Battery Promoting Policies in Selected Member States

Batstorm work package 5

- July 2018 –

Battery Promoting Policies in Selected Member States

Batstorm work package 5

By: Xavier Potau, Samuel Leistner and George Morrison

Date: June 2018
Project number: POWNL16059
Reviewer: Andreas Ligtvoet and Michèle Koper

Table of contents

Executive summary: Battery Promoting Policies in Selected Member States

This report provides an overview of policies that support the rollout of battery technologies in selected EU Member States – notably UK, Germany, Netherlands, Italy and Spain. In addition to this executive summary of the case studies, this report presents a list of Do's and Don'ts for national policies and the overall supporting EU environment.

National policies can have a strong positive influence on making electricity storage more or less attractive. While most countries do not have specific policies promoting battery storage, some of their **general renewable energy support schemes have a positive spill-over effect on the uptake of energy storage technologies**.

Countries with relatively weaker interconnection capacity have a larger need for the deployment of energy storage solutions to cope with variations in supply and demand. This is partially the case in UK which has a number of interconnections with closest EU countries, but is not as well interconnected as centrally placed "continental" EU Member States. The situation is opposite in countries with large interconnection capacity, such as the Netherlands.

The prospect of increasing grid congestion during peak-load periods also drives up demand for storage. E.g. the Netherlands are aware that national grids will hardly cope with future demand without any mitigating measures being taken.

Storage deployment is accelerating most remarkably in selected countries such as Germany and the UK over recent years. While in a number of other countries deployment is still stalling due to a lack of focus on storage, pilot projects are signalling that this is an issue that it is at least being taken seriously by network operators and electricity producers.

General positive conditions for the deployment and uptake of battery storage, be it through renewables support schemes, market design rules or otherwise, are clearly important for industrial competitiveness in the EU. Indeed, demand for batteries/storage implies increased demand for power electronics, software, assembly and a number of other services where EU is competitive. Demand for storage also creates demand for battery cells: this business sector is still to be developed in the EU as no mass production currently exists.

Conversely, any regulatory barriers and ill-constructed Renewable Energy Sources (RES) support schemes can negatively affect battery deployment.

There are a number of pilots and support schemes which can be identified as innovative and best practice. For the uptake of battery storage several countries have schemes in place which give an incentive for installing battery storage in-front of meters and at the residential level. For example, the **German government and its development bank KfW provide low-interest loans and repayment bonuses for batteries in conjunction with photovoltaic systems** (at least 50% self-consumption is required). Furthermore, **Germany now gives levy and grid tariff exemptions to**

grid-connected electricity storage facilities and recently also introduced levy exemptions for self-supply of storage and even the net consumption of energy related to round-trip losses of energy[1].

Some countries stopped paying preferential tariffs for feeding RES electricity into the grid, which can make storage more attractive. At the same time, in some countries where feed-in tariffs still exist, addition of storage to RES installations may lead to decreasing support. This works as disincentive for storage uptake.

Regarding the grid, the integration of storage systems into conventional and smart grids is an area where all countries could collaborate through sharing of data and experiences. Innovative approaches are demonstrated e.g. by the Netherlands, which has some **innovative projects to promote storing solar energy in the batteries of electric vehicles, projects involving 2nd use of EV batteries or collective batteries for PV electricity storage in the neighbourhood. The Netherlands also allow Electricity Law Experiments** - exemptions to stakeholders necessary to participate in pilots.

Some countries also include battery storage in their capacity auctions which accelerated deployment. However, the de-rating of short-term battery storage capacity in energy auctions (a recent example from the UK), can lead to less capacity installed until batteries that provide energy for more than 1 hour in times of outages are more widely available.

Some countries already have considerable targeted R&D funding for development of battery storage technologies, not only schemes facilitating (innovative) deployment techniques. E.g. the **British Faraday Challenge** comprises an investment of £246m to help the UK to become a world-leader in the design, development and manufacturing of batteries for the electrification of vehicles[2]. Also, **the German Battery 2020 programme** provides co-funding for projects concerning the advancement of battery storage system technology[3].

Regarding the public perception of battery storage there is currently an insufficient public understanding of battery storage and its related benefits, and overall consumer scepticism concerning smart meters and data security which leads to avoidance of decentralised solutions (including battery storage). Furthermore, due to the novelty of the technology there are a number of concerns about the safety, reliability and economic viability of battery storage facilities. From the industry perspective, naturally, established market players resist changes in the makeup of energy markets. In addition, there isn't always a strong enough business case for the uptake of storage facilities. Large companies are ready to pilot new solutions, but they may be wary to embrace new business models until regulation and market opportunities are clearer. In terms of technology development, the main concerns of people consulted were related to system integration, application design, design of battery systems and materials research. Action in these areas would be advised particularly through pilot projects and R&D efforts.

While these are rather soft barriers there are also some concrete regulatory issues which partly block the uptake of battery storage. **Liability, ownership issues and business models are still to be developed/improved. Moreover, electricity storage can be subject to discriminatory grid**

[1] https://www.gesetze-im-internet.de/eeg_2014/BJNR106610014.html
[2] https://www.gov.uk/government/news/business-secretary-announces-industrial-strategy-challenge-fund-investments
[3] https://www.bmbf.de/foerderungen/bekanntmachung-1146.html

tariffs in which battery storage is counted double (grid fees have to be paid during generation and consumption) which makes it expensive. In Germany, this has been legislated against as explained above. Also, the UK grid regulator OFGEM identified this as a problem and proposed to avoid 'double counting'. The new electricity market design rules under the Clean Energy Package will ensure the relevant issue is properly addressed throughout the EU.

Some barriers are also created through renewable energy support in a way unfavourable for battery storage, including priority dispatch rules, curtailment compensations, as well as subsidies during times of negative prices impact battery deployment[4]. Also net metering, which allows consumers to use some of their produced energy at any point in time, makes storage solutions on the residential level redundant and can be seen as very harmful for the uptake of battery storage at the residential level.

Similarly, **national support for** other, non-renewable, forms of energy production such as **coal or nuclear power plants** (introduced on the grounds of safeguarding capacity adequacy or ensuring security of supply) **can also seriously hamper the uptake of energy storage**.

In terms of raw material supply and production costs, **stronger environmental norms through revision of the Battery Directive could boost battery recycling** (where the EU is already strong), **and possibly also the battery production in the EU**. Currently recycling norms for LI-ion batteries have the potential to be considerably strengthened (they fall in the category of "other batteries" implying that only 50% of weight should be recycled; such indicator can be achieved without recycling Lithium, which is currently not economic).

[4] A comprehensive overview of curtailment policies is available at the European Commission RES Legal Database. Available at http://www.res-legal.eu/home/

DOs and DON'Ts in Battery Storage Policy

Based on country level analysis of Germany, Italy, Spain, the Netherlands, and the United Kingdom a number of DOs and DON'Ts could be derived. Some of these address the uptake of RES storage in a general way and others address research into innovative storage solutions.

R&I DOs

- **Exploring new options of storage uptake & use**: E.g. in the Vehicle2Grid scheme of the Amsterdam Smart City Project [5], participants will produce energy locally (e.g. from solar panels) and the excess that can't be used will be stored in the battery of an electric vehicle, with participants having the option to sell stored energy back into the grid. A similar initiative exists in the city of Delft[6]. This is without prejudice to the need to further develop storage solutions not based on EV use: country fiches enclosed include a number of good examples.
- **Battery R&I Support & Incentives:** An example of targeted storage R&I funding is the British Faraday Challenge – an investment of £246m to help the UK become a world-leader in the design, development and manufacture of batteries for the electrification of vehicles[7]. Also the German the German Battery 2020 programme provides co-funding for projects concerning the advancement of battery storage system technology[8].

  The Danish successful experience with development of the wind turbine industry shows that accompanying measures are also important. In Denmark a positive role was played by enforcement of a Danish Wind Turbine Certification. This was needed to ensure the safety, capacity, and quality-related requirements of wind turbines and to win consumer confidence. In batteries field different kinds of certification and testing standards may prove to be even more important.

Policy DOs

- **No preferential remuneration for feeding into the grid PV generated electricity by households:** In Germany suppliers with self-consumption, using facilities below 100kW, can feed excess energy into the grid but without preferential remuneration[9]. This incentivises the use of storage for self-produced energy.
- **Policy support schemes for combining electricity storage with renewable energy:** The government-owned development bank KfW, on behalf of the German Federal Ministry for Economic Affairs and Energy, rolled out a loan and subsidy scheme for energy-storage batteries in conjunction with photovoltaic systems linked to the electricity grid. The supported photovoltaic systems are limited to feed a maximum of

[5] http://www.smart-circle.org/portfolios/vehicle2grid/
[6] https://www.delft.nl/content.jsp?objectid=66492
[7] https://www.gov.uk/government/news/business-secretary-announces-industrial-strategy-challenge-fund-investments
[8] https://www.bmbf.de/foerderungen/bekanntmachung-1146.html
[9] https://www.iea.org/policiesandmeasures/pams/spain/

50% of their generated capacity into the power grid[10]. The scheme works through two channels, KfW provides low-interest loans and the Ministry provides repayment bonuses.

