European Commission

Enabling energy storage projects

A toolkit for just transition regions

December 2023

Regional and Urban Policy

Enabling energy storage projects – A toolkit for just transition regions

Contents

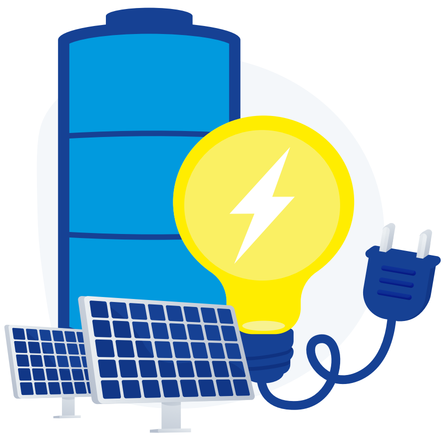
1. Aims and scope

This toolkit is intended to provide decision-makers with information on different types of energy storage systems as well as guidance on how to implement and integrate storage systems into their energy systems. Energy storage is key to enabling wide-spread renewable energy supply while ensuring high security of supply as well as decarbonising energy demand, making energy storage an essential factor in achieving net-zero objectives.

2. Who is this toolkit for?

The toolkit is aimed at local and regional authorities and decision-makers in JTF regions.

3. Key takeaways



- ✔ Energy storage can serve to ensure grid flexibility, stability and reliability
- ✔ Energy storage system performance, safety characteristics, and affordability have improved through technological advancements, meaning they are becoming increasingly compelling and cost-effective
- ✔ Energy storage is highly relevant for carbon-intensive and coal regions[12], as it provides a cleaner alternative to hard-to-abate industries and the traditional fossil-fuel powered thermal plants for flexibility services
- ✔ Energy storage projects represent new employment opportunities for former coal+ or carbon-intensive workers in JTF regions.

4. Energy storage and energy transition

As European countries strive to transform their energy systems, policymakers, regulators, and energy sector planning agencies are increasingly faced with complex decisions about developing reliable, affordable, and clean energy systems. Decarbonising the European energy system poses new challenges, such as increased energy demand coupled with intermittent energy supply, which can result in a mismatch between energy supply and demand, and cause supply interruptions such as power cuts.[3] An increasing number of variable renewable energy (VRE) sources, such as wind and solar power, in combination with the retirement of dispatchable, conventional generation units mandate greater grid flexibility and responsiveness in order to facilitate stable energy supply. System flexibility is particularly needed in the EU's electricity system, where the share of renewable energy is estimated to reach around 69% by 2030 and 80% by 2050.[4] Energy storage is a key flexibility tool to help address these challenges, as it can serve to ensure grid stability and reliability[5], manage voltage fluctuations and frequency control, and provide operating reserve, i.e. electricity supply that can quickly be made available in case of an unexpected loss of power generation.[6] Energy storage technologies can also facilitate the electrification of different economic sectors, such as buildings and transport while simultaneously providing greater grid stability and flexibility. Energy stored in electric vehicle batteries can be used to power homes at moments of low energy supply or can be used as a tool to absorb excess electricity in times of high renewable generation and low demand. Technological advancements in energy storage systems have also improved storage system performance, safety characteristics, and affordability, meaning these systems are becoming a compelling and increasingly cost-effective alternative to conventional flexibility options such as retrofitting thermal power plants or transmission network upgrades. This is particularly true for lithium-ion battery energy storage, the cost of which has dropped by 89% in the last decade.[7] As such, grid-connected energy storage has gained the attention of power utilities, regulators, policymakers, and the media across the world as a technology to provide cost-effective grid services and enable increased deployment of variable renewable energy (VRE) sources.[8] In Europe, energy storage to date remains below 60 GW of installed capacity, mainly in the form of pumped hydro storage, but is expected to increase by over 3-times by 2030 and 10-times by 2050.[9]

