*Smart system of renewable energy storage based on **<u>IN</u>**tegrated E**<u>V</u>**s and b**<u>A</u>**tteries to empower mobile, **<u>D</u>**istributed and centralised **<u>E</u>**nergy storage in the distribution grid*

Deliverable nº:	**D9.3**
Deliverable name:	**Report on legal policy implications**
Version:	**1.0**
Release date:	**12/06/2018**
Dissemination level:	**Public**
Status:	**Approved**
Author:	**ElaadNL – Baerte de Brey**

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 731148.

Document history:

Version	Date of issue	Content and changes	Edited by
0.1	18/05/2018	First draft version	Baerte de Brey
0.2	23/05/2018	Internal review	Øivind Berg
0.3	30/05/2018	Second draft version	Baerte de Brey, Frank Geerts
0.4	30/05/2018	Peer review version	Øivind Berg
0.5	08/06/2018	Review	Lennart Verheijen
0.6	11/06/2018	Review	Pol Olivella-Rosell
1.0	12/06/2018	Final version	Baerte de Brey

Peer reviewed by:

Partner	Reviewer
UPC	Pol Olivella
Greenflux	Lennart Verheijen

Deliverable beneficiaries:

WP / Task
WP9
WP10

Table of contents

Abbreviations and Acronyms

Acronym	Description
ACER	Agency for the Cooperation of Energy Regulators
AMI	Advanced Metering Infrastructure
CBA	Cost-Benefit Analysis
DER	Distributed Energy Resources
DSO	Distribution System Operator
EASE	European Association for Storage of Energy
EED	Energy Efficiency Directive
EEGI	European Electricity Grid Initiative
ENTSO-E	European Network of Transmission System Operators for Electricity
EPBD	European Performance of Buildings Directive
EPN	Energy Positive Neighbourhoods
ERKC	Energy Research Knowledge Centre
ESS	Energy Storage Systems
KPI	Key Performance Indicator
NII	Non-Interconnected Island
RAE	Regulatory Authority for Energy
SETS	Smart Electric Thermal Storage
TRL	Technology Readiness Level
TSO	Transmission System Operator
VPP	Virtual Power Plant
WG	Working Group
R&I	Research & Innovation
EC	European Commission
OECD	Organisation for Economic Co-operation and Development
REV	Reforming the Energy Vision
EV	Electric Vehicles
ETSI	European Telecoms Standards Institute (
RAE	Regulatory Authority for Energy
RES	Renewable energy sources

Acronym	**Description**
BaU	Business as usual
PV	Photovoltaic
FFR	Fast Frequency Response
EF	Energy Forecaster
RMSP	RES Management Service Provider
SMCP	Smart Meter Communications Provider
SMDA	Smart Meter Data Aggregator
SO	System Operators
AS	Ancillary Services
CMPs	Commercial Market Parties
LMP	Locational Marginal Pricing

Executive summary

In this report we identify institutional bottlenecks[1] that impede the development of the Smart Charging[2] of electric vehicles, as well as batteries in the distribution grid. Also, in the Norwegian, German, Bulgarian and Spanish locations there is a focus on batteries in household and grid. We subsequently identify possible solutions for the most important and urgent bottlenecks. In this way, both market and government are assisted with concrete ideas in order to accelerate the development of Smart Charging in the short term. The study also provides a starting point for the design of an efficiently and effectively functioning market.

To reduce emissions of harmful substances (such as CO2, NOx and particulate matter) from the transport in INVADE partners, a fuel transition is essential. Electric transport is one of the most important ways of achieving this. In recent years, the Netherlands and Norway have been actively involved in stimulating electric transport and have acquired leading roles internationally.

To facilitate electric driving, the development of new infrastructure is vital. The availability and quality of this charging infrastructure largely determines the future success of electric transport. For the efficient functioning of this new market for electric transport, charging must be further optimised (become 'smarter').

Major changes are also taking place in the electricity market. Historically, electricity was centrally generated in large power stations and subsequently transmitted to consumers in decentralised (regional) grids.

The transition to renewable energy increases the amount of decentralised (renewable) electricity fed into the grid. The volatility of (fluctuations in) the electricity supply thus

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[1] By 'institutional bottlenecks' we mean obstructions arising from existing or non-existing legislation and regulations at national, regional or local level, relevant sector agreements, and established or still absent/implemented standards.

[2] By 'Smart Charging' we mean the charging and discharging of an electric vehicle whereby the timing, speed and charging method (charging/discharging) is geared to the e-driver's preferences and market conditions then prevailing (such as availability of renewable energy). Smart Charging is important to:

- stimulate electric transport by means of an efficient charging experience for e-drivers (such as easy availability, timeliness of charging)
- deploy renewable energy as effectively as possible and
- create flexibility in order to maintain the balance in the electricity grid and to reduce or postpone investments in order to prevent regional congestion.

increases. At the same time, the peak demand for electricity also increases due to the growth of electric transport and electrification of the built environment. This creates a greater mismatch between moments of supply and moments of demand.

In order to guarantee a clean, affordable and reliable energy supply in the future, flexibility must be unlocked so that supply and demand can be better aligned.

‘Smart Charging’ can help to improve the alignment of demand and supply of (renewable) electricity by gearing the time, speed, and charging method to market conditions. This helps to give the e-driver an optimal charging experience, to optimise the use of renewable electricity and to unlock flexibility.

The flexibility unlocked by Smart Charging can be deployed for a number of purposes: optimisation of own use of the meter (private), optimisation of the charging session and availability of charging infrastructure (public and semi-public), preventing congestion in the grid of the regional grid operator, substantiation of the supplier’s programme responsibility and for use on the reserve markets of the national grid operator. This not only helps to prevent social costs, but also to be able to offer the e-driver an optimal charging experience, which stimulates electric transport.

In order for Smart Charging to work in practice, the various stakeholders in the chain must work together in order to create new partnerships.

A number of Smart Charging experiments are currently taking place in the INVADE project. They aim to scale up further but encounter institutional bottlenecks that delay or block the scaling-up. Current institutional frameworks do not comply with requirements accompanying these new initiatives and may therefore impede the development of Smart Charging. Structural changes to legislation and regulations must be further investigated and implemented:

- Determine optimal market bottlenecks for the acceleration of Smart Charging: regulation (roles and responsibilities of players in the Smart Charging chain);
- Adjust current sub-optimum financial incentive for Smart Charging on the basis of tariff components (energy tax, grid management and supply);
- Determine the data to be unlocked in order to efficiently develop Smart Charging concepts.

