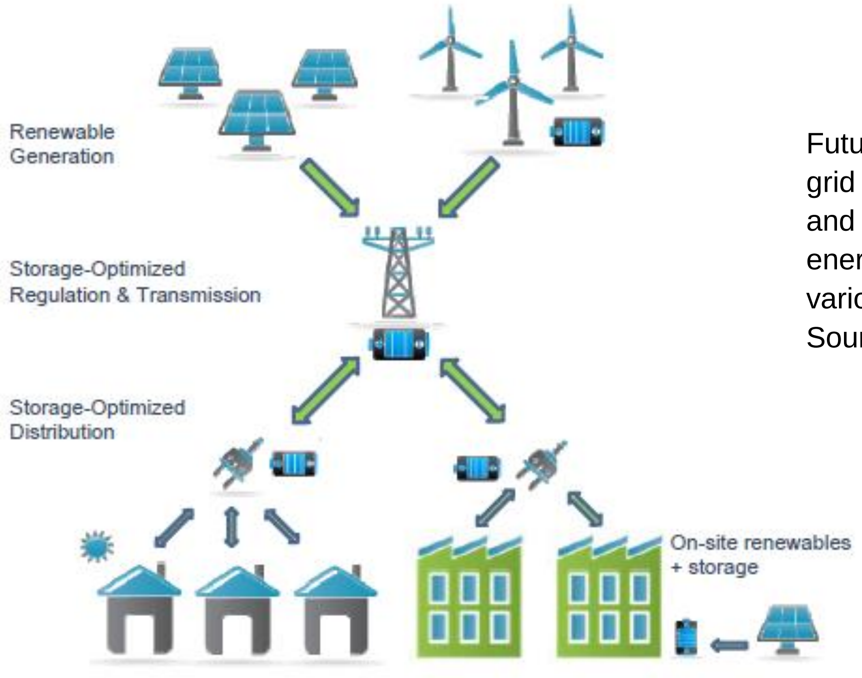
StoRE Project

TASK 5.3: Regulatory and Market Barriers

Deliverable D5.3 (draft): List of barriers to energy storage

The development and deployment of energy storage technologies in order to exploit their strategic advantages and many potential benefits, but not at the expense of creating distorted and unfair energy markets, is a great challenge for the development of future electricity grids infrastructure.

As with the integration of any novel technology, the deployment of energy storage systems faces many barriers – most significant of which is cost-competitiveness. Directly linked to this barrier is the challenge of regulatory uncertainty surrounding grid-scale energy storage deployment. Many of the regulatory issues trace back to the present structure of the electric power industry. Energy storage participates limitedly on the electric power system, serving needs that are very narrow, engaging in only one energy market. Potential roles of energy storage on the power grid are not clearly defined, there is no standard system for assigning value to energy storage services, and there are dissenting opinions on allowing single energy storage systems to participate in multiple energy markets.



Future electricity grid infrastructure and possible role of energy storage at various levels. Source: [9]

The following list summarizes and briefly presents the possible obstacles or barriers that can be encountered at an electricity system to deployment and further development of electric energy storage.

A. GENERAL BARRIERS

1. Lack of clear official definition of storage

There are now a substantial number of independent reports which support the view that energy storage is a key technology, vital part of our future electrical infrastructure and part of the solution of future system balancing. However, a clear official definition is required at EU level in order to be integrated in the corresponding regulatory framework of member states. (in Greece for example, the future energy storage is associated mainly with the recovery of RES rejected production in high RES share conditions).

2. Lack of definitive storage needs

A first key question is if and at what level grid-scale energy storage is needed. Estimations so far are quite different, depending on the particular grid and future electricity plans. Results indicate from a wide range of potential needs, to the lack of such energy storage needs. For example, at least for the present level of variable RES integration, in most grids there are many traditional and new methods and mechanisms (technical or market) available to cope with grid flexibility needs (e.g. diesel or OCGT, frequency control by wind turbines, demand response and management, etc.).

Storage power and storage capacity are the two main parameters that need to be determined in order to conclude to what extent energy storage can contribute in addressing the needs of a grid system, including high RES integration. Their optimum values may be partially independent, ranging from high power–short term storage to lower power–long term storage. Definitive determination of these needs in a specific electricity system is a great challenge but necessary for any further step.

