

BATTERY ENERGY STORAGE IN THE EU

BARRIERS, OPPORTUNITIES,
SERVICES AND BENEFITS

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EUROBAT





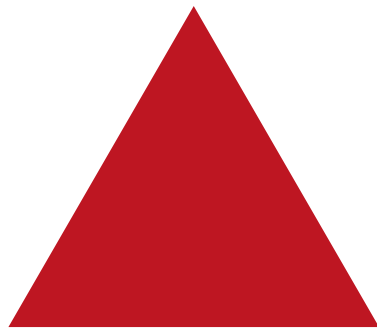
ASSOCIATION OF EUROPEAN AUTOMOTIVE AND INDUSTRIAL BATTERY MANUFACTURERS

EUROBAT is the association for the European manufacturers automotive, industrial and energy storage batteries. EUROBAT has 52 members from across the continent comprising more than 90% of the battery industry in Europe. The members and staff work with all stakeholders, such as battery users, governmental organisations and media, to develop new battery solutions in areas of hybrid and electro-mobility as well as grid flexibility and renewable energy storage.

This document was prepared by the Storage Working Group of EUROBAT, with contributions from the experts of the member companies of EUROBAT.

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Executive summary

Battery Energy Storage has the potential to effectively contribute to the decarbonization targets of the European Union. At every level of the grid, from generation to transmission, from distribution to households, batteries can deliver important services such as integration of renewable energy, grid stabilization, flexibility, energy security and independence.

Technology advancements, social needs and market demand are rapidly making batteries an attractive solution to decarbonize the European energy mix. All battery technologies (Lead, Lithium, Nickel and Sodium) have an important role to play in this regard. However, several unintended market and legislative barriers are hindering the potential of energy storage. With this publication, EUROBAT introduces battery energy storage as solution-provider, clearly points out the key barriers to energy storage at European level and suggests how to overcome them in the framework of a European energy market design tailored at renewable energy sources.

KEY BARRIERS TO BATTERY ENERGY STORAGE

Definition of energy storage

There is no definition of energy storage in the EU legislation, leading to a series of unintended barriers and thereby creating an uncertain investment environment. Storage should be considered as a fourth component of the energy system with its characteristics, properties and services taken into account. A clear definition of energy storage should be included in the Electricity Directive.

Ownership of energy storage systems

It is currently not clear if TSOs and DSOs can own or control storage systems. TSOs and DSOs have a clear interest in directly operating storage systems to balance the grid, and therefore grid operators should be granted the ability to own and control storage systems. Service providers should also be allowed to participate in the balancing market and to sell these services to TSOs and DSOs.

Double grid fees and taxation

Lack of framework for energy storage brought some member states to impose double grid fees on storage systems, while other states are proposing direct taxation on self-consumed and stored energy. These fees do not recognize the important flexibility and balancing services offered by storage to the grid: therefore, EUROBAT supports the elimination of direct taxation and double grid fees for stored electricity.

Curtailement and balancing responsibilities

Curtailling energy represents a failure of the system and a waste of energy: grid constraints could be addressed through the deployment of storage. Financial compensation for curtailed energy should be avoided, since it represents a relevant disincentive for energy storage systems. The revised Renewable Energy Directive should also include a precise timeline to assign flexibility responsibilities to the producers of renewable energy.

Ancillary services and the value of energy storage

The EU market does not currently recognize the value of ancillary services to balance the grid. Providing such compensation for these important balancing services is key to enabling the deployment of storage systems.

Electricity pricing

Electricity prices should reflect scarcity and transmission costs. This would represent an important market signal for demand-response, smart appliances (including electric vehicles) and storage solutions like batteries and would generally act as a critically important tool for ensuring flexibility.



1 Introduction: the contribution of Battery Energy Storage to EU energy policy

With this paper, EUROBAT aims to contribute to the EU policy debate on climate and energy and explain the potential of Battery Energy Storage (BES) to enable transition to a sustainable and secure energy system based on renewable sources, with reduced greenhouse gas emissions and enhanced energy independence for Europe.

According to the European Commission, the share of renewable energy in gross final energy consumption increased from 7.5% in 2000 to 15.3% in 2014, meaning that we are on track to achieve the 20% target predicted for 2020 (EU Commission 2015b). However, there is still a lot to do in order to achieve a decarbonized, sustainable Europe: specifically, there is still space for renewables to grow in the European energy mix. COP21 represented a turning point, but we must do more at both the European and international level to decarbonize our economies and limit global warming, and the way to achieve this is through renewable energy.

However, in order to deploy renewables and to release their potential for ensuring a stable and secure energy supply, Europe needs to work to overcome the intrinsic limits of renewables. One solution to these challenges is battery energy storage. Batteries can store energy from on-peak renewable energy and release it when it is more needed, in central, de-centralized and off-grid situations. Batteries can also offer grid support services like voltage control and frequency regulation, so maintaining grid stability and flexibility. Overall, batteries can bolster Europe's use of renewables, as well as its energy efficiency, sustainability, independence and security.

We strongly believe that, in the near future, battery energy storage and battery support services will be absolutely necessary in order to support the deployment of renewables and the stability of the grid. Batteries can be placed at every level of the grid, from generation to transmission, from distribution to domestic use by



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consumers. Nevertheless, battery energy storage is currently seriously hampered by legislative barriers and disincentives, both at EU and member state level. From lack of definition to double fee imposition, today Europe currently provides an unfriendly environment for battery energy storage.

The result is that the EU large-scale storage market lags behind its international counterparts in the US and Japan, and there is a real risk of wasting the significant knowledge and expertise built up within the European battery industry.

As has already been stated by the European Commission itself, 'European energy storage development requires new, European rules to enable its speedy development' (DG Energy 2013). The debate on the Energy Union offers a valuable opportunity to advance the deployment of battery energy storage in Europe.

If Europe wishes to be the World Number One in renewable energies, it must take the lead on storage solutions (EU Commission 2015a): now is the time to prepare the ground and remove legislative barriers to BES.

