Workshop Proceedings

IRENA's Electricity Storage Roadmap

Concluding Workshop

Düsseldorf, 10 March 2015

IRENA Innovation and Technology Centre, Robert Schuman Platz 3, 53175 Bonn

Participants of the IRENA Electricity Storage Policy and Regulation Workshop on 10 March 2015, which took place alongside Energy Storage Europe (for more info: www.energy-storage-online.com).

The workshop presentations can be found at: http://www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=30&CatID=79&SubcatID=556.

1. Introduction

The objective of the workshop was to discuss the blueprint of IRENA's electricity storage roadmap. This blueprint was based on the insights from three previous workshops organised on this topic:

- **The Transformative Power of Storage: Developing IRENA's Electricity Storage Roadmap,** 27 March 2014, Düsseldorf, Germany (presentations and proceedings can be found here);
- **Self-Consumption of Renewables: The role of storage in revolutionising grid infrastructure,** 7 November 2014, Tokyo, Japan (presentations and proceedings can be found here);
- **Electricity Storage: Technologies, regulation and policies supporting small- and large scale deployment of renewables,** 3 December 2014, New Delhi, India (presentations and proceedings can be found here);
- **Battery Storage for Renewables: Market Status and Technology Outlook,** January 2015 (report can be downloaded for free at www.irena.org/publications).

The workshop gathered together policy makers and stakeholders from the academia and industry sectors in order to identify the opportunity areas and to come up with recommendations that can be actionable in order to foster the development of electricity storage technologies as means to integrate renewables to provide sustainable and reliable energy.

1.1 Content of the blueprint

The aim of IRENA's technology roadmap on electricity storage is to identify – in more detail –priority areas for action, specify activities for international cooperation among different stakeholders, and provide a framework to monitor progress. The roadmap focuses on electricity storage systems (ESS), although it recognises that thermal energy storage will be – in many cases – a cheaper solution to storage power from variable renewable energy (VRE).

The scope of the technology roadmap includes all electricity storage systems. In the power sector, the most common (99%) form of electricity storage is pumped hydro stations. In these systems, electricity is used to pump water to an elevated reservoir in periods of excess generation. In periods of electricity demand, the water is subsequently released to run conventional hydro turbines to produce electricity again. In remote regions with unreliable or no centralised electricity grid and in the transport, lead acid batteries is the dominant technology to store electricity or provide back-up capacity. Traditionally, lead acid batteries have been relatively cheap, but their limited efficiency and life time made them less suitable for the integration of renewables. The relative recent developments in battery storage systems for consumer electronics and electric vehicles has led to a surge in development activities in so-called "advanced battery storage systems" to support the integration of renewables in the power sector[1]. Furthermore, flywheel technologies, adiabatic compressed air energy storage (CAES), supercapacitors, and superconducting magnetic energy storage systems

[1] An overview of battery storage technologies for renewables can be found here: http://www.irena.org/DocumentDownloads/Publications/IRENA_Battery_Storage_report_2015.pdf

(SMES) are electricity storage technologies that are used to support the integration of renewables into the power sector.

In the blueprint of IRENA's electricity storage roadmap - which was shared with the workshop participants ahead of the meeting – IRENA concludes that there is no single policy that can address electricity storage for renewables. Instead, IRENA identified four separate opportunity areas where electricity storage developments will impact a transition of the power sector towards renewables. For each of these four opportunity areas, IRENA identified key action items that need to be addressed to ensure that electricity storage developments will support renewables deployment. Table 1 provides an overview of these four application areas and key action items.

Table 1. Proposed opportunity areas and key actions needed for electricity storage for renewables.