5. What is storage?

Energy storage is the process of accumulating energy in particular equipment or systems so that it can be used at a later time, either when companies and sectors need to save energy or when demand increases, or grid outages occur. Energy storage always maintains the supply-demand balance for consumers and prevents challenges such as inconsistent power and sudden price surges through frequency regulation and flexibility ramping.[10] The storing of electricity typically occurs in chemical (e.g., such as lead acid batteries or lithium-ion batteries) or mechanical means (e.g., pumped hydro storage). Thermal energy storage systems can be as simple as hot-water tanks, but more advanced technologies can store energy more densely (e.g., molten salts, as used for concentrated solar power projects).[11] Storing energy will always be accompanied by energy losses, which is described by the efficiency of different energy storage types.

6. Why should JTF regions consider storage projects?

Energy storage is of particular relevance to carbon-intensive and coal regions[12], as it provides a cleaner alternative to hard-to-abate industries and the traditional fossil-fuel powered thermal plants for flexibility services. At the moment, fossil-fuel power plants (such as gas and coal plants) largely provide flexibility services for the energy systems and as fossil fuels are phased out, alternatives to provide this flexibility will be needed.[13] Energy storage is a key source for flexibility system services.[14] It can replace coal plants in ensuring grid stability and the adequacy of power systems by supporting the ability of available electricity supply to meet demand in all hours of a year, as well as providing system flexibility by matching energy supply to needed energy demand.[15] Energy storage projects can also create employment opportunities for former coal+ or carbon-intensive workers in JTF regions. Energy storage technologies require extensive value chains, from research labs and raw materials providers, to manufacturers, project developers, installers, companies, and many more.[16] Increased efforts to strengthen local value chains for energy storage will create new jobs in the energy sector.[17] Analyses show that over 10 million people were employed in the global advanced energy industry in 2017 from all backgrounds, disciplines, and skill levels, and that market growth could support 24 million jobs by 2030.[18]

7. What kinds of conditions are key for storage projects?

Connectivity

To ensure effective implementation and operation, energy storage facilities need to be well-connected to the energy grid, with transmission lines that can handle high-transfer loads. When possible, energy storage planning should aim to reduce transmission distances between supply and demand sources as much as possible to reduce energy losses related to energy transmission.

Location

When determining the location of energy storage facilities, the focus should be on reducing transmission distances between supply and demand sources as much as possible, to reduce energy losses related to energy transmission. Due to this, energy storage facilities should either be located in proximity to high-energy demand locations, such as industrial centres, or in proximity to energy generation facilities, in particular renewable energy sources, which tend to have fluctuating energy output. Another factor to consider when developing energy storage projects are which environmental conditions which are necessary for development of certain types of energy storage technologies.

Supply and demand

Energy storage projects are of particularly relevant for regions with high energy demand and/or variable energy supply, as they can provide flexibility system services.[19]

Duration need

The duration of an energy storage device often determines which services it can provide. For example, some energy storage technologies like flywheels and supercapacitors have short durations on the scale of seconds to minutes, making them better suited for applications that require quick reaction times for limited timespans (e.g., fast frequency response service), while other technologies, such as compressed air energy storage or pumped storage hydropower may react more slowly but can maintain output over the course of hours or even days, making them better suited for longer-duration applications (e.g., providing peak capacity and overcoming seasonal energy production variability).[20]

Environmental conditions (either benefiting[21] or limiting[22] factor)

Several environmental conditions need to be considered when examining different types of energy storage technologies. These conditions can either be beneficial, such as the availability of salt caverns suitable for retrofitting, or limiting, such as the need for elevated terrain to develop certain types of energy storage projects.

8. Challenges and opportunities

High upfront costs – Challenge

A significant challenge faced by the majority of energy storage projects are high upfront investments needed, before the projects become operational and begin generating revenue.[23]

Retrofitting of power plants – Opportunity

A unique opportunity for developing energy storage projects is through redevelopment and retrofitting of existing thermal power plants. In this way, existing infrastructure such as cooling towers can be utilised, reducing overall investment costs and making projects more economically viable.

