Energy storage

Trends and challenges in a rocketing market

A market analysis report by the STEPS project

2021

Interreg North-West Europe STEPS

European Regional Development Fund

EUROPEAN UNION

STEPS Market Analysis
Introduction & approach

This report is the main deliverable of activity 1 of WPT2 – Market Analysis within the framework of the Interreg North-West Europe (NWE) project STEPS. With this analysis, STEPS partners studied the market trends and challenges in the quickly growing energy storage (e-storage) sector.

STEPS is an Interreg NWE project, supporting SMEs in increasing their competitiveness and accelerating market readiness by optimising, testing and validating their energy storage solutions towards user needs, while raising awareness on local regulations and funding conditions in NWE.

Approach and process

The approach used to develop this market analysis builds upon a combination of analytical and market engagement activities carried out in three main phases:

- Phase 1: preparation

This phase focused on analysing publicly available information describing trends and challenges of different e-storage application areas, as well as market gaps and business drivers. The performance of this desk research resulted in the identification of a number of topics with significant importance for the current European e-storage developments as well as for our STEPS project. Among these, three topics were selected to be discussed in dedicated roundtables with experts to complement the STEPS consortium's knowledge and the market research with experts' insights. The following topics were selected:

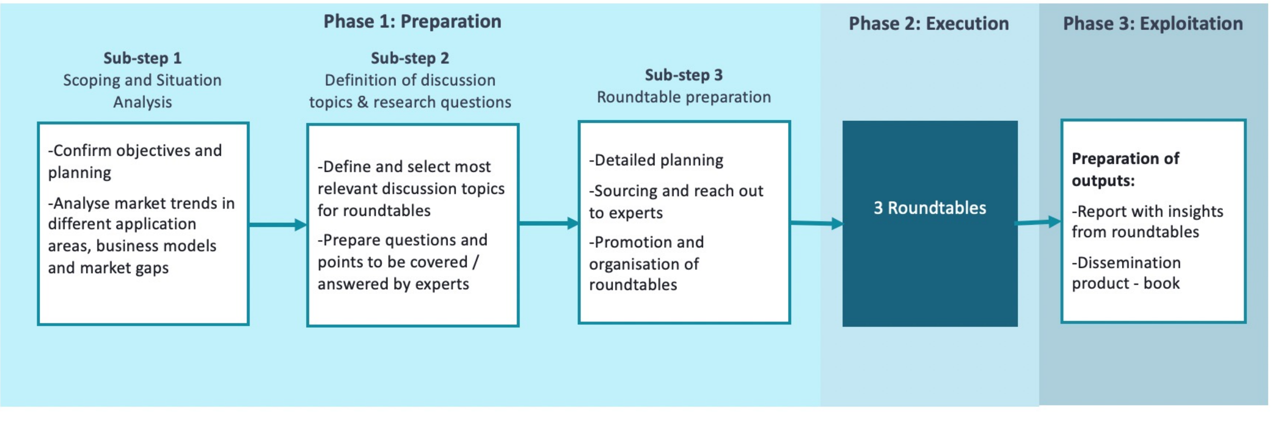
1) Roundtable 1: Market readiness and enabling conditions across NWE and the EU
2) Roundtable 2: Enhancing Circularity of Battery Energy Storage - end of life solutions
3) Roundtable 3: Front of the Meter Energy Storage - emerging business cases, revenues streams and ownership models

The STEPS partners and Bax & Company reached out to experts in their network with relevant experience in the topics selected and worked further in the preparation of the research questions to be addressed in each roundtable.

- Phase 2: execution of the three expert roundtables

The three STEPS roundtables were organised between late October and early November. They were extremely successful, with more than 40 participants per session. The audience included STEPS partners, SMEs participating in or that applied for the business support programme, STEPS testbeds, and other representatives from the general public.

- Phase 3: summarising and presenting the results of the analysis and expert roundtables into a deliverable report and an interactive booklet for dissemination to the wider public.



Trends in the e-storage market

Desk research results

Storage Capacity

World

- 2017: global large scale battery storage capacity installed was 10 GWh (1)
- 2019: 2,9 GW were added in 2019 (2)
- Until now the US has led battery storage deployment (3)
- 2030: 245 GWh/year battery storage will be installed; 210 GW installed battery capacity will be achieved by 2028 (4)
- 2050: 7,7 TWh will be installed by 2050 (5)

The EU is expected to overtake the US in terms of battery manufacturing capacity by 2023 (3)

European Union

- 2015-2020: 13 GW were installed (4)
- 2020: the EU energy storage market grew to 1,7GWh in 2020 with a cumulative installed capacity of 5,4 GWh (6)
- Currently, 90% of installed battery storage capacity is in 5 countries: UK, AT, DE, AU, SW. UK had the largest battery storage capacity followed by Germany (2/3 of volume) (7)
- 2021: the total annual storage market is expected to reach 3000MWh in 2021 (6)
- 2024: the annual storage addition in 2022 will be 1GWh → 7,2 GWh capacity will be achieved by 2024 (7)
- 2028: 49 GW of battery capacity will be installed by 2028 (4)
- Distributed battery storage systems need to cover 24% of EU power demand by 2050 (1600GWh) (7)