Opportunities	Actions
1. *Opportunities in minigrids; islands and remote areas*	1.1 *Action 1: financing upfront capital costs*
	1.2 *Action 2: local value chain creation*
	1.3 *Action 3: global database of projects, experts, and technology providers*
2. *Opportunities at the consumer side; residential and industrial customers*	2.1 *Action 1: Improved information sheets and labelling for residential/industrial electricity storage systems*
	2.2 *Action 2: Improved and accelerated standards development for safety and system performance*
	2.3 *Action 3: Regulation on ownership and liability*
3. *Opportunities at the generator side*	3.1 *Action 1: Innovative regulation and incentives for renewable energy power generators*
	3.2 *Action 2: Support for localised/distributed systems*
4. *Opportunities in transmission and distribution networks*	4.1 *Action 1: Expert webinars for policy makers*
	4.2 *Action 2: National systemic economic assessment tools to identify cost-competitive applications of electricity storage*
	4.3 *Action 3: Support for demonstrating new business models*
	4.4 *Action 4: Advanced models for assessing electricity storage as part of wider system*

1.2 Structure of the workshop

The workshop was subdivided into five sessions: one session for each of the priority areas and a concluding session. Workshop participants received the blueprint ahead of the workshop, and were invited to prepare short interventions for one or more of the action items addressing the following three questions:

- What is your assessment of the relevance of a particular action item? Do you agree/disagree? Do you see other action items that are more pertinent?
- Any practical obstacles that you may foresee?
- The specific role that you and other stakeholders could play in this (or your suggested) activity moving forward?

2. Results of the workshop

These proceedings will discuss the inputs per session (priority area) followed by a short summary with the proposed steps forward.

2.1 Session 1: Storage in Islands and remote areas.

Islands and remotes areas have been identified as key opportunity area due to their characteristics and high dependence on diesel generation place storage in this context closer to cost-competitiveness. These characteristics place islands and remote areas a key opportunity area for storage development in the short-term.

However, participants did mention the need for cautions. A stepwise approach of implementing renewable energies and storage was suggested that considers the current and future system, but also considers the current constraints. For example, islands that are considering to increase the share of solar PV may want to consider PV fuel saving first to allow for instantaneous penetration up to 50%. Once this is achieved, islands may want to consider PV + high power battery to allow for 100 % instantaneous penetration, and finally PV + mid-term storage that allows for day to night shifting of PV energy, and up to 100 % PV share over the year.

Three key actions were discussed to accelerate the development of storage in these areas.

- **Financing**

Financing is a barrier especially in islands and remote areas due to difficulties to get funding. In this line, cheap financing or innovative financing schemes can turn storage coupled with renewables a cost-competitive technology in diesel-based systems.

Before analysing the financial and technical challenges of the system in order to come with the design of a financing scheme, it is required the development of studies conducted to define what are the needs of the whole system. To start, the first action to stimulate the development of financing mechanisms is to engage policy makers. Government's commitment into the development of policies and financing schemes set the baseline to support the development of RE and storage implementation.

There is a large potential for cost reductions of SHS in Africa (around 50%). It is suggested to analyse the potential cost reductions of storage systems (not only batteries) with their interaction with other renewables technologies such as wind, PV, CSP, etc.

The diversification of storage portfolio will lead to a diversified consumption of services (electricity, desalination, cooling, thermal energy). Financing strategies should not only be focused on electricity storage but also in its interaction with other sectors such as solar cooling, desalination, thermal energy, and industry.

Regarding the importance of financing, it cannot be limited only to upfront financing, but financial models should also consider value creation (i.e. through tourism), or local income creation, and modularity – allowing for learning – renting/leasing/recycling schemes to be developed (creating value chain around storage).

In order to have a greater impact, the design of innovative financing mechanisms should not be entirely focused on a LCOE perspective but it should be complemented with an added value perspective, where supply, reposition and recycling should be taken into account in the analysis. Moreover, financing should be connected to schemes from Climate Change mitigation and adaptation.

Even if recent studies in the US show that storage can be competitive for some grid applications when its real value to the system is recognized, storage is still not contemplated in expansion by many utilities/operators (with the exception of pumped storage) due to lack of knowledge about the technologies and its lifecycle costs. In addition, in market regulated systems aiming to achieve high shares of variable renewables, storage has a difficulty to build a business case due to policy and market barriers. The World Bank is already considering storage technologies in some analysis, and for example, for a VRE integration study done for Mauritius, it was found that an investment in batteries could help to achieve the VRE targets set by the government and reduce considerably the fuel consumption at higher shares of VRE.

Nevertheless, it has been argued that the financing action is still very broad, it should be split in different actions that can be different among them, especially for islands (funding, life-cycle costs).