3. Lack of definitive storage role and integration level

In the future low-carbon energy systems there will be multiple possible roles for energy storage, and at different levels of electricity grid:
a) At generation level as balancing, reserve, etc.
b) At transmission level for frequency control and/or investment deferral,
c) At distribution level for voltage control, capacity support, etc.
d) At customer level, for peak shaving, cost management, etc.

Energy storage can also contribute to the solution of peak demand increase issue, either with centralized schemes as reserve or with decentralized demand management and response systems.

The above different possible implementations involve different stakeholders and may have different impacts on the grid services to be provided and on the corresponding income streams.

In any case, Electric Energy Storage (EES) will certainly compete and/or complement other methods and technologies to improve grid flexibility. Hence, reaching a consensus for the energy storage role and integration priorities in a particular grid system is a very challenge issue.

4. Lack of awareness of energy storage benefits.

Many policy-makers, grid operators, and the general public are unaware of what energy storage is, the specific technologies that comprise energy storage, the recent technological advancements, data about its effectiveness, and what benefits energy storage can provide. Therefore, an effective and timely planning of energy storage deployment may be obstructed. This can cause important delays in the development of the overall electricity system following the high RES share plans, because the time period from the initial design to commissioning of a grid-scale storage plant (e.g. Pumped Hydro Energy Storage, PHES), may exceed 10 years.

5. Conservative Industry culture

Power plants owners are reluctant to invest in new technologies like energy storage if they are unsure whether they will be able to recover their capital costs. Regulatory uncertainty hinders even more economic investment in energy storage.

Conventional generation options, including flexible natural gas-fired turbines, continue to be the primary option for load following, peak power generation, and ancillary services. Market uncertainty, combined with a lack of incentives for risk taking in regulated utilities, discourages the deployment of technologies that are new or have long lead times.

6. Public oppositions

PHS development on existing streams can affect water quality and ecosystems as with any other hydropower project. Moreover, the energy storage scheme design and operation is quite more complex than most other production units, because it combines energy consumption and production, even at the same time. This cannot be easily understood and causes increased concern or oppositions of local communities in respect of possible negative effects on the environment and water resources. Open-cycle plants has more environmental impact (and potential opposition) and hence higher investor risks. Public oppositions can delay significantly the licensing procedure and in some cases have prevented realization of large hydropower projects.

B. REGULATORY and PLANNING BARRIERS

7. Lack of cohesive and definitive regulatory and legislative framework at EU level

Regulatory barriers are the main challenges that deployment of grid-scale energy storage face. Also, regulatory uncertainty does not allow potential investors to determine the returns of such investments. A detailed and cohesive regulatory framework is required at national level, covering all aspects of energy storage usage and complying with the EU corresponding legislation and Internal Electricity Market, which are still under development. Important issues and uncertainties still exist, like for example the provision of ancillary services in the interconnected system across national borders, and need to be resolved. Consequently, the construction of a thorough and long-standing regulatory and legislative framework at national level is not yet feasible.

8. Incomplete and/or distorted national energy market

Many countries have not yet fully developed markets and transparent prices for all the types of ancillary services that EES and generation technologies provide besides providing electricity, such as regulation, spinning reserve, load-following, and other services.

Electricity purchasing processes contain no formal mechanism for calculating and recovering the full value of the resource savings and the more effective use of existing grid assets that energy storage offers, thereby distorting the perceived costs and benefits of energy storage as compared to energy generation.

Several distortions may exist in the market, due to existing regulations (e.g. feed-in-tariff, selective pricing, RES taxes etc.), thus creating a complex and uneven playing field, in which any new technology is difficult to enter. This obstacle is much more pronounced for the energy storage systems, which may affect several entrenched practices and interests in the energy market.