With this publication, EUROBAT wishes to establish a clear position in this debate and offer its support to European legislators. The benefits and services offered by batteries are presented in Section 2, which explains how batteries can make a valuable contribution to a decarbonized, sustainable and secure Europe. Section 3 illustrates the main characteristics of the battery technologies used for energy storage (lead, lithium, sodium and nickel). The EU battery industry and market trends are introduced in Section 4, while Section 5 presents the key barriers to energy storage in Europe and suggests some policy initiatives to address them.

Some interesting case studies of positive legislation by EU and non-EU countries are also presented.



2 The benefits and services of Battery Energy Storage in different applications

Batteries can store energy from intermittent energy sources and release it when it is more needed, boosting renewables and increasing their contribution to the energy mix. Moreover, batteries can offer important ancillary services to stabilize the grid.

Batteries can solve, or at least sensibly reduce, the problem of an inconsistent supply of energy, which is one of the key weaknesses of renewable energy sources. This valuable service has several positive effects for a continent such as Europe, which has relatively limited energy resources of its own and which is consequently dependent on energy imports.

Renewables are one of the few energy sources that are locally available in Europe: increasing their use in the energy mix allows energy imports to be reduced, with clear benefits for European energy independence and security. Decarbonization of the energy mix and reduction of overall CO₂ emissions are other clear, positive outcomes of an increased use of Battery Energy Storage in Europe.

Today, a range of different energy-storage technologies are available on the market, while others are still at the R&D stage. Storage technologies have different characteristics and application types; they can be differentiated according to their size, discharge time, or functionality offered.

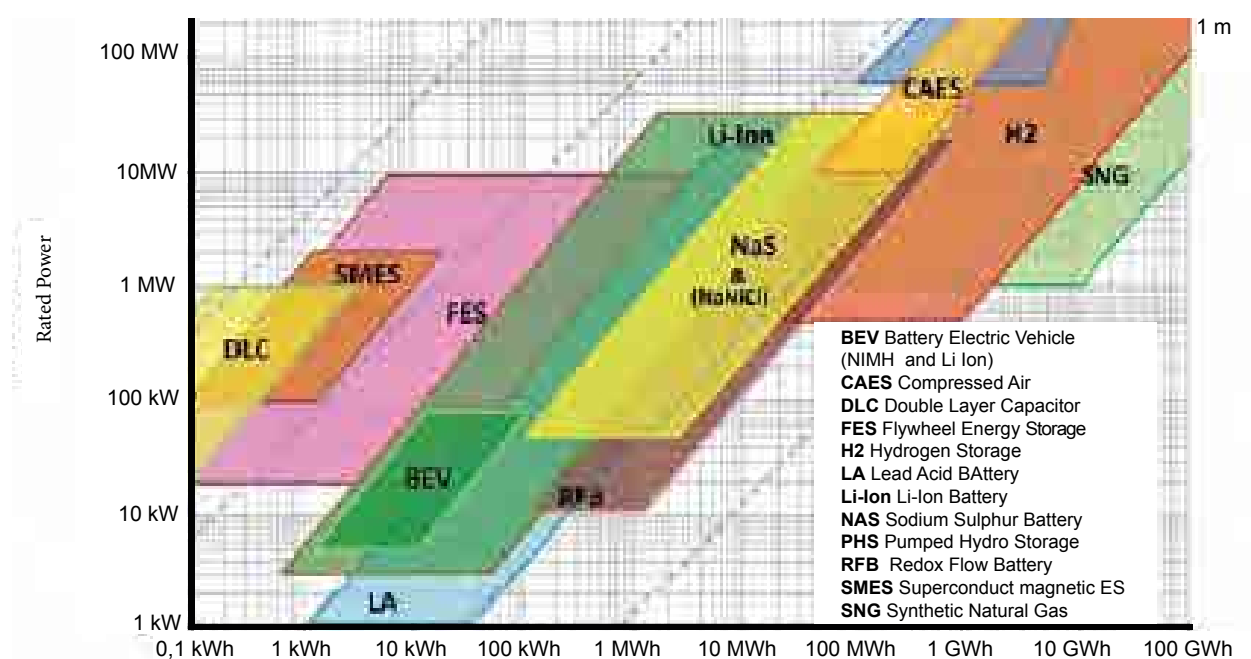


Figure 1: Comparison of rated power, energy content and discharge time of different Energy Storage Technologies. Source: IEC 2012

In this scenario, batteries are rapidly emerging as an optimum solution for both on-grid and off-grid options. Compared with other storage technologies, batteries can easily be placed at every level of the grid¹, from generation to transmission, from distribution to self-consumption, offering different services to integrate renewables and stabilize the grid. Batteries do not require complex infrastructure projects, can offer mobile and scalable solutions, and can be installed in low-risk and environmentally friendly conditions.

Batteries can be adapted to meet different system requirements, and they have the advantage of having a high speed of deployment: battery systems with a total of 250 MWh can be operative in six months.

¹ We focus here on on-grid applications. A traditional application of batteries has been the off-grid use. Batteries can power areas such as islands or rural areas, which are often powered by diesel generators. For more information on batteries for rural electrification, please refer to the EUROBAT report *Battery Energy Storage for Rural Electrification Systems*.

2.1 Bulk Energy Services: large RES facilities

MORE ENERGY INTO THE GRID WITH FEWER GENERATION FACILITIES

Batteries allow the owners of photovoltaic (PV) or wind generators to store the energy produced – when it is inexpensive and when it would be uneconomic to supply it to the grid – and then to release it when prices are higher. Similarly, batteries can store the energy produced with renewables that would otherwise have been curtailed. Arbitrage thus has a dual value. For owners of PV or wind farms it can represent an economic incentive, allowing energy trading to take place. For society, it enables energy waste to be reduced or eliminated. In order to be feasible, arbitrage requires electricity prices to be free to fluctuate. Overall, the effect is that every single PV panel or generation system injects more energy into the grid when it has a battery. This results in a reduced need for new central-station generation capacity.