Storage Cost Development

World

- E-storage cost development;
    - 2013: 650$/kWh
    - 2018: 176$/kWh
    - 2019: 149$/kWh (4)
- 2030: the total installed cost of Li-Ion battery could fall by an additional 54-61%by 2030 in stationary applications → decrease of both cells' costs and other components' costs (8)
- BTM storage remains twice as expensive as FTM (9)
- Li-ion batteries for stationary applications cost more than EV's due to more complex charging/ discharging cycles requiring a more expensive BMS & hardware (three times higher) (8)

European Union and NWE

- 2023: 10% storage price decrease for residential solar system, 33% for residential battery storage will be achieved (7)
- DE: small scale residential storage costs has fallen 71% between 2014 and 2020 (8)
- DE: the current cost of PV in combination with storage is 14,7€cent/kWh, which is half of the current electricity price (7)

Industrialisation of production process in combination with the learning curve is increasingly bringing down the cost of battery storage/kWh

Trends in the e-storage market

Desk research results

Stationary Battery

World

- 2023: Stationary battery storage market will surpass the electronic devices market in 2023, becoming a $30bn industry of 52GWh installations (10)
- 2025: the stationary battery storage market will achieve $36bn by 2025 (4)
- 2030: the stationary battery storage market will achieve $60bn by 2030 (4)
- 2035: the energy storage market will grow to $546bn in annual revenue by 2035 (10)
- The current EV battery market is 10 times bigger than the stationary storage one (grid scale battery). Despite the smaller market, it is interesting as it has a higher price premium (2)

European Union

- The largest market for battery storage in the EU is Germany, followed by Italy, Austria will soon overtake the UK (7)
- Key providers of the EU battery storage market are, among others, Samsung SDI, LG Chem, BYD (3)
- Key developers of battery storage projects are, among others, Statera Energy, Anesco, STEAG (3)

The stationary battery storage market will keep growing exponentially until 2050

Technology Trends and Drivers in stationary e-storage

World

- Stationary battery storage systems are mainly being deployed at utility scale to provide flexibility (4)
- 95% of current storage projects are Li-ion batteries (4)
- BTM e-storage has experienced a growth of 78% between 2015-2019 (3)
- Discharge duration for grid-scale batteries increased to 1.8 hours (60% higher than 2015). The trend is going beyond short-term applications (9)

European Union

- E-storage & PV increases self-consumption from 20-35% to 60-90% (7)
- BTM storage was impacted by the pandemic harder (6)
- NL: Most battery capacity is at utility scale to provide grid frequency regulation (11)
- Grid scale storage (stationary batteries) development will be boosted by EU battery growth, innovation and cost reduction

LI-ion battery storage is the main technology used in energy storage projects
FTM is growing quickly thanks to:

1) **Increasing flexibility needs of the system**
2) **Lowering costs**
3) **Mainstreaming of project development phases**
4) **Improvement of policy framework (in some countries)**

Interreg North-West Europe STEPS
European Regional Development Fund

STEPS ROUNDTABLE OF EXPERTS ON ENERGY STORAGE

Session 1: Market Readiness

Medium-Scale Energy Storage: market readiness and enabling conditions across NWE and the EU

22nd of October, 10:00-12:00 CET

Interreg North-West Europe STEPS

@STEPSNWE

Speakers Introduction
Roundtable 1

Peter Eckerle
Managing Director - StoREgio

Peter has 15 years of experience in energy storage in Germany in particular focusing on system solutions, applications and business models.

Boris Sučić
Senior Expert and Project Manager - Jožef Stefan Institute

Boris is a senior energy expert, and professor guiding the energy transition in Slovenia and supporting the development and implementation of innovative systems

Oliver Ingwall King
Project Leader – Johannesberg Science Park

Oliver is an energy and carbon management consultant currently working at Johanneberg Science Park, former energy advisor of West Suffolk Council with expertise in energy storage and renewable energy in the UK & Sweden.

Paddy Phelan
Council Member and CEO – IESA and 3CEA

Paddy is Council Member of the Irish Energy Storage Association and CEO of 3CEA – >10 years of experience in the energy sector, expert in renewable energy and storage

Speakers Presentations
Roundtable 1

StoREgio: Peter Ecklerle

Current Projects and activities: StoREgio focuses on e-storage from the market perspective, in particular on the development and evaluation of business models that fully unlock the value of storage and their flexibility:
→ Adressing the applications of storage systems in the context of future energy systems
→ Builiding business models for community energy storage, regional flexibility services, cloud storage and market acceptance

Trends in Germany:

- E-storage systems are booming in private households in combintion with PVs, commercial and industrial applications will follow up next.
- E-storage is now recognised by all market players and decision makers as a key element for the energy transition.
- Despite the availability of technologies, there is still room for innovation and improvement.

