over-the-counter markets and electricity exchanges for trading energy, capacity, balancing and ancillary services in all timeframes, including forward, day-ahead and intra-day markets. Tariffs may support dynamic pricing for implementing demand response by final customers, such as time-of-use tariffs, critical peak pricing, real time pricing, and peak time rebates.

The **renewable energy directive (2009/28/EC)** (European Union, 2009) acknowledges the necessity to integrate renewable energies for meeting climate protection goals. This integration of renewables goes along with the need to encourage strategic operations at different scales, such as states, regions and local authorities. Furthermore, this directive recognizes the need to support the integration of energy from renewable sources into the transmission and distribution grid and the use of energy storage systems for volatile generation of energy from renewables.

Article 16 of the renewable energy directive describes the access to and operation of grids. This article states that member states shall take the appropriate steps to develop transmission and distribution grid infrastructure, intelligent networks, storage facilities and the electricity system, in order to allow the secure operation of the electricity system as it accommodates the further development of electricity production from renewable energy sources. Such a grid infrastructure handling intelligent networks and therefore the bidirectional flow of electricity is, next to modern ICT in smart meters, a cornerstone for active participation of end-customers in future energy systems. Additionally, priority access or guaranteed access to the grid-system of electricity produced from renewable energy sources has to be provided.

Directive 2005/89/EC (European Union, 2006) establishes measures aimed at safeguarding security of electricity supply so as to ensure the proper functioning of the internal market for electricity and to ensure adequate level of generation capacity, adequate balance between supply and demand, and an appropriate level of interconnection between Member States for the development of the internal electricity market. Due to the increasing penetration of electricity from wind and solar energy, and the resulting challenges for the grid regarding power quality, stability of grid frequency and duration of interruptions, article 3 of directive 2005/89/EC explicitly demands that member states take account of renewal and maintenance of transmission and distribution networks as well as to ensure sufficient

transmission and generation reserve capacity for stable operation. Additionally, article 5 describes the balancing between supply and demand, facilitating new generation capacity and the entry of new generation companies to the market. Furthermore, this article considers real-time demand side management, by encouraging the establishment of a wholesale market framework providing price signals for generation and consumption.

The **Guidelines on State aid for environmental protection and energy 2014-2020** (European Union, 2014) describes guidelines for aid granted to environmental protection or energy objectives projects. In particular, article 220 demands that demand side management has to be considered with the objective of phasing out environmentally or economically harmful subsidies. These guidelines thus acknowledge the positive effects of demand side participating and integration, and support the development of these as a means for substituting subsidies for environmentally or economically inefficient subsidies.

4.2.2. Regulatory barriers

Although flexibility is expected to be significant for the safety and balance of the future electricity network, the current European regulatory framework has still not defined flexibility, nor has it set precise rules for the commercialization of flexibility.

The *internal electricity market directive (2009/72/EC)* has not clearly recognized flexibility as a key enabler of demand side management and the integration of fluctuating renewable energy sources, and consequently did not define the concept of flexibility. Such a definition would serve as the base of all services and capabilities offered and requested by end-customers and electrical network operators.

In order to coordinate and capitalize on customers' flexibility, aggregators that group a multitude of small-scale sources, are necessary (Sweco Energuide AB, 2015). It is foreseen that a strong competition between aggregators can result in additional benefits such as stimulating innovation and the development of new services and business solutions. In theory, aggregator services can be offered by energy suppliers, retailers, telecommunication companies, or even new, specialized companies. However, the roles and responsibilities of aggregators have not been defined yet, which impedes the commercialization of end-customers' flexibility.

Furthermore, the applicability of the unbundling principle to flexibility has not been addressed, yet. The *internal electricity market directive (2009/72/EC)* establishes the unbundling principle to separate supply and production from network transmission and distribution operation. In this manner, this directive has led to the development of increased operational flexibility, since the electricity market now incorporates a variety of different generation units that are controlled by multiple stakeholders. Before the unbundling concept was introduced, the electricity market only consisted of very few players that controlled generation and transmission, therefore less flexibility was required since both belonged to the same companies. However, as the definition of flexibility is not introduced, it may be uncertain if a transmission system operator or distribution system operator can commercialize its flexibility or the flexibility of its end-customers to support other grids.

In addition, in order to enable demand side integration, a clear framework should be defined for DSOs to value the positive and negative network impacts of the demand side, and use

flexibility to reduce network costs in a manner that does not distort wholesale and retail markets (Agency for the Cooperation of Energy Regulators, 2015).

4.2.3. European operation reserve markets

Since flexibility and local markets for flexibility are not yet well defined on a European level, this section presents an example for an already well regulated common market: Operation reserve. These markets could therefore serve as role-models for future regulations and directives concerning commercialization of end-customers' flexibility in local energy markets.

