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STORY

added value of STORage in distribution sYstems

Deliverable 8.3
Policy Brief on Recommendations

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1 Executive Summary

The recommendations presented in this document address real-life issues encountered by the project developers who led the technology demonstrations of the STORY project. Each of the demo leaders faced unique challenges in bringing technology to market, and in bringing systems from different providers together. It became clear during the project that the market for storage is in its infancy in all aspects of the value chain, fom the technology supply, to troubleshooting installed equipment, connecting and operating the technology, and participating in markets. It is the hope of the STORY project consortium that these recommendations will pave the way to enable an economically feasible growth of the storage market.

A first description of main regulatory topics was presented by Vlerick in a webinar in May 2019[1]. The main regulatory discussions were debated internally with demo leaders and STORY project participants during two General Meetings in April 2019 and in October 2019. An iterative process with the project participants was then carried out to identify the main issues affecting the STORY project demos. The issues identified were then narrowed down and discussed during a one-day meeting in Leuven Belgium in January 2020 followed by e-mail feedback rounds. The STORY project has identified five main areas of discussion regarding business models and regulation for storage:

- Legal definition of storage,
- Network tariffs,
- DSO participation in storage projects,
- Market design
- Business model enablers.

Section 3 presents a discussion and recommendations on the legal definition of storage. During the project it became apparent that it is unclear whether storage is treated as generation or as load in the grid guidelines of each country. This led to difficulties in assessing connection requirements, servicing by the DSO, as well as taxes and tariffs applicable. In light of these issues, three main recommendations are put forward: 1/ there should be a clear distinction in regulation between storage assets set behind the meter and storage assets directly connected to the network, 2/Heat and gas storage should also be contemplated in the regulation and grid codes, 3/ Regulation should make a distinction between permanent versus mobile storage units.

Section 4 presents recommendations on network tariff design. Network tariffs represent a significant portion of the energy fees that a market participant pays, thus directly affecting the business case for storage. This section presents the results of a study done during this project on tariff design trade offs. A central planner scenario is compared to capacity based tariffs, volumetric net-metered tariffs and volumetric bi-directional tariffs. The results show that volumetric net-metered tariffs de-incentivize investment in storage units as users then use the network as a battery; while volumetric bi-directional tariffs provide an incentive to over invest in batteries. Capacity based tariffs prove to be the most efficient design for society, taking into account network costs recovery as well as the individual business case for storage. The STORY project recommends that tariff design

[1] A recording of the webinar is available here: http://horizon2020-story.eu/webinar-on-regulation-for-storage/

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should aim for grid cost recovery, technology neutrality in tariff design, and a distinction should be made between energy destined for storage versus energy destined for final consumption.

Section 5 discusses the extend of DSO participation in storage projects. It was seen during the demos of the STORY project that integrating larger scale batteries into a distribution network can cause disturbances in the network. Active participation by the DSO was necessary to enable the safe and reliable operation of the battery systems. The main role of a DSO should be to act as a grid facilitator enabling market actors to perform their commercial activities. Therefore, on principle, and in line with European regulation, DSOs should not own storage assets. Nevertheless, every DSO needs to learn how to connect and manage storage in their network before they can efficiently facilitate the process. In the experience of the STORY project, the learning curve is quite steep and requires adaptations to the SCADA management systems of the DSO. Therefore, it is the proposal of the STORY project that allowing DSOs to exceptionally operate a storage system as part of their network assets could serve two purposes: 1/ Enabling the adaptation of the DSO's systems to accommodate and service storage facilities, 2/ Enabling DSOs to observe the impact of storage in their network in order to draft product definitions for services that should be later provided by commercial actors.

Section 6 discusses electricity market design considerations that affect the business case of storage. Two aspects of market design are discussed: the first is the design of balancing markets to allow the participation of flexibility coming from different types of technologies, and the second is access to markets for small consumers through aggregation. It was the experience of the STORY project demos, that the value created by the technology installed, was not directly monetizable. Market design requirements, and minimum volume criteria pose challenges for the participation of smaller scale storage in distribution. It became clear that aggregation of resources is necessary to reap the value of flexibility as a whole. Storage is a technology that can provide flexibility and should be considered in a portfolio of flexibility options. The STORY project proposes two main recommendations for market design: technology neutrality in service design and assurance that consumers are enabled to valorise flexibility.

Section 7 discusses business model recommendations for storage. An iterative process with the STORY partners and demo leaders lead to a classification of the storage business models based on two main criteria: 1/ the level of resource aggregation, 2/ the different revenue streams as value is created for different market parties such as the owner of storage, services for the DSO and TSO, and market arbitrage. It became clear that the business model for storage depends on being able to stack revenue streams coming from different markets. Reaping the value of storage from residential consumers is dependent on retailer and aggregation innovation. Finally, the markets to valorize storage are not well defined yet, especially at the distribution level, it is necessary that DSOs draft clear product definitions that would enable a business case for smaller local flexibility providers.

2 Introduction

The five topics mentioned above are presented in this document: legal definition of storage, network tariffs, DSO participation in storage projects, market design, and business model enablers.

In addition to the unified views of the STORY consortium, the views of specific partners are presented in Boxes. Each of these boxes represents the opinions of the partner who authored them, and may

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differ from the main recommendations in this document. It was decided to include these boxes as policy discussions should take the views of different stakeholder into account.

In order to present the recommendations, the background and relevance of each topic is discussed first, and then, the STORY project recommendation is presented. Each section is supported by work done in the STORY project, which can be found in Deliverable 8.5: Energy Storage in Distribution – Deployment Handbook; the relevant chapters are quoted in each section.

The authors of this document would like to thank the STORY partners who have been directly involved in the recommendations drafting process through phone meetings, email iterations and a one day workshop in Belgium in January 2020 are: VTT, UL, PI, JR, CEN, THNK, FLEX, EXL, BEN and VITO. Similarly, we would also like to thank other partners have been involved in the supporting studies to the recommendations through participation in business model workshops, and input during the STORY project general meetings: BASN, ABB, B9 and UCL.

3 Legal Definition of Storage

In order to discuss the issues encountered and the proposed recommendation regarding the legal definition of storage, first background information and exmples in regulation are presented, and second the STORY project recommendation is explained.