1 Introduction

1.1 The INVADE project

INVADE proposes to deliver a cloud-based flexibility management system integrated with Electric Vehicles (EV) and batteries empowering energy storage at mobile, distributed and centralised levels to increase renewables share in the smart distribution grid. The project integrates different components: flexibility management system, energy storage technologies, electric vehicles and novel business models.

1.2 Working on local policies and regulations: task 9.3

Regulation limitations are among the most prominent potential barriers for deployment of flexibility management system integrated with EVs. For example, the different roles in the value chain of charging, is not yet part of the liberalization of the market in many European countries. So far, EVs have not been adequately defined in this context: Are they a tool for more effective grid operation or must they also be considered a source of providing power? The consequences for potential ownership of storage systems, flexibility management system integrated with EVs, and in turn business model structures, are immense.

Task 9.3 aims to map the different local policies in practice at the pilot sites and their implications on ownership and operation of storage systems beyond technical feasibility. It will also attempt to provide an outlook on development, especially with respect to homogenisation of the European electricity market.

1.3 Objectives

The purpose is to compose, during the implementation period of the development of the cloud-based flexibility management system integrated with EV and batteries project, a document with recommendations and consultation on regulation issues based on the experience acquired in the projects for better development of the cloud-based flexibility management system integrated with EV and batteries in Norway and four European member countries. As regards energy storage, the regulatory issues very often include absence of clear rules and responsibilities concerning ownership, competition, technical modalities and financial conditions. In terms of smart grids, regulatory challenges arise regarding the incentives for demand-side response, commercial arrangements, smart meter data, etc.

2.3.1 Working Group on Local policy and regulation implications has assisted ElaadNL, the task responsible partner. From 2017 to 2018, Baerte de Brey (ElaadNL) acted as rapporteur.

1.4 Approach and structure of this report

The present report is the result of 18 months of work. The report identified a value chain from customer to generator. In each part of the chain possible bottlenecks are identified.

Chapter 3: Each project has provided a description of the regulatory aspects it addresses;

Chapter 4: Together projects have identified a list of 13 main regulatory issues. Each regulatory issue is defined, its main points identified.

Chapter 5: In the last chapter, conclusions are drawn.

1.5 Smart Charging contributes to the interests of different parties

The graph above consists of a number of specific agents:

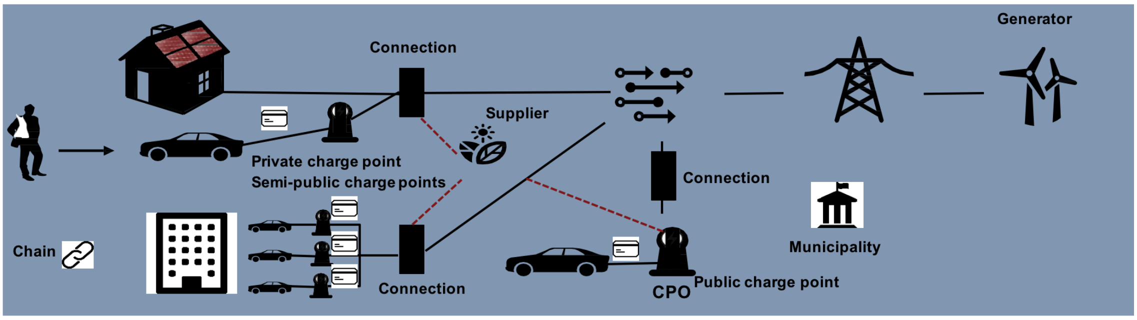

Figure 1: Specific agents in the INVADE project

1. **Electric driver**: Timely charging so that the e-driver's mobility requirements can be substantiated. The e-driver determines the time when the battery must be full in order to meet his/her mobility requirement. Optimise own consumption behind the meter (by means of bi-directional charging). An e-driver can charge his car during the day using self-generated solar energy, discharge his car for the night for his own use during peak hours and, if necessary, fully charge again in the

night with renewable wind energy, for example. The e-driver can thus optimise his own consumption behind the meter.

2. **National grid operator**: Use of the flexibility of electric cars for reserve markets. Reserve market providers can offer the flexibility of electric cars for TenneT's balance sheet maintenance by fully charging cars in the case of a surplus supply of electricity and temporarily stopping or postponing charging in the case of surplus demand. Smart Charging increases TenneT's ability to use renewable energy in order to solve the imbalance in the electricity grid.
3. **Regional grid operator**: Use of flexibility to avoid grid upgrades. Smart Charging can help the regional grid operator to resolve congestion in its regional grid at peak times in the grid. As a result, there is less need for grid upgrade investments.
4. **Program manager / supplier**: Use of flexibility to realise programme. Programme managers can use Smart Charging to ensure that their programme is realised. This will prevent any imbalance costs arising from non-compliance with their programme. Programme managers who are both suppliers and generators can also use Smart Charging to charge cars with any surpluses (for example, from wind energy).
5. **Charge Point Operator**: Load balancing to optimise the charge point power. Charge Point Operators can use Smart Charging to optimise the utilisation of their charge points. By applying Smart Charging (load balancing), they can optimally distribute the available power to the charge point between the cars that are charging there, based on the characteristics of the car (charging capacity) and the e-driver's preferences.

1.6 Batteries in the distribution grid

Grid companies are facing increasing demand for grid capacity. At the same time, prices for batteries are down, and in several countries, we see that batteries are being installed as an alternative to traditional grid construction. An example is Tesla's new large Powerpack energy storage system with a total power output of 18.2 MW to be used as a virtual power plant for grid balancing in Terhills, Belgium., reference:

https://electrek.co/2018/05/14/tesla-powerpack-project-grid-balancing-europe/

Batteries become an alternative to grid reinforcement:

- *Technology* and *price* developments on electrochemical batteries and modern communication and control technology have turned battery solutions into a real alternative to traditional grid investment.
- Several *capacity* challenges or *voltage* problems in the distribution grid may be handled by installing batteries rather than grid reinforcement. This may be particularly relevant in urban residential areas with growing demand, in cases where earth cables are required and in cases of weak and long grid cables. The smaller the requested capacity increase, and the less frequent the potential capacity problem, the greater the likelihood that batteries may compete with traditional grid reinforcement.
- Developments in *modern communication* and *control* technology (digitalization) also lead to *end-user flexibility* becoming a real alternative to grid enhancements. For many of the potential applications of batteries, such flexibility may therefore be (or become) more competitive opportunities.
- For use in the distribution grid network, it is reasonable to assume that a typical installation may be batteries with a capacity of a few kW and kWh, in some cases perhaps up to MW and MWh.