New sources of revenue generation – Opportunity

With the advent of variable renewable energy sources, energy storage projects represent a unique economic opportunity for new sources of revenue generation.

Reskilling and upskilling of the workforce – Both challenge and an opportunity

Energy storage projects, alongside of renewable energy installations, will have new workforce needs, which will generate employment opportunities in the regions. For regions in transition, this will also represent opportunities for reskilling and upskilling of the existing workforce.

Grid infrastructure upgrades (Challenge)

To facilitate energy transfers to and from energy storage facilities, grid infrastructure will need to be upgraded and new transmission lines and electrical substations constructed simultaneously alongside development of energy storage projects.

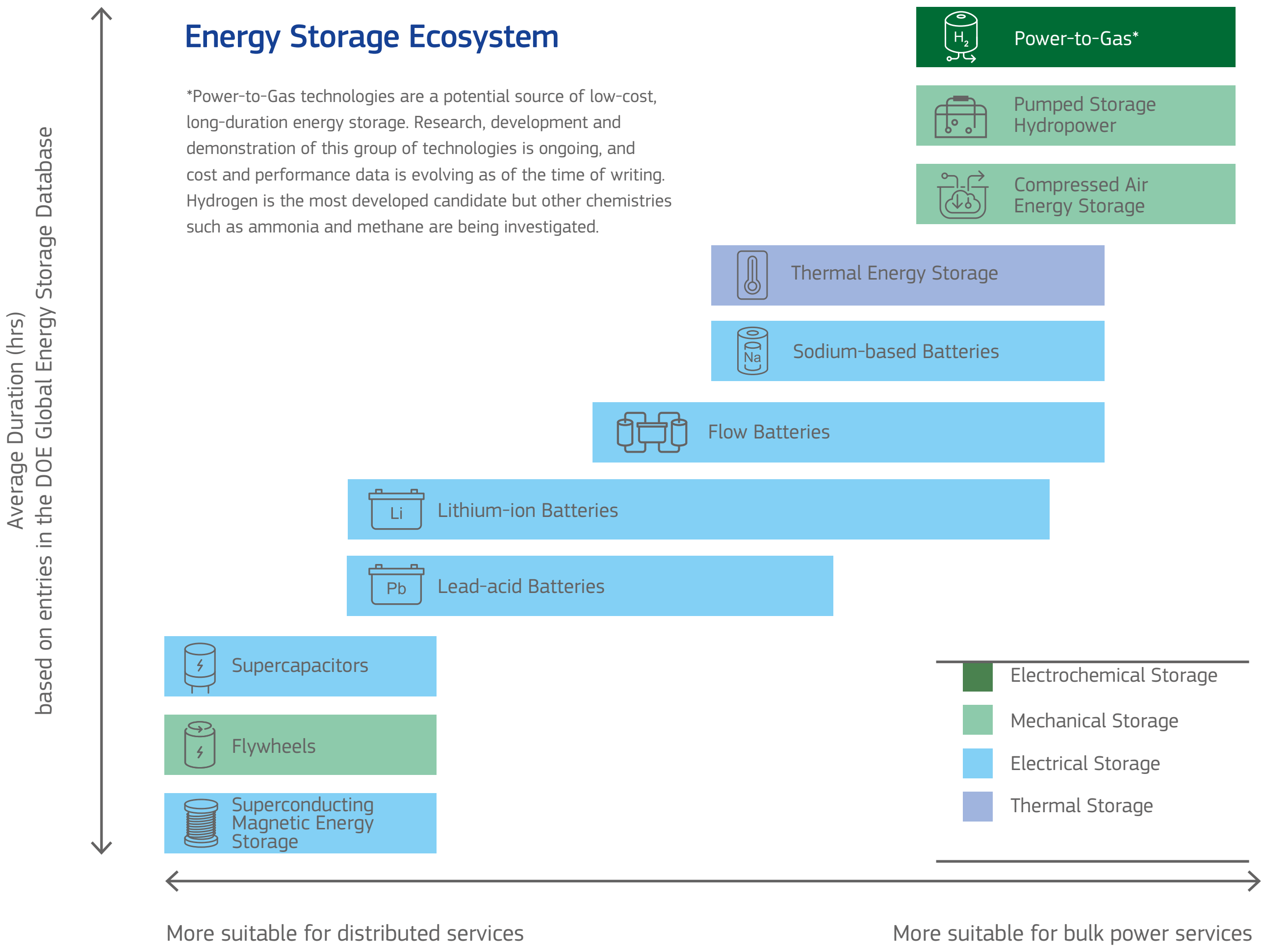
9. Key types of energy storage

Given the various kinds of storage technologies, this toolkit provides an overview of the most commonly used types of energy storage, as well as some of the most prominent emerging technologies, which have passed the pilot phase and are available on the market. The focus of the overview is to highlight different types of technologies and services they provide. Technologies are further assessed from the perspective of cost, energy efficiency, energy capacity, and the duration of storage cycles – whether they can be utilised for hourly, monthly, seasonal, or annual storage. In terms of energy capacity, pumped hydro storage, compressed-air energy storage and molten-salt thermal storage have the highest capacity, however these technologies are also limited by environmental factors when it comes to their implementation and scalability. In terms of cost efficiency, battery and thermal storage technologies tend to be the most affordable as demonstrated by the below table.

Technology type		Cost (€/kW)	Energy Capacity	Efficiency(%)	Duration	Environmental limitations
Battery (Li-Ion)	electrical	150 – 1300	< 10 MWh	90 – 100	Short to mid-term (10 min to 4 hours)	No
Battery (Na-S)	electrical	2000 – 3000	< 100 MWh	90 – 100	Mid-term (up to 6 hours)	No