3.1 Background

The legal definition of storage affects whether an asset is considered as a consumption or generation unit connected to the network. This point is recognized in the Commission staff working document 2017-61 which states that: "The lack of a clear definition for energy storage in the regulatory framework resulted in a lack of coherence in the classification of storage facilities into generation and/or consumption across Member States" (European Comission, 2017).

To facilitate the discussion on the effect on this lack of clarity and how this could be addressed, this section presents the legal definition in the clean energy package first. Then, the definition and practical use of storage as a service provider in Belgium and Spain are outlined.

According to the Directive on common rules for the internal market, in the EU clean energy package, energy storage means, in the electricity system, deferring the final use of electricity to a later moment than when it was generated or the conversion of electrical energy into a form of energy which can be stored, the storing of that energy, and the subsequent reconversion of that energy back into electrical energy or use as another energy carrier (European Parliament and the Council of the EU, 2019). More broadly, storage can be thought of as moving energy over time (Rastler & Electric Power Research Institute, 2010).

In Belgium, storage is defined at the DSO level as ‘a unit capable of receiving, storing and feeding back electrical energy connected to a distribution network, regardless of the nature of the technology in

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use' (Synergrid, 2019).[2] In the Energiebesluit a stationary installation for electrochemical electricity storage is defined as: 'a fixed installation consisting of one or more electrochemical cells with which electrical energy is taken from the network or the internal installation to which it is connected, to transfer that electrical energy at a later time back to the network or the indoor installation to which it is connected'[3] (Vlaamse Regering, 210AD). In terms of service provision by storage assets, Elia, the Belgian TSO considers storage as a 'limited energy content'; which are units that cannot unlimitedly provide a certain capacity for ancillary services and the capacity remuneration mechanism (Elia System Operator, 2019). Service provision from these assets follows a specific set of rules, for example, FCR providing units with a limited energy reservoir should be able to be fully activated for at least 30 minutes at any given moment during their delivery. The service provider also needs to present toward the TSO their energy management strategy, which needs to be approved.

In Spain they have introduced a different approach as they include the use of storage as part of a self-consumption installation. In Spain, storage is not considered within primary legislation, rather it is considered as a part of self-consumption activities of consumers and legislated in a self-consumption decree (Ministerio para la Transición Ecológica, 2019). Self-consumption is defined as 'consumption by one or several consumers of electrical energy coming from generation installations next to the consumption installation and associated with them'. There are two main modalities of self-consumption: with and without excess of energy (that will be poured into the grid). Self-consumption without excess can't pour energy into the grid while self-consumption with excess can pour energy into the distribution or transmission network

3.2 STORY Recommendation

The legal definition of storage that can be found in legislation so far, defines the role of storage in the system, broadly speaking, as a system to defer the use of energy over time. However, it fails to define whether to consider storage as generation or as consumption. This has implications on the tariffs for use of the network, the levies and fees, and the obligations of the storage asset management.

The STORY project advocates for the harmonization of the legal definitions of storage used by the TSO, DSO, market design platforms and participating actors. The energy package proposes a legal definition of the act of storing energy which can constitute a first step in this direction. However, we consider it could be extended by:

- Distinguishing between storage assets set behind the meter and storage assets directly connected to transmission or distribution assets as otherwise, directly connected assets run the risk of incurring grid double charges as will be discussed below.

[2] 'Een eenheid die in staat is om elektrische energie uit het netwerk van een DNG of het distributienet op te nemen, op te slaan en terug te voeden, onafhankelijk van de aard van de technische uitvoering van die eenheid.' Technish Voorschrift C10/11

[3] 'In dit artikel wordt verstaan onder stationaire installatie voor elektrochemische opslag van elektriciteit: een vast opgestelde installatie die bestaat uit een of meer elektrochemische cellen waarmee elektrische energie wordt afgenomen van het netwerk of de binneninstallatie waaraan ze gekoppeld is, om die elektrische energie op een later moment terug te voeden aan het netwerk of de binneninstallatie waaraan ze gekoppeld is.'

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- Including heat and gas storage, as well as their interaction with the electricity network as currently only electrical storage is considered in the regulation.
- Distinguishing in the grid connection codes between permanent versus mobile storage units.

4 Network Tariffs

The background subsection gives an overview of how tariff design affects the business case for residential storage and what are the current practices in the countries participating in the STORY project. This is followed by the recommendations for improvement from STORY project.

4.1 Background

Network tariffs have been studied in the context of WP8 and presented in 'D8.2 Intermediate Reporting for STORY, Advisory Board and Projects Council.' In addition, current practices regarding tariff design are also presented. This section presents the interaction between distribution tariff design and the business case for residential storage as well as the current developments in STORY participating countries.

4.1.1 Distribution tariff design and the business case for residential storage[4]

Storage installations can be used for two main purposes, one is to achieve savings on the electricity bill when coupled with self-generation and the other is to offer services to electricity stakeholders.

In both cases the network charges paid by storage affect the business case of the installation. Distribution network charges represent on average around 30 % (incl. VAT) of the final electricity bill in Europe, with a maximum of around 50 % in Norway and a minimum of around 15 % in Italy (ACER & CEER, 2018c). Network tariff design can encompass different modalities: capacity-based network charges, and volumetric network charges. The paragraphs that follow first define capacity-based network charges. Then, we define and compare the implications of three modalities of volumetric network charges: net-purchase volumetric charges, volumetric charges with net-metering and bidirectional volumetric charges. Finally, the conclusions of the study are presented.

With capacity-based network charges, a consumer pays for the grid according to his (individual) monthly or yearly peak capacity usage averaged per e.g. an hour. The idea behind capacity-based charges is that as the main driver of the network is (peak) network capacity, consumers ought to be

[4] This section is an excerpt from (Schittekatte & Meeus, 2019), a study made for the STORY H2020 project.