Variable renewable generation, combined with energy storage, represent a fixed generation capacity which can be valued on capacity markets. Additionally, storage devices can compensate for the destabilizing effects of variable generation on grid stability; they enable wind and solar generators to contribute to primary and secondary reserves respectively. For such functions, storage can be either associated directly with generation devices, or can otherwise be connected to the grid.

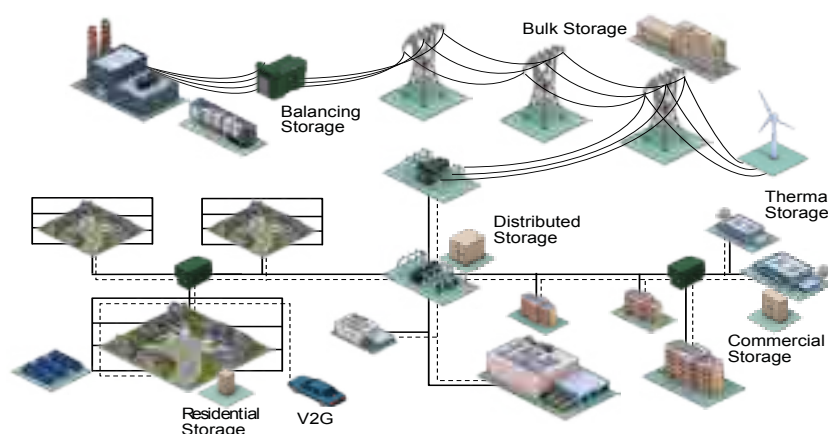


Figure 2: Location for electricity storage in the power system. Source: IRENA 2015

2.2 Grid level: transmission and distribution

ANCILLARY SERVICES FOR THE STABILIZATION OF THE GRID, ENERGY SECURITY AND RELIABILITY

Batteries can offer several means of ensuring the stability of the grid. The integration of intermittent and distributed renewable energy sources depends primarily on the availability of these ancillary services.

Batteries can rapidly store energy or feed in energy, even in milliseconds, in order to balance a grid area so as to avoid frequency instability, reconciling momentary differences caused by fluctuations in generation and loads. Batteries can provide reserve capacity to the grid to take over the role of the spinning reserves delivered by conventional rotating generation units.

BES is needed to restart and to provide necessary power to the grid – and to start other power generating systems – after a complete power outage or islanding situation (black start).

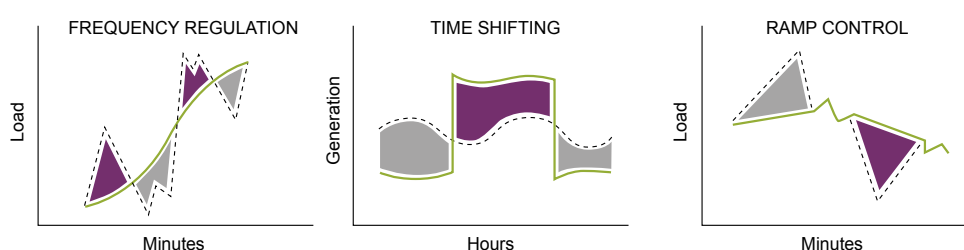


Figure 3: Ancillary services offered by batteries. Source: IRENA 2015



BES could also perfectly well offer load leveling to low-voltage grids and could help grid operators to avoid a fatal overload.

BES allows grid operators to shift load from peak to base load periods, and also for ramp control, in order to reduce the maximum currents flowing from the high-voltage grid through constrained grid assets.

These ancillary services improve the working conditions and stress-resistance of the grid, extending its capacity and making it more secure, reliable, and responsive. Storage can also reduce line congestion and line loss by moving electricity at off-peak times. Storage can thus extend the life of existing infrastructure, either allowing deferral of investment or entirely avoiding the need to make expensive investments in transmission/distribution system upgrades.

The possibility of installing BES systems should therefore be carefully considered as an economic alternative when costly upgrades to transmission/distribution lines are needed.

Bulk Energy Services	Transmission Infrastructure Services
Electric Energy Time-Shift (Arbitrage)	Transmission Upgrade Deferral
Electric Supply Capacity	Transmission Congestion Relief
Ancillary Services	Distribution Infrastructure Services
Regulation	Distribution Upgrade Deferral
Spinning, Non-Spinning and Supplemental Reserves	Voltage Support
Voltage Support	Customer Energy Management Services
Black Start	Power Quality
Other Related Uses	Power Reliability
	Retail Electric Energy Time-Shift
	Demand Charge Management

Figure 4: ancillary services. Source: DOE/EPRI 2013



2.3 Customer energy management services

MORE, BETTER, AND MORE RELIABLE SELF-PRODUCED ENERGY

At household level, a battery system connected to a PV or small wind generator can provide several services to end-users. BES will increase the amount of self-produced electricity as well as increasing self-consumption. A household PV + battery system can increase the percentage of self-consumed electricity from about 30% without storage to around 60-70%, optimizing efficiency and reducing the amount of additional power needed from the grid (Fraunhofer 2014). Furthermore, BES can minimize the distortion caused by inverters to optimize the injection into the grid. With disappearing feed-in tariffs, decreasing PV and increasing electricity costs, this model has started to become viable in countries with a high degree of PV penetration, creating more and more 'prosumers' (customers producing their own energy and, in some cases, selling it to the grid).

Prosumers can also use arbitrage to inject the surplus electricity into the grid when prices are higher, so enhancing the business case for wind or PV home systems. In Europe, Germany remains the leading market, with multiple systems of different battery types available commercially since 2012-13. Prosumers can offer ancillary services to grid operators: these services can also be aggregated and managed by third parties.

BES can support customer loads and provide backup power throughout an entire power outage period, working as an uninterruptable power supply unit (UPS). This service is particularly useful in areas with weak, low-voltage grids.