Battery technology can provide a range of services for *grid* and *market* purposes:

- Through the input and output of active or reactive power, a battery can assist grid owners to
  - ensure satisfactory quality of delivery,
  - optimize the operation of the grid,
  - postpone investments for grid reinforcement, and
  - improve security of supply.
- Batteries can also be used for trading
  - in the day ahead market or the intraday market, and
  - in the real-time markets for up and down regulation.
  - However, with a loss of energy for a load cycle in the order of 20 percent, the potential in the Norwegian power market is limited.

Batteries are *flexible* compared to power lines, cable and substations:

- Batteries can relatively easily be disassembled and moved to a new location or used for other purposes. Batteries are relatively independent deployable regardless of the size as they are often modular.
- If the grid load situation changes and powerline or cable investments later become applicable, it may be easier to terminate a rental or service purchase than if the grid company itself must find new uses for the battery or sell it.

Ownership considerations:

Ownership of batteries that provide grid services may be either with the *grid company*, with a *third party* or *a combination* of these. However, the winter package is referring to the battery ownership but as it is now, it does not allow grid companies to own batteries.

- Direct *ownership* may *benefit grid companies* as this gives full control and certainty about the delivery of battery services, without having to go through complex agreements with service providers. At the same time, today's *revenue regulation* incentivizes investments rather than purchases of services, given that the total costs otherwise are equal.
- On the other hand, *third party* batteries, with service delivery to the grid companies, could better *utilize* the battery *capacity for both grid and market purposes*. We have assumed that grid companies should not be able to use batteries purely for market purposes, i.e. without simultaneously solving a potential grid problem. Batteries owned by third parties will thus be able to ensure better utilization of the battery capacity in a socio-economic sense. Such a model can also facilitate the exploitation of economies of scale related to operation and maintenance.

Market considerations

A small number of small stand-alone batteries will not have any significant effect on the energy markets. On the other hand, many batteries that act together have the potential to affect price formation in all relevant markets (day ahead, intraday and real time).

- *Grid companies* should not have any interest in being active in these markets, but using 'many' batteries purely for grid services could also affect price formation, without this being the purpose. If a battery is used exclusively for grid services, market effects can be compared to traditional grid enhancement measures or purchase of consumer flexibility (for example, via an aggregator) in the grid company's assessment of actions to address specific challenges. In such cases, it does not matter who owns the battery and the price effects in the power market do not constitute a socioeconomic problem. If other actors believe they lose on the grid's use of batteries (if used as provided here), they must simply note that new technology has reduced the profitability of their business.

- A key argument against allowing a grid company to own batteries is a market consideration. Owning the batteries may cause installation and use of own batteries to be preferred over other flexibility solutions, also when other solutions are better. The concern for technology neutrality therefore implies that batteries should be owned by third parties, like consumer flexibility, which is also owned, administered and offered through third parties. Other arguments that pull in the same direction are the risk for cross-subsidization and suspicion of role-mixing.
- Today's market for batteries and battery services has few players and little propagation. The number of players willing to place batteries in the grid for the sale of battery services to (among other) grid companies is low. In the short term, this could be a barrier to profitable use of batteries in the grid business, perhaps especially if the grid companies are not supposed to own batteries. On the other hand, there will hardly be any actors offering services until the grid companies demand services and gain experience with both the use of batteries and different types of contracts for purchase of services.

2 Description of participating countries and the INVADE project

2.1 Netherlands

The Netherlands is one of the leaders in the field of e-mobility. In 2015, the Dutch share in electric vehicles (EVs) in use worldwide was ~8% (of the approximate 1.2 million vehicles in total). Growth of e-mobility leads to an increasing availability of storage capacity in the grid. This increasing storage capacity can be deployed for “Smart Charging”. The smart deployment of this storage capacity is particularly relevant to grid operators, which are united in one of INVADE’s partners, ElaadNL. Key principles of Smart Charging are: (1) free access to renewable - local - energy (provider chosen by EV driver rather than by charging point owner), (2) optimising local grid load (prevents extra grid investments) and (3) facilitates grid flexibility (storage of temporary excess of energy generated in a decentralised manner*)*.

The flexibility unlocked by Smart Charging can be deployed for a number of purposes: optimisation of own use of the meter (private), optimisation of the charging session and availability of charging infrastructure (public and semi-public), preventing congestion in the grid of the regional grid operator, substantiation of the supplier's programme responsibility and for use on the reserve markets of the national grid operator. This not only helps to prevent social costs, but also to be able to offer the e-driver an optimal charging experience, which stimulates electric transport.

In order for Smart Charging to work in practice, the various stakeholders in the chain must work together in order to create new partnerships.

A number of Smart Charging experiments are currently taking place in the Netherlands, one of them is INVADE where GreenFlux and ElaadNL strive to accommodate as much renewable energy in the energy system as possible and will explore the possibilities of matching demand to sustainable generation.

The Dutch pilot will cover three domains and two different approaches to charging electric vehicles on renewable energy.

The first domain explores a charge point at home in own driveway or carport. Usually there is only one charge point and the available maximum power for charging is low. If there is renewable energy available, it is almost always from roof solar panels. The charge point is connected to the grid connection of the house.

The second domain explores a group of charge points at an office building, a shopping centre, a football stadium, etc. The charge points are all connected to the same network connection and often have to divide the available capacity to prevent overloading this connection. The charge points can and are sometimes publicly accessible 24/7. Local renewable energy production can come from solar panels.

The third domain explores a charge point in the public domain. The charge point has its own connection to the electricity grid and its own energy contract. It is completely interoperable (everybody can charge there) and it is available 24/7. Connection to renewable energy sources is via the energy contract, this might be reflected in dynamic energy prices.

The two approaches are:

6. The ‘grid approach’: Where you are able to use renewable energy at the location that it is produced, and where electricity does not need to be transported over large distances which reduces energy transport losses significantly. Also, it diminishes the load on high power transmission cables, which reduces network costs in general.
7. The ‘system approach’: Supply and demand always need to be in balance. This effectively means that electric vehicles are charged when (renewable) energy is available and are not charged (or discharged) when there is none. This does not need to be locally produced energy (since electricity travels at one third of the speed of light through a cable), it is really the system balance of a country or large region that is considered here. The (im)balance of the energy system is reflected in the (dynamic) price of energy.

Together the approaches help building an interoperable and integrated value chain of charging.