- **Regulatory exemptions:** In 2015, the Dutch Government launched a temporary regulation that allows **Electricity Law Experiments[11],** which could potentially change the production and distribution of electricity in The Netherlands. Batteries and the promotion of smart grids are among the primary points of investigation of this scheme. This can be a good practice if it happens in line with the Clean Energy Package.
- **No double counting of electricity used by storage (and possibly even complete exemptions from grid charges)**. Levies for use of the network should apply only once, if at all. Currently often a levy applies while taking electricity from the grid and again after distributing energy from the storage. This was recently addressed by German and British regulation.
    - The German EEG does incentivise grid connected in-front-of-meters electric storage facilities, by giving them exemptions to levies and grid tariffs, but only if the stored energy is fed back into the grid. The 2017 update of the EEG expanded this, §61k allows now levy exemptions for self-supply of storage as well as for the loss of energy[12].
    - In the UK it was argued that final consumption levies (levies paid by final consumers to support key policies such as the Capacity Market and renewable generation schemes) should not apply for storage, since grid connected storage facilities are rarely 'final consumers' of electricity.
- **Limit to the minimum RES subsidies in times of negative prices**: German legislation - §51(1) of the EEG (formerly §24) – provides that renewable energy subsidies can continue for up to 6 hours of negative prices[13]. This can have negative implications on storage development. Maintaining subsidies during negative price periods gives no incentive to install or develop storage capacity, but rather to rely on an oversupply of renewable energy.
- **Good access to ancillary services:** The UK National Grid is running a service called Enhanced Frequency Response[14], which has the goal of achieving 100% active power output at a maximum of one second after registering a frequency deviation. The current best case for such a response is around 10 seconds. As part of this service, 8 companies are involved, all of which provide storage solutions to the grid. The total cost of tenders is just short of £66m. [18].
- **Domestic charge points for electric vehicles**: An initiative in Scotland[15], launched by Transport Scotland, the Energy Saving Trust (EST) and the Office for Low Emission Vehicles (OLEV), aims to introduce domestic charge points for electric vehicles. As an incentive, the initiative will fund £1,000 of the approximate £1,400 cost of installing a charge point at home. Furthermore, charging at home is expected to reduce charging time by 30-60 percent. Given that charging can be done overnight, this looks like an attractive policy which might further encourage the uptake of electric vehicles in this part of the UK.

[10] https://www.kfw.de/KfW-Group/Newsroom/Aktuelles/Pressemitteilungen/Pressemitteilungen-Details_341696.html
[11] http://www.batstorm-project.eu/electricity-law-experiments-netherlands
[12] https://www.gesetze-im-internet.de/eeg_2014/BJNR106610014.html
[13] https://www.gesetze-im-internet.de/eeg_2014/BJNR106610014.html
[14] http://www2.nationalgrid.com/Enhanced-Frequency-Response.aspx
[15] http://www.energysavingtrust.org.uk/scotland/grants-loans/domestic-charge-point-funding

- **Lower tax rates for energy clubs:** Lower energy tax rates for people who locally club together to generate energy from sustainable resources are worth considering. While this needs to be in line with state-aid rules it can incentivise the shared purchase of energy storage solutions for communities.

Policy DON'Ts

- **Subsidies and incentives for conventional energy generation** (e.g. support to nuclear power plants in UK and support to coal based generation in Spain). While such measures may exceptionally be allowed under State aid or internal market rules for reasons of ensuring capacity adequacy or security of supply, they have to be scrutinised by the Commission to limit such subsidies and respect the objective of gradual withdrawal of environmentally harmful subsidies.
- **Net metering:** In some countries, for example the Netherlands, net metering is offered which allows to feed electricity into the grid and receive the same amount back at a later point in time. While this might incentivise residential renewable energy generation, it discourages investments in energy storage.
- **Unclear licences:** In Spain electricity storage is not separately regulated amongst Spanish legislature and counts as generation. Thus, storage projects must hold separate licenses (e.g. for photovoltaic power), which places different regulations and obligations on the license holder.[16].
- **De-rating of storage in capacity market auctions:** While including battery storage in capacity auctions can boost storage uptake, de-rating the capacity of batteries with a capacity to provide electricity up to 1 hour, without leaving enough time to develop new batteries which last longer, can send out the wrong signals to the developers. Hence, leading to fewer participants in capacity market auctions.
- **Unstable policies and abrupt changes in the policy environment:** Experience from the Solar-PV and Wind market has shown that countries should avoid unexpected abrupt changes in their policy set.

[16] http://www.lexology.com/library/detail.aspx?g=e64deba5-e559-4732-b6b8-6dcf28446fc0

European Policy Environment & Industry Trends

On the European level some regulatory and perception issues around storage are starting to be addressed by the Clean energy package. This *inter alia* includes the formalisation of the definition of energy storage and clarification around issues of ownership, increase of price volatility (no price caps), prohibition of discriminatory grid charges for storage, access to dynamic price contracts, small minimum size of balancing products, and markets closure near the time of delivery. Also, the conclusions of the work carried out in the elaboration of new roadmaps from the European Association for Storage of Energy (EASE) and the European Energy Research Alliance (EERA) should be considered[17]. The main features of these roadmaps tackle inhibitive legislation, a description of the technologies available and anticipated, and market adaptations, all much in line with the findings in this report. More recently, the Battery Alliance established in October 2017 under leadership of Vice-President Šefčovič plays increasing role in creation of holistic eco-system for battery production, deployment and recycling.

In general, policies that support the development of an internal European market for all hybrid and electric vehicles should be encouraged further. The industry is now at a turning point in terms of technical feasibility, popularity and consumer appetite. Price and energy-density of batteries is improving rapidly and there are EU-wide activities that strongly support the rollout of electric vehicles (CO2 norms as well as legislation and financing with respect to alternative fuel infrastructure). This could be the catalyst for wider, industrial-scale battery storage solutions being accepted and implemented across Europe. As a matter of fact, electric vehicle batteries and stationary storage solutions share parts of the same supply chain. In line with the EU's ambition to promote recycling and a circular economy, in principle batteries are to be collected and recycled at end-of-life [11]. However, in practice, under the current Battery Directive Lithium batteries are treated as "other batteries" and it is enough to recycle 50% of the weight of the battery. This low recycling ratio, in turn, doesn't necessitate recycling of lithium which is currently non-economic (the ration can be met with recycling other materials/elements).

In terms of wider technology development, the main concerns of people consulted were related to system integration, application design, design of battery systems and materials research. Action in these areas would be advised particularly through pilot projects and R&D efforts. The SET-Plan Batteries' Implementation Plan[18] is the key reference document for the needed battery R&I and is usefully complemented by the Batstorm roadmap. H2020 Smart Grid and Storage projects can play an important role in improving the cooperation in grid issues. Overall, there are a number of European initiatives with a positive impact on the uptake of battery storage. EUROBAT[19] mentions the Horizon 2020 European Green Vehicles Initiative as an effective measure which stimulated Lihium-Ion battery development [24]. Moreover, the Knowledge and Innovation Community (KIC) Inno-Energy scheme, set up by the European Institute of Technology (EIT) funding innovation and start-up businesses across EU member states, in the thematic area of new energy solutions[20], plays a positive role.

[17] http://ease-storage.eu/ease-eera-storage-technology-development-roadmap-2017-hr/
[18] https://setis.ec.europa.eu/sites/default/files/set_plan_batteries_implementation_plan.pdf
[19] The association of European automotive and industrial battery manufacturers
[20] http://www.innoenergy.com/innovationproject/thematic-area/energy-storage2/

Appendix A1: Country studies

A1.1 United Kingdom

A1.1.1 Overarching policy framework

The United Kingdom is committed to decarbonisation. In 2008, the **Climate Change Act** set a target of an 80% reduction in greenhouse gas emissions by 2050, against a 1990 baseline. In the same year, the Department for Energy and Climate Change (DECC), now incorporated into the Department for Business, Energy and Industrial Strategy (BEIS), set out the goal of security and affordability of energy supply, along with decarbonisation as part of its focus on the **Energy Trilemma[21].** The UK is still rather dependent on fossil fuels, but the incorporation of wind energy is leading the way in the country's energy transition. Moreover, installed photovoltaic power units have experienced a five-fold increase between 2011 and 2014 [4]. In addition to its own national targets the UK is also subject to legislation from the EU (Emissions Trading System, 20:20:20 package and the UN (Paris agreement). The transition to a green energy solution is further incentivised by the recognition that it is a driver for the creation of jobs and economic growth [13].