Battery (Lead-acid)	electrical	100 – 500	< 10 MWh	90 – 100	Mid-term (Several hours)	No
Battery (Flow)	electrical	500 – 2300	< 100 MWh	90 – 100	Mid-term (Several hours)	No
PSH	mechanical	500 – 1500	1 – 100 GWh	50 – 85	Long term (Daily to seasonal)	Yes
CAES	mechanical	400 – 1200	10 MWh – 10 GWh	27 – 70	Mid-term (hours to days)	Yes
Flywheels	mechanical	500 – 2000	5 – 10 KWh	N/A	Short term only (5 – 30 minutes)	No
LWS	mechanical	N/A	Variable depending on application	65 – 90	Long term (Daily to seasonal)	No
Hydrogen	electro-chemical	2000 – 5000	Up to 100 GWh	30	Long term (Daily to seasonal)	No
Hot water	thermal	100 – 4500	Variable depending on application	50 – 90	Mid-term (hours to days)	Yes
Molten salt	thermal	100 – 700	3 GWh	40 – 93	Mid to long term (10 hours to seasonal)	Yes

Source: Based on data from the US Department of Energy, 2019[24] and IEA, 2014[25]

An overview of different energy storage projects is provided below:



Source: USAID, 2021[26]

9.1 Electrical storage

Battery storage (Li-ion, Sodium-sulphur, Lead-acid, Flow batteries)

Batteries can be used to provide short-term flexibility to the energy system. Unlike other energy storage systems, such as pumped hydro storage, batteries do not require any specific environmental conditions. Therefore, they have the advantage of geographical and sizing flexibility and can be deployed and scaled closer to the location where flexibility is needed. Storage duration varies between different types of batteries, ranging from 1, 2, 4 and 8 hours. There is no limit to the installed capacity of battery storage, and utility-scale battery storage systems typically have a storage capacity ranging from around a few megawatt-hours (MWh) to hundreds of MWh. In recent years, lithium-ion batteries have claimed the highest percentage of both market growth as well as market share, followed by sodium-sulphur batteries, and to a smaller extent, lead-acid batteries.[27] In 2017, li-ion accounted for nearly 90% of large-scale battery storage additions.[28] Utility-scale battery storage systems can be used to provide key services needed for the operation of a system with high shares of VRE.[29]