On a European level, as well as on regional and national levels, operation reserve serves as a good example for a well-defined service and market. *Regulation EC 714/2009* describes the establishment of a European Network of Transmission System Operators for Electricity (ENTSO-E) "in order to promote the completion and functioning of the internal market in electricity and cross-border trade and to ensure the optimal management, coordinated operation and sound technical evolution of the European electricity transmission network" (Article 4). Among other responsibilities, the ENTSO-E has developed the previously mentioned network codes for grid connection of generators (*regulation 2016/631*) and consumers (*regulation 2016/1388*).

As shown in Figure 4, the ENTSO-E network is divided into five regional groups (Nordic, Great Britain, Ireland-Northern Ireland, Baltic, and Continental Europe) as well as two voluntary regional groups (Northern Europe and Isolated Systems). These groups ensure compatibility between system operations as well as market solutions and address system development issues. Each group has different mechanisms and market structures for the operation of the transmission network. Among these, load frequency control and performance is a good example for a commercialized market product with clearly defined access rules and regulations.

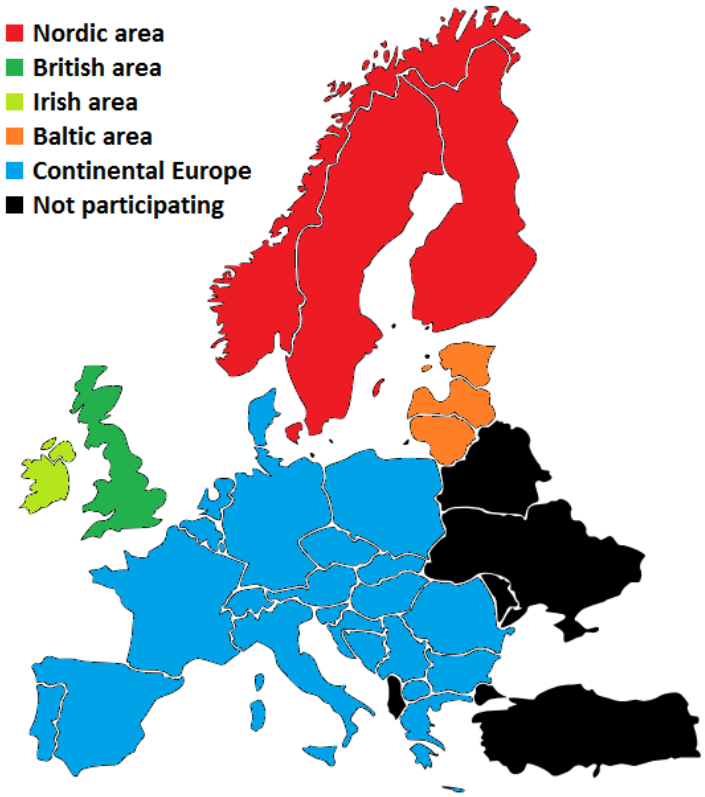

Figure 4. Regional synchronous areas (European Network of Transmission System Operators for Electricity, 2015, p. 15)

In **Continental Europe**, load frequency control and performance is divided into four different, successive steps with different qualities and characteristics that all depend on and interact with each other. Primary reserve is designed to balance generation and demand in order to stabilize the grid frequency. Currently, the primary reserve markets of Germany, Belgium, the Netherlands, France, Switzerland, and Austria are coupled on a common Internet platform (https://www.regelleistung.net). For the German grid, the German Federal Network Agency (Bundesnetzagentur) defines a legal framework for primary reserve (Bundesnetzagentur, 2011). Primary reserve is tendered through a weekly auction; the characteristics to participate require a minimum size of 1 MW (for either generation or load), the ability to be at full power in 30 seconds and the ability to maintain the power for 15 minutes.

Secondary reserve balances generation and demand within each local control area. Therefore, unlike primary reserve, secondary reserve is not provided on a European level, but for each of the four German control areas individually. The legal framework for secondary reserve in Germany is also defined by the German Federal Network Agency (Bundesnetzagentur, 2011). Secondary reserve is provided through a weekly tender, the minimum size to bid is 5 MW, and both negative and positive regulations are required. The asset has to provide full power within 5 minutes and hold it for at least 10 minutes.

Tertiary control uses tertiary reserve that is usually activated manually by the transmission system operators in case of observed or expected sustained activation of secondary control. It is primarily used to free up the secondary reserves in a balanced system situation, but it is also activated as a supplement to secondary reserve after larger incidents to restore the

system frequency and consequently free the system wide activated primary reserve. The German Federal Network Agency requires that participants have to offer at least 5 MW of power and are able to activate this power within 15 minutes (Bundesnetzagentur, 2011). The key conditions for participating in these markets are summarized in Table .