2.2 Norway

In Norway, effect-based tariffs are emerging and will be implemented during the next 2-3 years. This combined with the highest electric vehicle (EV) density in Europe, makes so-called vehicle-to-home (V2H) relevant, as the economic incentives for end-customers are getting a considerable boost. For this to happen, we need solutions to enable bidirectional management of customer loads. The load with the most potential and value is the battery (EV or fixed), as it can enable a two-way flow of electricity and increase the supply security to households. In addition, thermal loads like electrically heated water boilers will also be tested.

In this context, the distribution system operator (DSO) will be able to postpone grid investments, and end users can save money if they can avoid high loads in the high tariff periods, a typical win-win situation. Lyse Elnett has started to implement one of Europe’s most advanced four-quadrant automatic meter installations exploiting a generic gateway to collect real-time data. This rollout passed 50.000 installations in 2016 (Q1), including the whole Triangulum large-scale test bed area in Stavanger.

The Integrated INVADE platform will meet existing energy solutions in the European and international market. It will be crucial to demonstrate how existing smart energy solutions can be interoperable with the INVADE architecture and platforms. This represents a significant value increase to the INVADE project, as it is unlikely that early mover DSOs which have already started their smart grid and service rollout are willing to replace these investments.

We will demonstrate how big data, machine learning and analytics parts of the INVADE platform can be integrated into the existing smart home solutions demonstrated in the Triangulum Smart City solutions in Stavanger with respect to V2H, batteries and boilers. This will provide both the DSO and the end-customers with information, feedback and interaction to promote behavioural change, as well as enable them to use energy efficient solutions and to exploit new opportunities arising in the EV/battery/second-life battery domain.

2.3 Germany

In Dagebüll, Germany, INVADE will integrate the various assets such as renewable energy sources (wind energy, PV plants, biomass), batteries at both community and household levels within the existing infrastructure, and ICT tools at the pilot site.

The application of energy storages in private households creates direct experience relevant for the possibility of integrating storages in Germany. This promotes acceptance and proves the benefit of demand-response in private households. Increasing self-consumption ratios and reducing costs is an important goal for private households. There will be at least 10 private households with individual battery capacity of 10 kWh engaged in the pilot site.

2.4 Spain

The Spanish use case aims at demonstrating that a storage system shared with other users, is a safe, reliable and emission-free alternative, which will cover a gap of two hours without using a genset and thus no emissions.

The pilot will take place in Granollers since there is a secondary substation which supplies the headquarters of the DSO and a number of private households. The DSO is an example of an entity with critical services needing electricity redundancy. The issue here is that redundancy depends on the HV distribution and transmission network, meaning that in the event of a blackout impacting both, all services will be down. The current alternative is to have generator ready for use, which means storing fuel and an expensive investment.

Consumers such as hospitals, police stations, and utilities among others, which are connected to secondary substations and shared with other consumers, have specific quality of service and endurance needs. Currently most of them have an alternative feeder and generator. The use case consists in providing them with a 2 hours redundancy based on efficiently managed storage.

We consider a 2 hours capacity using batteries to be enough to cover most of incidents. The storage system, combined with the Integrated INVADE platform and Power Electronics will provide the network with a reliable and efficient energy backup, as well as a new business model for daily use by households sharing storage capacity.

2.5 Bulgaria

In Albena, Bulgaria, centralised electrical energy storage will be installed at a transformer substation that supplies two hotels, including restaurants, a spa centre and swimming pools.

Furthermore, on the hotel rooftop a PV system will be installed in order to cover the daily peak electricity consumption. Full energy monitoring structure is already installed at the site. The hotel has its own solar thermal station installed.

- The PV system will cover most of the daily electricity demand. As the daily electricity load curve is quite similar to the power generation profile, a PV system gives the opportunity to reduce the used grid peak power and increase the percentage of used renewable energy.
- Electricity energy storage will be installed in order to balance the power generation of the PV system, as well as to store surplus energy for evening peak power demand ensuring constant grid load.
- With energy storage, local peak power loads at the transformer station will be avoided, and the power quality and system reliability will be improved.
    - A local energy power balance between bought energy and actual consumed energy will be available. In that case costs for imbalance will be avoided.

The Integrated INVADE platform will enable the combination of a PV System, Solar thermal system and battery storage that will essentially increase the share of renewable energy in the hotel sector. This will utilise the enormous potential of solar energy for summer resorts. The energy consumption and CO2 emissions will be reduced.

3 Description of local policies and regulations

In this chapter we describe the local policies and regulations of the INVADE partners, starting with storage.

3.1 Storage

The Storage Working Group of EUROBAT[3] describes the "Legislative barriers and opportunities in Europe" as:

The biggest overall barrier to energy storage in the current EU legislative landscape is the lack of attention paid to storage itself. When the Electricity Directive (Directive 2009/72/EC) was approved in 2009, energy storage was simply not included in the picture, resulting in unintended barriers and bottlenecks in the legislation. Currently Europe does not have a common regulatory approach to energy storage, so potentially creating important differences between member states. In some cases, such as the recent approval of the Spanish decree on self-consumption, decisions taken by national governments are actually preventing any possible deployment of energy storage systems.

This lack of a definition of energy storage in the current EU legislation leads to a series of barriers, thereby creating an uncertain investment environment. Since energy storage is not mentioned in the Electricity Directive, storage is often considered to be a generation system and therefore falls under the network codes for generation systems. Nevertheless, a battery or other storage systems cannot technically be considered as generating units, since such an interpretation would simply overlook the entire set of services and properties of storage systems.

The position of EUROBAT in this regard is that storage should be considered as a fourth component of the energy system, after generation, transmission and distribution, with its characteristics, properties and services taken into account. A clear definition of energy storage should be included in the Electricity Directive. EUROBAT thinks that the definition should highlight the ability of storage to time shift the generation and consumption of energy. If, under the current energy system, electricity is produced and

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[3] Battery Energy Storage in the EU – Barrieres, Opportunities, Services & Benefits", 07 June 2016

then immediately consumed, storage allows us to absorb electricity, store it, and release it when needed. The definition should also be technologically neutral and should include different storage systems. The State of California defines energy storage systems as “commercially available technology that is capable of absorbing energy, storing it for a period of time, and thereafter dispatching the energy” and is a good example to also adopt for the EU; moreover, it also includes a list of services provided by energy storage systems.

Ownership of energy storage systems

A direct consequence of having storage systems as generation units is the unclear situation concerning ownership since, according to the unbundling principle, TSOs and DSOs cannot own or control generation systems. Therefore, according to some interpretations, grid operators cannot own or control a storage system. However, several actors, including for instance ENTSO-E, have repeatedly commented on how the ownership of storage systems remains an open question under the current legislative framework, thereby creating an uncertain investment environment for those TSOs and DSOs interested in storage (ENTSO-E 2014). Also, DG Energy recognizes that this uncertainty over ownership rights strongly affects the value assessment of energy storage (DG ENER 2013).

