

POLICY *brief*

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Electricity Storage: How to Facilitate its Deployment and Operation in the EU¹

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Highlights

- Many claim today that greater variability and intermittency of supply must inevitably go with a significant development of electricity storage. However, what the future power system needs is not electricity storage per se, but rather a well-adapted system architecture which allows for decarbonization while also ensuring system reliability and supply security, and thus, reacting amongst others to increasing variability and intermittency of generation and the proliferation of distributed energy/power resources.
- Alternative means of flexibility – including a more flexible operation of generating units as well as various demand-side measures – are all able to react to the system requirements of up-/ downward adjustment and also include the opportunity to benefit from inter-temporal arbitrage. The main differences relate to quantity and degree, i.e. response time, power rating, and energy rating. One flexibility means is not necessarily superior to another and the often expressed need for electricity storage to enable decarbonization is a technical and economic question.
- To reveal the overall value of electricity storage, multiple services need to be aggregated and multi-income streams need to be maximized. Viable business models can be categorized by the nature of the main target service, with a distinction between a deregulated-driven business model (where the main income comes from activities in electricity markets), and a regulated-driven business model (where the main income comes from offering services of which a regulated actor is the only buyer).
- The future role of the EU is to ensure a level playing field for all alternative means of flexibility, including electricity storage. An investigation of current market design and regulation shows that it is necessary to improve market price signals and to adjust regulatory incentives in order to better reflect the value flexibility means can provide. A relaxation and harmonization of market rule setting in balancing markets could allow small, decentralized market players (including storage operators) to access these markets, which would facilitate the cross-border exchange of flexibility resources. Regarding the provision of ancillary services, the use of competitive tendering instead of bilateral contracts wherever possible could help to evaluate and quantify value. As regards tendering, performance-based and source-neutral remuneration schemes should be adopted.
- The future role of the EU is also to provide smart direct public support for innovation. The coordination between Member State and EU support policies should be improved and public support should target a balanced portfolio of identified key technologies, including both centralized and decentralized energy storage technologies. Of particular interest are areas where European players already have a strong position in RD&D and/or manufacturing and which have potential for future growth.



Florence School of Regulation

The Florence School of Regulation (FSR) was founded in 2004 as a partnership between the Council of the European Energy Regulators (CEER) and the European University Institute (EUI), and it works closely with the European Commission. The Florence School of Regulation, dealing with the main network industries, has developed a strong core of general regulatory topics and concepts as well as inter-sectoral discussion of regulatory practices and policies.

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Background

The future electricity system will face various challenges originating from both supply and demand side, including an increase in variability and intermittency of generation, and the proliferation of distributed energy/power resources like distributed generation, controllable demand and electric vehicles. Adaptations in system architecture are required to allow for decarbonization while ensuring the stability and reliability of the system. Electricity storage technologies are one possible type of means, amongst others like flexible generation and demand side management, to provide various services to the system (e.g. capacity firming, voltage and frequency control, back-up capacity, or inter-temporal arbitrage).

The renewed interest in electricity storage is due to both new features of the European power system, as well as technical advancements and cost reductions of storage. Moreover, the difficulties and high costs associated with grid expansion have also focused more attention on the storage solution. To face up with the challenges of the future power system, a comprehensive approach to assess how to enable the deployment of electricity storage (and in the broader sense also of other flexibility means), and thus, how to establish a level-playing field where alternative means can show their potential, needs to be developed.

Electricity storage: A special class of assets for the future power system?

Alternative means of flexibility – including a more flexible operation of generating units as well as various demand-side measures – are all able to (a) react to the system requirements of up-/ downward adjustment and (b) also include the opportunity to benefit from inter-temporal arbitrage. Dissimilarities come from the form of energy in the conversion and the accumulation processes. The main differences relevant for the final services that alternative means of flexibility can provide are expressed in quantity and degree, i.e. response time [ms-s-min]; power rating [kW-W-MW]; and energy rating [kWh-MWh]. One flexibility means is not necessarily superior to another and the often expressed need for electricity storage to enable decarbonization is a technical and economic question.