Lithium-ion batteries have largely become the standard for battery energy storage systems and their technological improvements have been further accelerated by the rise of electric vehicles (EVs). They have a broad range of applications and can be deployed in both end-use appliances (e.g. electric vehicles) and at grid-scale. In power grids, they have mainly been used for power grid services such as frequency regulation and flexible ramping and are increasingly considered as support for VRE.[30]

Sodium-sulphur batteries are a molten-salt battery made up of sodium (Na) and sulphur (S) which can operate at high temperature ranges and are primarily suitable for applications with durations above 4-hour periods. They are a mature technology and have been deployed at grid-scale in several regions in the recent years, from Buzan, Japan[31], Dubai and Abu Dhabi, UAE[32], to Antwerp, Belgium, and Ludwigshafen, Germany.[33] They are available at a similar to slightly lower cost in comparison to li-ion batteries. However, sodium-based batteries have a few disadvantages including that they cannot hold a high charge for a long period of time and have shorter operating lifecycles.[34]

Lead-acid batteries are available at a lower cost than lithium-ion batteries. However, they have several disadvantages, such as lower energy density, shorter operating lifecycle, and low scalability (i.e., they cannot be used on a multi-MW and GW-scale). Due to this, their market share has been taken over by lithium-ion batteries.[35]

Flow batteries are large, rechargeable batteries with massive external liquid electrolyte tanks that hold a charge. They are available at a comparatively higher cost, however, they come with several key advantages. They have a longer lifespan than other batteries, ranging between 20–25 years, and can provide nearly unlimited recharge cycles. They also consist of cheaper and more abundant materials, such as iron, salt, and water, which makes them more readily available, and they can be deployed in a range of sizes and locations to provide grid services. The downsides of flow batteries are the use of expensive fluids which can be corrosive or toxic, as well as high onsite electricity demand associated with operating the pumps of the battery system.[36]

Box: Case study from Germany

ESS Tech, a US producer of iron-based flow batteries, has agreed to build a 50 MW storage battery facility for the German energy provider LEAG. The facility will be at the site of LEAG's lignite-fired power station in Boxberg, in eastern Germany, and it is scheduled to begin operating in 2027. ESS has developed an iron-based LDES technology, which is currently manufactured at the company's facilities near Portland, Oregon, USA, and deployed in commercial microgrid systems and utility-scale projects across the US and Australia. According to the company, the facility could store energy at a cost of about 3 cents per kW in optimal conditions.[37]

An overview of each battery types efficiency, reacion time, power density and operating life:

Technology	Round-trip efficiency	Reaction time	Power Density (W/kg)	Operating Life (Number of Cycles)
Lithium-Ion Batteries	86% - 88%	Sub-second to seconds	4.000 - 6.500	1.000 - 4.000
Lead Acid Batteries	79% - 85%	Seconds	30 - 50	500 - 1000
Sodium Batteries	77% - 83%	Sub-second	120 - 600	4.000 to 5.000
Flow Batteries	65% - 70%	Sub-second	0,5- 2,0	12.000 -14.000 (and above)

Source: Adapted from USAID (2021). Grid-Scale Energy Storage Technologies.

9.2 Mechanical storage

Pumped storage hydropower (PSH)

Pumped hydropower energy storage uses excess energy to pump water to an upper reservoir where it can be stored and later released to a turbine at a lower reservoir to generate hydroelectric power. It is the most established and efficient storage technology and can provide large-scale, long-term storage capacity. It is also the most common type of energy storage in Europe as well as around the world, representing 95% of current energy storage capacity.[38] Storage duration ranges from several hours to months, or even years, and can thus serve to counter seasonal variations or unique weather events. Downsides of PSH include relatively high deployment costs, specific environmental requirements for deployment, long construction duration, environmental impacts, and vulnerability to droughts and evaporation, especially in view of a changing climate. It is especially suitable for deployment in high alpine regions, and in Europe, there is still potential for 250 TWh/a new installations of PSH.[39]