3 Battery Technologies for energy storage

Today, different battery technologies are commercially available to address the needs of generators, grid operators and prosumers. **All four batteries technologies – lead, lithium, nickel, sodium – can provide distinct and important functions for grid operators and have the potential for significant further technological and economic improvement.**

There are no one-size-fits-all solutions in the energy storage world, and the decision to opt for one storage technology over another one depends on several parameters (IRENA 2015b).

EUROBAT supports the coexistence of all battery technologies, with their selection for on-grid and off-grid applications depending on specific requirements regarding performance, life, safety and the cost of a given application. The EU's legislative and regulatory framework should guarantee a fair and technology-neutral competition between battery technologies.

A new battery standard, the IEC 61 427.2, will be published in mid-2016, to enable comparison of suitable battery solutions for a given grid application.

Several mature technologies are available today for battery energy storage, but each technology has considerable potential for improvement: research is already ongoing into battery improvements for different applications, including, for example, vehicle hybridisation and e-mobility². In general, research should be directed at reducing the cost and improving the cycle life and energy density of batteries. Cost is already declining faster than expected: EUROBAT is confident that cell-level and systems-level research into BES will further improve the business case for BES at all levels of the grid. Support for battery energy storage R&D is thus crucial for the development of these technologies.

² See for instance EUROBAT E-Mobility Battery R&D Roadmap 2030 - Battery Technology for Vehicle Applications.



3.1 Lead-based batteries

Lead-based batteries have been well established in industrial applications for over a hundred years, and are well established in several on-grid applications for grid operators and end-users. Because of their low upfront cost, deep-cycling lead-based batteries are used to provide these functions in almost all small-scale PV installations requiring batteries that are currently on the market.

On the other hand, the worldwide capacity for lead-based batteries installed in large-scale renewable energy storage installations is currently smaller than for Sodium-Sulphur or Lithium-ion batteries; primarily because of their lower specific energy and power, longer charging time, and traditionally lower cycle life. However, work is being carried out to increase overall performance in all other aspects through advanced active materials and lower-resistance designs. Lead-based batteries have the lowest upfront cost of all technologies, and are well suited to providing services where the required depth of cycle is not too high (for example, frequency regulation).

Research is under way that aims to provide increased cycle life, charge acceptance, discharge performance, and cost reduction. Specific power will be improved with advanced additives to the active materials and lower internal resistance designs; while cycle life will be lengthened through design enhancements such as corrosion-resistant lead alloy materials and a more intelligent battery operation mode.

At the end of their life, lead-based batteries are collected for recycling. Within the EU, close to 100% of lead-based batteries are returned and recycled in a closed-loop system. The lead in batteries does not enter into free circulation, but instead is collected and recycled by the battery industry and other smelters, resulting in no direct environmental impact.

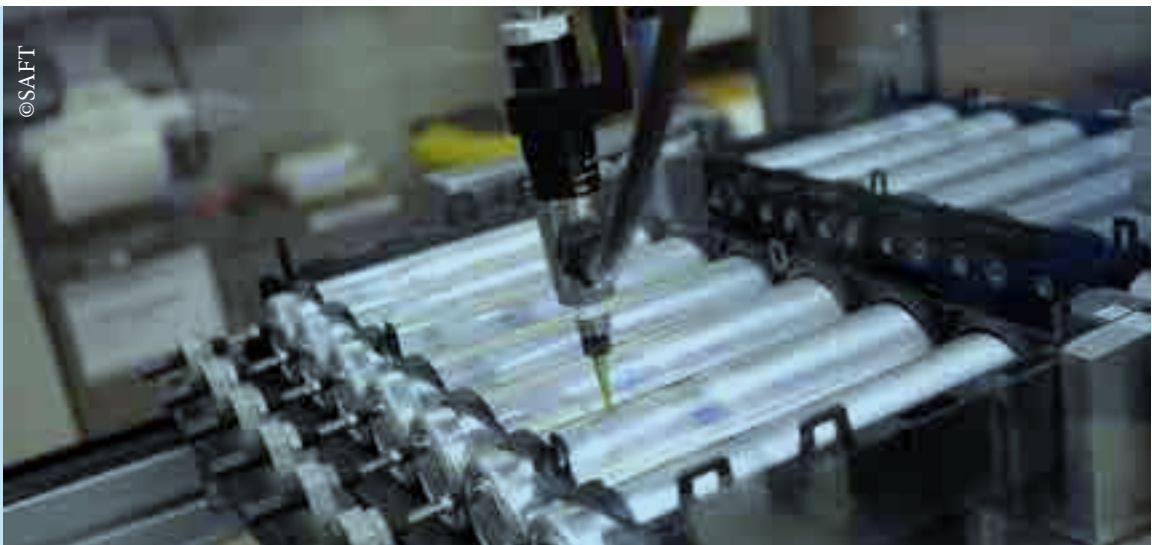
3.2 Lithium-based batteries

Industrial Li-ion batteries have been introduced into the industrial market for residential and commercial installations quite recently, drawing on the extensive experience gained in the development of batteries for electric and hybrid vehicles. About 200MW of stationary Li-ion batteries are currently operating worldwide in grid-connected installations, a figure which is rapidly increasing.

The choice of Li-ion is justified by its long lifespan, high energy efficiency, operation at undefined / low state of charge, as well as its compactness, maintenance-free design and system communication capability. A major advantage of Li-ion technology is its versatility: it is highly scalable and it can be adapted to practically any voltage, power and energy requirement. Li-ion batteries require sophisticated control electronics, which, on the one hand, makes the technology somewhat complex, but which, on the other, offers precise management and state of charge control in 'smart' applications.

Research on Li-ion batteries will further increase energy density, cycle and calendar life. Economies of scale and industrial capacity for the mass production of industrial-size cells and batteries will contribute to cost reduction. Different system solutions will be developed following an increase in market volume.