Barriers in Germany:

- Economic viability is still questionable in most of the applications of e-storage.
- The value of the flexibility provided by e-storage is not yet properly rewarded by the market nor enabled by the current regulations.
- Regulation in Germany currently does not favour e-storage and is too complex.
- Storage is always only part of a more complex solution which requires an increasing technical know-how.
- Consumer acceptance and awareness is low.

IESA & 3CEA: Paddy Phelan

Trends in Ireland:

- Battery projects mainly rely on revenues from Irish DS3 market but there is the possibility to stack revenues with capacity market and energy arbitrage.
- Move from short duration to long duration storage for energy balancing.
- Li-ion batteries are still the main technology. Hydrogen is also emerging.
- The majority of battery projects are funded through 100% equity mainly due to the regulary risk associated with the system services and revenues from DS3.
- Potential to add debt in the funding mix moving towards longer duration storage, revenues stacking, trading price floor.

Barriers in Ireland:

- Uncertainty over system services procurement framework.
- Lack of a level playing field in existing support mechanisms.
- Grid connection policy that is implicitly disadvantaged against storage --> connecting processes can take longer than expected.
- Transmission charging regime does not incentivize flexibility.
- Complex market structure.
- Lack of policy emphasis on long-duration storage.
- Local communities and citizens are against the construction of large renewable energy plants and new electricity infrastructure.

Speakers Presentations
Roundtable 1

Jozef Stefan Institute: Boris Sučić

The key challenges and areas of potential cooperation that are indicated in the Slovenian National Energy and Climate Plan (NECP) are:

- Local enhancement of existing distribution networks through digitalisation, e-storage, advanced services
- Wider implementation of renewable energy sources and energy efficiency in all sectors
- Sector coupling and implementation of modern technologies such as power-to-gas (green hydrogen)

Trends in Slovenia:

- Large e-storage systems are connected with energy intensive companies and provide local balancing and system services (50% secondary regulation needs).
- New instruments supporting deployment of e-stoarge will be implemented very soon.
- Energy communities are a key element of NECP which will steer adoption of storage for increasing self-consumption and facilitating local balancing.
- Changes in the tariff system will foster implementation of e-storage systems in households and SMES --> in 2023 end of net metering scheme.

Barriers in Slovenia

- Distributed energy resources are installed mainly at distribution network level creating challenges for the Distribution Network Operators (DNOs) related to congestion and power quality.
- Fossil fuels still have an important role in the supply of electricity hindering the deployment of low-carbon resources.
- Value chain needs to be fully developed and particular attention should be focused on sustainability and resource efficiency.
- Current tariff system and double “taxation” of storage are important barriers that are planned to be modified soon.

Johanneberg Science Park: Oliver Ingwall King

Trends in the UK and Sweden:

- Electrification, increasing demand need enhanced management and peak reduction → growth of flexibility needs.
- UK flexibility markets are being improved and growing to address the above needs → current flexibility markets are at national level but are being brought down to regional level to better address local flexibility needs.
- Visibility on real time consumption will facilitate monitoring, deployment of e-storage by enabling an better pricing of storage capacity and avoided grid demand.
- In Sweden, regional energy companies are directly involved in the development of e-storage projects while in the UK are mainly commercial actors.

Barriers in UK and Sweden:

- Lack of knowledge of how the electricity system works and how storage should be used.
- Uncertainties related to future pricing and revenue streams challenge the development of a sustainable and profitable business case.
- Lack of data sharing and standardisation .
- Sale processes are usually not realistic undermining the confidence of customers.
- For a positive business case you cannot rely on the value of the electrical energy only but there should be other drivers.
- Support mechanisms should be more consistent and reliable to support long-term investements.

Insights
Roundtable 1 discussion

Interreg North-West Europe STEPS

From your perspective, how can regulation and policy support the deployment of storage systems and especially their bankability? What is the most successful measure you have seen implemented in your country or in other European countries?

The transition to ”net-zero” comes with an increasing penetration of intermittent RES resources and the electrification of e.g., transports and heating systems. Flexibility and consequently storage are becoming increasingly important to ensure the security of supply and prevent/address congestion and capacity issues in both the distribution and transmission networks.
However, regulatory uncertainty related to market accessibility, permitting as well as revenue stacking for e-storage is still too high in most of EU countries as regulation is still under development.
The following key aspects should be improved to support the successful deployment of e-storage and its financial viability.