Frequency deviations can accumulate over longer periods of time, leading to deviations between grid time and universal coordinated time. According to UCTE/ENTSO-E (UCTE, 2004), the Swiss Laufenburg control centre controls the set-point frequency in order to limit the time deviation under 30 seconds. This is done by changing the set-point frequency to either 49.99 Hz or 50.01 Hz for periods of one full day.

Table 4. German balancing market segments

Balancing reserve	Tendering	Minimum tender	Activation time
Primary reserve	Weekly	± 1 MW	≤ 30 seconds
Secondary reserve	Weekly	5 MW	≤ 5 minutes
Tertiary reserve	Daily	5 MW	≤ 15 minutes

In the **Nordic region** (Eastern Denmark, Finland, Norway, and Sweden), operational reserves are divided into automatic active reserve, fast active disturbance reserve, slow active disturbance reserve and reactive reserve (European Network of Transmission System Operators for Electricity, 2014). The automatic active reserve is again split into frequency controlled normal operation reserve, frequency controlled disturbance reserve, and voltage controlled disturbance reserve. Frequency controlled normal operation reserve and frequency controlled disturbance reserve are achieved via automatic frequency regulation for the generating facilities. The frequency controlled normal operation reserve is at least 600 MW at 50.0 Hz and shall be fully activated if the frequency is below 49.9 Hz or exceeds 50.1 Hz and regulated within 2-3 minutes. Each participating country has to provide a specific amount of frequency controlled normal operation reserve depending on its annual consumption.

The frequency controlled disturbance reserve is designed to prevent the frequency from falling below 49.5 Hz. It is activated if the frequency drops below 49.9 Hz and increases linearly between 49.9 and 49.5 Hz. In case the frequency drops to 49.5 Hz, 50% of the frequency controlled disturbance reserve has to be regulated upwards within 5 seconds and the full reserve has to be available within 30 seconds. Next to generators, also load shedding is allowed for providing frequency controlled disturbance reserve if it meets the described technical requirements. Load shedding includes among others, industrial, district heating and electric boiler consumption. The required power is normally 1000 MW and decided on a weekly basis due to current N-1 criterion (European Network of Transmission System Operators in Electricity, 2010).

The fast active disturbance reserve (also called manual reserve and secondary response) is used to restore the frequency controlled normal operation reserve and the frequency controlled disturbance reserve. It shall be available within 15 minutes and its size is

determined by the subsystem's local requirements. Bidders have to provide at least 10 MW of power and mark their price as well as grid area.

In the **United Kingdom** operational reserves are procured through a number of different markets. The Short Term Operating Reserve (STOR) market is a manual reserve that serves as the main tool for keeping the frequency of the grid between 49.2 Hz and 50.8 Hz over the longer term (although the frequency can only breach a range of 49.5 Hz to 50.5 Hz for up to a minute). Flexibility providers acting in the STOR must be able to reach full contracted load by 4 hours and be able to last for up to 2 hours. In practice only assets that can respond within 20 minutes are accepted. There is a minimum requirement of 3 MW to enter the market but this can be achieved through aggregation of assets.

Frequency response markets in the United Kingdom are designed to maintain security in the national grid and keep frequency within statutory (49.5 Hz - 50.5 Hz) and operational limits (49.8 Hz - 50.2 Hz). Transmission connected capacity above a 100 MW threshold are mandated to have the ability to provide this service and are allowed to compete in the "Mandatory Frequency Response" market. Other providers may compete in the "firm frequency response market". Providers may choose to provide dynamic response (i.e. output follows the frequency) or static response (where output is triggered by a certain frequency level and held for a pre-determined amount of time). Static response is divided into Primary provision (Providing power to the system within 10 seconds and lasting for 20 seconds), Secondary provision (providing power to the system within 30 seconds and lasting for 30 minutes) and High provision (taking power from the system within 10 seconds).

In summary, the European Network of Transmission System Operators for Electricity (ENTSO-E) has been established based on a European guideline which has then developed precise rules for demand and generation connection to the grid. Furthermore, this entity has defined rules for participating in operation reserve markets that could serve as a role-model for regulations and directives regarding the commercialization of end-customers' flexibility within a local energy market.

4.2.4. Improvements of the regulatory framework

The "Clean Energy for all Europeans" ("Winter Package") is the fourth European package on energy markets. The regulatory proposals and facilitating measures presented in the package aim at accelerating, transforming and consolidating the EU economy's clean energy transition thereby creating jobs and growth in new economic sectors and business models. The legislative proposals cover energy efficiency, renewable energy, the design of the electricity market, security of supply and governance rules for the Energy Union. Hereby, the package pursues three main goals: (1) Putting energy efficiency first, (2) achieving global leadership in renewable energies, and (3) providing a fair deal for consumers.