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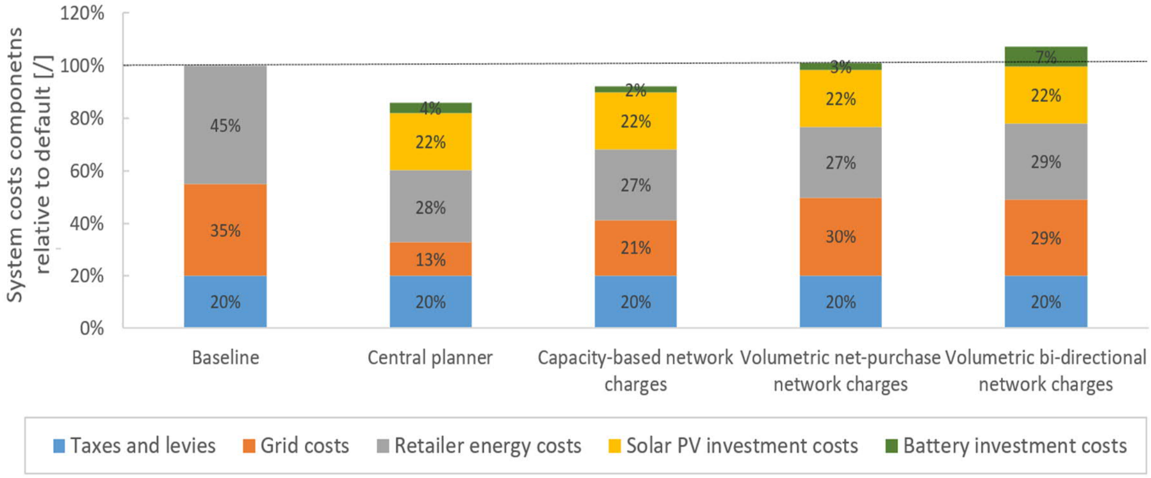

Figure 1: System costs and its components for the different network tariff designs

charged according to their maximum network capacity needs. The problem is, however, that individual consumer maximum capacity-usage does not always coincide with the main network cost driver: the aggregated peak capacity needed over all consumers connected to the same network.

An alternative to the capacity-based network charges is the use of volumetric charges. In here three different options for volumetric charges are presented :

- Net-purchase volumetric charges: a consumer pays a network fee for every kWh withdrawn from the network
- Volumetric charges with net-metering: energy injected into the grid is counted as negatively consumed energy, so it is subtracted from the total amount of energy withdrawn. The traditional meters installed would run backwards when energy is being injected into the network from a consumer's facility.
- Bi-directional volumetric charges: energy withdrawn and energy injected into the network are metered and billed separately; a €/kWh network fee is paid for each kWh of electricity withdrawn and injected into the network. By creating a difference between the value of on-site generated electricity that is self-consumed or injected back into the network, this network tariff design incentivises self-consumption.

These definitions show that these charging methodologies can have very different effects on the incentives of batteries owners. On one extreme, net-metering charges do not stimulate self-consumption at all. With this tariff the grid acts as a free battery, and the price a consumer receives to inject 1 kWh into the grid is always equal than the price a consumer pays to consume 1 kWh from the grid. On the other extreme, bi-directional metering will give the incentive to minimise the exchange of electricity with the grid and thus to maximise self-consumption, if the network tariffs are designed properly. The incentive to self-consume under volumetric charges with net-purchase lies in the middle.

To evaluate the effect of these charges structure on the overall costs of the system, this study introduced a game-theoretical model to capture the interaction between the distribution network

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tariff design, the decisions made by active consumers investing in PV and batteries and their aggregated effect on the network cost. The results are presented in Figure 1. The first vertical bar presents the case that no active consumer invests in DER (baseline scenario). The following columns compare the findings for the other cases to those of the baseline scenario:

- Central planer: it represents the trade-off between the grid costs, retailer energy costs, solar PV and batteries for the given parameter settings. This combination of grid costs, retailer costs and investment in solar PV and batteries, lowers the sum of the interacting components of the electricity bill to a total system cost which is 14 percentage points lower than the baseline since a large portion of grid costs are avoided by the installation of solar PV and batteries.[5]
- Capacity-based charges: this case also leads to an investment mix which lowers the total system costs relative to the baseline. However, due mainly to an under-incentive to invest in batteries and sub-optimal operational signals, the grid costs are not decreased as much as would be optimal.
- Volumetric network tariffs with net-purchase: these tariffs lead to a total system cost with around the same value as the baseline, even though the composition of the different components is very different. Some batteries are installed, less than in the optimal central planner case, and they are not operated in a way that the grid costs are decreased. This happens because the network is being used as a battery, and therefore grid costs don't decrease as much as in other scenarios.
- Volumetric charges with bi-directional charges: this case results in a system which is more expensive than the baseline case without any DER investment. An overinvestment in batteries by the active consumers occurs. The active consumers are incentivised to increase self-consumption to a level which is not cost-efficient from a system point of view under the given assumptions.

From a grid perspective, there is little need for batteries and the main exercise is to find a network tariff design which remains acceptable in terms of distributional impacts while minimising any possible distortion. Examples can be found in e.g. Pérez-Arriaga et al. (2017), Pollitt (2018) and Wolak (2018): differentiated fixed network charges are not recovering all sunk grid costs through the electricity bill. In a preceding study, Schittekatte and Meeus (2018) show that spreading the grid costs over capacity-based charges, volumetric charges and fixed charges can also mitigate the induced distortions.

In the other extreme, still many grid investments have to be made, and the future grid costs are driven by the growing aggregated peak demand of consumers. Under this scenario, our model shows that in that situation the tested network tariff designs will not only give an inadequate investment signal to the consumers, also the consumers will operate their installed batteries sub-optimally from a grid point of view. If consumer electricity demand profiles are rather homogeneous, batteries are under-invested by capacity-based charges. If consumer electricity demand profiles are heterogeneous, consumers will lower their individual demand which will have little effect on the system peak demand; a similar dynamic as in the sunk grid cost scenario occurs. With a network tariff design that

[5] Taxes and levies are assumed to be invariable and recovered through a fixed charge which does not distort the decisions of consumers.

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encourages self-consumption, the business case of storage is unrightfully negatively impacted when the batteries are not coupled with onsite generation such as solar PV. Oppositely, when active consumers combine solar PV with cheap batteries or grid costs are high, an over-investment in batteries can result under the network tariff designs that encourage self-consumption. The batteries are fully charged with self-generated solar PV to increase self-consumption, but it can happen that by the time the system peak demand occurs, the batteries are already fully discharged again. In that case, a high capacity of batteries is installed, but they do not contribute to overall grid costs savings.