Battery storage in the UK benefits from the support schemes for renewable energy which increase the profitability of renewable energy installation. Mechanisms active in the UK are a feed-in tariff system with fixed rates for plants with capacity below 5MW, a quota system for suppliers above 5MW capacity which obliges them to supply a proportion of renewables from their total supply, a Contracts for Difference scheme which pays a low-carbon energy generator the difference between a low-carbon cost adjusted price and average UK market energy prices. Taxation on fossil fuel use for commercial and industrial users (Carbon Price Floor) also incentivises the use of renewable energy[22,23]. Furthermore, the UK government uses carbon prices for appraisal and internal evaluation [27]. There is no priority dispatch available for renewable energy in the UK.

The main stakeholders in energy policy in the UK are the UK Government, the independent regulator Ofgem, the system operator National Grid and the 'Big Six' energy companies (EDF, E.ON, SSE, British Gas, Scottish Power, N-Power). In general, the British public supports climate change mitigation and green energy policies, but they represent a stakeholder with little influence compared to the 'Big Six' energy companies. A 'liberal market economy' ideology has meant that the UK government has tended to adopt technology neutral instruments and has resulted in a preference for close-to-market technologies. Energy policy over the last generation has focused on market competitiveness. The UK Government does not provide direct subsidies for the deployment of storage systems (either large facilities or behind-the-meter devices). However, the Government is working to remove a range of regulatory and policy barriers for energy storage, with the aim of creating a sustainable energy system and an energy storage industry not reliant on subsidy. The UK Government has also made significant funding available to support innovation and R&D focused on energy storage, and particularly battery technologies. Other less influential stakeholders include think tanks, consumer groups, green

[21] The 'energy policy trilemma' is a common expression in UK energy policy circles that refers to the difficulty of striking a balance between affordability, decarbonisation, and security of supply.
[22] https://www.gov.uk/government/publications/contracts-for-difference/contract-for-difference
[23] http://www.res-legal.eu/search-by-country/united-kingdom/summary/c/united-kingdom/s/res-e/sum/204/lpid/203/

organizations and new entrants, all of whom could represent the interest of battery companies and the uptake of electrical storage.

In 2014 the UK Department of Energy & Climate Change estimated that up to £100bn of investment is required for the period between 2014-2020 in the country's networks and plants, to accommodate the UK network to cope with expected supply and demand pressures[28]. This allows some scope for the potential introduction of battery storage facilities in the national grid, since they can increase flexibility and capacity of the current grid arrangements.

The effects of regulation aimed on energy security can be illustrated by the example of battery storage as a part of capacity auctions in the UK. Since the end of 2017 long-duration storage capacity is being incentivised over short-duration storage capacity to achieve higher levels of energy security. In 2016, T-4 capacity auctions, for capacity delivered by 2020/21, saw around 500MW of new capacity in battery storage of the total 3.2GW in storage capacity awarded [29]. In December 2017 the UK government, following a consultation, set new rules regarding the de-rating of storage capacity for future UK capacity auctions. De-rating in a capacity auction means that a technology has an assigned de-rating factor which indicates the real forecasted capacity of the technology. For example, a de-rating of 50% leads to only 50% payments for this capacity, the rationale for this is to provide enough energy security in times of short capacity. The new UK rules are likely to have a strong impact on future battery storage auctions. The de-rating of storage is now divided by duration i.e. the amount of time for which a storage capacity market unit can generate at its full connection capacity without recharging. Short-term battery can receive a low rating factor because it cannot provide enough capacity if an outage lasts longer than the batter capacity. This has significant impacts on battery storage which often has short durations. While previously de-rating was at 96.11% for all battery storage capacity, this does now only apply for batteries with a duration over 4 hours. For the T-1 auctions 2018/19 and the T-4 auctions for 2021/22 the most impacted class will be storage with a duration between 0.5 and 1 hour which has now a de-rating down to 21.34%. While pre-qualifications for the next T4 auctions show around 6GW of battery storage capacity, it is likely that the final outcome will be negatively influenced by these new regulations. The UK Government reasons that short duration battery storage does not deliver sufficient energy security and estimated £50 to £500 million pound of additional costs from awarding more battery storage with the old de-rating levels to guarantee energy security [30]. The new levels of de-rating give an incentive to focus more on battery storage with higher duration in the long-term. However, since these changes do not happen gradually they could also cause a negative impact in the short term.

A1.1.2 Instruments to foster the uptake of battery storage

Instruments to support the implementation of storage into the grid

The **Electricity Market Reform**[24] was an appendix to the **Energy Act** of 2013, which introduced a number of instruments to encourage investment in renewable and nuclear energy, essentially to encourage the transition away from fossil fuels, which consisted mostly of economic incentives. Although battery storage is not mentioned in the legislation, the energy landscape has changed since the inception of the bill and this could provide instruments to encourage the uptake of battery storage solutions.

[24] https://www.gov.uk/government/publications/2010-to-2015-government-policy-uk-energy-security/2010-to-2015-government-policy-uk-energy-security#appendix-5-electricity-market-reform-emr

The National Grid is running a service called **Enhanced Frequency Response**[25], which has the goal of achieving 100% active power output at a maximum of one second after registering a frequency deviation. The current best case for such a response is around 10 seconds. As part of this service, 8 companies are involved, all of which provide storage solutions to the grid. The total cost of tenders is just short of £66m. [18].

With the advent of electric and hybrid vehicles, the transport industry has made great strides in the implementation of electrical storage. At the end of 2011 there were 2,441 licensed plug-in vehicles (cars, vans and quadricycles) in the UK. By the end of 2016 this figure had risen to 84,884[26]. The use of electric vehicles in the UK is anticipated to rise further, so much so that the project **My Electric Avenue**[27] (MEA) has been set up to pre-empt the additional stress on the electricity distribution network. The project also wants to quicken the uptake of electric vehicles and reduce their cost.

Another initiative in Scotland[28], launched by Transport Scotland, the Energy Saving Trust (EST) and the Office for Low Emission Vehicles (OLEV), aims to introduce domestic charge points for electric vehicles. As an incentive, the initiative will fund £1,000 of the approximate £1,400 cost of installing a charge point at home. Furthermore, charging at home is expected to reduce charging time by 30-60 percent. Given that charging can be done overnight, this looks like an attractive policy which might further encourage the uptake of electric vehicles in this part of the UK.

Away from transport there are other policies in motion regarding electricity storage. The **Smart Network Storage** project[29] has £18.7m in funding, £13.2 from the regulator Ofgem, and has one test site in the UK which uses lithium-manganese battery cell technology, with the objective of storing energy created from renewable sources and to be used to help supply the distribution network at peak times. It is also hoped this will reduce electricity bills for consumers. As of 2016, there were a further 23 operational battery facilities in the UK, with a maximum of 10MW power output capacity, Most of these are considered 'proof of concept' projects, to illustrate that the technology is in place for a larger uptake [4]. The 10MW units in Cumbria[30] and in the the Kilroot Power Station project in Northern Ireland are good showcases of storage projects in the UK, with the latter expecting to increase the capacity of its storage array to 100MW in the near future[31].

Other battery-based projects are in operation or have been recently announced in the UK, largely exploiting lithium-ion or lead-ion battery technology [19]. The purpose of these projects is primarily to test different storage configurations and to increase the support and flexibility on the national grid to accommodate the demand at peak times. Smart Network Storage in Leighton Buzzard (Bedfordshire) has one of the highest capacities amongst battery-based projects with 6MW rated power. According to the Research Energy Association (REA) report [19] there were 26 operational battery storage facilities operational in the UK, as of May 2015. Other projects in the former Roosecote coal and gas-fired power station in Cumbria and in the West Burton gas plan in Nottinghamshire are expected to go online in

[25] http://www2.nationalgrid.com/Enhanced-Frequency-Response.aspx
[26] Department for Transport (DfT) https://www.gov.uk/government/collections/vehicles-statistics
[27] http://myelectricavenue.info
[28] http://www.energysavingtrust.org.uk/scotland/grants-loans/domestic-charge-point-funding
[29] http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-2-projects/Smarter-Network-Storage-(SNS)/
[30] https://www.green-growth.org.uk/article/cumbria-set-large-scale-battery-storage-facility
[31] http://aesenergystorage.com/2016/01/07/aes-announces-completion-of-the-uks-biggest-battery-energy-storage-array/

2018, with a projected capacity of 49MW each. These of course differ in capacity and varying degrees of interconnectivity with the national grid or large power stations, but this study does confirm that the relevant technology is ready and available in the UK to see a larger uptake in battery-based energy storage solutions.