- **Local value chain**

Accessibility to islands and remote areas with storage technologies is considered a barrier. In order to overcome this, it is important to build a local value chain around storage systems in order to create a sustainable system that can be locally managed. When assessing the local value chain, it is important to make clear that different island systems have different structures and needs (e.g. electrification, SHS, desalination).

Besides the direct benefits of storage systems, the creation of a local value chain around storage systems will work as a way to generate and maximize value of local resources. In terms of local value creation, mobility is an important area to be considered, especially for islands and remote areas. Mobility is the fastest growing market in the storage sector and the implementation of electric motorized vehicles in islands (island-to-island) could be a strong driver for the development and deployment of electricity storage in island systems.

In the creation of a comprehensive value chain, non-traditional stakeholders should be engaged. For instance diesel genset sellers (e.g. Caterpillar) are expanding their business to storage solutions.

The training and empowerment of local human capacity is crucial to create a sustainable system and to maintain it.

- **Database**

It is important to get more information in projects, analysis tools (feasibility, supply) in order to take more informed decisions and clearer for different stakeholders. The development of a database is seen as a key action to provide reliable information regarding storage systems. The database should collect information on costs, vendors, standards, best practices and implementations. It is also important to decide what kind information is needed for islands and remote areas to be included in such database.

The open access of a database will support to standardize processes and to reduce technology costs. Database should share best practices and it is important to frame it within a stepwise implementation.

The global database could be very difficult to compare among different areas and to implement best practices of a given system into other systems, especially due to the drastic differences in market structures and regulatory frameworks. For this reason, it is recommended that database should also consider or mention the regulatory framework in order to have a better understanding of the best practices and to adopt the benefits in other systems.

Additional suggestions

It is suggested that a framework that guides decision makers to different tools to help to calculate the financial effectiveness of the storage systems would be helpful. Such guiding framework could help decision makers to determine which tools to use to calculate the value of energy storage in terms of LCOE and based on specific diesel, PV panel and storage costs in given islands or remote areas. There are modules already available such as HOMER, RETScreen (RETScreen is a decision support software to help evaluate the viability and performance of renewable energy projects) or the simulation tool for island energy storage developed by Reineir Lemoine. However, it is necessary to ask developers for archetypes so that they can be applied to different situations, especially the consideration of storage systems to assess its impact and viability in the system. Tools could be part of database or be in a separate action item in the roadmap.

Tools can only support the decision making process, afterwards specific methodology and logistics is needed on case by case basis. Logistic is not a model or tool issue but it is a more site-specific issue. It requires more working into case-to-case because different places (especially islands and remote areas) have characteristics that cannot be generalized to be included into models and tools.

In order to make the database constantly valuable it has to make sure that the database is up to date; taking into account that collecting data may be challenging to obtain and make this information public in a useful way.

Next steps:

- Make clearer the scope of the financing action: Financing action is still very broad, it should be split in different actions that can be different among them, especially for islands (funding, life-cycle costs, and cost-and-benefit analysis).

- Add an action item on tools: Provide a tool to help to calculate the financial effectiveness of the storage systems based on specific diesel costs, PV panel costs, storage costs. This tool should not be focus entirely on LCOE analysis but it should also consider an added value perspective and evaluate the interaction of storage with the whole system.
- Expand database: it can be structured by a series of activities. It should also include videos to describe specific processes, policies, system specifications and procurement process (contract procedures). This last item will help serve as a starting point for policy makers that want to implement storage solutions.
- Broaden the scope of stakeholders to involve: diesel gensets manufacturers.
- Make clearer that even though islands and isolated systems are analysed in a separate section due to their potential for storage development in the short term, they do not require a completely different analysis and actions to larger systems; in fact most of the actions from other opportunity areas are also applicable for these systems.

2.2 Session 2: Consumer-located storage

The abruptly reduction of solar PV system costs have boosted its large deployment at the residential level. For this reason, the consumption side has been identified as an opportunity area to exploit the deployment of electricity storage systems coupled with VRE generation in a distributed manner. Three key actions were discussed to accelerate the development of storage in this area.