9. Lack of national pricing policy for energy storage services

A main objective of the European internal electricity market under development is the definition of all required services and formulation of clearly defined market conditions for all participants. However, the pricing of reserve, balancing and ancillary services of energy storage units is a much more difficult task than for any other part of the electricity system. For example, even if the EES is used only to increase RES penetration, there are multiple operation modes and corresponding energy streams that need specific pricing: Storage of RES rejected production; Storage of absorbable RES production (if FIT is replaced by a less regulated model); Injection of stored energy into the system; Direct injection of RES production stabilized and reserved by the storage unit (e.g. in case of a hybrid power plant); Night-time storage from grid to secure next day's guaranteed production; Capacity credits for guaranteed power and/or energy. Considering also the possibility of shifting production from base (thermal) units from off-peak to peak times, as well as any additional balancing and ancillary services, it is evident that the development of a fair and viable national pricing policy for energy storage units is a puzzling task, and depends strongly on the characteristics, constraints and future development plans of each particular grid system.

Commercial value of various services may be much different (e.g. frequency or voltage stabilization, compared to RES penetration support). Also, there may be various compensation schemes for storage, especially if it is considered as part of the regulated market (transmission/distribution system operators, TSO/DSO), or as part of the deregulated market (producers and customers). Regulators do not yet know how the energy storage system costs and benefits should be allocated among the three main elements (generation, transmission, distribution) of the electric system.

10. Unclear or complex licensing

Licensing procedure for grid-scale energy storage is not clear, or may not exist at all for some new technologies. Licensing requirements of traditional energy storage systems like PHES are similar with those of large hydropower units or with the ones for RES production units. In both cases the procedure are very lengthy and quite complex, disregarding the fact that energy storage cannot be seen as a stand-alone production technology. Even in the most developed systems, like in USA, the licensing procedure lasts about 5 years, while state and local permitting can add to this time. In the non-interconnected islands of Greece the hybrid (RES-hydro pumped storage) plants are considered as RE units, and the licensing procedure is similar to that for RES, which however, is still quite lengthy.

11. Unclear potential ownership

Critical questions arise concerning the ownership and managing of EES. Should storage be owned only by utilities or could TSOs also participate in this market? A definitive answer cannot be extracted from the latest EU Electricity Directive, and situation is also unclear at national level. Existing regulatory framework for energy storage (if any) treat EES as a type of electricity generation technology rather than as an investment in transmission capacity. Thus, transmission and distribution companies are barred from owning ESS.

However, TSOs may have interests in the energy storage market not only to improve their services but also in the extent to which market outcomes rely on new investment in transmission lines. But abusive market behavior might be unavoidable if TSO controls both owned generation and energy storage units. On the other hand, the optimal technical, economic and social performance of a particular grid system may allow some kind of energy storage control by TSOs at specific locations.

Multi-market participation is presently not permitted by energy market regulations, as grid assets only fall under one asset category (generation, transmission, distribution) and thus can only draw from a single revenue stream.

12. Lack of cost-effective and efficient transmission planning

Energy storage facilities provide ancillary services to the grid that help it run more efficiently and can avert the need for new transmission lines and power plants. These benefits may translate to cost savings for utilities and ratepayers. However, utilities and policy-makers lack methodologies to quantify these savings. As a result, the current regulatory structure discourages them from considering energy storage as an alternative to building new transmission lines and power plants that may be more costly than comparable energy storage facilities.

It is also unclear as to what entity will take on the costs of storage provided to the grid. This can depend on regulations that are to be developed, but also on transmission planning decisions, which still are to be made.

Transmission planning bears a lot of weight on the jurisdiction under which energy storage facilities may fall. Two possible ways in which energy storage can be incorporated for the purposes of increasing the value of wind energy: Storage of surplus RES production, or hybrid RES-storage with ability to buy from the grid during low-value time periods (off-peak). This also depends on transmission planning decisions.

13. Strong interdependence between energy storage and system development

The optimal market regulatory framework for energy storage depends on the future development plans and targets of the entire electricity system, and can greatly affect both the size and capacity, as also the type of EES future systems (e.g. stand alone storage units or hybrid schemes), which in turn contribute decisively to the realization of future plans for high RES integration.

Consequently, it is not possible to schedule the future EES deployment in the same independent way like other parts of the electricity system (wind and solar deployment, decarbonization, nuclear removal etc.). Decisions to invest in energy storage in Europe are closely linked to developments such as (a) electricity super-highways with large-scale RES in North Sea and North Africa, combined with distributed/regional RES solutions; (b) penetration of electric vehicles; (c) improvements in demand response/demand side management/smart grids.