Compressed air energy storage (CAES)

The CAES energy storage system uses electricity to compress air. Compressed air is stored and then released when needed, passing through a turbine to generate electricity. This form of storage can be implemented in pressure tanks for small-scale storage or in underground caverns for large-scale storage. CAES is more affordable and cost competitive in relation to other energy storage technologies, such as PHS, and its storage duration can range from hours to days. However, large-scale implementation is limited by specific environmental requirements, as salt caverns are necessary to deploy this form of energy storage technology. In Europe the highest share of CAES systems are deployed in Germany and Poland[40]

Case study in Germany

Kraftwerk Huntorf Compressed Air Energy Storage System is a 321 MW energy storage project located in Lower Saxony, Germany, which was commissioned in 1978. The facility stores the compressed air in two solution-mined salt caverns comprising of a total of 310,000 cubic meters. To form the cavern water is pumped into and out of a salt deposit to dissolve the salt. The depth of the caverns is more than 600m, ensuring the stability of the air for several months' storage and guaranteeing the needed maximum pressure of 100 bar. One cavern is cycled on a diurnal basis. The second cavern serves as a black start asset if the nearby nuclear power plant unexpectedly shuts down. The project was developed by Man Energy Solutions.[41]

Case study in Poland

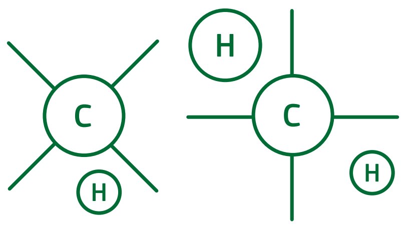
Scientists from the Silesian University of Technology in Poland have developed a compressed air energy storage (CAES) technology using a thermal energy storage (TES) system built into a disused mine shaft, which is effectively repurposed as a compressed air tank. The group sees mining sites as having potential for low-cost energy infrastructure, as it allows the use of existing grid connection infrastructure, and the proximity to highly industrialized areas reduces energy transmission losses. They calculated that the facility's energy storage capacity would be at 140 MWh, with a round-trip efficiency of around 70%, and energy efficiency of 95 % for the heat storage tanks.[42]

Flywheels

A flywheel system converts electrical energy to kinetic energy using a rotating mechanical device, and then reconverts kinetic energy back to electrical energy for instantaneous ramping. This storage system relies on kinetic energy from a rotor spinning through a "nearly frictionless enclosure" which can provide short-term power through inertia. They are commercially available and are particularly useful as short duration storage technology in contexts where fast ramping response and high numbers of daily cycles are needed, such as for management of voltage fluctuations and frequency control. Downsides are that this technology is not always scalable due to the need for rare minerals and complex manufacturing processes, and that it is costly to produce and deploy. A 500kW Flores flywheel project has been in operation in the Portuguese Azores since 2005.[43]

Lifted weight storage (LWS)

Lifted weight storage systems operate by converting electrical energy into gravitational potential energy through raising blocks with a crane, lowering weights underground, or transporting rail cars up a slope. With the opposite action, gravitational potential energy can be converted back to electricity. It can be used for long duration storage as the energy potential doesn't degrade over time and may be available at a comparatively low cost for deployment. Round-trip efficiency ranges from 65% to 90%.[44] A commercial demonstration unit with the storage capacity 20MWh – 80MWh is operational in Switzerland,[45] and the first grid-scale gravity energy storage system was developed in China, which can provide 25 MW of storage at full power for up to four hours, with the capacity of 100 MWh.[4647]