Between November 2016 and January 2017 BEIS, together with regulator Ofgem, organised a Call for Evidence [7], consulting on a proposed approach for managing the transition to a smart, flexible energy system. The document identified six main policy and regulatory barriers discouraging the uptake of storage solutions, that are to be tackled by BEIS and Ofgem. BEIS are charged with dealing with regulatory issues (e.g. unclear definition of energy storage), planning consents (establishing that storage facilities should be treated as generation facilities for planning purposes) and final consumption levies (levies paid by final consumers to support key policies such as the Capacity Market and renewable generation schemes) – this final point being an issue as storage facilities are rarely 'final consumers' of electricity, so many stakeholders believe they should not face these charges. Currently the regulations can result in 'double counting' where both the storage provider and the consumer pay the levies. regulator Ofgem leads on issues around securing network connections for storage facilities, network charging and the use of storage by established network operators. BEIS and Ofgem are soon due to publish a **Smart Systems and Flexibility Plan** in response to the Call for Evidence, which will clarify the measures that will be undertaken to address these barriers, and timescales for doing so. It is expected that appropriate action to address these issues will significantly facilitate the incorporation of energy storage in the UK energy system.

Instruments to support R&I in battery storage

The UK also has funding in place in the context of competitions, to encourage R&I in the area of new technologies in energy distribution. Ofgem offers up to £81m per year available for the "*development, demonstration, commercial arrangements and operation of new technologies*". Electric storage is one of the main areas of interest for this competition, and projects in the field have been beneficiaries in the recent past. Moreover, the UK Government (via BEIS) is making significant funding available for energy storage and innovation projects. In the Spring 2017 Budget, the Government committed at least £50 million to support innovation in smart energy technologies, including energy storage. As part of this commitment, in January 2017, two competitions were launched, with up to £9 million available to reduce the costs for energy storage technologies and a further £600,000 to support feasibility studies for a potential first-of-a-kind, large scale future storage demonstrator. Meanwhile, as part of its Industrial Strategy the Government has unveiled the **Faraday Challenge** – an investment of £246m to help the UK becomes a world-leader in the design, development and manufacture of batteries for the electrification of vehicles[32]. It has been noted (see [4]) that these R&I funding structures seem to be taking priority over actual projects concerning battery storage.

[32] https://www.gov.uk/government/news/business-secretary-announces-industrial-strategy-challenge-fund-investments

A1.1.3 Country profile: United Kingdom

Policy Framework	• In 2008, the **Climate Change Act** set a target of an 80% reduction in greenhouse gas emissions by 2050, against a 1990 baseline. In the same year, the Department for Business, Energy and Industrial Strategy (BEIS) set out the goal of security and affordability of energy supply, along with decarbonisation • Several RES-favouring schemes in place such as: Feed-In Tariffs for small generators up to 5MW, Quota System, Contracts for Difference System, Fossil Fuel Taxation (Carbon Price Floor), Carbon Pricing in public procurement,
Main Stakeholders	• Independent regulator Ofgem • System operator National Grid • 'Big Six' energy companies EDF, E.ON, SSE, British Gas, Scottish Power, N-Power. • In general, the British public supports climate change mitigation and green energy policies, but they represent a stakeholder with little influence compared to the 'Big Six' energy companies.
Battery specific Support Instruments	• The Government is working to remove a range of regulatory and policy barriers for energy storage, with the aim of creating a sustainable energy system and an energy storage industry not reliant on subsidy. • Approach towards capacity subsidies through Enhanced Frequency Response service. • The UK Government has made significant funding available to support innovation and R&D focused on energy storage, and particularly battery technologies. • In the Spring 2017 Budget, the Government committed at least £50 million to support innovation in smart energy technologies, including energy storage.
Barriers	• A 'liberal market economy' ideology has meant that the UK government has tended to adopt technology neutral instruments and has resulted in a preference for close-to-market technologies. • The UK Government does not provide subsidies specifically aimed at the deployment of storage systems. At the same time it is one of the first countries where batteries could enjoy subsidies under capacity adequacy scheme. • BEIS Department, together with Ofgem, identified six main policy and regulatory barriers discouraging the uptake of storage solutions. These are regulatory issues, planning consents, final consumption levies, secure network connections, network charging and uptake of storage by established network operators.

	• The UK still supports the building of nuclear power plants which has a negative effect on the uptake of storage.
Innovative Storage Examples	• The **Smart Network Storage**[29] project has £18.7m in funding, £13.2 from the regulator Ofgem, and has one test site in the UK which uses lithium-manganese battery cell technology, with the objective of storing energy created from renewable sources and to be used to help supplying the distribution network at peak times. It is also hoped this will reduce electricity bills for consumers. • According to the Research Energy Association (REA) report of 2015 there were 26 operational battery storage facilities of varying capacity operational in the UK.

A1.2 Germany

A1.2.1 Overarching policy framework

The main policy concept in current and future energy production in Germany is the Energiewende, or energy turnaround, which outlines the transition away from nuclear energy and fossil fuels and towards renewable energy sources. Batteries and energy storage solutions are recognised as an important part of the future of energy in Germany, as they are indispensable to accommodate the increasing supply from renewable sources. A feature of German energy policy is the commitment to phase out nuclear energy entirely by 2022 [22].

The renewables era in Germany started in 2000 with the passage of the **Renewable Energy Act** (EEG). Since then, there has been a big uptake in solar, wind, hydro and bio-based energy. Despite a supportive popular opinion with regards to renewable energy, there are sectors of the population with strong objections to wind farms and photovoltaic plants spoiling the rural landscape of the country. The Government (nationally and locally) has been subject to lobbying against the instalment of these renewable energy sources.

Germany has a wide range of support mechanisms in place both for mass-production but also on the residential level. However, recent forecasting estimates that Germany will miss its 2020 target of 18% renewable energy by 2%, and is likely to reach only 16% by 2020 [31]. The main instrument is a tender based market premium system (EEG-Umlage) [33]. Moreover, a feed-in tariff is in place as regards smaller installations or under "grandfathering" rules, as well as several investment support programmes operated by the government-owned development bank KfW[33].

Priority dispatch is applied for renewable energy and curtailment only happens to guarantee the safety of the grid.

German legislation - §51(1) of the EEG (formerly §24) – provides that renewable energy subsidies can continue for up to 6 hours of negative prices[34]. This can have negative implications on storage development. Maintaining subsidies during negative prices gives no incentive to install or develop storage capacity, but rather to rely on an oversupply of renewable energy.

The major stakeholders in Germany's energy policy - the 'Big Four' utilities : E.ON, RWE, EnBW, and Vattenfall which hold together around two-thirds of the German power market - are now also acknowledging the importance of RES as a part of their business and improving their involvement in RES[35]. However, in the first years of the Energiewende they had very small shares of renewables. In 2012 they owned less than 5% of renewable energy capacity in Germany. The majority of capacity in Germany is owned by private shareholders/households [32].

A1.2.2 Instruments to foster the uptake of battery storage

It appears that the biggest instrument in future German energy policy is a raft of subsidies for the use of renewable energy schemes, brought in with the EEG. The EEG does incentivise electric storage

[33] http://www.res-legal.eu/search-by-country/germany/tools-list/c/germany/s/res-e/t/promotion/sum/136/lpid/135/
[34] https://www.gesetze-im-internet.de/eeg_2014/BJNR106610014.html
[35] https://www.pv-tech.org/news/renewables-on-the-rise-for-germanys-big-four-utilities-conventional-generat

facilities, by giving them exemptions to levies and grid tariffs, but only if the stored energy is fed back into the grid i.e. targeting grid-connected batteries in front of meters. The 2017 update of the EEG expanded this, §61k allows now further levy exemptions for self-supply of storage as well as for the loss of energy[36].

There are some government initiatives and policies aimed at fostering the development of pilot projects combining electricity storage with renewable energy. For example, the government-owned development bank KfW, on behalf of the German Federal Ministry for Economic Affairs and Energy, are rolling out a loan and subsidy scheme for energy-storage batteries in conjunction with photovoltaic systems linked to the electricity grid. The supported photovoltaic systems are limited to feed a maximum of 50% of their generated capacity into the power grid[37]. The scheme works through two channels, KfW provides low-interest loans and the Ministry provides repayment bonuses. The program is available for companies and private persons which feed their generated electricity into the grid. Beside providing support for new instalments, the scheme also allows to retrofit PV power stations installed after 2012. Only instalments which do not exceed 30kWp are eligible. The overarching aim is to improve the integration of small and medium PV power stations into the grid [34].

This is an example of conjoining batteries and the boom in renewable energy sources seen in Germany. Furthermore, **Battery 2020**[38] is a government-funded programme with the goal of increasing the provision of renewable energy and electro mobility. The programme provides grant funding up to 50% of research project costs of projects concerning material and process technology for Lithium-Ion-Systems, materials for secondary high-energy and high-performance battery systems, and battery systems of the future. The advancement of battery storage system technology falls under both initiatives.

There is a commitment to increase the number of electric vehicles on the road, but it comes with the recognition that as things stand the battery technology required is too expensive and needs advancement. The EU co-funded **Green eMotion** electro mobility project covers Germany as well and is committed to increasing the provision of electric vehicles and charging points throughout the EU. In 2010 the **National Electric Mobility Platform**[39] was launched which advises the government on electric transportation and hopes to see one million electric vehicles on the road by 2020. By 2017 there were more than 50 different models of German electric vehicles in the market which suggests the project has helped drive R&I in the field. This is a leading initiative by the German government and there were multiple billions of industry funding provided by the German government in this field which shows a commitment to the uptake of electric vehicles.