C. ECONOMIC BARRIERS

14. High capital costs of storage units

The capital costs of EES technologies are high compared to natural gas units (except of some pumped-hydro schemes), which can provide several similar services. An element of this cost is the long construction time and associated uncertainty and risks, under a continuously changing market conditions and technology.

For the new, less mature technologies this is either because they have not yet reached cost parity with other market (generation/demand) resources or transmission/ distribution assets, or economies of scale have not yet been achieved because of low market penetration.

Also, due to the above reasons, the access to finance support for large electricity storage plants is difficult. Moreover, the economic environment and financial factors in several European countries, like Greece, remain negative, hence obstructing large investments in the electricity sector.

15. Lack of adequate valuation of energy storage services and benefits

Although the net social benefits of large storage plants are positive, the benefits are distributed among power produces, system operators, distribution companies, end-users, and society at large. The decision to build a plant, however, must be made by a single entity, and it is often unclear how that entity can capture enough benefit to justify the investment.

Assessment of energy storage value is very difficult, due to several uncertainties: Because energy storage could potentially provide transmission, distribution, and generation services, it is possible to recover cost under both cost-based and market-based rates. But there is not a clear way to fit energy storage into the existing regulatory and cost recovery structure.

The benefits for users/operators are closely linked to the question of storage location in the system (generation, transmission, distribution). Energy storage studies in Europe indicate that provision of single service (e.g. reserve) will be not sufficient to a viable storage scheme.

There are still several widely acknowledged benefits and value streams associated with bulk storage for which cost recovery/financial return is elusive under current policy and electricity market mechanisms. But there is no regulation in place that would allow energy storage facilities to recover costs from providing multiple kinds of services to the grid, which would greatly increase the economic argument behind the incorporation of energy storage. Even in the U.S., where operate a significant number of PHES and CAES units, several services or benefits to the grid (energy reserve, capacity, ancillary services, frequency regulation) are usually not paid, and hence the benefits of storage remain undervalued.

Unfortunately, the holistic costs for grid balancing – many of which are not routinely quantified by utilities, or which impose externalities (emissions penalties, reliability impacts, etc, which do not show up in costs) – are not transparent nor known with any degree of precision on a real-time basis. Therefore, better ways of providing the balancing service, such as with bulk energy storage, are difficult to evaluate properly.

Wholesale electricity markets also do not capture all the potential benefits of storage to the electric distribution system, including deferral of new equipment and reduced power line losses.

16. Lack of investments motivations and incentives

The uncertainties surrounding energy storage regulation do not provide any motivation for future investments. Most renewable portfolio standards or government investment or production incentives are written for renewable generation only and exclude energy storage.

The capacity credit mechanism is designed for peak generation units but does not recognize the contribution of other flexible means, like energy storage.

Moreover, no any incentives are given to energy storage in recognition of its important contribution to enable higher penetration of variable RES production in the grid. On the contrary, such incentives are for the same reason provided to both RES power plants and transmission infrastructure (e.g. feed-in-tariffs, subsidies etc.).

17. Double or uncertain grid access fees

Pumped hydro storage is seen as an electricity consumer and electricity generator. Therefore, pumped hydro storage pays in most EU countries double fees (tariffs) for access to the network; some TSOs charge nothing for the pumped hydro storage's role as electricity consumer; other TSOs charge nothing for the little net consumption of PHS (withdrawal injection) or recognize it as a renewable based generator. There is no EU legislation or common rules to regulate this issue and TSOs treat pumped hydro storage as they see it fit to their local market circumstances.

18. Competition with other technologies for grid flexibility

Energy storage is one of many technologies proposed to increase grid flexibility and enable greater use of intermittent RES production. Utilities can have many “flexibility” options for incorporating greater amounts of RES into the grid, many of which may cost less than using energy storage (e.g. supply & reserve sharing, flexible generation or demand, RE curtailment, new loads like hydrogen, vehicle electrification, etc.). The cost of energy storage needs to be compared to the alternatives, considering also the efficiency losses in the storage cycle that may be avoided by using other enabling technologies.