9.3 Electrochemical storage

Renewable hydrogen

Renewable electricity can be stored by converting it to renewable hydrogen or ammonia through the process of electrolysis. These fuels can then either be used directly by the end-use-sectors or stored for later use and conversion back into electricity. When produced with renewable or low-carbon energy sources, hydrogen represents a unique opportunity for the decarbonisation of energy-intensive and hard-to-abate industrial sectors where thermal heat is required.[48] Hydrogen is also suitable for long-term storage and seasonal demand flexibility. The key downside of hydrogen usage for storage is that the process of converting electricity into hydrogen and back again is very inefficient and only around 30% energy content of the initial electricity is retained. A key factor to provide flexibility benefits to the power grid is a cost-efficient method for storing hydrogen. For large volumes and long time periods such as inter-seasonal storage underground, hydrogen storage is more viable than storage in tanks.[49] The four major underground storage types are depleted gas reservoirs, aquifers, salt caverns, and (with a small share) hard rock caverns. Salt caverns are the most suitable for hydrogen storage, both for technical and economic reasons, although this creates an environmental constraint.[50] In the EU member countries, 83% of the salt cavern capacity is located in Germany (140 TWh), and only France (8.1 TWh), the Netherlands (7.9 TWh), and Poland (5.9 TWh) also have sizeable salt cavern storage capacity in place.[51] There is one operational hydrogen storage project in UK, two in the US, and a couple of demonstration projects under development in Europe.[52]

9.4 Thermal storage

Hot water storage

One of the most common thermal energy storage technologies is hot water storage based on the sensible heat of water. A heating device produces hot water outside or inside an insulated tank or storage basin, where it is then stored. Examples of application include underground thermal energy storage (UTES) systems, which pump heated or cooled water underground for later use as a heating or cooling resource. UTES systems include aquifer and borehole thermal energy storage systems, where water is pumped into (and out of) either an existing aquifers or man-made boreholes. Another approach is via pit storage systems that use shallow pits, which are dug and filled with a storage medium (frequently gravel and water) and covered with a layer of insulating materials.[53] A simpler approach is to store energy at households in domestic thermal storage tanks. The stored energy depends on the hot water temperature and on the tank volume. Domestic tanks can store heat for a short period of time (a couple of days maximum). The tank insulation determines the thermal losses and limits the storage period.[54]

Molten salt

Molten salt energy storage operates by storing thermal heat, either directly from renewable energy sources such as concentrated solar power (CSP) or indirectly via electric heaters or heat pumps. Stored thermal energy can later be converted into steam for heating purposes or used to power a steam turbine and generate electricity. Molten salt can be used for storage periods of 10–12 hours or longer.[55] Molten salt energy storage systems can be particularly beneficial for regions in transition, as they are suitable for retrofits, for example as a replacement for coal-fired steam generation parts in an existing coal plant. By utilising the plant's original facilities, such as power block and cooling systems, and adding electric heaters or heat pumps, storage tanks, and molten salt heat exchangers for steam generation, a truly decarbonized generation asset can be created with reduced investment costs compared to a newly built plant.[56]

Case study – Malta Iberia

Malta Iberia was selected by the European Innovation Fund to develop its Sun2Store Pumped Heat Electricity Storage project in Spain. The project has been granted a Project Development Assistance Agreement from the European Union and the European Investment Bank. This project was selected as a viable breakthrough technology that is easily scaled and capable of providing timely, high-impact reductions in greenhouse gas emissions. The Sun2Store project in Spain will provide 100MW of thermal energy storage at a ten-hour duration, providing 1,000MWh of clean energy. The storage solution will be the first of its kind in Europe, combining pumped heat technology with molten salt to provide efficient, reliable, and dispatchable renewable energy. Malta is partnering with Alfa Laval on the heat exchangers and Siemens Energy on the project's turbomachinery.[57]

10. How to develop energy storage projects

Following are the necessary steps regions need to take as part of the process in successfully developing and implementing energy storage projects. These steps are designed to serve as practical guides for the development of a variety of energy storage technologies, however, each individual project may also have specific requirements that go beyond this framework alone.