Hence, the value of storage needs to be assessed under a double uncertainty. First, there is uncertainty concerning the direction and timing of innovations in storage technologies themselves, as many are still highly immature or not technically proven. Second, there is uncertainty concerning the pace of change in generation-, demand- and grid flexibility as well as concerning the configuration of the future power system. It will also make a difference for storage technology choice and scale if we move towards ‘Europe-wide energy superhighways’ or if instead we move towards a system of increasing local energy autonomy, featured by a further increased penetration of small-scale distributed generation and widespread demand-side management.

Viable business models for electricity storage

The core of the business model for electricity storage is how the storage facility’s functionalities (regarding up- and downward adjustment and accumulation) are matched with the services to be provided (Figure 1). Numerous studies have shown that by focusing on only one specific application, electricity storage typically cannot reach profitability in the cur-

rent market context. Today's challenge is how to aggregate multiple services and how to maximize multi-income streams.

Second, business models are categorized by the nature of the main target service. In the *deregulated-driven business model*, the main income originates from activities in electricity markets.

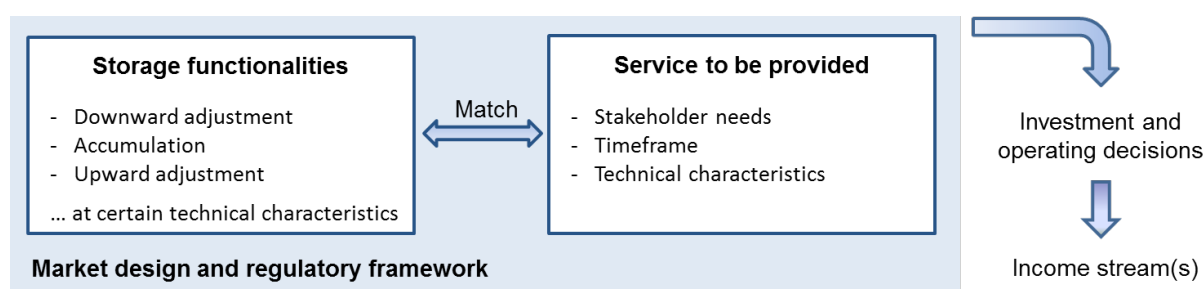


Figure 1: Illustration of the electricity storage business model

Source: Own depiction

The report provides a systematic approach to the search of viable business models for storage. First, the location of storage is decisive in deciding which main target service storage will provide. Previously, electricity storage was mainly employed in the form of bulk, centralized units providing storage over relatively long durations (mainly PHS) as well as some systems providing fast response (batteries, flywheels). Today, there is an emerging interest in small-scale, decentralized storage and, in the future power system, electricity storage could fulfill a variety of functions and provide benefits to various stakeholders. It might be connected directly to transmission or distribution grids, to renewable generators, or to consumers (Figure 2). Hence, electricity storage could be located closer to generation or closer to load; it could be operated in a more centralized or in a more decentralized manner; it could be a 'shared resource' benefiting the whole system or a more 'dedicated resource' benefiting a single actor.

Spare capacity may be used to provide services to regulated actors. Storage facilities which fall into this category are, for instance, large-scale storage units directly connected to the transmission grid such as pumped hydro. In contrast, in the *regulated-driven business model*, the main income originates from offering services where the sole buyer is a regulated actor. Spare capacity may be used for competitive activities. An example are battery systems, supporting quality of supply and being directly connected to the distribution grid.

Box 1 highlights some interesting international experiences on which factors have led to a more ambitious development and use of storage in selected non-European countries. Reasons include individual industry structures, strong public support for innovation, and also specific rules in market design and regulation facilitating the participation of storage in ancillary service markets.