Some energy storage systems (like batteries, hydrogen, etc) have difficulty competing with other technologies, such as fossil fuel-based power plants, due to their stage of commercialization, the expense of materials, the lack of large-scale manufacturing, and the uncertainty surrounding the calculation of their benefits and their cost-recoverability under the current regulatory structure.

D. R&T BARRIERS

19. Difficulties in selecting the appropriate storage technology and scheme

There is a considerable number of traditional or new and possibly competitive in the future energy storage technologies and practices (e.g. pumped-storage, CAES, flow batteries, hydrogen etc.). For example, the storage of heat (or cold) may be more cost-effective than storage of electricity in district CHP systems. There is also the option of stand-alone or hybrid (combined with RES) storage schemes.

Selection today of the most effective and efficient storage solution for a specific grid level and location of an electricity system is not obvious, and there is luck of such studies and results that take into consideration the future system development and demands.

20. Siting and connection constraints

Energy storage technologies may face permitting or sitting challenges and difficulties. The less expensive and most mature PHES systems require particular topological features and possible commitment of large land areas for reservoirs, hence limiting the number of appropriate sites. Environmental issues and terms may often exclude favorable sites.

Large energy storage units typically require new high-voltage transmission, which adds additional siting challenges. Transmission planning today considers the location of generation units and centers of demand, but not of remote EES facilities, which may have limited access to the grid.

21. Technical/Technological barriers

The capacities and efficiencies of most new existing technologies cannot address the energy storage needs at grid-scale level. Further research and developing of these technologies for decentralized or large centralized energy storage is needed to increase capacity and efficiency, and to achieve market deployment.

Even for the most mature and proven pumped-storage technology, further design and operation control improvements are possible and required to improve machinery performance and increase overall efficiency, especially for the future multiple role of storage facilities. Ancillary service capabilities can be also further improved (e.g. variable speed, reversible pump-turbines).

Refurbishment of old PHES units may be required to comply with the future grid demands and conditions.

22. Insufficient modeling of future electricity systems design and operation

The modeling of the future electricity system with high intermittent RES penetration, few base load production and substantial energy storage incorporation is a very demanding task, and only few initial approaches have been developed so far, including the ones in the present StoRE project.

The existing widely used software tools for engineering planning do not support storage today as a type of equipment and hence the many applications of energy storage are not going to be considered as part of the future grid solution. This restricts demand, and the lack of demand for storage not only depresses the overall market development but also provides little demand for the providers of software tools to incorporate storage.

Current modeling cannot adequately quantify the full value of energy storage due in part to the limited ability of simulating realistic power plant and storage system operation over multiple time scales. In addition, there are several uncertainties and unpredictable variables in the future electricity grid system, including structural and financial aspects (e.g. RES technologies blending, type and flexibility of remaining thermal units, fossil fuel prices, CO_2 emissions framework, etc.). The incorporation of other potential means to store energy and/or increase flexibility, like the hydrogen production, the demand management, and the use of electric vehicle batteries (charging and V2G), is also required for a more elaborate modeling of the future grid and energy storage participation.

On the other hand, there are no methodologies to simulate the various economic benefits associated with enabling renewable energy sources at various grid levels. For example, no cost-effectiveness methodology exists for storage as an alternative to investment in new or upgrade transmission or distribution networks, or as a mean to defer such needs. Also, if intermittent RES production increases regulation service requirements, then it also increases market opportunities for storage. However, there are various potential synergies between intermittent RES and storage that need to be modeled.

The planned interconnection of the large Greek islands with the mainland system is such an example that needs to be thoroughly studied, because interconnection will definitely affect the needs, the role and potential benefits, and in turn the optimum sizing of hybrid RES-PHES power plants that can be installed in the islands.

23. Lack of demonstration plants

New EES technologies such as CAES require a few large-scale demonstration projects to verify their technological maturity and economic feasibility before utility managers will have the confidence to invest in these technologies. However, even for the mature PHES technology, the operation and financial outcomes of conventional pumped storage units in a future environment with very high share of variable RES production are uncertain, and need also to be investigated and proven by some pilot plants.

Some pilot energy storage schemes in smaller, autonomous grids are being constructed (Ikaria, Greece), or have reached commissioning stage (El Hierro, Spain), but real operation data are still missing.

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