The study finds that the business case of batteries and overall system benefits are not always aligned. In one extreme, in the case where most grid costs are sunk and little future grid investment is expected, the evaluated network tariffs mostly over-incentivize battery adoption. In this case, network costs are simply transferred from active to passive consumers, and each investment in batteries by active consumers increases the (private) value of an additional investment in batteries.

4.1.2 Current Practices

A description of the current tariff designs in Spain, Belgium, Finland, and Austria is presented next. In Spain, consumers pay a mixed tariff consisting of capacity charges (€/kW) and energy charges (€/kWh) (Ministerio de Economía, 2001). In low voltage, users with a contracted capacity under 15kW can opt for a flat network tariff, or a stepped tariff with two or three different prices for the energy (kWh) consumed throughout a day. The tariff that differentiates three different prices is meant for users that have an electric vehicle. Users who demand over 15kW capacity must enter into a tariff with three daily price periods. Higher voltages can have up to six differentiated network tariff energy prices per day. In recent self-consumption regulation, self-consumers with excess energy who meet certain requirements can be compensated by their retailer for the energy they inject into the grid. The terms will vary depending on the bilateral agreement between the retailer and the consumer. Self-consumption with excess that can opt for compensation will be net-metered. However, those who will not receive compensation for their excess, must pay grid tariffs for the energy injected into the network. Self-consumed energy from renewable energy is exempted from tariffs and levies (Ministerio para la Transición Ecológica, 2019).

In Belgium, the electricity tariff scales mostly with the energy consumed kWh. Given that most Belgian households have classic meters, the most common tariff methodology is volumetric tariffs with net-metering. The price is mainly reflecting the energy consumption, together with a small connection cost. In Brussels, bi-directional meters are mandatory for customers with an electricity production unit. Further, the Flemish regulator is considering changing to a capacity-driven tariff mechanism.

In Finland, the DSOs are free to choose their tariff structures, however, to prevent abuse of monopoly power, the Energy Authority regulates and monitors the total turnover and return of the companies. In Finland the distribution tariffs of small-scale customers consist of a volumetric charge based on transmitted energy and a fixed basic charge, which in some companies depends on the size of the main fuse. Some companies have incorporated a power-based cost component into the distribution tariff. This is considered justifiable especially from the viewpoint of cost-reflectivity and steering effects. In Finland, storage is tax free since April 2019. Electricity taxes used to be paid twice, first

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Box 1: Flexcity's's View on Tariff design

To flexcity, a combination of smart capacity-based network charges and volumetric bi-directional metering seems an optimal tariff type. The smart capacity based network tariff should not only be based on the maximum yearly demand peak but on the number and size of the 5 biggest peaks. This smart capacity based tariff would strike a balance between reflecting the real costs one puts on the electricity system and financially incentivizing household flexibility, which can be delivered by batteries. Capacity based network charges should come together with volumetric, bi-directional tariffs which incentivize to decrease overall electricity consumption.

- Flexcity

when charging the battery storage system, and second when using the electricity in consumption. The change in regulation is related to each situation, when electricity is transferred to the energy storage system and then back to the grid, then it is tax free. According to the tax law, a battery energy storage system which is part of a power plant does not need a license for tax free storage. The owner of a stationary electricity storage may apply for a license for operating a tax free storage, if the electricity is destined for consumption. The license application is made to the Finnish tax administration. The electricity fed back into the grid remains tax free until it is used for final consumption. The owner of the tax free storage is responsible for monthly and annual reporting to tax authorities. Today the DSO's are expected to apply the present tariff structures for battery energy storages due to absence of public tariff's tailored for storages only.

In Austria the tariff is mainly volumetric based. A local tariff for energy communities is being developed indirectly supporting storage. The plan is that for electricity shared only within the Energy community only low voltage volumetric grid tariff elements have to be paid, leading to a reduction of about 50% of the volumetric grid tariff elements. Also, other taxes and surcharges that are part of the grid tariff may be removed.

4.2 STORY Project Recommendation

The STORY project recommends that tariffs design should aim for grid cost recovery, technology neutrality, and separation of energy destined for storage vs final consumption. Each item is discussed next with additional discussion in Box 1 that presents the specific point of view of the STORY partner Flexcity.

Grid cost recovery means that grid charges should adequately recover the grid costs incurred by network operators. Capacity-based network tariffs incentivise consumers to lower their individual peak demand. The two other network tariff designs, volumetric net-purchase and volumetric bi-directional, result in a difference between the value of on-site generated electricity that is self-consumed and electricity that is directly injected back into the network. There is a trade-off between cost reflectivity and complexity. Detailed cost reflectivity implies more complexity, while tariffs that are too simple may not give adequate incentives. Spreading the grid costs over capacity-based charges, volumetric charges and fixed charges can help mitigate possible distortions.

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Tariff design should be technology neutral as tariffs should aim to legislate for service provision or consumer behaviour in general. A first step in this direction is, for example, the Spanish approach, which regulates self-consumption (including storage) rather than specific technologies.

For storage facilities directly connected to the network, legislation should make a distinction between energy stored for service provision and energy destined for final consumption. It is the view of the STORY project that energy stored for service provision should not pay the taxes and levies imposed on energy destined for final consumption.

5 DSO Participation in Storage Projects.

In the Background subsection DSO participation in storage projects is discussed from a practical and a regulatory point of view. The practical point of view includes potential problems stemming from DSO participation in storage projects but also current practice and possible exceptions. In the second part of this section recommendations based on the activities and finding of the STORY project are defined.

5.1 Background

Integrating storage into the system poses technical challenges regarding the behaviour of the storage technology, safety over the connections and considerations on grid requirements. These factors make it necessary for DSOs to get involved in storage projects. The main role of a DSO should be to facilitate the interactions of market players and consumers while maintaining a safe and reliable grid.

The clean energy package places the ownership and operation of storage facilities in the hands of commercial parties with some exemptions in specific cases (European Parliament and the Council of the EU, 2019). The Suha Demo in the Story project sheds light on what may constitute an exceptional situation. To present background information this section summarises the main points of these regulations. More concretely, this section considers as an example the regulatory decision of Ofgem, the EU Clean Energy package, and finally discusses what constitutes an exceptional situation where DSOs may operate storage.