The European Commission's communication on "Clean Energy for all Europeans" (European Commission, 2016) recognizes the current and future importance of fluctuating renewables, specifically wind and solar electricity generation. Accordingly, the legislative package proposes that market rules have to be adapted to facilitate the integration of these renewables and ensuring security of electricity supply. In order to achieve this goal, the European Commission further states that markets have to provide specific rules for shorter term trading as this reflects the volatile behaviour of such fluctuating energy sources. In this sense, the European Commission foresees that short-term electricity markets will reward

energy flexibility for generation, consumption and storage. Furthermore, this communication obliges that renewables shall participate in all market segments, also explicitly mentioning system services markets.

According to ACER and CEER (Agency for the Cooperation of Energy (ACER), Council of European Energy Regulators (CEER), 2017), a holistic approach is needed for exhausting the full potential of energy flexibility and customer participation. The framework of all integrated elements of flexibility in such a holistic approach is shown in Figure 5. Flexibility originates from generation, storage and changes in consumption patterns. The beneficiaries of flexibility are listed in the bottom part of this figure and the middle part displays the enablers that support sources in accessing options for valuing their flexibility.

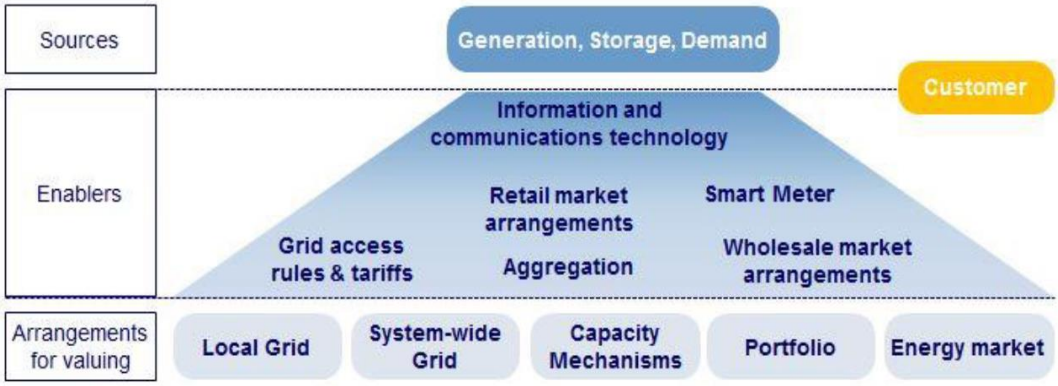

Figure 5. Framework of integrated elements of flexibility

A key enabler for customer participation and demand side flexibility are smart meters. Expert Group 1 of the Smart Grids Task Force describes the interoperability of different interfaces of the flexible demand architecture in a large-scale roll out of smart metering devices (European Smart Grids Task Force, Expert Group 1 - Standards and Interoperability, 2016). This work considers European recommendations, such as 2012/148/EU that presents recommendations on preparations for the roll-out of smart metering systems (European Union, 2012) and also European mandates on smart metering (European Commission, 2009) and smart grids (European Commission, 2011).

Concerning the fair deal for consumers, the aforementioned communication describes and facilitates that future, decentralized, smart and interconnected markets will enable consumers to easily generate electricity themselves and allow for storing, sharing, consuming and selling this energy – either directly or via energy cooperatives. Furthermore, consumers are expected to offer demand response directly or through an explicitly mentioned energy aggregator. These and other business models are expected to evolve, facilitating innovation and required digitalization. The European Commission's communication therefore strongly acknowledges the concepts previously described in this study.

ACER and CEER (Agency for the Cooperation of Energy (ACER), Council of European Energy Regulators (CEER), 2017), additionally advise that these aggregators shall be independent, which means that they are not affiliated to a supplier or any other market participant. Furthermore, Member States have to ensure that aggregators' market access may not be foreclosed by suppliers since this would be disadvantageous for customers and that

arrangements provide (monetary) compensation for resold energy. Such a payment for resold energy serves system efficiency and reduces consumers' bills.

The "Clean Energy for all Europeans" package also describes the creation of a new European entity dedicated to DSOs. This new entity will define rules on grid management and use as well as EU-level cooperation with TSOs. Thereby, this new entity will promote the integration of renewables, distributed generation, storage, demand response, and smart meters (European Commission, 2016). The Third Energy Package established ENTSO-E that set precise rules for participation in the transmission system. Therefore, this new entity on distribution grids can be interpreted as a first step towards future local energy markets and the participation of end-customers.