EUROBAT believes that TSOs and DSOs should be granted the ability to own and control storage systems. Grid operators have a clear interest in directly operating storage systems to balance the grid and having direct control over them would allow a safer and prompter balancing of the electricity grid. At the same time, service providers should be allowed to participate in the balancing market and to sell these services to TSOs and DSOs. The EU electricity market involves different conditions in many countries, and we should therefore not look for a one-size-fits-all solution. Instead, a build-or-buy choice should be guaranteed, so allowing operators to choose the most efficient solution, depending on the specific situation on the ground. Restrictions on the use of electricity storage facilities by system operators might be included in situations when those operators are allowed some kind of control over them.

Ownership rights in Italy and Belgium

In the EU landscape, a partial exception to the unclear ownership rights of energy storage systems is **Italy**. Here, the transmission operator Terna launched two grid-connected battery energy storage pilot projects. A first project was launched in 2011 and envisages the construction of three storage systems in southern Italy (34.8 MW capacity) to ensure flexibility in the management of renewable power plants and to boost the transmission grid's capacity. A second 40MW project was launched in 2012 to increase the security of electricity systems in Sicily and Sardinia.

The Italian government supported Terna's projects and allowed TSOs and DSOs to build and operate batteries and storage systems under certain conditions (Italian decree Law 93/11, Art. 36, paragraph 4). After this overall decision, in the Italian network regulator AEEGSI approved a decision (574/2014/eel) to define network access rules for energy storage. Terna also foresees the introduction of annual auctions for reserve capacity.

Another important example is **Belgium**: Article 9 (1) of the Belgian Electricity Act, establishes that: (i) the electricity is generated for balancing purposes only, with an explicit prohibition for commercial purposes; (ii) the stored electricity is called upon as a last resource; (iii) under the form of negotiated drawing rights; (iv) to the limit of the power needed for ancillary services; (v) upon the prior approval of the regulator; (vi) after having completed all relevant procedures for calling upon the market.

Ownership recommendation in Norway

A clear signal from the regulator should be given that in the long term, batteries should not be owned by the network companies. This is the conclusion of DNV GL in a report written on behalf of NVE.

Double Grid fees and taxation

Another consequence of the lack of clarity concerning the definition of storage is the possibility of double grid fees being imposed on storage systems. Storage systems take electricity from the grid when they are charging and inject electricity into the grid when they discharge. However, since some member states impose taxation on both generation and consumption, storage system owners consequently have to pay double grid fees. This penalty can apply to all storage systems connected to the grid, including the batteries of electric and hybrid vehicles in vehicle-to-grid mode.

The situation regarding grid fees is quite different across Europe and should be addressed with common rules regarding transmission access fees and the use of system fees for electricity storage systems. If these disparities are not addressed, a situation could be created where a storage system would be set up in one state with favourable rules in order to provide cross-border services to another state with less favourable rules.

Battery energy storage offers important services to the grid, in form of ancillary and balancing facilities. The THINK Project correctly points out that grid tariff should be based on the principle of cost causality: storage systems do not represent a burden for the grid, while they actually offer services to the grid and can defer or reduce the need for grid investments (THINK 2012). **Therefore, EUROBAT supports the elimination of double grid fees for stored electricity. Direct taxation on storage, such as that included in the new Spanish national law on self-consumption, should be avoided.** The inclusion of grid costs in the energy bills of prosumers, under discussion in Italy and in other states, represent another important disincentive to self-consumption.

Curtailment and balancing responsibilities

Directive 2009/28/EC (Renewable Energy Directive, RED) mandates member states to provide priority access or guaranteed access to the grid-system for electricity produced from renewable energy sources (art. 16). However, in some cases, the production of renewables has to be curtailed in order to ensure the stability and security of the grid in case of transmission congestion or lack of transmission access, but curtailment can also occur for excess generation during low-load periods, or when there are voltage or interconnection issues.

Curtailing energy represents a failure of the system and a waste of energy: grid constraints that naturally prevent renewable energy from having priority of dispatch could be addressed through the deployment of BES. Storing electricity when there are system constraints and then releasing it at a later stage allows an increase in the quantity of renewables in the energy mix, so ensuring the security of the system; this is especially the case if the stored renewable energy is also granted priority of dispatch.

Financial compensation for curtailed energy represents a relevant disincentive for renewables producers to install energy storage systems and, in our view, contradicts the intended transition to a market-based commercialization of renewable energies. Such financial distortions prevent an adequate promotion of electricity and grid services based on supply and demand.

Moreover, the RED establishes that operators of renewable energy plants do not have any responsibility to contribute to the flexibility of the system. This measure, combined with the uncertain ownership landscape for TSOs and DSOs, clearly prevents the deployment of storage systems. The revised RED should therefore include a precise timeline to assign clear flexibility responsibilities to the producers of renewable energy, but their value should also be recognized and rewarded. EVs can be used as storage, however, there is no connection yet.

3.2 Lack of inspection of the electrical engineering electric vehicle

Vehicle Authorities in the mobility chain have developed expertise through years of experience in executing statutory and assigned tasks on licensing of vehicles and vehicle parts, supervision and enforcement, registration, information provision and issuing documents. However, electric vehicles are a new kid on the block.

The manufacturer of electric vehicle supplies the EV to e-driver and he determines whether EV is suitable for Smart charging. The car manufacturer has access to important data, such as the State of Charge and Time of departure. This is very important data for building a smart Charging profile. Therefore, this data should be unlocked, open and freely available for the e-driver. This applies for all five countries of the INVADE project. Furthermore, manufacturers of electric cars must ensure that the techniques used in the car are applicable in combination with the charging infrastructure. For example, the car must use relevant (existing and new) communication protocols.

National administration could play an important role in these issues. For example, in Norway the approval of EVs is handled by the Norwegian Public Roads Administration (NPRA) "Statens vegvesen" which is the same organisation which is approving the "conventional cars". EVs imported from and manufactured in EU countries is simply relying on EU standards and "type"-approved. From non-EU countries a more thorough approval process is imposed, e.g. different electrical parameters (e.g. Voltage) may be imposed and must be guaranteed to work in the Norwegian grid environment. If you replace batteries (typical after 10-15 years), NPRA must approve the change. They encourage you to use original or equivalent equipment and follow the manufacturer's instructions.

Based on the information provided in Norway, it cannot be considered as major concern and that the regulatory responsibility, national organisation and information to the public are handled satisfactory and is not considered as an obstacle for EV owners or EV importers yet. This also applies for other countries. Regulation on data and the use of it is not in focus in none of the countries.