Reforming energy markets and creating new market mechanisms that properly recognise and remunerate the value of flexibility
Current market mechanisms were designed to operate the traditional centralised energy system and, therefore, do not properly respond to the needs of a more decentralised, renewable-based system.
Regulation should provide the framework for fully unlocking the value of storage and properly translating such flexibility value into a financial reward and incentive. Fair pricing as well as capacity payments need to be implemented in most EU countries to make e-storage business cases attractive for investors and profitable in the long-term. National ancillary service markets should be brought down at the regional level to reflect the local network conditions and source local flexibility while offering an additional revenue stream for e-storage.

Defining storage as a specific asset within regulation to apply proper network fees and taxes
In most EU countries e-storage is not yet defined as a new “asset” in the energy market regulation. This means e-storage is sometimes evaluated as “generator”, “consumer” or both. Therefore, traditional fees related to both generation and consumption of energy are usually applied to e-storage systems which, in the worse cases, result in double taxation. Regulatory changes are ongoing in most countries to avoid such an issue, but large systems directly connected to the grid (Front-of-the-Meter) are sometimes still subjected to e.g., generation fees when they inject electricity into the grid (e.g., in Slovenia), negatively impacting the business case and the future development of new projects.

Simplifying regulation to favour market accessibility and permitting processes
The E-storage business case is based on the combination of different revenue streams generated by different markets and applications which are characterised by different technical and economic requirements, fee structure and pricing. Complexity increases exponentially every time meaning that more value streams are stacked requiring more knowledge, time and resources from the project developer or e-storage owner. Permitting processes should be streamlined and conditions to access different markets made more transparent and open.

Reflecting regulatory changes into proper services and value offering
Network operators and market players need some time to adapt their services to the new regulations. This discrepancy should be overcome by aligning decision making processes and ensuring the technical viability of e-storage services.

Insights from the roundtable discussion
by Peter Eckerle, Boris Sucic, Paddy Phelan, Oliver Ingwall King

Roundtable 1 discussion

Where do you see the potential for innovation in storage systems, which could help their deployment?

Reducing cost of storage and developing new business models

Although battery storage is already economically attractive in some applications, innovation should support its economic viability more broadly and demonstrate successful business cases. This can be done by:

- Reducing cost of storage: investment cost is still an important barrier for many customers
- Enhancing revenue streams for reducing the cost of energy

Innovation in business models and services can help tackle the above issues while enabling the development of solutions that are better tailored to the local conditions and encourage the deployment of storage.

Developing new technologies to meet current and future flexibility needs of a RES-based energy system

The transition to renewable energies leads to an increasing need for flexibility and system services for ensuring the security of supply. Li-ion battery storage is currently the main technology adopted for the development of large scale e-storage projects. However, this technology is not able to cover all different flexibility needs in terms of duration of services, response time, ramp up / ramp down time, etc. Further innovation efforts should be invested in the advancement and implementation of other technologies that better respond to the various flexibility requirements of the system, such as long-term duration storage or short-term "fast" responses. In many countries such as Ireland, most of short-term flexibility needs are currently still being met with diesel generators. Innovation should drive the development of new technologies that enable a true phase out of fossil fuels whilst ensuring the provision of the services needed for system stability.

Improving sustainability and circularity of batteries and of the entire value chain

Battery storage systems are key to enable the energy transition but, as of now, their environmental footprint throughout their lifecycle is still relatively high. There is a very large untapped innovation potential to make the entire battery value chain more sustainable and circular, from the sourcing of materials to the end of life treatments. Research should therefore focus on making battery energy storage a truly sustainable solution by e.g. developing new battery technologies, improving circularity of components and materials, upscaling recycling processes.

Increasing level of digitalisation and monitoring while ensuring data protection

Designing and properly operating a battery storage system requires a certain visibility and understanding of the energy flows e.g. in a building or in the network. Current practices for monitoring are sometimes obsolete and the unavailability of data from stakeholders is a major barrier in storage deployment. Without visibility behind the meter, it is not possible for Distribution Network Operator (DNO) to understand demand and allocate a correct value to the services battery storage could offer. Vice versa, knowing congestion points and network status enables storage systems to run to relieve pressure on the grid and provide the needed flexibility. Innovation should improve current monitoring and digitalisation practices while addressing data protection and privacy issues.

Overall the knowledge and understanding of energy systems as a whole needs to be further promoted in society to raise awareness of low-carbon technologies and facilitate their wider adoption.

Insights from the roundtable discussion
by Peter Eckerle, Boris Sucic, Paddy Phelan, Oliver Ingwall King

Insights

Roundtable 1 discussion

Have any of the panelists come across good conditions facilitating the application of a cloud approach to aggregate community renewables and storage?

Some of the existing approaches for aggregation of e-storage systems are described below. Panellists have agreed that currently there are no particularly favourable conditions for implementing such approaches. However, the lessons learned are very valuable especially regarding data safety, energy management systems as well as consumer acceptance and drivers (e.g. 1/3 of consumers involved in a project in Germany have confirmed that they would be willing to give access and control of their storage system to a third party if additional economic savings are guaranteed).