- **Information Sheets**

The greater participation of the consumption side in the evolution of power systems can be maximized with the integration of storage systems. Information sheets facilitate the communication to consumers of the characteristics, limitations and benefits of storage systems, especially to households.

In order to be useful for the consumption side, information sheets must be able to translate technical information into understandable and applicable information. This will transform technical data into a value proposition that can be incorporated by households into their decision making process.

The information sheets should not only include information regarding the storage component (say battery) but it should also consider the other components of the system such as inverters, charge controllers or other hardware.

One of the main issues with energy storage is the lack of information on operational data, life of equipment and life cycle costs. Therefore, any effort to disseminate knowledge and standardize tests and performance requirements for specific applications that allow operators to compare technologies and discriminate types of manufacturers may help storage to be considered as part of expansion plans, and be properly modelled by planning tools in different points of the system.

Adequate labelling is also key in the process to inform consumers about the characteristics of storage systems in order to make the decision making process more transparent and informed.

- **Standards**

The process of creating standards should be accelerated in order to support the deployment of electricity storage in the consumption side. One of the main aspects that have captured the attention in the development of standards is the safety concern. In this regard, standards should consider issues like safety installation, fire responding and safety operation.

The fact that consumers can turn into generators should be also conceived in the development of standards. There is not standardization in the generation of electricity for self-consumption at the residential side and therefore it is important to make an emphasis in the development of standards for functionality aspects that ensures that storage applications can be implemented at different levels. Moreover, consumer's impact goes beyond the consumption and generation (prosumers), it can also impact in the provision of services for the grid operation. Every electricity storage system located at the consumer side should support the operation of the grid. For this reason, standards should be more inclusive and cover a wider range of aspects than what they are currently focused on, which are mainly safety and performance. The development of functionality standards and an institutional framework can ensure that storage application can interact in unison at different levels in the power systems` (consumers/generators, T&D).

Regarding the possibility of storage systems to provide services for grid operation at the residential level poses new requirements from the consumption side that should be standardized in order to guarantee a safety operation of the system. One proposal to achieve this is by developing grid codes for PV storage systems at the residential level to guarantee the stability of the grid. Creating grid codes in the consumption side will help to improve the development scheme for storage systems.

Besides standards for safety, performance and functionality, it was also suggested to make a special emphasis on recycling standardization. This is under research and requires a greater attention because is a critical issue with the uptake of storage and PV (especially for those with short-to-medium lifetime).

A crucial step for the development of standards is an assessment of the current standards or standards committees in place, and identify existing gaps. International standard bodies should be encouraged to identify standards that will achieve specific objectives. For example, the standards for energy storage could: enhance safety, smooth permitting for storage installation, facilitate equipment standardization, facilitate communication protocol standardization, etc.

Finally, meeting standards is much more difficult than simply establishing them. A procedure should be implemented that supports institutions in order guide the accomplishment of standards.

- **Ownership Regulation**

The opportunity to use electricity storage systems to support the growing trend of electricity generation for self-consumption at a residential level raises the concerns of who will own the assets and what would be the most effective ownership structure (leasing, full ownership, shared ownership). Liability and risk are also key aspects that have to be addressed when designing the ownership structure.

Given that on the consumption side it is also possible to have prosumers that can generate electricity for self-consumption and for provision of services to the grid, there should be a clear regulatory framework that considers these benefits and challenges and reflects the value of storage both for households and the system as a whole. In this regulatory framework, it is crucial to design an ownership structure that defines the borders of each actor in the operation, liabilities and benefits of storage systems. The design of an adequate ownership structure could therefore provide incentives for the effective participation of consumers in the power sector (for instance using an aggregator structure).

In order to foster the adoption of electricity storage systems at the residential level it is crucial to define a clear ownership structure that specifies the way consumers are going to perceive the value of using storage applications and how they are going to be remunerated. In this line, a transparent ownership structure is a key component that is assessed by financing institutions in order to provide funds for storage applications at the residential level.

There are other concerns that should be tackled when designing an ownership structure. The large and decentralized deployment of storage systems at a residential level will pose the problem of who should be in charge of their operation and dispatch. There are several structures to determine the dispatch of storage devices such as being managed by the system operator, aggregators or households themselves. When making this decision, the system should be analysed as a whole rather than from a consumer-alone perspective. Moreover, the ownership of data and information is also a key issue that have to be considered in order to elaborate a reliable business model. Privacy concerns become significant when defining ownership of data (i.e. who owns the data, who can have access to the data and what can they do with it).