Along with cars, e-bikes have also been considered as an important part of the electric mobility market in Germany by an interviewee. The uptake in usage of e-bikes has happened with no state support; simply through private initiatives. The German government and its economic operators are also working intensely in the faster rollout of an intelligent charging infrastructure to support the uptake for electric cars. Furthermore, there are preliminary talks in place to implement schemes in which energy used by

[36] https://www.gesetze-im-internet.de/eeg_2014/BJNR106610014.html
[37] https://www.kfw.de/KfW-Group/Newsroom/Aktuelles/Pressemitteilungen/Pressemitteilungen-Details_341696.html
[38] https://www.bmbf.de/foerderungen/bekanntmachung-1146.html
[39] http://nationale-plattform-elektromobilitaet.de/en/the-npe/publications/

electric cars could also be provided into households, making the vehicles an active energy storage component of the electric grid.

One interviewee stressed the point that the technology is already sufficiently in place for Germany to see a fast uptake in battery-based electrical storage. An example of this is a large facility in Schwerin[40], started as a 5 MWh battery storage to support intermittent renewable energy generation and has been upgraded to 15 MWh. This facility allows to 'kickstart' disconnected or dysfunctional grids. It can bring grids which went offline back into operation: a novel functionality with strong benefits for energy security. This black start grid restauration ability makes it possible to decrease the duration of black outs. This happens by powering up a gas turbine and then synchronizing the grid[41]. The facility competes in primary frequency regulation markets in order to pay for the cost of operation, and is being upgraded to support black start capability and full island modes. Another multi-site large scale storage facility built by STEAG has 90 MW in six 15MW units across the country, contributing to the stabilisation of the country's grid via frequency regulation and voltage control. An interviewee suggested that Germany only needs to see an increase in storage capacity of around 5GWh in order to appropriately balance supply and demand in the national grid, which is a small amount proportional to overall electricity usage in the country.

A1.2.3 Country profile: Germany

Policy Framework	• The main energy policy concept in Germany is the **Energiewende**, or energy turnaround, which outlines the transition away from nuclear energy and fossil fuels and towards renewable energy sources. • A feature of German energy policy is the commitment to phase out nuclear energy entirely by 2022. • The **Renewable Energy Act** (EEG) is the main instrument behind the uptake in solar, wind and hydro-based energy. • Subsidies are in place for the use of renewable energy bought in with the EEG.
Main Stakeholders	• Major stakeholders in German energy policy are the 'Big Four' energy providers: E.ON, RWE, EnBW and Vattenfall. • Associated lobby groups influence national energy policy.
Battery specific Support Instruments	• The bank KfW, on behalf of the German Federal Ministry for Economic Affairs and Energy, are rolling out a loan and subsidy scheme for energy-storage batteries in conjunction with photovoltaic systems linked to the electricity grid. • **Battery 2020**[42] is a government-funded programme with the goal of increasing the provision of renewable energy and electro mobility.

[40] https://www.younicos.com/case-studies/schwerin/
[41] https://www.energy-storage.news/news/expanded-15mwh-german-battery-park-demonstrates-successful-black-start
[42] https://www.bmbf.de/foerderungen/bekanntmachung-1146.html

Barriers	• Renewable energy subsidies can continue for up to 6 hours of negative prices. Maintaining subsidies during negative prices gives no incentive to install or develop storage capacity, but rather to rely on an oversupply of renewable energy.
Innovative Storage Examples	• There is a large facility in Schwerin[40], which started as a 5 MWh battery storage unit to support intermittent renewable energy generation and has been upgraded to 15 MWh. The facility allows black starts of disconnected or dysfunctional grids by powering up a gas turbine in the grid. • The six 15MW large-scale facilities from STEAG in Germany operate from different locations in North Rhine-Westphalia and the Saarland and play a big role in stabilising the grid through frequency regulation and voltage control.

A1.3 the Netherlands

A1.3.1 Overarching policy framework

Power supply in the Netherlands still depends mainly on fossil fuels. The transition away from them has historically been rather slow, indeed the country is behind its own national targets for usage of renewable energy [14]. The main reason for this is the abundance of natural gas reserves in the country, which provided a big economic boost and less pressure for a quick energy transition. There is however public disapproval of the use of fossil fuels, firstly for reasons associated to climate change fears, but also due to the risk of earthquakes related to gas extraction, specifically in Groningen [4]. As a stakeholder in national energy policy, if the Dutch public were to encourage the use of electric storage facilities this could quicken the uptake of such initiatives.

Due to its position in Europe, the Netherlands enjoys good connections with other countries such as France and Germany to spread out the burden on its grid. One interesting new initiative is a link with the UK called BritNed, which is operated by the system operator TenneT [4]. This connectivity is potentially slowing down the changing makeup of the Dutch grid. There is also a lack of the provision of financial or legislative support from the government's side.

Still, the Netherlands is seeing the supply of energy from renewable sources increasing quickly now, largely thanks to vast wind farms in the North Sea. As this supply increases, storage facilities will become a necessary feature to facilitate its deployment. RES-E is promoted primarily through a feed-in premium/tariff and there are also investment subsidies for PV.

Furthermore, net metering is in place which however is harmful to storage deployment. There are also tax regulation mechanisms for renewable energy which include tax exemption for self-consumption and the possibility to write off investments in renewable energy plants against tax for companies[43].

The Netherlands is subject to EU legislation on energy and climate targets, and the national government is committed to promoting the generation of electricity from renewable sources in order to cut its greenhouse gas emissions and meet international targets. Indeed, the country's energy policy is based on the EU 20-20-20 scheme, transposed to fit its own appropriate national targets.

In 2013, the Social and Economic council (SER) in The Netherlands set out an **energy agreement** which outlines the ambition for the makeup of the energy market in the country in 2020 [14]. Some key features are:

- Tax breaks for locally-generated renewable energy, which are implemented by lower energy tax rates for people who locally club together to generate energy from sustainable resources
- The creation of a new integrated offshore electricity grid,
- Completing the **energy transmission** network which is promising to include storage facilities,
- Encouraging commercialisation of new technologies,
- A commitment to sustainable energy and improved energy efficiency.

Despite these pledges, the government still needs to pass new legislation which will help storage become an important part of the national energy makeup.

---

[43] http://www.res-legal.eu/search-by-country/netherlands/summary/c/netherlands/s/res-e/sum/172/lpid/171/

A1.3.2 Instruments to foster the uptake of battery storage

In terms of more concrete policy, the Dutch government has launched grants for **Energy Innovation Demonstration** (DEI). These became available in 2014 and total around €16m a year, and can be spent on any "*concrete demonstration of an energy innovation*". Energy storage certainly falls under this bracket and has already been the topic of some projects under scheme.

The Dutch government is directly funding other R&D projects pertaining to energy innovation. Funding for these is also coming from the EU, to be spent in The Netherlands as well as elsewhere. One such example is the Knowledge and Innovation Community (KIC) **Inno-Energy**, an initiative of the European Institute of Technology. The Dutch government has also implemented the **Top Consortia for Knowledge and Innovation Scheme** (TKI)[44], a public-private partnership focused on energy innovation. Amongst their many support schemes there is a €750k subsidy for systems integration projects that heavily targets new energy conversion and storage solutions.

Additionally, the **Amsterdam Smart City**[45] project is a large innovation project to redevelop the Amsterdam metropolitan area with a primary focus on reducing CO2 emissions. Energy storage and the implementation of batteries has been identified as a key part of the project, due to the necessity of smart grids and integrating electric transport. There will be funding for R&D of electric storage in this context as well as the provision of such initiatives. A part of the focus is configuring bi-directional charging ports for electric vehicles, to ensure that these can also act as storage facilities integrated into the city grid. Under the Amsterdam Smart City umbrella, the **Vehicle2Grid** project[46], involving the Amsterdam University of Applied Science, Alliander, ABB, Mitsubishi Motors and others, aims to develop such solutions. Participants in this scheme will produce energy locally (e.g. from solar panels) and the excess that can't be used will be stored in the battery of an electric vehicle, with participants having the option to sell stored energy back into the grid. The scheme is starting off on a small scale and in 2016 it covered one street in Amsterdam. A similar initiative exists in the cities Delft[47] and Utrecht[48]

The Dutch are pioneering an initiative to upcycle used car batteries, using them as devices for electrical storage using which support mechanisms. This is applicable for all cars, not necessarily electric ones. One of such schemes is being trialled on the small island of Pampus, which is not connected to the main national grid. If successful this would have benefits not only for advancing energy storage uptake but also for increasing battery re-use and recycling. This type of second-life initiative can be easily transferred to other locations and it is already being piloted in the country's national football stadium, the Amsterdam Arena. In place there are batteries that have been re-appropriated to form a storage facility for back-up energy[49]. This is the largest example in Europe of a project which re-uses car batteries to provide a stationary storage solution. These pilots are having good results and similar initiatives could follow in the Netherlands or elsewhere in Europe. Another interesting pilot project is the "buurtbatterij" which is a neighbourhood battery project which allows 35 homes to store the energy from their roof Solar-PV modules[50].