Demand side response and virtual aggregation – some technology providers have developed an intelligent energy saving system for commercial buildings that also gives the possibility to remotely control the various energy assets. This involves the installation of different control devices connected to the electrical system and a platform through which different control and monitoring mechanisms can be set (for example: monitoring the HVAC, the refrigerators etc.). These devices can also be virtually "aggregated" to provide demand response and overall optimise consumption / feed-in to the grid.

Virtual storage - bundling of small residential storage systems in households to create a "larger virtual storage" that could tap into three different value streams: 1) provision of grid and balancing services to the Transmission System Operator (TSO) 2) enhancing self-consumption at household level 3) community balancing of local demand and generation.

Community storage – installation of a storage system at neighbourhood level that can be used by different households to store their energy while potentially providing grid services. However, the business case was "tight" and there were some difficulties in managing the system.


STEPS ROUNDTABLE OF EXPERTS ON ENERGY STORAGE
Session 2: Enhancing Circularity of Battery Energy Storage
End of life solutions: Recycling and repurposing
29th of October, 10:00-12:00 CET
Interreg North-West Europe STEPS
@STEPSNWE

Speakers Introduction
Roundtable 2

Silvia Fiore
Associate Professor – Politecnico di Torino

Silvia holds a PhD in Environmental Engineering and a MSc in Analytical Chemistry. She leads the research group on circular economy with focus on waste treatment, process recycling and biorefinery processes.

Noshin Omar
Founder & CEO – ABEE Group

Noshin has more than 10 years of experience in energy storage systems. At ABEE Group he leads the development of next generation battery technologies such as polymer and solid state based batteries.

Silvia Bodoardo
Associate Professor – Politecnico di Torino

Silvia holds a PhD in Materials Engineering and a MSc in Chemical Engineering. She is responsible for storage research and laboratories at the Energy Center Lab and in CARS@polito interdepartmental lab.

Speakers Introduction
Roundtable 2

Nigel Dent
Head of Sales – Connected Energy

Nigel has more than 15 years of experience in the energy sector and holds a MSc in Project Management as well as a BEng in Mechanical Engineering. He is the Head of Sales of Connected Energy, a world leader that delivers energy storage systems utilising second-life EV batteries and turn-key solutions from design up to operation.

Radu Achihai
Co-Founder & COO – RePack

Radu holds a MSc and a MBA and has more than 15 years of experience in selling and delivering best-in-class services to customers. He is the COO and co-founder of RePack, a start-up that delivers scalable high-quality battery storage systems based on second-life EV batteries and technologies that enable the industrialisation of the repurposing process.

Battery energy storage: an exponentially growing demand and emerging market

Global Li-ion battery market size will achieve 1040 GWh in 2027 (at cell level). This is mainly due to the exponentially growing demand for batteries for transportation, the market share will become larger than 90%. Demand for stationary storage applications will also slightly increase but in 2027 and will represent only 5% of the worldwide demand for batteries.

The above trends demonstrate that the volume of end-of-life Electric Vehicle (EV) batteries will keep increasing in the coming years. Repurposing will extend the lifetime of a limited amount of systems which can cover the entire demand for stationary applications. More than a third of end-of-life batteries have a remaining capacity higher than 80% which make them suitable to be repurposed for stationary applications (ISO 12405-1/2).

However, this means that a large volume will still have to be disposed and should therefore be recycled.

Repurposing and recycling solutions and processes will play a crucial role in enhancing the circularity of the battery storage value chain. These two are not exclusive but rather complementary.

RePack: Radu Achihai

The current approach to the repurposing process:

- "New" battery storage systems for stationary applications are delivered by assembling modules that are bought from car manufacturers, tested and selected based on their quality.
- The repurposing process is currently characterised by complex issues such as the classification of the modules by quality, the optimisation of the assembly process, predictive maintenance and lifetime system optimisation through adaptability of the maximum state of charge and the depth of discharge. Innovative digital solutions such as those provided by SMEs and start-ups like Repack are needed to industrialise the repurposing process.

Connected Energy: Nigel Dent

The current approach to the repurposing process:

- End-of-life modules are supplied directly by OEMs (Original Equipment Manufacturers such as Renault, Nissan, JLR) and are selected to meet specific requirements set by the repurposing company.
- Differently from other repurposers, the modules are not disassembled and reassembled. Selected modules and battery packs are controlled through a proprietary Power Control System that communicates directly with the battery Battery Management System (BMS).
- Products delivered with second-life batteries can range from 300kW up to MW-scale and can be used in different applications.
- Current research efforts in the UK are focusing on the creation of a circular supply chain for batteries and the reduction of costs for end-of-life disposal by collaborating with OEMs to integrate simple design changes that would improve the potential for repurposing and recycling.