Next steps:

- Include labelling in information sheets.
- Include the importance of functionality standards in the residential side as means to maximise its participation, to support in the grid operation and to ensure the efficient interaction of storage applications at different levels.
- In order to have a more impactful action in standards, it will be beneficial to add what international standard bodies should be working on standards development for energy storage? And identify what specific standards or standard areas are deemed to be deficient? One suggestion might be to rewrite the standards action as "encourage efforts at international standard bodies (naming them) to identify standards that will achieve specific objectives (mention them). For example, the standards for energy storage could: enhance safety, smooth permitting for storage installation, facilitate equipment standardization, facilitate communication protocol standardization, etc.

- In order to determine the impact of storage on the grid, it was suggested to assess or create a database/map of studies that analyse what levels of ancillary services can be provided by renewable at different levels of penetration and how it is affected with the implementation of storage (best practices).
- Make an emphasis in standardisation of recycling.
- Ownership regulation action will be expanded to ownership of data/ safety / recycling.

2.3 Session 3: Generator-located storage

Storage applications at large scale have a big potential at the generation side, where storage can help to smooth the production of variable renewables, flatten the generation load, reduce curtailments of cheap undispatchable technologies (e.g. wind and solar PV), efficiently manage the interaction of different technologies' generation, among others. Two main actions have been identified in order to foster the development of electricity storage systems at the generation side.

- **Innovative regulation**

Suitable and innovative regulation frameworks are important all along the value chain. Due to the large deployment of variable renewable energy generation, it is crucial to come up with regulation directed to the generation side that values the importance of system's flexibility. The design of such a regulatory framework will have an impact on the development of storage systems at the generation side.

There is a wide range of benefits of storage systems at a large scale that have to be analysed before designing innovative regulation. In the case of India, large scale storage integration of grid-tied storage is with the purpose of supplying electricity to those areas where there is no electricity 24h due to low resources or low interconnection capacity. Moreover, in India there is not a lot of flexible generation in place (mostly base load generation). For these reasons, storage should not be considered as a solution that is only relevant for the integration of variable renewables, but its value added to the system as a whole – include improved provide reliability, efficiency, and cost-effectiveness – should be considered.

Before the design of a regulatory framework, there should be a deep analysis to make clear what the reasons for regulation are. Some of the reasons that might be evaluated are generation smoothing, time-shifting, ancillary services provision, limiting power injection, production forecasts or a combination of them. It is important to bear in mind that innovative regulation should also impact on other areas in the value chain besides generation and therefore new opportunities or barriers will be created in the development of electricity storage systems.

Different approaches of regulation will affect stakeholders in different ways. For instance, from a developer's perspective, the impact of regulation on 'Performance Ratio' (P90) is the main criteria to adhere to these rules and will consequently affect their way to develop electricity storage systems. Performance ratio regulation is crucial in the profitability of storage because it fosters the development of more efficient technologies, contrary to a total capacity regulation approach.

A suggested action to be evaluated and put in place is to share regulation best practices, such as grid codes, and assessment of their impacts in order to have a baseline in the development of innovative regulatory frameworks around the world, taking into account the site-specific condition of regulation policies.

A good practice that was discussed was the case of French islands regulation. The regulatory framework offers *Feed-In Tariff* (FIT) for those wind power plants that are coupled with storage and requests for a flat trapezoid pattern for solar generation. In this sense, regulation requests constant ramping rate, predictable renewable generation and limited variation and fluctuation around the mean value. For most of these requirements, the implementation of electricity storage systems is highly valuable or even mandatory.

In order to facilitate the progress of emerging technologies in the most efficient way, it is suggested to develop an innovative regulatory framework that promotes the development of technologies in terms of functionalities and do not lock-in to specific technologies.