---

[44] https://topsectorenergie.nl/urban-energy/subsidie
[45] https://amsterdamsmartcity.com/
[46] http://www.smart-circle.org/portfolios/vehicle2grid/
[47] https://www.delft.nl/content.jsp?objectid=66492
[48] http://www.lombox.nl/nieuws/vpros-tegenlicht-over-wereldprimeur-vehicle-to-grid
[49] http://www.amsterdamarena.nl/default-showon-page/amsterdam-arena-more-energy-efficient-with-battery-storage-.htm
[50] https://www.nrc.nl/nieuws/2017/11/27/je-stroom-bewaren-in-de-buurtbatterij-14189442-a1582717

There are increasing examples of policies in place at a local level to reuse car batteries (not necessariyly from electric vehicles) in stationary domestic energy storage solutions. In the Netherlands a good example are initiatives by Alliander[51].

In 2011, the Dutch Ministry of Economic Affairs launched the **Green Deals** initiative[52], a public-private sector collaboration aimed and starting sustainable initiatives. Energy storage is relevant to 2 of the 9 thematic areas of the Green Deals scheme, namely mobility and energy. Since the inception of the scheme there have been 20 deals made in the domain of electrical transport, with an impact in energy storage and battery initiatives. Furthermore, the Ministry has initiated an **Energy Storage Roadmap[53]** in association with the Technical University of Delft and consultancy companies DNV GL and Berenschot. The aim of this initiative is to increase flexibility in the national electricity system and to accommodate the increasing input from renewable energy sources via electrical storage, as well as encouraging R&D in the field. Finally, in 2015, the national Government launched temporary regulation that allows **Electricity Law Experiments[54],** which could potentially change the production and distribution of electricity in The Netherlands. This regulation is meant for projects that combine local production of renewable energy and consumption for 'local' (up to 500 end users) or 'regional' scale (up to 10.000 end users). An interviewee clarified that the Experiments are a government scheme that allows pilot projects to be run and participated by publically-owned regional network operators (which need this kind of exemption to participate in these pilot activities that are outside of their initial charter). Private energy suppliers and other companies also participate in the experiments, without having to ask for explicit permission. Batteries and the promotion of smart grids are among the primary points of investigation of this scheme.

A1.3.3 Country profile: The Netherlands

Policy Framework	• There is an abundant fossil fuel supply on the country which slowed down RES uptake in the past. • The Dutch national grid is operated by TSO Tennet, and regional networks are owned and managed by (public) utility companies. • The Government is now committed to promoting the generation of electricity from renewable sources in order to cut its greenhouse gas emissions and meet international targets. • There is no adequate legislation on energy storage, which discourages its uptake. • In 2015, the national Government launched temporary regulation that allows **Electricity Law Experiments,** which could potentially change the production and distribution of electricity in The Netherlands. • Premiums on top of market prices for renewable energy, taxation regulation mechanism i.e. levy exemptions for self-consumption & tax

[51] https://www.alliander.com/nl/media/nieuws/batterij-uit-elektrische-auto-krijgt-tweede-leven-op-forteiland-pampus.nl
[52] http://www.greendeals.nl/green-deal-aanpak/
[53] https://www.dnvgl.com/news/dnv-gl-berenschot-and-tu-delft-present-energy-storage-roadmap-in-the-netherlands-for-topsector-energie-22785
[54] http://www.batstorm-project.eu/electricity-law-experiments-netherlands

	incentives for RES investments, preferential loans are available for RES investors.
Main Stakeholders	• Stakeholders in Dutch energy policy include trade unions and environmental NGOs, as part of the country's consensus-based *Polder* model. • TenneT as the transmission systems operator, and several DSOs.
Battery specific Support Instruments	• In 2014 the Dutch government has launched grants for **Energy Innovation Demonstration** (DEI). There is also direct funding in place for R&D projects pertaining to energy innovation. • In 2011, the Dutch Ministry of Economic Affairs launched the **Green Deals** initiative, a public-private sector collaboration aimed and starting sustainable initiatives. • There is priority access but not priority dispatch available in the Netherlands for RES-E. • Lower energy tax rates for people who locally club together to generate energy from sustainable resources are available.
Barriers	• Financial and legislative incentives are lacking to support transition to new grid solutions. • There is a lack of business interest for the implementation of storage facilities. • Due to the national grid's good connection to the French and German grids, there is less urgency towards implementing new energy solutions. • Net-metering is in place which is a disincentive for the uptake of battery storage
Innovative Storage Examples	• In the end of 2015 a stationary 10 MW battery array was completed by AES in Vlissingen. • The **Amsterdam Smart City** project is a large scheme to redevelop the metropolitan area of Amsterdam, of which energy storage facilities are involved in line with a host of green energy solutions. • The Dutch are pioneering an initiative that upcycles used car batteries, and uses them as devices for electrical storage. • In the country's national football stadium there are recycled car batteries that have been re-appropriated to form a storage facility for back-up energy. • Neighbourhood based shared battery storage

A1.4 Italy

A1.4.1 Overarching policy framework

Italy still depends heavily on fossil fuels for its energy production, with coal, oil and gas making up 86% of its energy sources as recently as 2013 [8]. However, energy reserves are scarce and the country depends heavily on the import of fossil fuels. In 2013, the country published its **National Energy Strategy** (NES) [20], which identifies the need to reduce imports, with the goal of saving €14bn per year by 2020. The NES also established a commitment to decarbonisation and to exceed EU 2020 environmental objective. Crucially, the NES does pledge to conduct research in smart grids and storage systems, particularly in relation to sustainable transport. One interviewee noted that particular regions of Italy are very densely populated and amount to some of the most polluted regions in Europe. A contributing factor is the density of cars per inhabitant and the emissions coming from these. As such, transitioning to electric vehicles could be an important policy in the Italian energy transition.

There are no dominant providers of electricity in Italy. The state-owned Enel accounts for around a quarter of electricity generation, but otherwise no other player constitutes more than 10% [15]. This is due to a government effort to liberalise the energy market. This leaves some room for new players to enter the market, and for new technologies (e.g. storage) to be implemented by existing companies. On the other hand, the electricity transmission network is almost entirely owned by Terna [15], a state-owned company.

In terms of energy storage itself, the market is growing swiftly due to a recent boom in photovoltaic solar energy[55] for which the current national grid is not well-suited. As such, interest in energy storage solutions is growing quickly. There are obstacles though and government regulation could unblock storage uptake.

Electricity retail tariffs in Italy are amongst the highest in Europe, this is also due to a high grid charges component [15], which also works in a way which seems discouraging storage.

Energy storage benefits from the overarching RES support mechanism in Italy and also priority access for installation and priority dispatch is given to renewable energy. A mix of instruments are in place to support RES primarily feed-in tariffs, tender schemes, and feed-in premiums as per current State aid rules. Solar-PV and Wind plants can benefit from a discounted tax rate of only 50% of the VAT.

However, also Net-metering is in place which is a disincentive for the uptake of battery storage.

A1.4.2 Instruments to foster the uptake of battery storage

'Key policies' in future Italian energy provision focus on renewable energy sources and energy efficiency [15] without specifically mentioning storage.

Terna itself though has launched a major investment plan[56] called **Storage Lab**, which tests battery technologies in five locations of particularly high demand, three of which are completed. This is part of a new grid development plan, looking to change the makeup of the national grid. Terna also wants to improve public knowledge of the topic. This project employs sodium-sulphur and lithium-ion batteries

[55] http://www.lexology.com/library/detail.aspx?g=4bf3dda1-44ba-47c3-a860-af76ca74cbe4
[56] http://www.ispionline.it/en/energy-watch/has-time-batteries-italy-arrived-or-not-13748

and was approved by the Ministry of Economic Development (MiSE) in 2012. Italian universities and research centres are contributing to the initiative, which in turn will lead to an advancement in knowledge and increased R&D on the subject.

The Ministry of Economic Development in Italy has also set aside funding for the electricity sector for research, development and innovation activities regarding the electricity supply of the country. These research activities are being carried out by some of the major energy stakeholders such as **Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA)** and **Ricerca Sistema Energetico (RSE)** as well as various universities. One interviewee mentioned that Italy's main research activities in this area aim to reduce the cost of electricity, improve reliability of service and ensure the country's conditions to sustainable development. The same interviewee mentioned that the country expects to reach 46,000 energy storage installations by 2025, between large and domestic systems. To get some perspective this amounts to approximately 20% of the number of residential photovoltaic units in the country anticipated by 2025.