Ofgem has identified that 'where flexibility assets are owned and/or operated by network operators there is potential to distort competition in markets for flexibility services or deter new entrants' (UK Department for Business Energy & Industry Strategy & Ofgem, 2018). As a result, Ofgem has added a new condition in the electricity distribution licence such that distribution network operators are 'prohibited from carrying out any generation activities (including storage), unless the activity is captured by an exception or the licensee has been issued with a direction' (Ofgem, 2018). The decision is related to the operation of storage assets, and does not extend to ownership. Therefore, under this ruling, network companies may own but may not operate storage assets unless they have been granted an exemption.

Article 36 in the Clean Energy Package directive on common rules for the internal market goes a step further and states that 'distribution system operators shall not be allowed to own, develop, manage or operate energy storage facilities' (European Parliament and the Council of the EU, 2019). The article then goes on to state an exception where DSOs may own, develop, manage or operate energy storage facilities which are 'fully integrated network components and the regulatory authority has granted

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approval'. In the same Directive, in Article 32, DSOs are mandated to publish a network development plan every two years. The network development plan should include the use of demand response, energy efficiency, energy storage facilities, or other resources as an alternative to system expansion. This regulation makes it clear that DSOs are expected to be network facilitators who will procure flexibility services from market parties.

The cases when an exemption may be appropriate are discussed. Storage being a new technology, DSOs are not yet sure of how and what services can be expected from such a facility. In the STORY demo case in Suha, the DSO directly operates a medium scale storage unit of 170 kW, 450 kWh. This unit is used in network load management and power balancing, power quality, peak demand control, reduction of line congestion, and avoiding PV curtailment. It is the first system of its type to be installed in Slovenia and the DSO had to make significant efforts to adapt their grid management systems to accommodate the battery. Through the demo, Elektro Gorejnksa is learning the possibilities and limitations of the technology. As a pilot project it is providing valuable information that may later be translated into commercial service requirements. Article 36 quoted above, outlines that a DSO may operate a storage facility when no acceptable bids have been obtained after a tender procedure. The pilot done in the STORY project provides the DSO with information that can help them structure a tender procedure in the future and further define technical requirements enabling the future flexibility market. See Box 2 for more details on the Suha demo, and the position of Elektro Gorejnska on the topic. In conclusion, in exceptional situations, it may be useful for DSOs to operate storage as a learning process to be able to later facilitate commercially owned storage systems.

5.2 STORY Project Recommendation.

The STORY project proposes three main recommendations: storage assets should be operated by commercial actors, the DSO should have procedures to integrate the operation of these assets and the DSO should follow a balanced process when choosing between network reinforcements and new storage solutions.

Storage assets should be owned and operated by commercial actors. The storage market is yet immature and commercial parties should be able to valorise their assets by offering services where they add the most value. This may be for internal electricity savings, or for service provision to a DSO, TSO or another market actor who may need it. Storage ownership and operation by a DSO could distort competition thus limiting the possible revenues that market parties may earn. It is important to make a difference between ownership an operation. Ownership of storage by a DSO should be an exceptional situation, where commercially owned storage is not available, but operation could be possible under service agreements. Under normal circumstances, appropriate channels should be enabled, to allow the DSO to contract flexibility services and send signals to a storage owner when needed.

Allowing DSOs to exceptionally operate a storage system as part of their network assets could serve two purposes:

1/ DSOs who have had experience operating a pilot storage project will be able to provide a better service as network facilitators for commercial projects. This will avoid large time delays that a small company may not be able to accommodate.

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2/ A DSO can learn and define what services can be expected from a battery to create appropriate service tenders.

DSOs should have procedures that enable the efficient connection and servicing of a new storage facility into the network. For example, the lack of standard procedures in the STORY Oud-Heverlee demo has caused significant time delays in the deployment of the neighbourhood battery. In this demo, the DSO was not involved in the STORY project. In contrast, in the Suha Demo, the DSO was fully involved in the connection and setup of the battery. Even in that case several issues had to be solved on a day to day basis to get the battery to be operational, and once operational to be able to run it smoothly. Elektro Gorejnska and ABB, the technology provider, had nearly daily exchanges of information during several months for troubleshooting.

As a result, the DSO should evaluate the grid impact of the local battery energy solution and control. DSOs must study the value of using flexibility versus network reinforcement. Only then will they be able to draft clear service definitions up for tender. Flexibility is an instrument that will allow network operators to connect more decentralised production, and eventually electric vehicles, into the network while maximizing the use of the existing infrastructure. It is a challenge to correctly compare the value of flexibility versus physical grid reinforcements. Methodologies to calculate the value of flexibility, and thus the services that a DSO will tender for, are necessary.

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Box 2: SUHA Battery as a fully integrated network Component for the DSO

A medium scale storage unit (170kW, 450 kWh) is connected to a distribution substation in Suha, a residential village grid. The unit is connected to a 400 kVA OLTC MV/LV transformer station of Elektro Gorenjska (EG). The substation low voltage network entails seven PV locations and nearly 90 households. The grid experiences flows in both directions due to the PV generation. There is 210 kWp of PV installed across seven units in the area.

From the DSO's point of view, a fully integrated network component represents the equipment providing DSO services, being an integral part of DSO regular technology systems and completely operated by the DSO. The Suha BESS demo system utilises EG network and control equipment used on a daily basis. It is also fully integrated into the EG SCADA network control system on demonstration (but not production) level due to sensitivity of BESS operation.

The BESS control algorithm very efficiently manages (minimises) MV/LV distribution transformer loads and by doing that effectively compensates local PV surplus production. Some additional functionalities are handy (reactive power compensation, THD compensation) but are not vital or necessary needed for the Suha demo explicitly. Beside functionalities available, islanding will maybe be a step ahead in future storage utilization.

If an aggregator provides a service, the DSO will be one of his customers, among the TSO, and local communities as well. If the DSO service would not be the most important service in the aggregator's hierarchy (which will be most likely strictly financially based), it could happen, that those services would not be available for the DSO when needed or even would have the opposite effects on network operations serving other purposes. This is also one of the reasons, why storage should be in special cases allowed to be owned and operated by DSOs.