Li-ion batteries meet the average recycling rate of 50% mandated for this family, and recycled materials are reused by other industries where they replace the extraction of primary metals. As this technology is growing fast, recycled material from volumes currently collected – sold at a time when the Li-ion market share was insignificant – do not match the quantities required to manufacture batteries offered on the market today; therefore, due to its growth, this segment is currently a net 'taker' of raw materials.



3.3 Nickel-based batteries

Nickel-based batteries serve special markets where energy must be stored in extreme climate, long-cycle or fast-charging conditions. The capacity of Nickel-cadmium batteries in grid-support applications installed worldwide remains small. Where temperatures are very low (down to -40°C), Nickel-cadmium batteries still operate correctly, while the electrochemical processes of other battery technologies no longer function. In addition, Nickel-cadmium batteries have a good cycling pattern as well as long cycle and design life. As a result, where renewable energy is stored and used cyclically and where temperatures are very low or high, Nickel-cadmium batteries can be a competitive technology choice. The world's most powerful battery is a Ni-Cd battery, providing up to 46MW into a distribution grid in Fairbanks, Alaska.

Future development will focus on increasing cycle life, extending temperature range and reducing self-discharge and costs. Because of their performance, reliability, operational safety and durability in the face of adverse environmental conditions, alkaline batteries will continue to be irreplaceable in their established applications.

Nickel batteries are recycled in a well-developed infrastructure, and due to their high recyclability, nickel is reused in the manufacture of a wide variety of industrial products, and cadmium is reintroduced in the manufacturing of new batteries. Reserves of nickel and cadmium are also sufficient to satisfy demand for decades.

3.4 Sodium-based batteries

Sodium-sulphur batteries are primarily manufactured in Japan, with no manufacturing base in Europe. They have been promoted for on-grid energy storage primarily because of their high efficiency, long cycle life, fast response and high energy density. However, such batteries have high temperature requirements, requiring extra insulation and active heating. The fragile nature of the electrolyte is also a concern. They have a significantly higher cost than competing technologies.

Sodium-nickel chloride batteries are in the early stages of commercialization for on-grid applications, being used in several pilot projects (MW scale) for on- and off-grid energy storage. Therefore, there is still space for development, with R&D focused on improving the recharge power, and on increasing cycle life through design enhancements. Automation, process improvement and economies of scale will bring further cost reductions. Nickel chloride cathodes offer several advantages, including a higher operating voltage, an increased operational temperature range, a slightly less corrosive cathode, and somewhat safer cell construction. Sodium based batteries also have high recycling rates, driven by economic returns from the process.

4 The EU battery industry and market trends

The EU battery industry is ready to play its role in the shift towards the decarbonization of the energy system. Battery technology is already available to support the requirements of generators, grid operators and prosumers, but regulatory barriers should be removed to allow the energy storage market to grow.

The EU automotive and industrial battery sector directly employs around 30,000 workers and has an annual turnover of approximately €6.5 billion. This figure reflects only the manufacturing and research aspects of the industry and does not account for the thousands of dependent jobs across the supply chain, including those located in the recycling industry. As well as manufacturing sites, many research and development centres are located in Europe. The EU battery manufacturing industry collectively spent €740 million on Research & Development & Innovation-related investments (i.e. infrastructure) over the last five years, with an additional €105 million for R&D&I-related expenses (e.g. material costs), as well as manufacturing-related investments (e.g. pilot lines) of €915 million. EUROBAT members currently operate 16 R&D centres in Europe. These centres depend on an effective and competitive manufacturing base in Europe being maintained.

To enable the transition to a sustainable and secure EU energy system, the contribution of the whole EU battery value chain should be considered. Alliances between manufacturers from different layers of industry (raw/advanced materials suppliers; component suppliers; cell, battery and battery pack suppliers; grid storage integrators) will be needed to develop sustainable grid-storage products and services in order to make Europe stronger and more independent. These centres depend on an effective and competitive manufacturing base in Europe being maintained.