This new legislative package additionally presents a proposal for a revised internal electricity market directive. In Article 32 of this proposal, DSO tasks for using flexibility are defined. The yet to be developed national regulatory frameworks shall enable DSOs to use among others distributed generation, demand response or storage in order to optimize grid efficiency and ensure secure operation of the system. These markets explicitly consist of renewable energy sources, demand response capabilities and aggregators. This article therefore directly considers flexibility and the concepts of demand response and aggregation, which significantly reduces the barriers described previously, allowing for a free, market-based commercialization of end-customers' flexibility.

ACER and CEER (Agency for the Cooperation of Energy (ACER), Council of European Energy Regulators (CEER), 2017), additionally specify that distribution system operators should be required to act in a non-discriminatory manner when procuring and using flexibility. Flexibility providers should also take advantage of other arrangements for valuing their flexibility, for instance balancing markets.

4.3. Regulations and Rules in Sweden

The main piece of regulation regarding electricity markets in Sweden is the **Electricity Act** (Sveriges Riksdag, 2017). This act regulates network concession and operation, tariffs, balancing of electricity grids, and related topics such as liability for damage, supervision and protective measures. Based on the Electricity Act and the Regulation on measuring, calculating and reporting distributed electricity (Sveriges Riksdag, 2017), Sweden has begun a roll-out of smart meters that was completed in 2009. These smart meters can be seen as the foundation for a successful and widespread implementation of end-customers' participation through demand response and micro-generation. However, since Sweden completed this roll-out very early, most devices are limited in their functionality. For instance, all customers with a fuse size of less than 63 Ampere are measured and reported on a monthly basis, whereas hourly meter readings are employed for larger customers (THEMA Consulting Group, 2015).

According to THEMA (THEMA Consulting Group, 2015), there are currently no regulations in force that handle the access to the measured data or an interface allowing for controlling loads remotely. Therefore, potential flexibility services involving direct load control are not defined on a legal level, yet.

Furthermore, there are no obligations or constraints on a price structure for supplier contracts at the moment. Hence, there is neither an obligation for suppliers to provide

hourly prices to their customers nor is such prohibited. The Electricity Act (Sveriges Riksdag, 2017) only describes a general rule on grid tariffs that tariffs should be objective, non-discriminatory and set in a way that is consistent with efficient use of the electricity grid as well as efficient production and use of electricity. Accordingly, suppliers could use such dynamic pricing schemes for affecting customers' demand and induce load shifting.

According to JRC (Bertoldi, Zancanella, & Boza-Kiss, 2016), the role of an independent aggregator is not defined yet. In order to be an independent aggregator, the company should register as a balancing responsible party. However, aggregators require the retailer's permission to aggregate loads and may only group customers in a given balancing region, which strongly reduces the potential size of an available pool. In contrast to other European countries (e.g. Germany), prequalification for market access is carried for the pool instead of each participant in the pool, which simplifies the prequalification process. An additional barrier are the high minimum bid sizes for participation in different markets, which are shown in Table .

Table 5. Main programme requirements in the balancing products accessible to DR in Sweden (Smart Energy Demand Coalition, 2015, p. 140)

Product		**Minimum size (MW)**	**Notification time**	**Activation**	**Triggered**
FCR	FCR-N	0,1	63% in 60 s, 100% in 3 min	Automatic with frequency is out of 49,9-50,1 Hz	Constantly
	FCR-D	1	50% in 5 s, 100% in 30 s	Automatic with frequency under 49,9 Hz	Approx. 500 times/year
FRR-A		5	2 min	Automatic	Constantly
FRR-M		10 (SE1, SE2, SE3), 5 (SE4)	15 min	Manual by phone call	Before 2014, every hour
Slow active disturbance reserve		n/a	15 min	Manually	n/a
Reactive reserve		n/a	n/a	n/a	n/a
Strategic reserves		5	15 min	Manually	Historically less than 10h/year
Balancing Market		10	15 min	Market based	Market based

Article 19a of the **Electricity Regulation** (Sveriges Riksdag, 2017), which is a bill related to the Electricity Act, states that the Swedish NRA is obliged to make a publicly available list containing the technical demands and other terms and conditions for demand response services. This regulation must be seen in connection with the implementation of the Energy Efficiency Directive, and ensures that parties that would like to offer energy services have the required knowledge necessary for doing so. It is already possible for Swedish electricity consumers to adjust their consumption over time, however, there is no (monetary) compensation guaranteed by law for offering flexibility, which currently impedes the development and establishment of demand response. Additionally, electricity prices are relatively low in Scandinavia, providing small incentives to demand side flexibility (Bertoldi, Zancanella, & Boza-Kiss, 2016).