3.3 Fixed electricity tariff for e-driver

NVE (The Norwegian Water Resources and Energy Directorate) has made a proposal for controlling the grid activities including tariffs. This is out to the stakeholders for rehearsal. NVE wishes to introduce grid tariffs based on customers' hourly consumption, kWh/h, so called effect tariffs. This can be implemented when the new AMS meters have been installed. This will encourage customers to optimize consumption and their EVs to be charged when other loads/consumption is low. NVE proposes to have the same cost model for all customers and introduce time-differentiated cost models[4]. The consequence and impact of this means that EVs will not be handled differently from other appliances. And that the tariffs will be on hourly basis, to optimize grid capacity.

In Germany, rigid rules of the "eichrecht", regulation on metering imply that no price per kWh is charged, but a price per time of charging.

3.4 Netting gives no incentive for optimization of storage in electric vehicles behind the meter

In the wake of the 2008 financial crisis, the Spanish government drastically cut its subsidies for solar power and capped future increases in capacity at 500 MW per year. In 2010, the Spanish government went further, retroactively cutting subsidies for existing solar projects. Until recently, Spain had a very general self-consumption policy framework that applied to both grid-connected and off-grid systems. However, in 2015, Spain's Council of Ministers approved a new self-consumption law that it taxes self-consumption PV installations even for the electricity they produce for their own use and don't feed into the grid[5]. Spain's PV sector calls the new law a 'sun tax'. With only 0,3% market share of EVs on a 22,5 million car market in total, and only about 1800 charging stations6, the forecast on a strategy of the Spanish government to smart charge electric vehicles. In 2018, the Spanish retail market offers many spot market indexed tariffs and they are incentivized to charge the EV during low-cost hours. The current Spanish law lets end-customers to do self-balancing and charge the EV using PV generated power.

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[4] Ref. http://publikasjoner.nve.no/hoeringsdokument/2017/hoeringsdokument2017_05.pdf

[5] http://www.renewableenergyworld.com/articles/2015/10/spain-approves-sun-tax-discriminates-against-solar-pv.html

[6] http://www.eafo.eu/content/spain#summary

The netting rule also discourages optimal use of electricity in the Netherlands. This rule has stimulated the purchase of solar panels because low-volume consumers only pay for the balance of kWh that they consume from the grid on an annual basis. This arrangement actually allows low-volume consumers to 'virtually' store electricity that they generate themselves on the grid. No costs are charged for this. As a result, low- volume consumers (with a private charge point) have no incentive to optimise the self- generated electricity behind the meter, for example by storing it in their electric car for later use. This may cause a double peak in the grid: supply peak due to the generation of solar energy that is not used immediately and a demand peak if the electric vehicle is charging. The rule will be revised as of 2023[1].

3.5 Double energy tax discourages bi-directional charging

The use of the electric car for bi-directional charging (charging and discharging the car), whereby the stored electricity from the car can be used at a later time, can lead to double energy tax. An e-driver must pay energy tax on all kWh with which his car is charged. This does not make it attractive for him to make his car available for bi-directional charging since energy tax has to be paid on the charged kWh every time the car is discharged after charging. The existing netting rule in principle prevents low-volume consumers with a private charge point paying double energy tax in the case of bi-directional charging at a private charge point. It is currently unclear to what extent this also applies to (semi-)public charge points.

3.6 VAT-duty e-driver discourages bi-directional loading

Norway has both energy tax and VAT. In 2015 Norway achieved its goal of reaching 50,000 zero emission vehicles by 2018. Among the existing incentives, all-electric cars are exempt in Norway from all non-recurring vehicle fees, including purchase taxes, which are extremely high for ordinary cars, and 25% VAT on purchase, together making electric car purchase price competitive with conventional cars. Electric vehicles are also exempt from the annual road tax, all public parking fees, and toll payments, as well as being able to use bus lanes. These incentives were in effect until the end of 2017.

In a fundamental study the think tank Agora Energiewende[7] has examined in the tax and levy system for the German energy market. This study shows that energy prices are very different according to energy sources. For instance, the governmental surcharges (taxes, charges and levies) per kilowatt hour for electricity are in Germany at 18.7 cent on average. That makes 75-80 percent of the price components for most consumers (households) while other energy carriers are charged much less. In the case of petrol, it is only 7.3 cents/kWh, for diesel 4.7 cents/kWh, for natural gas 2.2 cents/kWh and for heating oil only 0.2 cents/kWh. The trend behind these numbers is the same for the Netherlands

It is thus hardly surprising that electricity (which is becoming increasingly decarbonized by the expansion of renewable energies and thus more climate-friendly) is much more expensive in comparison to other energy carriers and its use in other sectors of the energy industry like transport and heat is less common. In other words, imbalance of the energy price benefits climate-damaging energy carriers. Unfortunately, this piece of Agora research did not have a specific focus on electric vehicles, nor did it have a focus on the smart charging of these vehicles. It might be that the outcome of such research will show an even more ineffective and disrupting view of the government’s role in relation with e-mobility and energy taxes. However, the regulations of German electricity market have prevented the application of the proposed system to the frequency regulation, determining an implementation of control strategies mainly oriented to peak shaving. In fact, the actual regulatory system limits the access to the ancillary service market to power bids able to provide a minimum capacity of 1 MW.

Moreover, the actual regulation in Germany, related to the subsides for renewable energy sources, does not allow the use of installed renewable energy sources in combination with storage systems for regulation without losing the economic benefits associated to the subsidies. This limits economically the possibility to use the installed intermittent renewable energy production in conjunction with new energy storage systems for providing ancillary services.

Another aspect of interest for the project and which represents an obstacle in the development of proposed energy and business model is represented by the regulations of the management structure of distributed energy storage by means of aggregators. Now, the energy services provided by the energy storage are limited to the application

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[7] https://www.agora-energiewende.de/en/projekte/-agothem-/Projekt/projektdetail/152/

behind the point of common coupling, in correspondence of which the electricity meters are installed. This approach does not make possible, at the distribution level, to share the energy and the hardware among the neighbour customers avoiding the aggregation of the owners of energy storage, prosumer and consumer to manage locally their demand/production per a market-oriented approach. Moreover, the cost of network services that are limited by the local aggregation of prosumer and consumer is the same of all other electricity customers in the electric bill.

This represents a barrier for the development of an energy platform able to optimise the distributed energy and storage resources, increasing the energy efficiency per a bottom-up approach.