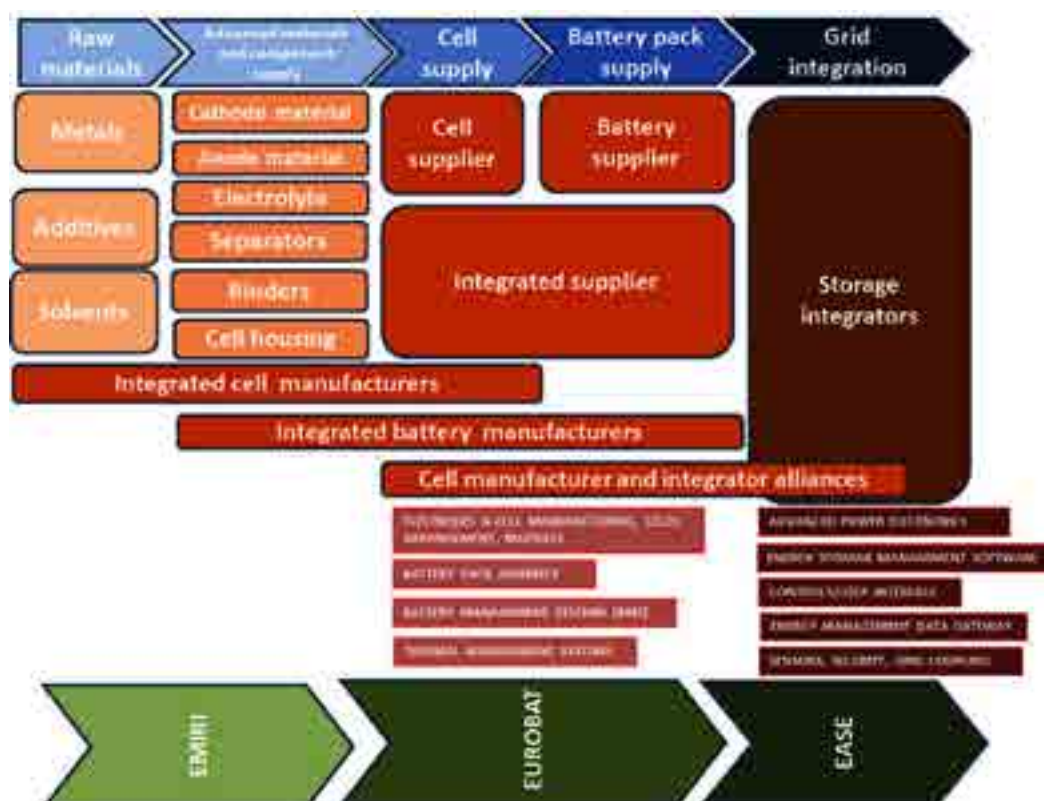


Figure 5: Rechargeable battery value chain

Batteries and the EU battery industry will play a key role in the growth of the storage market. When we look at the current share of storage technologies and their world deployment, pumped hydro still accounts for almost the entire storage capacity. Pumped storage will, of course, have a place in future electricity systems, but the entire storage market is poised to grow substantially. In this landscape, the decreasing cost of batteries, social and environmental requirements and technological advances are making battery energy storage a viable choice for multiple applications.

Navigant Research estimates that the annual battery energy storage capacity solely for utility-scale application will rise from just 360 MW in 2014 to 14 GW in 2023, with annual revenues increasing from \$220 million to \$18 billion (Navigant Consulting, 2014). CitiGroup estimates a 240 GW market for energy storage (excluding pumped-storage). Overall, CitiGroup predicts that 'storage batteries will be the third major driver of demand for rechargeable batteries after the consumer electronics and auto battery markets' (CitiGroup 2014).

From the demand side, the need to integrate an increasing share of renewables into the grid is potentially a powerful driver for battery energy storage. Additionally, with more and more consumers shifting to home-installed PV panels for their electricity consumption, battery energy storage for self-consumption is rapidly becoming an attractive option for many Europeans. Several analyses are showing that solar-plus battery systems are rapidly becoming cost effective (Rocky Mountain Institute 2014). For example, Roland Berger estimates that the PV + storage system will reach grid parity in Germany in 2016 (Roland Berger 2015).

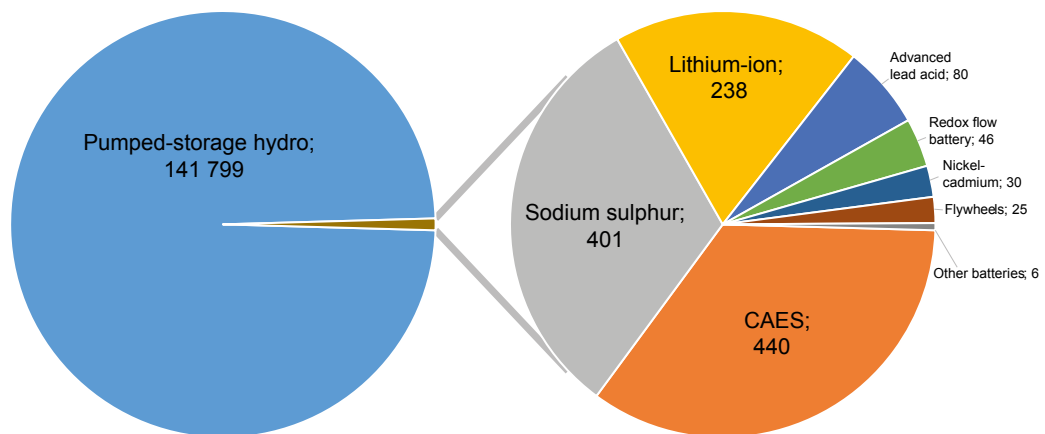


Figure 6: Share of pumped-storage hydroelectricity in global electricity storage system (in MW).

Source: IRENA 2015

Incentive schemes can speed up the deployment of battery energy storage systems: a good example is Germany, where a market incentive programme for battery storage + PV systems was launched in 2013 and renewed in 2016. The programme offers a 30% investment grant on equipment purchased with low-interest loans and already supported the deployment of almost 30,000 PV + battery systems.

Self-consumption is only one option: prosumers can also sell the excess energy produced to the grid. This potential will definitely be enhanced by the deployment of household PV systems and an increasing demand from consumers. For this development to take place, international and European standards will have to be developed and implemented. Also, IT improvements will have to be put in place to manage the real-time situation of the grid.

Turning to the offer side, the battery industry is constantly working to improve the performance and reduce the cost of batteries. Interestingly, an article recently published by Nature shows how the cost of electric car batteries is decreasing faster than expected, and it is now already cheaper than some 2020 predictions (Nykqvist, Nilsson 2015). CitiGroup predicts that the cost of batteries for energy storage will follow a trend similar to that of consumer electronics and auto battery prices, with high costs in the nascent market stage and then a steady decline as demand grows (CitiGroup 2015).

However, the fact that the technology exists does not necessarily imply its deployment if legislators do not create the proper conditions. In the case of battery energy storage, these conditions are simply a level playing field for all flexibility options, taking into account the multiple benefits offered by each specific solution. In the EU, even if the technical solution is available today, or will soon be available and cost-competitive, a lack of legislative and market measures and incentives are slowing down the deployment of this technology. In some cases, real barriers created by obsolete legislative systems are in place and these barriers prevent batteries from being connected to the grid.

What it is needed at EU level is a recognition of the importance of energy storage by the legislators, with the removal of legislative and market barriers. In the next section we will analyse these barriers at EU level, and will suggest concrete solutions for overcoming them.



5

Legislative barriers and opportunities in Europe

DEFINITION OF ENERGY STORAGE

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.