Nevertheless, it is important to take into consideration that if penalties are too strict, it might evoke strategic behaviour, as it is the case in French islands (e.g. it might be more convenient to shut down plants rather than to continue operating them and fall into high discrepancies with the pre-defined pattern that will bring big penalties). To overcome these situations, new regulation has been adjusted in order to align the interests and incentives of generators with what the regulator decides it is needed for the safe operation of the system.

- **Localised/distributed systems**

The support of localized/distributed systems that are able to operate, maintain and balance a local system in an autonomous way will impact on the development of storage system at a large scale. In this action item, it was identified that capacity building is crucial for the development of localised/distributed systems. Besides training personal to maintain and operate the system, it is even more important to train trainers to continue the capacity building loop and establish the basis for knowledge creation and sharing *in-house*.

Next steps:

- Financial indicator to assess the impact of regulatory measures is crucial.

2.4 Session 4: T&D-located storage

The storage applications have an impact on the way grids are operated and therefore transmission and distribution systems represent an opportunity area for the development and deployment of electricity storage systems. In these areas, storage can help to relieve transmission congestions, defer T&D upgrades, provide voltage and frequency control, among others. Four actions have been identified in order to foster the development of electricity storage systems at transmission and distribution.

- **Engage policy makers**

The process of development of electricity storage as means to accelerate the deployment of renewables require the active engagement and commitment of policy makers. It is crucial to connect many policy makers into the process by educating them and to identify those "*champions*" and inspiring them in creating adequate regulatory framework and environment to boost the implementation of RE and storage. In the process of engaging policy makers, the one-to-one interaction is crucial.

In order to facilitate the engagement of policy makers, a broad and understandable set of tools and information should be provided to them to foster their active involvement in the development of RE and storage. This information should be well structured to 1) identify the fundamental reasons why storage is needed, 2) determine the applicability of storage at a given level, 3) identify alternatives to storage, and 4) identify what are the barriers to value storage. This information can be complemented with best practices and examples to show what can be achieved.

An eight-step process for engaging policy makers was proposed:

1. Step zero: make policy makers to think about storage technologies, catch their attention. This can be done with the development of webinars and workshops that raise new ideas in them.
2. Connect with stakeholders and start building up the storage development plan with them: Educate them, discuss challenges and strengths of ESS for the system, review potential drivers for storage/flexibility in the region (e.g. renewables penetration, fuel prices, GHG policy, transmission constraints, etc.), consider key grid needs and structure, identify financing hurdles.
3. Determine regionally appropriate applications, based on successful applications implemented elsewhere.
4. Identify alternatives to storage.
5. Independently model storage applications vs. alternatives.
6. Reconvene; prioritize applications with greatest benefit.
7. Determine the barriers to applying storage in high priority applications.
8. Work with stakeholders to build practical implementation plans.

All steps should be based on regional-specific inputs and each step should be complemented different best practices, tools, etc. to inform decision process.

California represents a practical example of the successful involvement of policy makers in the development of a regulatory framework to support the progress of RE and storage. In California, policy makers involved and understood VRE technologies, storage and other applications. All this turned into a robust and complete development of a regulatory framework.

The process of engagement of policymakers is iterative and dynamic with the complement of information and tools to support the decision making process and the establishment of regulatory framework.

- **Systemic economic assessment tools**

This action item is based on a tool that has been developed for California to set the targets for their energy storage mandate. However, participants suggested that this action item should be broadened. For example, this action item should also consider or help guide new rules and markets for energy storage, such as the new provision by FERC and ERCOT in the United States. Therefore, it has been suggested to rename this action item into "*Provide value assessment for storage* ".

By broadening this action item, it should also be mentioned that the value is very specific to the characteristics of the market that is being examined. For example, the generation mix, over- or undersupply, the institutional structure of the power sector (market, regulated, government-owned) and the existing grid infrastructure are key parameters to consider while assessing the value. Although valuation of storage systems is very specific to each region and its conditions, this value assessment should provide an approximate picture of what would be the perceived value of storage systems.

The development of value assessment tools is helpful to measure the value of electricity storage systems and to assess their economic profitability in order to support an efficient decision making process. This could facilitate the setting of targets (and mechanisms to achieve those targets), or help in establishing new (market) rules or regulation impacting energy storage. In the design of such value assessment tools, externalities should also be calculated and included into the analysis in order to have a broader – and closer-to-real – valuation of storage systems.