3.7 Lack of transparency for the e-driver discourages participation

It is currently unclear who determines that the battery of the electric car is used for Smart Charging, and, when the e-driver has connected his electric car to several initiatives, which initiative takes precedence. The roles and responsibilities of the various parties involved in providing flexibility by means of Smart Charging are still unclear. The CPO may be concerned with load balancing (control via the charge point) while the e-driver has given the supplier permission to use the car on TSOs reserve markets (control via the car).

Furthermore, privacy/GDPR regulation limits exploitation of data in Smart Charging initiatives This is a question of openness and communication in order to reduce distrust between customers on one side and vendors/authorities on the other. In Norway, solutions on the local level - down to concentrated housing associations - tend to solve the issue.

3.8 Regional differences in costs for municipalities for charging stations

Four different forms of charging infrastructure can be distinguished:

- **the private charge point**, where the e-driver installs a charge point on his home connection,
- **the semi-public charge point**, where the e-driver can charge at a bulk consumer who has installed charge points on his connection,
- **the public charge point**, where the municipality, in a tender, subsidises the roll out of charge points for public use and

- **a fast charging station**, where the driver can quickly charge his electric car on roads and motorways.

With all forms, the charge point is connected to the grid of the regional grid operator. The energy supplier is responsible for the supply of electricity on the connection. New roles have also arisen: The Charge Point Operator (‘CPO’) that manages the charge point and the Electric Mobility Service Provider (‘EMSP’) that is responsible for the (monthly) settlement via the charging card. To charge an electric car, interaction between the various players in the chain is required at both technical and administrative levels.

Communication standards for these interactions are further optimised. The charging of an electric car is still relatively easy at the moment. If the e-driver inserts the car’s plug into the charge point and presents his charging card, the car starts charging. Very little account is currently taken of the wishes of the e-driver (when should the car be fully charged) and the market conditions (such as the availability of renewable energy, or the grid load at the regional grid operator).

The roles distillated form the Netherlands can also be applied at Halden Municipalities, which has just a few charging stations which has been financed by the Fortum Charge and Drive. But the Municipality has now the plan to build out charging stations by their own and are now at the application stage. The neighbour town Sarpsborg has made a strategy document saying that the policy there is not that the municipality owns the charging stations but will stimulate private actors to develop charging stations. The pricing should be for self-cost of operation. A third example is Stavanger, where the municipality-owned parking company runs charging stations in its parking areas. The customer pays half of regular parking tariff.

3.9 Long lead time application process charging stations at municipalities

Various parties, such as municipalities and grid operators, are involved in the process of realising a charge point. They work together to improve the efficiency of processes and thus to improve the costs for realizing a charge point. Although different countries have been taken different steps to optimize here, further efficiency in the processes and thus a cost reduction must be realised in the future to help improve the business case for public charge points. For example, realization in the Netherlands can range from 4 to 26 weeks. Halden and Stavanger: A few weeks. An average German city takes up to half a year.

3.10 No incentive to roll out charging infrastructure with optimum charging capacity

Charge point connections can have different capacities, such as: 3 x 25, 3 x 35 or 3 x 63 amps. The higher the capacity of the connection, the faster a car can be charged, and the more flexibility is generated for the use of the car for Smart Charging. If charging is temporarily stopped, for example, the car can be charged on time by speeding up the charging (according to the e-driver's wishes).

A high capacity connection is significantly more expensive than a lower capacity connection. One of the reasons for this is the difference in capacity that must be reserved on the grid in order to meet the peak load of the connection. The tariffs for the connection are determined by national administrative boards. Because of these higher costs, mostly low-capacity connections are installed in the (semi-)public domain.

Increasingly, CCS DC charging stations with 50 kw capacity is considered optimal in Norway with CHAdeMO DC stations in second place. Smart charging doesn't apply with DC fast charging.

3.11 Uncertainty about the possibility of using Smart Charging for congestion management grid operator

The core task of the grid operator is the transmission of electricity to the consumer: they may not trade, generate or supply. Under current legislation (group prohibition and rules for congestion management from the Electricity Act and Grid Code), it is unclear whether they may purchase flexibility from third parties. The question is whether this is in line with the statutory duties of the grid operators. As a result, it is unclear whether they may deploy Smart Charging. Under current regulations, grid operators may only temporarily apply congestion management. They are obliged to eliminate situations of transmission scarcity as quickly as possible by investing in grid upgrades.

Grid operators are not allowed to own batteries themselves, nor are they allowed to give compensation for offering flexibility in the Netherlands.

In Norway the new report by DNV GL[8], propose that grid operators should not be allowed to own batteries them self for congestion management (only for handling emergency situations). Third parties can own batteries. But the new tariff system will motivate/stimulate the users to use smart charging which implicitly helps congestion management.

3.12 Risk of congestion at regional network operator

The use of the storage capacity of electric cars for certain types of Smart Charging, which, for example, aspire to the use of reserve markets for balancing or complying with the programme responsibility could lead to congestion in regional grids. For example, when the cars that are used for this simultaneously charge (or discharge) on the same regional low voltage grid.

Increased EV charging paired with increased other power consumption in homes. Some local risks of reduced stability/outage. Met with grid upgrade in some areas in Norway. Effect based tariffs are expected to decrease or delay demand for grid investment in some areas.

3.13 Rules of the TSO-E for participation in reserve markets lack

The Norwegian TSO Statnett takes a point of departure in the plans and prognoses available before the operating hour to plan the balancing of the power system9.

Even though the market creates a balance during the planning phase, the system is continuously exposed to factors that may disturb this balance, such as weather-related fluctuations in consumption, short-term changes in major industrial consumption, breakdowns in production facilities or power line outages or other grid component breakdowns. To be able to handle such unforeseen events, it is essential that there are sufficient reserves in the power system.

Momentary imbalances are initially regulated by primary regulation. If the imbalance continues for several minutes, secondary regulation will take over, thus freeing up primary regulation resources for regulation of new imbalances. Both primary and

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[8] https://www.nve.no/nytt-fra-nve/nyheter-reguleringsmyndigheten-for-energi/bor-nettselskapene-fa-eie-batterier/

[9] http://www.statnett.no/en/Market-and-operations/reserve-markets/

secondary reserves are activated automatically due to changes in the grid frequency. If further regulation is necessary, tertiary regulation (regulating power) will be activated which, correspondingly, will make secondary regulating resources available. Tertiary regulation is activated manually by the Nordic system operators. In Norway this is Statnett's National Control Centre.

Primary, secondary and tertiary reserves are acquired through market solutions.