Public awareness and dissemination of knowledge and projects surrounding battery storage solutions seem to be on the rise in Italy. This is thanks to knowledge-sharing activities by universities and other R&D institutions. However, the low awareness, lack of clear roles and regulatory frameworks as well as a lack of policy and instruments are preventing the uptake of battery storage initiatives.

A1.4.3 Country profile: Italy

Policy Framework	• In 2013 Italy published a **National Energy Strategy** (NES), which identified the need to reduce imports of coal, oil and gas, as well as a commitment to decarbonisation. • The NES does pledge to conduct research in smart grids and storage systems, particularly in relation to sustainable transport. • The NES notices the need to overhaul electricity prices to achieve convergence in the North and South of the country, as well as the islands with the mainland.
Main Stakeholders	• There are no dominant providers of electricity in Italy; the state-owned Enel accounts for around a quarter of electricity generation, but otherwise no other player constitutes more than 10%. • The electricity transmission network is almost entirely owned by Terna, a state-owned company.
Battery Specific Support Instruments	• Feed-in tariffs, tender schemes, and premium tariffs and net-metering are available. There are also tax benefits for PV and wind energy plants. • The Ministry of Economic Development in Italy has also set aside funding for the electricity sector for research, development and innovation activities regarding the electricity supply of the country.
Barriers	• Current high grid charges disadvantage storage and may discourage the uptake of electricity storage.

Innovative Storage Examples	• Terna has launched **Storage Lab**, testing batteries in five locations nationally of high electricity demand. • One interviewee mentioned that the country expects to reach 46,000 energy storage installations by 2025, most of them being domestic units.

A1.5 Spain

A1.5.1 Overarching policy framework

Spain is a big importer of energy, with around 70% of its energy supply coming from imports in 2014. However, this is down from around 80% in 2009 and is attributed to the country's increasing use of renewable energy sources [16]. As such, the decarbonisation efforts of the country were slightly slow to take off, but now there is a manifest commitment to using renewable energy. Wind already competes with nuclear as the main energy source in the Spanish energy mix.

Spain has a feed-in premium ('specific remuneration regime') allocated through tenders which allows to make RES plant competitive to traditional sources of energy[57]. These were dominated by wind energy in 2017[58]. RES are given priority access and priority dispatch to the grid.

Suppliers with self-consumption, using facilities below 100kW, can feed excess energy into the grid but without any preferential remuneration[59] which can be seen positive from a storage perspective since it does not discourage to store energy for self-consumption.

At the same time Spain has incentives for coal power plants in place to reduce emissions which seems to go against polluter pay principle[60]. Furthermore, the Spanish Ministry of Energy released in November 2017 a draft for a new regulation which would allow the Government to veto coal plant closures when there are economic reasons or when they pose a threat to security of supply or sustainability[61].

It's not the first time ES supports coal based power-plants. E.g. in 2010-2014, e.g. coal-based power plants benefited from priority dispatch[62].

In 2015, the government revised its **infrastructure plan**, since its 2008-2016 targets were deemed unrealistic. Key aspects of the plan include energy security and energy efficiency. Clearly energy storage initiatives could potentially be involved here, but it is unclear to what extent this is the case.

Since electricity storage is not separately regulated amongst Spanish legislature and counts as generation, storage projects must hold separate licenses (e.g. for photovoltaic power), which places different regulations and obligations on the license holder[63].

Moreover, Spain imposes a tax on self-consumption RES above 10kW which feed into the grid[64].
This tax can be seen as a consequence of an oversupply of capacity which leads to high operating costs of existing capacity. This potentially provides an incentive for combined deployment of PV and batteries

[57] http://www.res-legal.eu/search-by-country/spain/single/s/res-e/t/promotion/aid/feed-in-tariff-regimen-especial/lastp/195/
[58] https://derstandard.at/2000058357826/Energiewende-Sonniges-Spanien-verzichtet-auf-Solarenergie
[59] https://www.iea.org/policiesandmeasures/pams/spain/

[60] http://europa.eu/rapid/press-release_IP-17-4965_en.htm
[61] https://www.elconfidencial.com/empresas/2017-11-13/energia-nadal-iberdrola-galan-carbon-lada-velilla_1476918/?utm_source=twitter&utm_medium=social&utm_campaign=ECDiarioManual
[62] Article 15 (4) of Directive 2009/72/EC (the Electricity Directive) allows for the priority dispatch of electricity generated from indigenous coal provided this doesn't exceed 15% of electricity consumption, there is a genuine security of supply issue; the measure is of temporary character
[63] http://www.lexology.com/library/detail.aspx?g=e64deba5-e559-4732-b6b8-6dcf28446fc0
[64] https://www.boe.es/buscar/act.php?id=BOE-A-2015-10927

which is done in a way to ensure that no electricity is injected into the grid. Still, this may not be the optimum way to promote storage as it limits its use in demand response mechanisms.

In June 2017 there was an appeal by Catolonia to Spains Constitutional Court which lead to an amendment of the tax. It is now allowed for autonomous regions to regulate shared self-consumption by enacting legislation on their own. This is likely to have positive effects on battery storage for community projects[65].

The national grid operator is Red Electrica Española (REE), which has a **2014-2019 strategic plan** with electrical storage as one of its focal points. Although this tends to focus on hydroelectric storage facilities it does explore the expansion of battery-based technologies and certain projects are being realised by REE, as the next section illustrates. Despite there being some resistance from the national government to energy storage, and a complex regulatory framework in place, we see that there is some appetite for new technologies to be incorporated into the country's national grid.

A1.5.2 Instruments to foster the uptake of battery storage

The grid operator REE is overseeing **Project Almacena**[66], an energy storage system with lithium-ion battery technology with the aim of improving energy efficiency of photovoltaic systems. The system is part-funded by the EU-led European Regional Development Fund (ERDF). Furthermore, REE is taking on 64 innovation projects in 2017 alone, at an anticipated cost of €9m[67]. One of these, the **ALISOS project**, will oversee the installation of an electrical storage system in Tenerife, with the goal of increasing the use of these facilities in the energy supply and making the supply of the island more secure.

Endesa is a large energy company based in Spain and has many initiatives on the topic of energy storage. A large project in the area is **Store**[68]. Under this, Endesa has commissioned three electrical storage facilities in the Canary Islands and Andalucía, with the aim of demonstrating the technical and economic viability of energy storage. The project employs lithium-ion battery technology, as well as ultracapacitors and flywheels. Endesa has partners from industry and education on the project from all over Europe, and aims to enhance R&D along with innovation on the topic of energy storage.

Other projects to do with energy storage undertaken by Endesa include smart grid projects, which look at changing the makeup of electric grids and incorporating energy storage facilities. Such smart grid initiatives are part of **Smart City** projects too, with the revolution of the metropolitan areas of Barcelona and Malaga[69] already in progress. Endesa also claims to be the national leader in electric vehicle uptake and charge points, which would feature in the smart cities[70]. Spain is also a beneficiary of the **Green Emotion** project, which aims to increase the number of electric vehicles and charging points across numerous EU member states. As of the end of 2015 there were less than 6,000 registered plug-in cars in Spain. Coupled with photovoltaic power, this is an area of potential future growth for

[65] https://www.energy-storage.news/news/shared-installation-marks-spains-self-consumption-rethink
[66] http://www.ree.es/en/red21/rdi/rdi-projects/almacena
[67] http://www.ree.es/en/press-office/press-release/2017/04/red-electrica-undertakes-64-innovation-projects-2017-overall-investment-of-over-9-million-euros
[68] http://www.energynews.es/english/endesa-commissions-three-electricity-storage-facilities-under-the-store-project/
[69] http://www.smart-circle.org/portfolios/malaga-smart-city-smart-grid-pilot-project/
[70] https://www.endesaclientes.com/large-customers/relevant-projects/research-development-and-innovation.html

Spain, which is still far from catching up with to other EU Member States in terms of electrification of transport.

This being said the pressure to focus on energy storage is not there, partly due to the fact that current power plants are very flexible in the current over-capacity situation and also coal is still regarded as an important power source.

A1.5.3 Country profile: Spain

Policy Framework	• Wind competes with nuclear as the main energy source in the Spanish energy mix. • Coal is still regarded as an important source of energy generation given vested interests and support measures to coal-based generation have not been completely abandoned • Spain is divided into 17 autonomous regions, each of which has its own parliament and is responsible for large chunks of legislature pertaining to energy. Basic provisions still come from the central level. • Electricity storage projects are not separately regulated and count as generation.
Main Stakeholders	• Due to decentralisation, local governments are far more invested in pilot projects than in other nations. • The national grid operator Red Electrica Española • Endesa is a large energy company based in Spain and has many initiatives on the topic of energy storage.
Battery Specific Support Instruments	• Priority Access, and Priority Dispatch is given to RES. A premium tariff is available through tenders. • Innovation grants from the grid operators • One-off pilot projects supported by the main electricity providers
Barriers	• Legislation around storage is complex. Electricity storage is not separately regulated amongst Spanish legislature and counts as generation. These two factors make licencing of battery storage rather difficult.
Innovative Storage Examples	• REE is overseeing **Project Almacena**[66], an energy storage system with lithium-ion battery technology with the aim of improving energy efficiency of photovoltaic systems. • Again run by REE, the **ALISOS** project, will oversee the installation of an electrical storage system in Tenerife. • **Store**[68], commissioned by Endesa, sees three electrical storage facilities with the aim of demonstrating the technical and economic viability of energy storage. • Smart grid initiatives in Barcelona and Malaga.