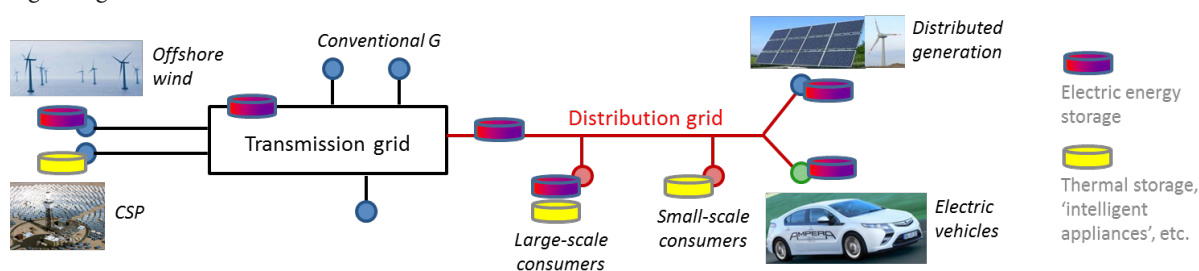


Figure 2: Possible locations of electricity storage applications in the future European power system

Source: Own depiction

Box 1: International experiences

Several factors have led to a more ambitious development and use of electricity storage in other countries. US experience has shown that the emerging policy framework at federal level supports both development and deployment of electricity storage. First, public (co-)funding which comes from organized programs is explicitly targeting RD&D in the area of electricity storage, and is triggering numerous research activities. Second, with the FERC orders 890, 719, and 755, recent changes in regulation modifying tariffs and market rules (such as that non-generation resources can fully participate in established markets alongside traditional generation and that providers of frequency regulation receive just and reasonable remuneration) make the electricity storage business case more attractive.

Japan, in contrast, has a particular energy industry structure which is highly dependent on primary energy imports from third countries. The Japanese experience is interesting as its energy storage technology development results from a strong industrial policy. For example, the 'Moonlight Project' was dedicated not only to developing energy storage technologies, but also to the search of alternative solutions to ensure Japan's energy independence. TEPCO's project on NaS batteries was among the alternative projects that were developed with this industrial support. Even today, various publicly financed projects seek solutions to particular problems, and energy storage technologies benefit from funding as they may be part of a solution. The Fukushima accident has had a substantial impact on the country's energy strategy, and has also stimulated interest in small-scale energy storage systems directly connected to end-consumers to develop resilience at the individual household level.

Need for a renewed EU involvement?

Current EU involvement related to the facilitation of electricity storage development and deployment is limited and it mainly involves some public co-funding of RD&D, as well as the general definition of underlying principles for electricity market system operation, dispatching and balancing, and the provision of ancillary services. The following paragraphs summarize proposals for improvements in market rule setting and direct support to innovation.

Market design and regulation

Manufacturing costs and technical parameters are often cited as major barriers to the deployment of electricity storage; however, there are various non-technical issues preventing its adoption as well. Major obstacles for an efficient pricing in spot and balancing markets have been identified, including ad-hoc peak load arrangements implemented in some markets, frequent inconsistencies regarding price fixation mechanisms in day-ahead and balancing markets, and restrictive bidding

requirements. There is also wide heterogeneity regarding the implementation process of the 3rd Package and, so far, a low degree of compatibility of market designs has been achieved. This situation does not only create obstacles for the transition to a single European market, but it may also hamper an efficient participation of 'new' sources of flexibility in ancillary service markets. The future role of the EU is to ensure a level playing field for all alternative means of flexibility, comprising well-functioning markets and efficient regulation.

Energy-/balancing markets: The negative effects of heterogeneity in national balancing mechanisms on competition and the completion of the internal market should be recognized in the Framework Guideline on Electricity Balancing, due to be published by ACER this year. The proposals made in the first draft (April 2012) call for an integrated balancing market approach and the facilitation of the participation of alternative flexibility sources in balancing markets. This would go some way to removing certain barriers to the adoption of alternative flexibility means such as electricity storage. However, the pro-

posal remains silent on concrete balancing market design issues. Market rules should be modified to relax minimum bidding requirements and rules which require symmetric up- and downward bids in order not to impede market access for small, decentralized market players. This will allow storage and other flexibility means to valorize services they can technically provide, which will probably also have a positive impact on market liquidity.