Speakers Presentations
Roundtable 2

ABEE Group: Noshin Omar

ABEE is a dynamic engineering company that specialised in battery storage and energy technologies for automotive and stationary applications. Its expertise includes state-of-the-art battery manufacturing infrastructure, processing and prototyping.

Current challenges in repurposing

- Current repurposing approaches are quite complex and require the testing, dismantling and refurbishing of the module (resource intense process).
- Most OEMs do not provide the necessary data from the "first life" battery operation to make a fast assessment and selection of the still good-performing modules.
- Enhancing transparency on the state of health of end of life EV batteries through the adoption of a "battery passport" is a MUST for enabling quick assessment and decisions regarding potential repurposing or recycling.
- There is high uncertainty regarding the economic competitiveness of second life batteries compared with new batteries.
- There is uncertainty regarding the business model and allocation of responsibilities/ liabilities related to second life batteries.

Current challenges and trends in recycling

- Current recycling processes and recyclers mainly focus on the recycling of batteries that contains valuable metals such as Cobalt, Nickel and Manganese.
- Lithium Iron Phosphate batteries' penetration in the market is growing as main battery manufacturers such as Tesla and BYD are currently using this technology.
- In the EU, there is very little interest in the recycling of Lithium Iron Phosphate batteries. As the volume of LiFePO will increase exponentially, the end of life treatment of this type of battery should become an important focus for EU policy and innovation (e.g. implementing obligations to manufacturers, developers or importers to recycle).
- Current recycling efficiency is about 55% but the EU is moving towards 70% and aims to achieve 90% in the near future.

Politecnico di Torino: Silvia Bodoardo

Current trends to enhance circularity of batteries

- Production of the cells and sourcing of materials should aim to enhance circularity enabling low-cost recycling processes → sustainability and circularity should look a the entire value chain perspective.
- Materials represent the main cost component within the battery cost structure and are the main responsible for the battery performance (e.g. energy density, number of cycles) as well as for their environmental impact (e.g. recyclability of materials, their carbon footprint).
- Research is focusing on the development of the next generation of cells with high energy density and power safety: 1) advanced Li-ion 3b generation (2025) 2) solid state batteries (2025-2030)
- Cathode and Anode materials are those that first should be recycled. There are difficulties in recycling the electrolyte due to the need for complex chemical processes.

- At present, most materials used for the production of cells are mainly sourced outside the EU (Cobalt, Lithium, Nickel, natural Graphite). Material production in the EU is very limited and, despite the several Lithium initiatives being developed in the EU, the overall Li production is still low compared to the main producer which is Chile.
- Production of cells should move towards the use of minimal quantities of critical materials while ensuring good battery performance (high energy density) → further technology development is needed.
- The reduction of critical materials will reduce the value of recycling and of the secondary raw materials that could be produced → new recycling techniques will be needed.

Politecnico di Torino: Silvia Fiore

Trends and challenges in battery recycling:

- The increasing demand for Li-ion batteries over the next years will lead to a critical increase in the demand for raw materials, particularly metals (used in cathodes), and consequently to a higher price. Developing local capacity for recycling will enable to reduce such pressure and dependency from other countries by producing locally secondary raw materials. This will also cut emissions coming from transportation of materials and modules e.g. from Asia or Africa to Europe.
- Currently, the EU has a recycling capacity of about 50.000 tonnes/year which is mainly concentrated in few countries (Germany, France, the UK, Austria and Belgium).
- Today recycling processes are economically sustainable thanks to the high value materials that are recovered (Nickel, Cobalt, Manganese). However, these will be reduced in the future generation of batteries.
- The environmental impact of recycling processes is currently relevant → technology advancement and new solutions are needed to reduce such an impact. Cost-benefit analysis should take into account the emissions avoided from mining and transportation thanks to the utilisation of secondary raw materials.
- Current and future battery generations will use a lower amount of critical materials which will reduce the overall value for recyclers. Most batteries produced by the word-leading manufacturers are already using LiFePO cathode which does not have an economic value to economically sustain the recycling process. Solutions and technology innovation are therefore needed to solve this economic challenge in particular by 1) reducing the phases of industrial recycling process 2) exploring different recycling perspectives for low-value cathodes (e.g. direct recycling).
- Short loop recycling processes have a high potential to solve the above mentioned challenge and reduce the energy demand of the recycling process but these processes need to be further advanced to reach the necessary maturity and scale.
- Eco-design applications applied to Li-ion must support the recycling operations.
- Cost-benefit analysis of Li-ion value chain should consider both economic and environmental aspects including the potential recycling operations.

Roundtable 2 discussion

From your point of view, what are the key challenges related to recycling and repurposing of battery storage?

The demand for batteries is growing exponentially due to the increasing electrification of transport and the penetration of renewable energy sources in our energy system. In this roundtable, the speakers explained the required and upcoming changes in the energy storage industry to ensure sustainable and environmentally friendly growth of the entire value chain. End of life solutions like reuse and recycling as well as other necessary developments such as the next generation of cells and a battery identity passport are crucial issues for the industry that are at the core of EU policy makers' discussion. These were discussed in detail by our speakers who presented the current market trends and the main technical, economic and regulatory challenges.