The figure below presents an example of a sunny day where the transformer performs load compensation. The upper diagram shows real time measurements, the lower diagram represents algorithm calculations. The green line would be a transformer load without BESS connected, the white line is the transformer load compensated by the BESS, the purple line represents the BESS charging and discharging levels, and the blue line represents the battery state of charge level.

-Elektro Gorenjska

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6 Market Design

This section starts with the background sub-section that explains the balancing market from the point of view of the technologies that can provide flexibility and small prosumers. The section concludes with the STORY project recommendations for the market design changes.

6.1 Background

Two main aspects of market design are discussed in this section. The first is the design of balancing markets to allow the participation of flexibility coming from different types of technologies; the second is access to markets for small consumers through aggregation.

6.1.1 Balancing Market Design

Storage technologies have capabilities to provide services to grid operators or other market actors. Specifically, storage is capable of providing ancillary services to TSOs in the reserves markets, and potentially to DSOs in the future. These markets have been designed with traditional generation in mind but current legislation opts for technology neutrality in market design. First, the dispositions at a European level regarding technology neutrality in balancing market design are outlined. Second, the openness of balancing markets to different types of assets is discussed.

First, legislation at EU level regarding balancing market design is discussed. The Clean Energy Package, in the internal regulation for energy markets, article 6-1 states that 'Balancing markets, including prequalification processes, shall be organised in such a way as to ensure that services are defined in a transparent and technologically neutral manner and are procured in a transparent, market-based manner' (European Parliament and the Council, 2019). European legislation acknowledges thus the importance of transparency and technologic neutrality in balancing market design. The same article also states that balancing markets should 'ensure effective non-discrimination between market participants taking account of the different technical needs of the electricity system and the different technical capabilities of generation sources, energy storage and demand response.' The regulation must be applied by EU countries, which may require a redesign of balancing markets.

Second, to illustrate the practical implementation of these requirements, we discuss the following examples regarding technology neutrality:

- In Belgium, the effects of this legislation can be seen in the opening of the aFRR balancing market. Currently, at the time of the writing of this brief, this balancing service can only be delivered by CCGT, with plans to open the aFRR services towards non-gas powered assets as demand-response units and batteries. In Belgium the TSO ELIA has an ambitious timeline to reform the current FCR, aFRR and mFRR products. All changes which would, be implemented are aimed at improving the market accessibility (shorter tender periods, 4-hour granularity,...) and technology neutrality.
- In the UK, in contrast, an enhanced frequency response (EFR) service was tendered by National Grid, the TSO, in 2016. This product was aimed primarily at battery storage, catering to their fast acting capabilities to respond to system needs. In 2020, this technology specific

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Box 3: The BESS as a Service and it's role as an aggregator
Fortum owns and operates a BESS, which will be installed in distribution system operator's (Elenia) grid area in Kuru, in North Pirkanmaa. The BESS will be connected to Elenia's medium-voltage network and the batteries will supply electricity to a limited grid area during a power outage. This makes it possible to keep the electricity running in a limited area during repairs. In normal situations, the BESS will function in the reserve markets as part of the Fortum Spring virtual battery along with thousands of household electrical hot water heaters. The capacity of the virtual battery is offered to the transmission system operator's (Fingrid) reserve markets as regulating power. In Finland there are a few aggregators (Fortum Spring, e2m, Sympower) who are doing business selling flexibility but they are still evaluating different independent aggregator models and the wider impacts on electricity markets as well from technological as well as from regulative aspects.

-VTT

view is now being redesigned into the 'dynamic containment' response service, capable of responding within one second to frequency deviations. According to National Grid: 'this new product is a step up in capability from EFR, and while open to battery providers initially, it will in the longer term widen the range of possible providers ' (National Grid, 2020).

- In Finland, Fingrid and other Nordic TSO's have outlined a need for fast acting reserves during frequent low inertia operating conditions. Operating conditions with low inertia have become more frequent in the Nordic power system, and at times the inertia is so low that the current reserve products alone are not fast enough. Therefore, the Nordic TSOs are currently implementing FFR (Fast Frequency Reserve) to handle low inertia situations with a plan to have the new reserve in operation by summer 2020. While the product is not technology-specific, batteries easily fulfil the service requirements (Fingrid, 2019). An illustrative example of a battery system providing services to the DSO and TSO in Finland is provided in Box 3.

6.1.2 Access to markets for small prosumers

This section discusses market design considerations that enable small prosumers to valorise their flexibility coming from storage. These considerations can be explained by considering how prosumers can valorise flexibility from storage at a local level by saving on their electricity bill and by participating at a wholesale level through aggregation. This section also discusses the importance of setting a baseline for flexibility services given that the economic value that can be reaped from flexibility is dependent on it..

One example of how prosumers can valorise flexibility can be observed in Spain. In the self-consumption legislation introduced in Spain in 2019, a self-consumer with excess production, and with an installed capacity of less than 100kW is entitled to a simplified compensation, the retailer ought to pay the consumer for energy fed into the network. The price is to be agreed between the

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retailer and the consumer. A self-consumer with an installation bigger than 100kW total power needs to be registered as a generator and is entitled to sell energy in the wholesale and balancing market.

From a system point of view small consumers can add value when they are aggregated. The clean energy package directive for the internal market states that members states should enable 'the right for each aggregator to enter the market without consent form other market participants' (European Parliament and the Council of the EU, 2019). Access to markets for small consumers is paramount for the business case of storage.

Consumers participate in electricity markets through intermediaries. Until recently they participated as electricity buyers through their retailers. Now, prosumers can sell energy and flexibility in the market through a new intermediary called an aggregator. The introduction of a new intermediary between the consumer and the electricity markets creates friction with the existing retailer. The independent aggregator modifies the consumption profile of consumers already served by a retailer.