Ancillary services: The co-existence of several forms of procurement and remuneration (including mandatory provision, bilateral contract, tendering, or spot markets) can be justified on economic grounds. The suitability of certain options depends on the service targeted. However, replacing bilateral contracts wherever possible with competitive tendering could help to evaluate and quantify the value of alternative flexibility means, including storage. In terms of tendering, it is recommended that performance-based, source-neutral remuneration schemes are adopted. Such measures pave the way for the emergence of transnational markets for ancillary services, leading to more efficient procurement and use of ancillary services across Europe. Political borders should not restrict the flow of ancillary services. It is the market that should create its own pliable borders, acknowledging technical and economic aspects. However, heterogeneity in the procurement of ancillary services might hamper an efficient sharing of flexibility resources in the European power systems.

Capacity mechanism: Capacity mechanisms are currently being extensively debated in several European countries. However, the necessity of such a mechanism to address the risk of long-term under-investment in (peak) generation capacity remains to be proven. Instead, to address the causes of the lack of investment incentives, the improvement of existing market signals is required, namely the quality of price signals transmitted in energy and balancing markets and for the provision of ancillary services.

Besides, heterogeneities in national market design and regulatory frameworks applied to storage could impose distortions

in competition, and therefore should be the main focus of EU involvement. For instance, grid tariffs applied to storage or market access eligibility deserve more exhaustive survey and benchmarking. A proactive regulatory intervention could also be helpful in several areas to allow the emergence of new business models. This includes for instance the promotion of market access for aggregators which would allow for the participation of small-scale flexibility sources such as electricity storage in energy-, balancing-, and ancillary service markets; or incentivizing renewable generators towards output firming or direct usage of own consumption. It is important to note, though, that any evaluation of which policy approach to advocate requires a careful assessment of which policies would be optimal from a societal perspective.

Innovation in storage technologies

Electricity storage has been identified as one of the key technology priorities in the transition of the European power system towards decarbonization, but the majority of possible technologies is not yet commercially available. Financial support for RD&D is already in place; however, support programs are hardly coordinated – neither between different Member States, nor between them and the EU. This restricts knowledge sharing, increases the likelihood of costly duplication of similar research and fails to exploit potential benefits from economies of scale and scope via a pooling of resources and active networking. The existing European energy technology policy (SET-Plan, launched in 2008) does not provide a comprehensive strategy for electricity storage development which takes into account the whole set of technologies and their possible applications. There is no clear vision of the future role of electricity storage in the European power system.

A renewed European energy technology policy, which goes beyond the SET-Plan horizon of 2020, should include a technology roadmap for electricity storage. Coordination between the support policies of Member States and EU need to be improved and public support should target a balanced portfolio of identified key technologies, including both centralized and

decentralized energy storage technologies. The policy should consider an extended timeframe up to 2050 with intermediate milestones for 2020, 2030 and 2040, thus including also highly immature but possibly promising technological options. Areas where European players already have a strong position in RD&D and/or manufacturing and which have potential for future growth should be of particular interest.

Improved communication is of utmost importance, too. For instance, this could involve a knowledge pool to collect information on installed capacities of various technologies (commercial and also pilot and demonstration facilities) in different Member States, or the exchange of information regarding the functioning practice of ‘real-world’ pilot projects. The European Association for Storage of Energy should take an active role here.

Box 2: EU’s position among storage manufacturers

To assist the European Commission in deciding how to effectively use RD&D to the benefit of the European citizens, the report also provides a review of on-going R&D activities of different storage technologies as well as a survey of manufacturers showing the EU’s relative position in this specific industry. In fact, the market for energy storage is quite vibrant, with start-ups co-existing alongside well-established firms, reflecting the importance of innovation. For PHS, for instance, Alstom is

one of the leading manufacturers worldwide, but smaller firms such as Gravity Power Inc. (US) or Riverbank Power (Canada) offer new alternative solutions based on traditional PHS technologies. The former exploits gravity power, while the latter offers underground storage solutions. While the first compressed air energy storage facility was developed in Europe, the US has witnessed a surge in firms offering this storage solution nowadays. Both American and European manufacturers are also very active in flywheel storage technologies. Asian companies seem to focus their commercial strategy on battery solutions.