There is no discrimination between generation and demand in the regulation or product definitions in the reserve and balancing markets. However, the volumes, response time, duration and other characteristics defined by the TSOs to participate in these markets, which are described in section 4.2.3, may serve as a barrier for demand response in these markets.

Regarding power generation and feed-in, there are no special rules regarding the connection of micro-producers to the public grid. However, the Swedish law supports micro-production by offering exemptions from all charges connected with exporting electricity to the grid. Furthermore, micro-producers are allowed to sell their generated electricity to any electricity supplier company. Regeringens proposition 2013/14:151 (Regeringskansliet, 2013) however recommends obliging the supplier to receive the electricity from the micro-producer. According to THEMA, a generation facility is considered to be a micro-producer, if it generates up to 63 Amperes and has a capacity of at most 43.5 kW feed-in. Additionally, micro-producers have to be net consumers of electricity over a period of one year.

4.4. Regulations and Rules in Germany

Flexibility is required to meet political targets of reducing greenhouse gas emissions by increasing the usage of renewable energy sources. In 2016, 29% of Germany's gross electricity generation was produced by renewable sources, with 12% from wind and 6% from solar energy (Agentur für Erneuerbare Energien, 2017). The German government has pronounced the target of generating at least 80% of the country's electricity from renewable sources by 2050. In order to reach this aim, 40-45% of the gross electricity consumption should be generated from renewable energy sources by 2025 and 55% to 60% by 2035 (Gesetz für den Ausbau erneuerbarer Energien, 2017). Therefore, the current problem becomes even more immense in the near future and the necessity for utilizing flexibility more urgent.

4.4.1. Relevant regulatory framework

The *Energy Industry Act (EnWG), Electricity Grid Access Ordinance (StromNZV), Renewable Energy Sources Act (EEG), Interruptible Loads Act (AbLaV), Distribution Code,* and *Transmission Code* provide a legal framework for offering and requesting energy and flexibility in Germany. These key regulatory references are listed together with their original German title in Table .

Table 6. Key regulatory references in Germany

English title	German title	German abbreviation
Energy Industry Act	Energiewirtschaftsgesetz	EnWG
Electricity Grid Access Ordinance	Stromnetzzugangsverordnung	StromNZV
Electricity Grid Charges Ordinance	Stromnetzentgeldverordnung	StromNEV
Ordinance on General Terms Regulating Universal Service for Household Customers and Replacement Supply via the Low Voltage Network	Stromgrundversorgungsverordnung	StromGVV
Renewable Energy Sources Act	Erneuerbare Energien Gesetz	EEG
Interruptible Loads Act	Verordnung zu abschaltbaren Lasten	AbLaV
Ordinance for Proving Electrotechnical Properties of Energy Conversion Units	Elektrotechnische-Eigenschaften-Nachweisverordnung	NElEV
Distribution Code	Distribution Code: Regeln für den Zugang zu Verteilungsnetzen	
Transmission Code	Transmission Code: Netz- und Systemregeln der deutschen Übertratungsnetzbetreiber	
Generation Units in the low voltage system	Erzeugungsanlagen am Niederspannungsnetz	
Regulation on reserve power plants	Netzreserveverordnung	NetzResV
Ordinance on measuring points operation	Messstellenbetriebsgesetz	MsbG

The **Energy Industry Act** (Gesetz über die Elektrizitäts- und Gasversorgung, 2017) describes the liberalization of the German electricity market, allowing the system of third party access. Furthermore, this act includes the implementation of EU directives 2003/54/EC and 2009/72/EC (internal electricity market directive), especially regarding unbundling of electricity generation and distribution, and creating the German Federal Network Agency.

The **Electricity Grid Access Ordinance** (Verordnung über den Zugang zu Elektrizitätsversorgungsnetzen, 2016) establishes requirements for electricity feed-in and consumption. Regarding commercialization of flexibility, article 26a opens up balancing

markets, in particular minute reserve and secondary control, for participation of end-customers.