It has been shown in STORY deliverable 'D8.2 Intermediate reporting' that retailers and aggregators have an inherently different core business model. A retailer is a dealer-type of business while an aggregator is a platform-type of business. Aggregators are defined in the Directive of the European Parliament and of the Council on common rules for the internal market in electricity (from now on 'the directive') as a 'market participant that combines multiple customer loads or generated electricity for sale, for purchase or auction in any organised energy market'. Two main issues have been identified that affect the development of the flexibility business by aggregators: information exchanges between the aggregator and a final consumer's BRP and unharmonized rules regarding the transfer of energy payment from the aggregator to the BRP.

One challenge that has been identified to incorporate the flexibility coming from prosumers into the energy system is the need to calculate a retribution system that accounts for the actual flexibility they deliver. More concretely, it is necessary to calculate the changes in behaviour as a result of a demand response program. To deliver this calculation, it is necessary to set a baseline in demand response that sets the load that users would have consumed in the absence of a demand response program. Storage is one of the technologies that consumers could use to deliver demand response. The baseline is important because payments for demand response are directly based on the difference between the baseline and actual metered demand. There are several different methods proposed to establish the baseline that can be grouped into three categories: statistical approach with adjustments, last X of Y, meter before/ meter after. The variety of methods proposed has policy implications given the amount of demand response calculated may vary depending on the method used. A policy that clearly outlines principles to build a baseline would serve to clearly define the demand response product. In turn this would homogenize the expected profit gained by demand response providers.[6]

The theory has evolved significantly throughout the past 10 years. To consider the robustness of this theory we compare practices in selected countries to the theory. In this comparison, it is found, that the practices regarding baseline setting in Europe have not caught up to the academic theory due to difficulties in measurement and real-time implementation. The difficulty in the practical application of this methodologies arises from the lack of readily available data to calculate the baseline appropriately taking seasonal and situational variations into account. A paper written in WP8:

6 Excerpt from (Ramos, 2019)

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'Consumer access to electricity markets: the demand response baseline', examines both the theory and the practices regarding baseline calculation.

6.2 STORY Project Recommendations

The STORY project proposes two main recommendations for market design: technology neutrality in service design and assurance that consumers are enabled to valorise flexibility.

The STORY project considers that technology-specific products can distort the market towards a specific solution. This distortion could mean that new technology cannot compete/be adopted as they cannot participate on a level playing field. Grid operators should strive to make specific service definitions in terms of time granularity, bid size, and location in the case of distribution grids. Storage is a technology that can enable consumers to offer flexibility services, and ought to be considered within the wider scope of flexibility procurement by system operators.

The business case for storage facilities largely depends on being able to stack revenues. Storage asset owners that can provide flexibility to the network should be able to valorise their contribution. A retailer can remunerate, or rebate, a consumer's electricity bill when electricity is injected into the network; following the example set by the self-consumption regulation in Spain. An aggregator can pool and valorise the final consumer's flexibility in the electricity markets where they are most valued (balancing, DSO services, etc…). Smart meters that enable remote monitoring and control of loads are essential to enable prosumer participation into markets. Fair management of data from smart meters is similarly relevant. To create a level playing field for aggregators the relationship between third party aggregators and balancing responsible parties needs to be clarified in terms of information confidentiality and transfer of energy payments between both parties need to be harmonized across different markets.

7 Business Models

The background of the business model discusses different value streams that can be created by storage aggregation models. This section concludes with specific STORY project recommendations.

7.1 Background[7]

A mapping of the business models in the STORY demo was carried out through a series of three workshops during 2018 involving the demo leaders and other project participants[8]. Figure 2 presents a mapping of the demos comparing the value they create and the level of aggregation of the

[7] This section is an excerpt from D8.2 Intermediate Reporting for Story, Advisory Board and Projects Council, Chapter 4.
[8] The three internal workshops mentioned consisted of defining the business model canvas for each demo within the project, representatives or STORY H2020 partners were present at each session, including an aggregator, demo leaders and technology providers. Two workshops took place during the story general meetings in April and October 2018; while the third workshop took place in Brussels in November 2018. In addition, an advisory board workshop was held in Slovenia in October 2018, it consisted of 14 professionals in the energy sector invited to provide their opinion on business models for storage, and related technologies.

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Figure 2: Business Model Archetypes in the STORY project

resources. Participation in different markets is related to project size and aggregation of resources. The main value categories refer to:

- Savings for the owner are achieved when storage technologies enable an in-house optimization by storing renewable energy when available or storing energy from the grid at specific times of the day when it is cheaper. The saved energy is then used at an optimal time when the energy provided by the grid is more expensive. In the STORY project the Navarra, Oud Heverlee Building (OHD building), Olen and OHD Neighbourhood (Nbhd) demos include strategies and systems that enable them to do in-house optimization to decrease the energy bill. Box 4 the experience of the Oud Heverlee neighbourhood demo.
- Services to DSO & TSO refer to either reserve energy that can be provided for balancing the network or services for voltage stability and power quality. Balancing services are specifically FCR, aFRR, and mFRR, also known as primary, secondary, and tertiary reserves traditionally procured by TSOs. It has been shown in STORY that the OHD Nbhd, Suha and Lecale demos can provide value for the DSO. They can offer power quality support for the local grid. However, it is not possible to monetize this value in every case. In the OHD Nbhd case, the acting DSO has not defined products for power quality that would receive remuneration. Therefore the value is purely theoretical at the moment. See Box 4 for a description of the barriers encountered in this demo. In the Suha case, the DSO itself is steering the battery and can measure power quality improvements which can contribute to grid investment deferral. The Lecale case could provide services for both the DSO (congestion management) and the TSO (balancing energy).
- Market arbitrage refers to trading energy in long term, the day-ahead, and real time spot markets to help market players balance their portfolios. Market arbitrage with a storage unit

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consists of buying energy at a time when it is cheap and storing it to sell later at a time when it is more expensive. The Lecale demo would work with an aggregator to participate in the electricity market in Northern Ireland. The Lecale demo would offer load on-demand services for a local wind power plant that often gets curtailed due to grid congestion.

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Box 4: Oud-Heverlee Neighbourhood Demo

This demonstration features 13 houses in Oud-Heverlee which are developed towards an energy community. The aim was to demonstrate the synergy of a neighbourhood strategy for flexibility and grid balancing. In order to accomplish this, everything in the neighbourhood that can store energy is monitored.