Appendix A2: References

[1] "Stakeholder kick-off report", Batstorm, April 2016. http://www.batstorm-project.eu/sites/default/files/BATSTORM_StakeholderKick-off_WorkshopIRES_report.pdf

[2] "Expert meeting implementation plan", Batstorm, April 2016. http://www.batstorm-project.eu/sites/default/files/BATSTORM_ExpertMeetingIP_report.pdf

[3] "Initial Implementation Plan 2016-2018", Batstorm, June 2016. http://www.batstorm-project.eu/sites/default/files/Implementation_plan_2016-2018_final.pdf

[4] "Costs and benefits for deployment scenarios of battery systems", Batstorm, March 2017. http://www.batstorm-project.eu/sites/default/files/BATSTORM_D7_%20SocioEconomicAnalysis_Final.pdf

[5] "10 year R&I roadmap 2017-2026 (D10)", BATSTORM, May 2016. http://www.batstorm-project.eu/sites/default/files/BATSTORM_D10_%20Roadmap.pdf

[6] "Technical analysis of ongoing projects", Batstorm, March 2017. http://www.batstorm-project.eu/sites/default/files/BATSTORM_D5_%20Technical%20analysis%20of%20projects_Final.pdf

[7] "A smart, flexible energy system: A call for evidence", Department for Business, Energy and Industrial Strategy, Ofgem, November 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/576367/Smart_Flexibility_Energy_-_Call_for_Evidence1.pdf

[8] "European Energy Market Reform. Country Profile: Italy", Deloitte, 2013. https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Energy-and-Resources/gx-er-market-reform-italy.pdf

[9] "Towards an Integrated Strategic Energy Technology Plan: Accelerating the European Energy System Transformation, European Commission, September 2015. https://ec.europa.eu/energy/sites/ener/files/publication/Complete-A4-setplan.pdf

[10] "Clean Energy For All Europeans", European Commission, November 2016. http://europa.eu/rapid/press-release_IP-16-4009_en.htm

[11] "EUROBAT feedback on the EC roadmap on the Batteries Directive", EUROBAT, September 2016. https://eurobat.org/sites/default/files/160928_eurobatposition_batteries_directive_roadmap_clean.pdf

[12] "Towards a '2030 Battery Strategy for Europe'", EUROBAT, February 2017. https://eurobat.org/sites/default/files/170224_eurobat_battery_strategy_for_europe.pdf

[13] "Energy Policies of IEA Countries: The United Kingdom", International Energy Agency, 2012. http://www.iea.org/publications/freepublications/publication/UK2012_free.pdf

[14] "Energy Policies of IEA Countries: The Netherlands", International Energy Agency, 2014. http://www.iea.org/publications/freepublications/publication/Netherlands2014.pdf

[15] "Energy Policies of IEA countries: Italy", International Energy Agency, 2016. https://www.iea.org/publications/freepublications/publication/EnergiePoliciesofIEACountriesItaly2016Review.pdf

[16] "Energy Policies of IEA Countries: Spain", International Energy Agency, 2015. http://www.iea.org/publications/freepublications/publication/IDR_Spain2015.pdf

[17] "Energy Technology Perspectives 2012: Pathways to a Clean Energy System", International Energy Agency, 2012. https://www.iea.org/publications/freepublications/publication/ETP2012_free.pdf

[18] "Enhanced Frequency Response: Market Information Report", National Grid, August 2016. http://www2.nationalgrid.com/Enhanced-Frequency-Response.aspx

[19] "Energy Storage in the UK: An Overview", Renewable Energy Association, 2016. https://www.r-e-a.net/upload/rea_uk_energy_storage_report_november_2015_-_final.pdf

[20] "Italy's National Energy Strategy", Ministero dello Sviluppo Economico, March 2013. http://www.sviluppoeconomico.gov.it/images/stories/documenti/SEN_EN_marzo2013.pdf

[21] "ICET Country Study: United Kingdom", Technopolis, November 2016. http://www.technopolis-group.com/wp-content/uploads/2017/03/InternationaalVergelijkEnergietransities_161215.pdf (in Dutch)

[22] "ICET Country Study: Germany", Technopolis, November 2016. http://www.technopolis-group.com/wp-content/uploads/2017/03/InternationaalVergelijkEnergietransities_161215.pdf (in Dutch)

[23] "Batstorm survey results of the qualitative survey questions", Technopolis (unpublished)

[24] "Eurobat E-Mobility Battery R&D Roadmap 2030: Battery Technology for Vehicle Applications", Eurobat, June 2015 https://eurobat.org/sites/default/files/eurobat_emobility_roadmap_lores_2.pdf

[25] "Combining feed-in tariffs and net-metering schemes to balance development in adoption of photovoltaic energy: Comparative economic assessment and policy implications for European countries", F. JavierRamíreza; A.Honrubia-Escribano; E.Gómez-Lázarob; Duc T.Phamc, March 2017. https://doi.org/10.1016/j.enpol.2016.12.040

[26] "The regulatory framework for wind energy in EU Member States", Javier Serrano González & Roberto Lacal Arántegui, 2015.
http://publications.jrc.ec.europa.eu/repository/bitstream/JRC93792/d1_regulatory_framework_wind_energy_in_ms_march_2015 (2).pdf

[27] "Valuation Of Energy Use And Greenhouse Gas", Department for Business, Energy & Industrial Strategy, March 2017.
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/615374/1._Valuation_of_energy_use_and_greenhouse_gas_emissions_for_appraisal_2016.pdf

[28] Delivering UK Energy Investment, Department of Energy & Climate Change, July 2014.
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/331071/DECC_Energy_Investment_Report.pdf

[29] " Final Auction Results: T-4 Capacity Market Auction for 2020/21", National Grid UK, December 2016.
https://www.emrdeliverybody.com/Capacity%20Markets%20Document%20Library/Final%20Results%20Report%20-%20T-4%202016.pdf

[30] "Capacity Market Consultation – Improving the Framework: Government Response", Department for Business, Energy & Industrial Strategy, December 2017.
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/664272/capacity-market-consultation-improving-framework-response.pdf

[31] "Aktualisierung der BEE-Prognose Entwicklung der Erneuerbaren Energien bis 2020", Bundesverband Erneuerbare Energien e.V., September 2017.
https://www.bee-ev.de/fileadmin/Publikationen/Positionspapiere_Stellungnahmen/BEE/BEE-Prognose_EU-Ziel_Anteil_Erneuerbarer_Energien_bis_2020_Sep2017.pdf (in German)

[32] "Anteile einzelner Marktakteure anErneuerbare Energien-Anlagen in Deutschland (2. Auflage)", Trendresearch, 2013.
http://www.trendresearch.de/studien/16-0188-2.pdf (in German)

[33] "Erneuerbare Energien in Zahlen: Nationale und internationale Entwicklung im Jahr 2016, BMWi, September 2017.
http://www.bmwi.de/Redaktion/DE/Publikationen/Energie/erneuerbare-energien-in-zahlen-2016.pdf?__blob=publicationFile&v=16 (in German)

[34] "Merkblatt Erneuerbare Energien: KfW-Programm Erneuerbare Energien 'Speicher', KfW, 2017.
https://www.kfw.de/Download-Center/F%C3%B6rderprogramme-(Inlandsf%C3%B6rderung)/PDF-Dokumente/6000002700_M_275_Speicher.pdf (in German)

Appendix A3: Interviewees

Name	Company	Country	Date Interviewed
Professor Richard van de Sanden	Dutch Institute for Fundamental Energy Research (DIFFER)	The Netherlands	31/05/17
Michael Deutmeyer	EAS Germany GMBH	Germany	31/05/17
Giovanni Pede	Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA)	Italy	31/05/17 (in writing)
Professor Tomás Gómez San Román	Institute for Research in Technology, Universidad Pontifica Comillas	Spain	01/06/17
Annelies van der Stoep	Citizen, Amsterdam Smart City	The Netherlands	02/06/17
Gian Piero Celata	ENEA	Italy	07/06/17 (in writing)
Karolien de Bruine	Alliander	The Netherlands	08/06/17
Dr Alexander Berland	Department of Business, Energy and Industrial Strategy (BEIS)	UK	04/07/17

ECOFYS Germany GmbH

Albrechtstraße 10 c
10117 Berlin

T: +49 (0) 30 29773579-0
F: +49 (0) 30 29773579-99

E: info@ecofys.com
I: www.ecofys.com