Given the intrinsic uncertainty and dynamics of the power systems, stochasticity should be considered by the assessment tool. Stochasticity should be reflected in weather patterns, demand, investment decisions, fuel prices, etc.

- **Support for business demonstration projects**

Technical demonstrations are already in place, however, demonstration projects are required to measure the impact of storage systems upon T&D and the system as a whole. Some of the actions that can foster the implementation of business demonstration projects are the development of roadmaps – e.g. China system flexibility roadmap where EV is a major part, Request for Proposals (RFP) – e.g. French islands and Puerto Rico – and Expression of Interest (EOI) – e.g. Indian EOI for Energy Storage Demonstration Projects for Supporting Renewable Generation.

- **Modelling electricity storage as part of a wider system**

Due to the cross-border impact of storage systems, the analysis of storage should be supported by modelling and considering the whole system and its interaction with related systems such as electricity/heat, electricity-to-gas, electric vehicles, etc. The impact of storage on these systems results in additional market segments that need to be considered. Models will help to assess the value of storage from a cross-border system perspective (broad valuation). Furthermore, planning models will need to be combined with dispatch models and pricing models. However, some data is simply not available and therefore should be estimated in order to be included in the modelling process (e.g. 30 year data on meteorological impacts on solar PV production).

There are some practical examples of models of electricity storage systems as part of broader systems. For instance, in Germany there are already systemic models in place that comprise the interaction between different actors and applications.

Similarly to the development of systemic economic assessment tools, the development of cross-system models should be adapted to the specific conditions of each region.

Next steps:

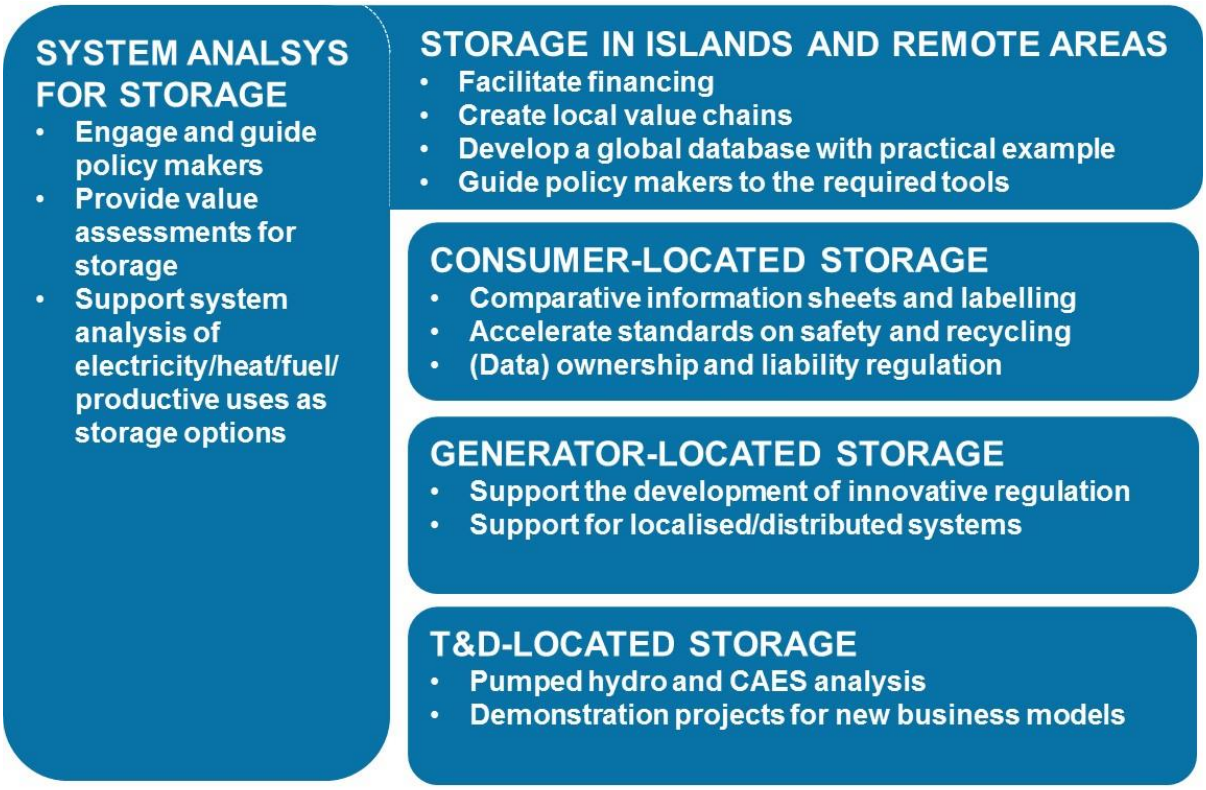
- Engage and guide policy makers should be covered from a system perspective impact rather than only from a transmission and distribution perspective.
- Due to the large capacity and storage duration of pumped hydro and CAES, an analysis of these technologies deserves an additional action item in this section.
- The development of systemic economic assessment tools should be covered from a system perspective impact rather than only from a transmission and distribution perspective.
- The analysis of electricity storage as part of a wider system with models that comprise the interaction of different systems should be covered from a wider perspective rather than only from a transmission and distribution perspective. Some of the sectors that should be analysed are power sector, electricity/heat/fuel relationship, power-to-gas and transportation (EV).