Low economic efficiency and high carbon footprint of current recycling processes

The economic performance of the battery recycling industry is characterised by high costs which account for about 10-15% of the battery overall value (about 3,5€/kg) and is currently dependent on the recovery of high-value materials such as Nickel, Cobalt and Manganese. Current and future battery generations will use a lower amount of critical materials which will reduce the overall value for recyclers and, therefore, further challenge the financial viability of the recycling processes. On the other side, these processes have a high environmental impact that must be reduced. Solutions and technology innovation are needed to enable the cost-effective and ecological recovery of low-value materials by e.g. 1) reducing the phases of the industrial recycling process 2) exploring different recycling perspectives for low-value cathodes (e.g. direct recycling) 3) achieving economy of scale and "industrialisation" to reduce recycling cost down to 0,5€/kg.

Limited recycling capacity and material accessibility risks of the European battery industry

The EU has a recycling capacity of about 50.000 tonnes/year which is far from sufficient to process the current and future increasing volume of end-of-life batteries from the automotive and energy sectors. Currently, China is already able to treat 2,4 million tonnes/year and is continuously expanding its capacity.
While there are plans to build 27 cell manufacturing plants across the EU, there is still a lack of accessibility to materials and of European material producers that can ensure a reliable coverage of the future demand. Secondary materials from recycling can play an important role in tackling this issue and contribute to the development of a closed sustainable European value chain loop. Therefore, the upscaling of battery recycling capacity in the EU should be a key priority to reduce dependence on extra-EU countries for the supply of raw materials while cutting CO_2 emissions due to transportation and mining.

High repurposing costs and lack of financial incentives challenge competitiveness of second-life batteries

The economic model of second-life batteries is very much under pressure. To become competitive from a purely economic perspective, second life battery costs should halve. This is challenging seen the high costs related to dismantling and testing of modules, reassembling and integration. Lack of standardisation of EV battery modules requires tailored solutions that hinder the industrialisation of repurposing processes and increase costs. Regulation should reward circularity of second-life battery products by offering financial incentives that enhance their competitiveness and accelerate the market evolution.

Energy performance of second-life batteries is highly dependent on the quality of EVs' end-of-life modules

The power output of the second-life battery depends on the effective sourcing of EVs' end-of-life modules. Availability of data from the battery's first life operation is a major barrier to optimising its future operation in second-life and avoiding performance or safety issues.

Insights from the roundtable discusssion
By Noshin Omar, Nigel Dent, Radu Achihai, Silvia Bodoardo, Silvia Fiore

Roundtable 2 discussion

What is or should be the European strength in the battery storage sector?

Environmental sustainability: European battery value chain will be circular

To become a global leader, Europe should and will develop a fully circular and energy efficient battery storage industry based on renewable energy. European players and R&D initiatives such as Battery 2030+ are working to make European batteries sustainable and to reduce the environmental footprint and energy demand of the entire value chain, in particular:

- Sourcing materials locally and increasing the use of recycled materials;
- Applying eco-design principles;
- Developing new battery technologies with low or no content of critical materials;
- Creating European capacity for manufacturing of cells;
- Creating European capacity for recycling.

By using secondary materials, manufacturing and recycling cells locally, the EU can reduce its dependence on extra-EU countries and the carbon footprint due to transportation and the use of unsustainable energy. This will strengthen the EU's position in the battery storage market and its competitive advantage seen the increasing interest of consumers and industry players in sustainability and the commitment of policymakers to the European Green Deal strategy and UN Sustainability Goals.

Financial sustainability: strong business models supported by favourable regulation

Regulatory uncertainty and lack of financial incentives hinder the upscaling of battery recycling and repurposing market as current costs overcome the potential financial benefits.

To make repurposing and recycling business cases sustainable, regulation should enforce a proper evaluation of the avoided CO_2 emissions, energy and materials as well as promote financial incentives that reward "circularity" and "sustainability" of battery products. These measures would facilitate competition with low-cost first-life batteries coming from e.g. China and enable financial sustainability of second-life battery business models while steering industrialisation of recycling processes. The upcoming new battery directive will already address some of these aspects to accelerate the growth of the sustainable battery industry in the EU.

Roundtable 2 discussion

What are the current warranty models that are offered with second-life batteries? Who is responsible for guaranteeing the performance of the battery?

The allocation of liabilities and responsibilities related to second-life batteries' performance or their potential failure is complex due to the change of product "ownership" from their first- to their second-life. As the market and the technology are not yet mature, "repurposers" are currently exploring different warranty models. The two second-life battery providers involved in this roundtable, Repack and Connected Energy, presented their experience and approach as follows.