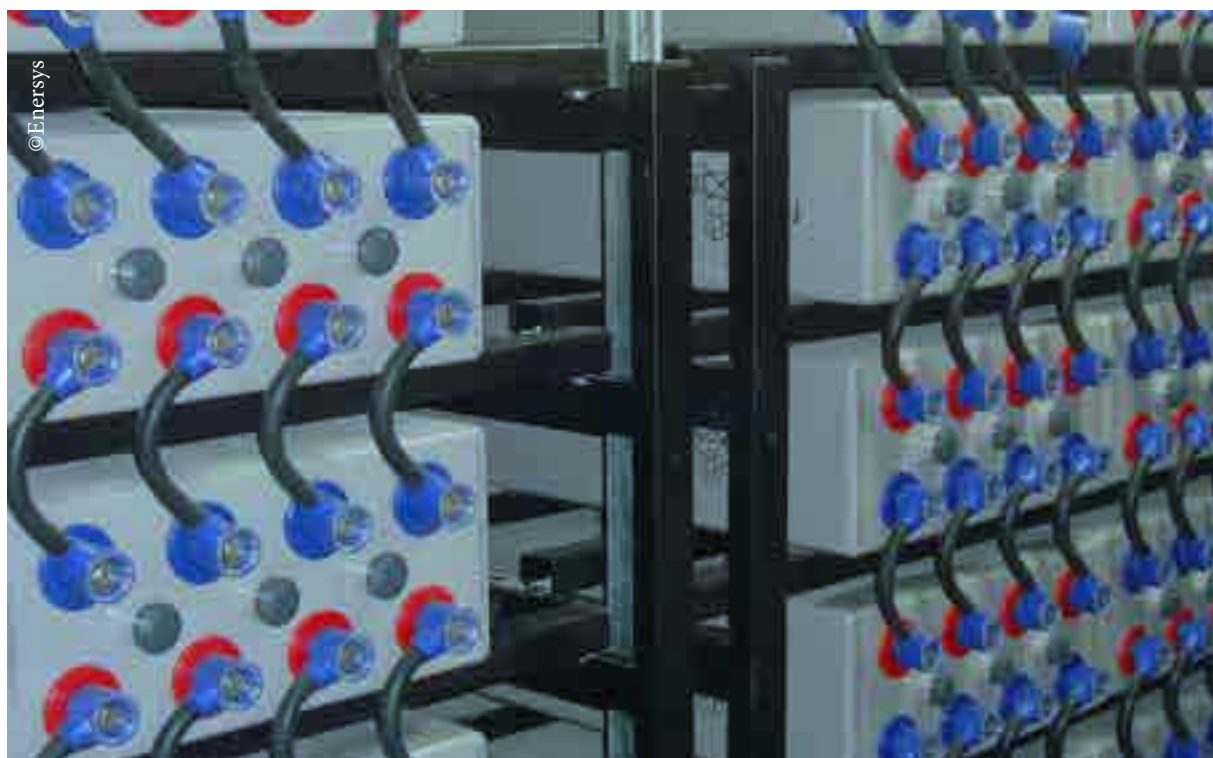
This lack of a definition of energy storage in the current EU legislation leads to a series of barriers, thereby creating an uncertain investment environment. Since energy storage is not mentioned in the Electricity Directive, storage is often considered to be a generation system and therefore falls 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 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 definition adopted by the State of California [see box below] is a good example for the EU; moreover, it also includes a list of services provided by energy storage systems.

Storage in California

California offers a practical demonstration of the importance of involving policy-makers and of the positive effects they can have on the deployment of energy storage systems. In 2010, California had already started looking at storage as a way of ensuring the integration of renewables in the grid; in 2013 this discussion resulted in a storage procurement target for the utilities operating in the State. Utilities have to procure 1325 MW of non-pumped hydro-storage capacity by 2020. Moreover, California provided a precise definition of storage, clearly defining its attributions, services, characteristics and purposes.

Assembly Bill No. 2514 of 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.’ The Bill lists the possible services provided by energy storage systems: ‘reduce emissions of greenhouse gases, reduce demand for peak electrical generation, defer or substitute for an investment in generation, transmission, or distribution assets, or improve the reliable operation of the electrical transmission or distribution grid.’ The Bill also specifies the characteristics, ownership and purposes of the system. The system can be either centralized or distributed, and can be ‘either owned by a load-serving entity 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.’



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.

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 favorable rules in order to provide cross-border services to another state with less favorable 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 [see box below], 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.

Self-consumption and storage fees in Spain

In October 2015, the Spanish government approved a decree on self-consumption (Real Decreto 900/2015). The decree goes much further than other European legislation on storage, which imposes double grid fees on storage systems connected to the grid. With this new decree, the electricity self-produced and stored with PV + storage home systems will be taxed directly, even if the electricity is not fed into the grid. Owners of PV systems of up to 100 kW cannot sell electricity, but they are required to feed the surplus electricity into the grid for free. Finally, the new law is retroactive and can already be applied to all PV systems that have already been installed. The consequences of this law cannot be overestimated: it would simply destroy the market for PV + storage and grid-connected storage in Spain.

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.

Different national legislative systems establish which system operators are allowed to curtail the production of renewables under which conditions, and whether financial compensation for curtailment should be guaranteed to renewables producers.

So far, the amount of curtailed electricity is quite low, even if the ratio is significantly higher in high-renewables penetration areas, such as island grids. In 2014, the Republic of Ireland and Northern Ireland had to curtail 277 GWh (4.1% of the total) of available wind energy, an increase of about 81 GWh compared to 2013 (Eirgrid 2015). Nevertheless, with the increasing share of renewables being introduced into the energy mix, this amount might increase if corrective measures are not taken.

In other cases, such as in presence of negative electricity prices, RES generators can also have an incentive to curtail their production, resulting in negative social effects. Energy storage systems can help reduce these negative social effects, storing electricity in order to release it at a later time.

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 amount 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.