Additionally, the **Electricity Grid Charges Ordinance** (Stromnetzentgeltverordnung – StromNEV) regulate the fees for accessing electricity grids (Verordnung über die Entgelte für den Zugang zu Elektrizitätsversorgungsnetzen, 2016). It regulates grid usage charges in the liberalized energy market for the transmission of electricity through networks of electricity grid operators to consumers as well as charges for decentralized feed-in. The **Electricity Supply Ordinance** (StromGVV) (Verordnung über Allgemeine Bedingungen für die Grundversorgung von Haushaltskunden und die Ersatzversorgung mit Elektrizität aus dem Niederspannungsnetz, 2016) is a German ordinance regulating the conditions under which household customers are to be supplied with electricity by the basic electricity supplier.
The purpose of the **Renewable Energy Sources Act** is the mitigation of climate change and environmental protection (Gesetz für den Ausbau erneuerbarer Energien, 2017). Therefore, this act demands that fossil energy resources should be conserved and the further development of technologies to generate electricity from renewable energy sources should be promoted. Furthermore, the cost to the economy should be kept to a minimum level and the energy supply should be developed in a safe and sustainable manner. This act guarantees grid priority for renewable electricity. Grid system operators have to connect renewables without delay and as a priority.

The **Interruptible Loads Act** (Verordnung über Vereinbarungen zu abschaltbaren Lasten, 2016) establishes compensation rules for large electricity consumers that offer to shed their loads in order to stabilize the grid. Article 13 of EnWG states that interruptible loads have to be traded on non-discriminating and transparent markets via a common internet platform. This act therefore defines technical constraints and economic remuneration rules for interruptible loads as well as the market procedures for offering such interruptible loads. In its initial version from 2012, a minimum power of 50 MW had to be offered. In its current version, this power has been reduced to 5 MW, opening this market for smaller loads. Additionally, virtual power plants can participate by aggregating smaller devices. According to DENA (Deutsche Energie-Agentur, 2013), in 2013 there were already 251 MW of immediately interruptible loads that have to be shut down within 350 milliseconds and even 804 MW of quickly interruptible loads that have available in less than 15 minutes.

Rules for proving electrotechnical properties of energy conversion units are defined in the **Ordinance for Proving Electrotechnical Properties of Energy Conversion Units** (Verordnung zum Nachweis von elektrotechnischen Eigenschaften von Energieanlagen, 2017). This ordinance is a national implementation of EU Regulation 2016/631 (European Commission, 2016). It also explicitly applies to electricity storages.

Furthermore, the **"transmission code"** (Verband der Netzbetreiber, 2007) describes the cooperation as well as responsibilities of the four German transmission system operators (TSOs) and the **"distribution code"** (Verband der Netzbetreiber, 2007) describes the competency of the distribution system operators (DSOs). Moreover, the German Association for Electrical, Electronic, and Information Technologies (VDE) publishes guidelines on generation plants in the low voltage grid. These guidelines describe the regulations to connect decentralized power plants to distribution grids (VDE, 2011). Currently, these guidelines are being extended to a complete package that also deals with the connection of storage units (VDE, 2017).

The four German transmission system operators are responsible for the security and the reliability of the electricity supply system, defined by §13 of the Energy Industry Act. In the case that the security and system reliability is endangered, the TSOs have to stabilize the grid with network related measures like network switching or based on market related measures like balancing energy or contracted interruptible loads (Gesetz über die Elektrizitäts- und Gasversorgung, 2017). The technical constraints for this frequency control are described in the Transmission Code 2007. Rules for provisioning grid reserve are defined in the German regulation on reserve power plants (Verordnung zur Regelung der Beschaffung und Vorhaltung von Anlagen in der Netzreserve, 2016).

TSOs and DSOs are responsible for the voltage control in their networks according to the Transmission Code 2007 and the Distribution Code 2007. Furthermore, they have to ensure the balance between reactive power requirement and the generation of reactive power. Also, the Distribution Code describes the obligation of DSOs to ensure the voltage quality according to the corresponding standards.

In order to enable smart grids and end-customer participation through digitalization, the operation of measuring points has been regulated (Gesetz über den Messstellenbetrieb und die Datenkommunikation in intelligenten Energienetzen, 2016). This law describes, among other things, the minimum requirements for intelligent metering systems and the data communication with smart meters.

4.4.2. Regulatory barriers

Similar to the European regulatory framework, the German regulations still have not defined flexibility or set rules for its commercialization. Since the Energy Industry Act describes the implementation of the European internal electricity market directive (2009/72/EC), a definition of flexibility would have been expected in this act. With such a clear specification of the concept of flexibility, applicable services and capabilities offered and requested by end-customers and grid operators could be derived and implemented.

Furthermore, the unbundling principle has not been addressed in the context of flexibility. The Energy Industry Act implements the unbundling of generation, transmission, and distribution as it has been demanded in the European internal electricity market directive (2009/72/EC); however, it is uncertain if a transmission system operator or distribution system operator is allowed to commercialize its available flexibility in order to support other grids.

The Interruptible Loads Act allows for commercialization of demand flexibility. However, due to the high minimum tender, this market is currently hardly accessible for non-industrial end-customers. This minimum tender has already been reduced from 50 MW to 5 MW, but it still prohibits the participation of small-scale customers.