1. Establish supportive regional and municipal strategies

From the perspective of national and region decision-making, strategies need to be developed to guide, support, and regulate energy projects on the regional, municipal, and local level. To facilitate the adoption and implementation of energy storage projects, energy storage needs to be integrated in the future power system planning and modelling on both national and local level, and it needs to be included in national power market strategies and technological roadmaps, to ensure it is aligned with other developments and future plans. At the same time, policies and wholesale market rules need to be adapted to allow energy storage to receive compensation for a wide range of services it provides. Strategies should aim to address the employment, social, economic, and environmental impacts of the energy transition, and are also a key output of just transition planning. They may include policy and fiscal reform, dedicated support programs, and strategic investments in affected regions.[58]

2. Pre-engineering phase

During this step, energy storage projects would be considered from the perspective of each type of energy storage technology, taking into account their respective pros and cons, such as cost-effectiveness, quality, needs, environmental factors of the region, and satisfaction in meeting the engineering criteria, and determining the most viable type of technology for implementation in the target region.

3. Analysing impacts and benefits

Following the establishment of the energy storage project, its impacts and benefits need to be assessed in detail and with measurable data. This would include viewing the economy as a complete system of interdependent components, such as industries, households, investors, government, importers, exporters, and would also include a cost-benefit analysis. Part of this step would also be local and national environmental assessments, depending on the scale of the project and as mandated by national legal requirements.

4. Tendering, matchmaking and mobilising stakeholders

During this phase the project is put out to tender. This phase includes advertising, answering of bidder questions, holding pre-tender meetings, and opening of a tender for storage projects. Regional and local authorities can facilitate matchmaking events between different stakeholders and service providers to ease and expedite the processes for interested investors and project developers.

5. Business plan

Following selection of the energy storage project and the relevant tender for development, it would be up to the tenderer to develop a respective business plan for the project, including cost-analysis and revenue generation activities.

6. Mobilising financial resources

A decarbonised energy system will require significant investment in storage capacity of all forms.[59] Finance is needed not only at the national level, but also for municipal governments, small and medium enterprises (SMEs), and local communities, and it can cover research, analysis, coordination, stakeholder engagement, and monitoring and evaluation, as well as offset potential revenue losses.[60] One of the key challenges energy storage projects face are high upfront investment needs and a time delay before operational income generation. High upfront capital investment requirements pose a particular barrier in contexts where future revenue streams remain uncertain. As a result, it is essential to establish financial incentives to support the deployment of storage technologies.[61]

There are a number of specific support and financing tools available to incentivise the deployment of energy storage in the EU, financed from both EU's long-term budget as well as from the NextGenerationEU (NGEU) package. At the same time, cohesion policy continues to support Member States, regions and local authorities to invest in energy storage through the available funding of the European Regional Development Fund (ERDF), the Cohesion Fund (CF) and the Just Transition Fund (JTF). Furthermore, energy storage is also eligible for support under the EU Renewable Energy Financing Mechanism (REFM), when deployed in combination with new renewable-energy capacity. Other instruments and funds contribute in some specific territories to the financing of storage, such the Innovation Fund (IF) and the Modernisation Fund (MF). In addition, the Trans-European Networks for Energy (TEN-E) regulation makes it possible to identify energy-storage projects with cross-border impacts in the EU-wide ten-year network development plan (TYNDP) and their selection as a project of common interest (PCI) in the Union list. By being selected as a PCI, the project can benefit from accelerated permitting procedures and financial support from the Connecting Europe Facility funding stream for energy.[62]

11. Conclusion

Successful implementation of energy storage projects requires careful planning, technology comparison, business plan analysis, environmental assessments, stakeholder engagement as well as adherence to sustainability criteria and legal frameworks. We hope this toolkit serves as a guide to just transition regions in their own endeavours to implement energy storage projects and decarbonise their energy systems. With the right strategies, energy storage can provide numerous benefits to the society and play a crucial role in supporting the transformation of JTF regions towards a sustainable and energy-efficient future for all.

Endnotes

1 Carbon-intensive regions rely heavily on the usage of (fossil-fuel based) energy to produce metals, chemicals, cement, or fertiliser. Coal+ regions are defined by the extraction of solid fossil fuels – including lignite, hard coal, peat, and oil shale – and their subsequent use in energy production.

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