Curtailement in Germany and France

The 2014 Renewable Energy Law (Erneuerbare Energien Gesetz – EEG) of **Germany** allows both DSOs and TSOs to curtail the production of RES in the event of grid congestion (Section 14 EEG 2014). Plants above 100kW (CHP) and 30kW (PV) can be curtailed in normal operations, while all plants can be curtailed in emergency conditions. A 95% compensation of lost income is guaranteed when there is congestion of the DSOs grid (Section 15 EEG 2014).

In **France**, all plants can be curtailed to ensure the security of the grid, while plants above 1MW can be curtailed when there is congestion in the distribution grid. Nevertheless, no financial compensation is guaranteed.



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ANCILLARY SERVICES AND THE VALUE OF ENERGY STORAGE

Energy storage itself is only a part of the services that batteries and energy storage systems can offer. Important ancillary services such as voltage control, frequency regulation and ramp control should be taken into account in order to understand and correctly estimate the real value of energy storage. It is therefore important to recognize the multiple purposes that storage systems can serve. The key barriers for ancillary services are the unequally balanced market and the underestimation of the value of ancillary and flexibility services.

In the US, the Department of Energy acknowledged that there is a concurrent need to quantify the ‘value’ of storage in the various services provided to the grid to achieve economic viability (US DoE 2013). Legislative intervention to ensure proper evaluation of storage services should be promoted to boost the deployment of battery energy storage.

Currently, TSOs and DSOs have a strong interest in the various services provided by storage systems. Moreover, the current market landscape makes them more suited to providing these services from a centralized standpoint. In the future, ancillary services might also be provided by individual customers and prosumers through aggregation services. In this sense, it will be important to develop an appropriate regulatory framework for aggregators in order to allow them to participate in the market on a level playing field with established providers.

The recognition of the value of the services offered by storage systems is central to creating the business case for storage. The EU market does not currently recognize the value of these services: for example, generators are currently required to provide power services without any compensation. **Providing such compensation for these important balancing services is key to enabling the deployment of storage systems.** The International Energy Agency suggests providing compensation based on the value of reliability, power quality, energy security and efficiency gains (IEA 2014). The regulatory framework should include rewards for grid services and for overall capacity of energy storage in order to stabilize quality and supply for the generation of renewables.

The ancillary market in the US

The first step towards the creation of the ancillary market in the US was Order 890 of the Federal Energy Regulatory Commission (FERC) of 2007, which required taking into account non-generation units as service providers for the grid and having them fully participating in the established energy market. In 2011, with Order 755, FERC acknowledged the added value of fast-response storage systems – such as batteries – for frequency control, but also recognized that ancillary services were not adequately compensated. The remuneration for primary reserves under Order 755 consists of two parts:

- Capacity payment that includes the marginal unit's opportunity costs
- Payment for performance that reflects the quantity of frequency-regulation service provided by a resource when the resource is accurately following the dispatch signal

The market for ancillary services was further expanded in 2013 with Order 784, which also clarified accounting rules for energy storage technology participation.

However, the US Department of Energy recognized in 2013 that one of the key barriers to the deployment of energy storage is still 'the need to quantify the value of storage in the various services it provides to the grid' (DOE 2013). The DOE proposes exploring 'technology-neutral mechanisms for monetizing grid services provided by storage'.

ELECTRICITY PRICING

One of the key points in the recent open consultation on new energy market design launched by the European Commission is the issue of electricity pricing. EUROBAT is convinced that if **electricity prices reflected scarcity, this would represent an important market signal for demand-response, smart appliances (including electric vehicles) and storage solutions like batteries and would generally act as a critically important tool for ensuring flexibility**. Moreover, we are also convinced that electricity prices should reflect transmission costs: storage solutions could be used for transmission congestion relief, for deferring expensive investments and for extending the life of existing transmission infrastructures. Having transmission costs integrated into the final cost of electricity would allow a fair market-based selection of the most efficient solution.

The first results of the open consultation on a new energy-market design reflect this view, with a large majority of stakeholders agreeing that scarcity pricing, i.e. having pricing structures that better reflect current supply and demand, is an important element in the design of future markets (DG Energy 2016). At the same time, most stakeholders agreed that electricity prices should reflect differences in location (e.g. by meaningful price zones or location-based transmission pricing) and they highlighted the link between scarcity pricing and incentives for investment. Giving the right short-term and long-term price signals to the market will be crucial for creating a level playing field between different flexibility options.

6 Conclusion

In this paper, EUROBAT has presented the various services that battery energy storage can offer to the European energy market.

Batteries and energy storage systems in general can be key ways of contributing to the decarbonization of the European energy mix. However, despite the remarkable technical advances in batteries and their increasingly keen competitiveness, the deployment of storage will not happen by itself. Batteries can offer services at multiple levels of the grid and in different areas, and they will need the appropriate regulatory and market environment to flourish. This favorable environment does not currently exist in Europe, so preventing batteries and storage systems from fully exploiting their potential. For this reason, the contribution and engagement of policymakers at EU and national level, as well as of other stakeholders from industry and civil society, is fundamental in order to ensure a prompt transition to a new energy system based on renewables and supported by storage systems.

California is a positive example of cooperation between all the actors involved in this process, which has resulted in an extremely positive environment for storage and in the development of innovative technical and regulatory solutions. The opposite example is Spain, where the new law on self-consumption risks preventing any possible positive developments for renewables and storage.

For its part, the European battery industry is fully committed to developing advanced, innovative solutions for the EU energy market. However, it will be essential to ensure close collaboration between all the parties involved in order to set Europe firmly on the path of decarbonization, energy security, energy independence, jobs and growth. The removal of unnecessary and unjustified barriers to the deployment of storage will be the first step in this direction.



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Battery Energy Storage effectively contributes to the decarbonization targets of the European Union. At every level of the grid, from generation to transmission, from distribution to households, batteries ensure the integration of renewable energy, grid stabilization, flexibility, energy security and independence.

BATTERY ENERGY STORAGE IN THE EU

BARRIERS, OPPORTUNITIES,
SERVICES AND BENEFITS