The specific STORY case of residential smart home management faces the largest market barriers which today make it impossible to realize any meaningful part of its economic potential. For almost every potential value stream, one or more barriers stand in the way to realize its potential and barriers are present on every level of the supply chain: TSO, DSO, Supplier. The benefits of the project towards the DSO is that the project minimizes grid exchanges, has the potential to reduce required grid investments by addressing congestion issues and improves the power quality which is today lacking due to the fact that the residential neighbourhood in question is at the end of the distribution line. The value generated however cannot flow back towards the end customer as there are no local flexibility markets organized on which the value of the flexibility can be monetized nor does the DSO tariff give any incentive.

The potential of the project towards the TSO is that the flexibility could be offered as balancing service. Primary and tertiary reserves can be offered with heat pumps, electrical boilers and local storage. There are however two important barriers: the metering requirements put forward by the TSO would require investments which cannot be carried by the revenue streams they would generate. Also the minimum volume that needs to be bid for these services is 1MW, very high from the perspective of these energy communities. A solution for the first issue could be the roll-out of smart meters by the DSO which would meet the qualifications of the TSO thus making every household a potential flexibility supplier. The second element would require the participation of an aggregator.

Lastly the flexibility of an energy community can also be beneficial to the supplier/BRP as the consumption and (renewable) injection of the community could be optimized based on both the day-ahead prices and in intraday towards the imbalance price. There is however a cascade of complex barriers to overcome before the generated value could stream towards the energy community. Before energy communities can profit from changing day-ahead and intraday or imbalance prices they need to receive an exposure to these prices. An exposure to wholesale markets of the consumer can traditionally be created by the energy supplier who can link the energy tariff to market and imbalance prices. However, a supplier will only be able and willing to expose residential customers to these markets when they themselves can, back to back, expose the consumption of these residential customers to these markets. This will require the roll-out of smart meters and the implementation of new allocation rules which correctly allocate the consumption and injection of residential consumers towards the correct supplier. This would require that TSO's, DSO's and suppliers would be able to generate/measure, store and process large amounts of data as for every consumer two quarter hourly values would need to be known: the offtake and injection.

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7.2 STORY Project Recommendations

The STORY project has three main business model recommendations. In addition, Box 5 presents the view of STORY partner Flecity on incentives for storage.

- First, the business model for storage depends largely on being able to stack revenue streams coming from either, energy savings, services to system operators or services to other market parties. The potential of a specific project are defined by its technical characteristics. Energy savings can be maximised when a consumer is exposed to varying market prices, both on the energy and grid tariff component. Larger storage facilities have the potential to offer services to system operators directly. Smaller household consumers are currently facing limitations due to the need to comply with market metering and participation requirements. The STORY project has proven that storage assets have the potential to offer services to both distribution and transmission system operators.
- Second, the aggregation of resources is key to enable the value of the flexibility that can be provided by residential consumers. Consumers now can also sell energy and flexibility though at a much lower scale than conventional generation. However, they find that the mechanisms to do so are not available and, as a result, the potential flexibility from smaller consumers is not being reaped. Storage project developers find difficulties in securing long term revenue streams. Energy communities and individual household consumers who have a flexibility potential need to partner with intermediaries who have access to markets. Similarly, smart meter availability is key to reap flexibility from final consumers.
- Third, clear product definition, especially from the DSO perspective is necessary to enable a business case for smaller local flexibility providers. Flexibility services offer value for society when their use would defer grid investment. DSOs need to define technology neutral service tenders that enable prosumers or their intermediaries to valorise their flexibility. More study is needed from the point of view of the DSO to evaluate when and under what conditions flexibility is a better option than grid investment.

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Box 5: Flexcity on incentives for storage

Flexcity prefers indirect incentives over direct incentives for storage. The European commission defined three main parameters on which direct state aid should be assessed and direct aid for batteries does not meet any of these criteria according to our analysis. The first question to be asked is if the state aid is aiming at a clearly defined objective of common interest. Especially in this case, the state aid should address a market failure, where for example external, environmental costs are not accounted internally. In our opinion, there is currently no market failure in the flexibility market which justifies the support for specifically the battery technology. However, we see a market failure in the accounting of grid costs, so we think direct support for household flexibility would be justified based on this parameter. The second question to be asked is if the aid is well designed to meet the objective. This means that first other instruments like indirect incentives should be examined (as in this case, redesigning grid-tariffs).
Moreover, the subsidy should be designed to change behaviour fundamentally. This was not the case with the current Flemish battery subsidy, which did not render a battery investment profitable. The last question to be asked is if the aid does not distort competition or trade. This means that everyone should have equal access to aid.
Based on these three parameters, as defined in European law, Flexcity does not consider direct aid for batteries as desirable. We think that batteries should be seen as a measure to achieve a flexible power system, not as a goal on itself. Storage can benefit from indirect support such as identifying and removing barriers of participation to ancillary services, creating and testing new flexibility markets as local congestion markets to increase the number of services a battery could get revenues from.

- Flexcity

8 Conclusion

The STORY project has identified five main areas of discussion regarding business models and regulation for storage: legal definition of storage, network tariffs, DSO participation in storage projects, market design, and business model enablers.

Technology development is moving forward at a faster pace than markets and regulation can adapt. The project developers that led the demos in the STORY project faced the challenges of an immature market. Technology providers were slow to fulfil their promises, system integration and interoperability ended up being a bigger challenge than expected, and in many occasions the demo leaders were pioneers in permitting and connection procedures with their local authorities. The recommendations set in this document reflect real-life challenges faced by project developers when bringing new technology to the market.

Storage technology is a key factor that will enable the large-scale integration of renewable energy into the system, and the decarbonization of transport. The results of the STORY project pave the way to enable the storage market to grow in a commercially viable fashion.

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9 Acronyms and terms

DSO		Distribution system operator
TSO		Transmission system operator
BESS		Battery Energy Storage System
JRC		Joint research centre
FSR		Florence School of Regulation.
EC		European Commission
OLTC		On load tap changer
I-SEM		Integrated Single Energy Market
NIE		Northern Ireland Electricity Networks
IP		Intellectual Property
MV		Medium voltage
LV		Low voltage
PV		Photovoltaic
RES		Renewable Energy Sources
SMEs		Small and medium enterprises

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