3. Conclusion of the workshop and restructuring of the roadmap

After the feedback and insights received from all the participants, one of the comments that was repeatedly suggested during the workshop is the need for a section that undertakes a systemic perspective and comprises a set of actions that are relevant and have an impact on the different opportunity areas previously proposed (i.e. islands/remote areas, consumer side, generation side, T&D). Furthermore, participants suggested to highlight the role of pumped hydro stations more as it is and will remain one of the most important options for the integration of variable renewable power generation.

The new structure proposed for the roadmap includes an initial section called "System Analysis for Storage". This section includes a set of actions that impact upon the system as a whole and should be taken into consideration when carrying out the actions on each opportunity area. The section includes the actions 1) engagement and guidance of policy makers, 2) provision of systemic economic assessment models, and 3) support system analysis of electricity/heat/fuel/ productive uses as storage options.

Figure 1. Suggested structure for IRENA's electricity storage roadmap.



The "System Analysis for Storage" section will include the importance of creating mechanisms (such as markets or incentives) to value flexibility at a system and local level. Flexibility is crucial for the integration of renewable energy in power systems. The efficient valuation of flexibility in the power systems will change the way to do business and positively impact the development of electricity storage systems (however, it is important to take in mind that storage is only one out of several technologies that provides flexibility). The reason for the need for valuation mechanisms of flexibility is that market designs are not at the level to provide such valuation yet.

Another aspect that will be included in a new section is the need for an analysis, from a systemic perspective, of combining different technology options (VRE, storage, DR, etc.) and assessing their interaction and impact upon the system.

Moreover, there were some actions that were suggested to be added, removed or restructured into the roadmap. In the section dedicated to islands and remote areas and action "Guide policy makers to the required tools" was added

In the T&D-located storage a "Pumped hydro and CAES analysis" was added.

It was suggested to outline the technologies that can be used in each segment of the system, and the current status (commercial, pre-commercial, under development).

Some suggestions regarding the structure and scope of the roadmap:

1) Clarifying the audience for the roadmap and tailoring the roadmap to this audience could increase the impact of the document. Who is the audience for this roadmap? Governments? Regulators? Policy makers? Utilities? Grass-roots?
2) Clarifying the geographic region for the intended audience could also increase the impact: Many regions have different fossil and renewable energy mixes, some have over-generation issues and some have under-generation issues. Understanding what region(s) this roadmap is targeting can help make the roadmap more impactful.
3) Identifying key stakeholders by name or loose group affiliations (e.g. utilities in the country or region of interest) could allow for more direct engagement with those organizations.
4) The content deemed most critical to the successful deployment of energy storage should come first in order to have a more impactful roadmap.

4. Next steps

Based on these proceedings, IRENA will be preparing the final draft of its electricity storage roadmap. This final draft will be shared with all workshop participants for the last round of feedback.

The aim is to present IRENA's electricity storage roadmap to policy makers during IRENA's Council meeting in June 2015.