4.5. Summary

End-customers' flexibility can significantly support the integration of renewable energy sources. Additionally, flexibility can be used to reduce grid constraints potentially resulting from peak generation or peak load, make better use of the existing grid infrastructure and thereby possibly reducing the need for investments in the grid. Flexibility can result from shiftable loads, storage and controllable local generation, and can either be commercialized individually or grouped by aggregators.

On a European level, the existing regulatory framework already describes related concepts such as free energy markets, integration and aggregation of customers as well as distributed and small-scale generation. Network codes already exist defining the connection of generators and demands. Moreover, the importance of renewable energy sources and customers' participation is acknowledged.

However, energy flexibility has not been defined yet. Furthermore, aggregator service providers that are foreseen to play a significant role for integrating renewables, are not defined either in a regulatory context. The current regulation also does not clarify if grid operators are legally allowed to commercialize upon their customers' flexibility in providing energy to other grids, since this could contradict the unbundling principle that separated electricity generation and transmission.

The investigated examples of national level regulations illustrate that necessary preparations have partly been made so far. In Sweden, the smart meter roll-out has already been completed. Additionally, customers are allowed to adjust their consumption over time, but there is currently no guaranteed compensation, which impedes the development of demand response. In Germany, the Interruptible Loads Act in theory enables commercialization of demands. However this market requires a high minimum tender that discriminates against small-scale customers. Similar to this market, regional and national balancing markets also consider end-customers in theory, but due to their high entry barriers are not accessible for end-customers yet.

These drawbacks have been addressed in the European Commission's "Clean Energy for all Europeans" legislative package, which is as a main step towards customers' participation. This package foresees and facilities a greater customer integration on all market segments. Customers will be allowed to generate, store, share and consume energy directly or through aggregators. Furthermore, this package presents proposals for new and updated directives. The proposal for a revised internal electricity market directive, for instance, recognizes that electricity generation has become more decentralized, therefore delegating balancing responsibilities from TSO level to DSO level. This proposal requires distribution system operators to consider the creation of markets for distributed generation, demand response and storage, in order to support the efficient and secure operation of the grid and supplant the need to upgrade or replace electricity capacity.

5. CONCLUSIONS

In order to achieve the ambitious European targets for reduction of greenhouse gas emissions, an increased generation from decentralized, locally available, renewable energy sources is necessary. Renewable energy sources will concern to a significant extent fluctuating generation systems, such as wind and solar energy. For integrating these renewables, local energy markets as well as end-customers' flexibility are expected to play a vital role.

On a European level, the existing regulatory framework describes related concepts such as free energy markets and distributed generation. However, the concept of local energy markets has not yet been defined. The EU's Third Energy Package took a step into the direction of market competitiveness but did not explicitly define the role and position of local energy markets in the already existing framework.

The investigation of two exemplary Member States (Sweden and Germany) has shown that on a national level, some preparations have already been undertaken to enable local energy markets. Sweden, for example, has already finished a complete roll-out of smart metering devices that are key technologies for enabling bi-directional communication in close to real-time that is required for successful local energy markets. In Germany, large shares of wind and solar generation capacities have already been installed. However, the current German legislative framework is still focused on large, centralized production facilities, not providing precise rules on local energy markets.

Regarding energy flexibility, the existing European legislature also still lacks a definition that allows for offering and commercializing flexibility. Furthermore, roles, responsibilities and business models for different actors have not been defined either. For example, aggregator service providers are foreseen in future grids, but their competences and sphere of responsibility is not clarified. In addition, it is not clear whether or not grid operators are legally allowed to commercialize upon their customers' flexibility in providing energy to other grids, since this could contradict the unbundling principle that separates electricity generation and transmission.

The analyzed examples of national level regulations illustrate that necessary preparations have partly been made so far. Similar to local energy markets, the smart meter roll-out in Sweden is a key enabler of trading flexibility. In Germany, the Interruptible Loads Act in theory enables commercialization of demands. However, this and other related markets require high minimum tenders that discriminate against small-scale customers.

The European Commission's "Clean Energy for all Europeans" package is perceived as a major step towards local energy markets and customers' participation. The goal of this package is to facilitate a greater customer integration on all market segments. Its intention is to allow customers to participate directly or through aggregators. Furthermore, this package presents proposals for new and updated directives. These proposals recognize that electricity generation has become more decentralized, therefore suggests delegating balancing responsibilities from transmission system level to the distribution system level. These proposals require distribution system operators to consider the creation of local energy markets for distributed generation, demand response and storage, in order to support the efficient and secure operation of the grid and supplant the need to upgrade or replace electricity capacity.

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