3.14 Limited possibilities for Smart Charging at public charging stations by another supplier that supplies the charging station

In Norway, operators of charging stations have to hold a licence for selling electricity and would normally have contracts with one grid operator and one power supplier. Risk of market lock-in

The interest of the CPO differs in some cases from the interest of the e-driver, the programme manager, regional grid operator and the national grid operator. The CPO's business model is usually based on maximising the utilisation of the (semi-)public charge point and optimising the use of available charging capacity between the two charging points on the charge point. Smart Charging initiatives by one of these other players may result in the car being kept at the charge point for a longer period. There is a risk that the CPO will intervene in the planned delayed or bi-directional Smart Charging session in order to optimise its use of the charge point.

4 Conclusions

The identified institutional bottlenecks for Smart Charging and batteries in the distribution grid are basically divided into four overarching themes:

4.1 Market regulation issues

The Smart Charging Market is new, thereby creating new roles and responsibilities. This leads to institutional bottlenecks because A) the new roles have not yet been incorporated into legislation and regulations and B) existing roles may need to be adjusted. In order to stimulate the further roll-out of Smart Charging, it is important that the necessary new or adapted roles and responsibilities are included in legislation and regulations. The goal is to achieve an optimal operation of the market that leads to socially optimal welfare outcomes.

The Smart Charging market must be optimally designed to unlock flexibility and to encourage smart charging moments. To this end it is necessary to consider the extent to which new roles and responsibilities must be introduced and to what extent existing roles and responsibilities must be adapted to achieve optimal alignment with the desired operation of the Smart Charging market.

4.2 Sub-optimum financial incentives

The new Smart Charging Market is confronted with existing legislation and regulations that affect the charging price for the e-driver or other parties (energy tax, VAT, tariff structures, grid costs, but also electricity transmission costs). This is not designed to encourage Smart Charging and may in some cases even (inadvertently) obstruct Smart Charging. The financial incentives arising from existing legislation are not optimally designed to stimulate Smart Charging.

In order to accelerate Smart Charging, a complete revision of the (energy) tax system is ultimately desired. This should incorporate an incentive to reduce CO_2 emissions. In the current system, grey and green energy are taxed the same, so that it does not reflect the original regulatory nature of the energy tax. Negative financial incentives for sustainable (energy) solutions should be removed and replaced where necessary with positive financial incentives. This includes the introduction of an exemption for CO_2 neutral solutions or the use of a fixed tariff for low CO_2 solutions or a progressive tariff as the CO_2 emissions increase. A *level playing field* for Smart Charging can also be achieved in this way.

The tariffs of grid operators do not currently give customers any incentive to purchase electricity from the grid at the right times, in order to avoid peak loads in the grid as much as possible. At present, the transmission tariff does not depend on the time of purchase from the grid, so that users do not take account of a possible peak load when they decide to purchase electricity.

Electricity consumers are not encouraged to adjust their consumption to the supply of electricity by means of the retail tariff. In order to fit renewable electricity in the electricity grid, the demand must be more closely aligned to the (volatile) demand. This can be stimulated by means of a financial incentive to purchase more if there is a lot of renewable electricity available, such as by means of a variable supply tariff (part of the total retail tariff). However, this only provides a limited incentive because the tax component in the retail tariff (for low-volume consumers) currently determines a major part of the electricity tariff. A holistic approach is therefore necessary when creating the right incentives for consumers, which includes different tariff components.

4.3 Data exchange for optimum coordination

To enable Smart Charging, multiple parties in the chain must work together and share information with one another. At present, there is no shared vision of the data that must be shared to ensure optimum collaboration. Technical standards and information protocols that apply throughout the chain are still under development. This can result in coordination problems that slow down the further development of Smart Charging.

The operation of the Smart Charging chain depends on digital data exchange (vehicle charging status, possible charging speed, time when the e-driver wants to leave, and minimum battery charge level).

It must be determined which data should be made available to market parties in order to optimally perform their task or to develop new services and products that maximise social welfare.

Protocols for data access and exchange must also be developed. To develop a true sustainable model, all aspects must be solved.

4.4 Batteries in the distribution grid

Based on research in the Netherlands, batteries might be a very useful and economically advantageous alternative to traditional investments in grid reinforcement.

- However, in the long term, grid companies should purchase battery services rather than buying batteries. Such a line will be consistent with the rules for functional separation between grid business and other businesses, and it will help a market for grid related battery services emerge and become viable.
- In the short term, both the grid companies, other actors as well as regulators, need experience with what batteries can do and how use and ownership should be organized.
- Some grid companies have established *pilot projects* and *test cases* to learn more about special *technical possibilities* and *challenges*. Such attempts are important to

gaining experience with a relatively unfamiliar and new technology among grid companies.

- Therefore, we should allow further activity with trial and error before strictly enforcing a ban. Future trials should include both *technical* as well as *commercial* and contractual issues.

5 Annex 1 definition "Energy Storage"

The Bridge report defines energy storage as follows:

> *Energy storage in the electricity system is the act of deferring an amount of the energy that was generated to the moment of use, either as final energy or converted into another energy carrier*. Other forms of energy storage include oil in the Strategic Petroleum Reserve and in storage tanks, natural gas in underground storage reservoirs and pipelines, thermal energy in ice, and *thermal mass/adobe.*
>
> *An Energy Storage System (ESS) for the electricity sector is a system used for the intake and stocking of electricity in different suitable energy forms. The release of this energy, at a controlled time can be in forms that include electricity, gas, thermal energy and other energy carriers. One common categorization of ESSs per the energy carrier is based on the following:*
>
> - *Power to power conversion;*
> - *Power to heat conversion and storage of heat for final consumption;*
> - *Power to gas conversion.*
>
> *While, depending on the ESS technology used and the desired effect, energy can be stored from fractions of a second to longer periods, e.g. months.*

In general, an ESS may be either centralized (large scale) or distributed, which also reflects to the fact that energy storage can be applied to all steps of the energy value chain. It can allow decoupling of energy supply and demand and can used to bridge temporal and geographical gaps between them.

Energy storage applications aim to:

- the reduction of emissions of greenhouse gases,
- the support of increased RES penetration,

- the reduction of demand for peak electrical generation,
- the avoidance of grid power reserves and the alleviation of the high cost production of energy or the high cost energy trading,
- the deferral or substitution for investments in generation, transmission, or distribution assets, as well as to
- the reliable and stable operation of the electrical transmission or distribution grid through the provision of ancillary services

Finally, an ESS can be either owned by a load-serving entity ((including both investor owned utilities and energy service providers) or local publicly owned electric utility, a customer of a load-serving entity or local publicly owned electric utility, or a third party, or is jointly owned by two or more of the above.