Data on the first-life operation and strict requirements on performance and safety are critical factors to enable effective sourcing of modules for repurposing and mitigation of risks

The lack of data on the batteries' first life operation makes it difficult for "repurposers" to assess their actual condition and health. Nowadays, OEMs provide the second-life battery companies with modules that meet certain technical requirements (e.g. capacity of about 80% and a specific cycling rate), but also prescribe certain operating parameters (e.g. rate of discharge, charge interval) that should always be respected during the second-life battery's operation. Such requirements and specifications are important factors that enable a fair distribution of responsibilities and liabilities between the actors involved in the battery value chain. However, there is the risk that these batteries may have suffered invisible damage e.g. due to an accident or improper maintenance, or may not perform as expected. Such risks should be mitigated with a proper warranty model or by enhancing a "battery passport" to improve transparency on the battery's first life.

Combining short-term warranty from OEMs with a longer specialist insurance is a proven model

Connected Energy works with a 2-year backed warranty from the OEM. The OEM has the responsibility to provide end-of-life modules that fit with the safety and performance requirements agreed with Connected Energy. If the repurposed modules fail or do not perform as expected during these first two years of operation, it is most probably an issue due to the sourcing of the modules or their first life operation and the OEM is therefore responsible to replace them. After these two years, Connected Energy offers an extended warranty working with a specialised battery insurance company backed by a large UK bank. The company evaluates the application and conditions under which the battery will operate to decide whether to extend the warranty or not. Individual warranties are offered depending on cycling rate, depth of discharge and application area. Connected Energy will monitor the battery operation and make sure it runs within the warranty requirements. Similarly, Repack has developed a portfolio of products that can fit different applications and have different warranty duration depending on the operational requirements. Warranties offered range from 5 to 15 years.

Current regulation should be further developed to provide clear definitions of actors' roles and enforce responsibilities related to warranty

Under current EU regulation, the "producer" is liable for the performance and safety of the battery. However, for second-life batteries, this role is assumed in the first place by the OEM and later by the "repurposer", leading to some uncertainty and confusion. This represents a structural challenge of the repurposing industry, hindering the participation of OEMs due to their risk-averse nature and fear of damage to their image in the event of a safety or performance issue. There is also a lack of clarity about the role of insurance companies and the responsibilities of the other players involved in the battery value chain. These gaps pose a major challenge to the development of the second-life battery market and should be addressed in the next battery directive to incentivise participation and reduce risks.

Insights from the roundtable discusssion
By Noshin Omar, Nigel Dent, Radu Achihai, Silvia Bodoardo, Silvia Fiore

Interreg
North-West Europe
STEPS
European Regional Development Fund

STEPS ROUNDTABLE OF EXPERTS ON ENERGY STORAGE

Session 3: Medium Scale Front of the Meter Storage

Emerging business cases, revenue streams and ownership models

10th of November, 13:00-15:00 CET

Interreg North-West Europe STEPS

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Speakers Introduction
Roundtable 3

Matthew Lumsden
CEO – Connected Energy

Matthew has 15 years of experience in the low carbon energy and transport sectors. He founded Connected Energy to commercialise a range of energy storage and control systems developed by the parent company Future Transport Systems.

Paul Jordan
Business Leader – Catapult Energy Systems

Paul has over 25 years of experience in the global energy sector covering the low-carbon market digitalisation, commercial and technical developments in renewable energy enabling solutions (demand response, energy storage, hydrogen, fuel cells, EVs and V2G).

Bobby Smith
Senior Policy Advisor – Wind Energy Ireland and Energy Storage Ireland

Bobby works at the largest representative body for the wind industry in Ireland. His work areas include energy policy, renewable energy integration, electricity grids and energy storage.

Speakers Presentations
Roundtable 3

Front-of-the-meter storage as a key enabler of the transition to renewable energies
Utility-scale batteries are stationary batteries directly connected to the distribution/transmission network or power generation assets. These are defined as In-front of the meter as the energy they dispatch needs to pass through the households/businesses utility meters before being used. These medium-large scale batteries are mainly used to provide flexibility to the network allowing the penetration of an increasing share of RES.

Connected Energy: Matthew Lumsden

FTM storage - trends in the UK:

- FTM storage landscape in the UK is very complex: despite the small number of developers focusing on the development of utility-scale storage systems, there are many connection requests and permitting processes ongoing to secure sites.
- This dynamic picture does not properly reflect all the uncertainties and barriers that hinder the development of FTM storage systems:
    - Infrastructure investors do not have much experience with this asset and lack understanding of the business model backing FTM battery storage system.
    - Utilities are still sceptical about the longevity and resilience of the business case
    - Stakeholders (DNOs, aggregators, project developers) have different expectations about the business model and how different revenues can be stacked.
- The revenue model is characterised by a high degree of uncertainty especially related to merchant risk. However, revenue streams are now becoming clearer and more certain thanks to favourable regulation and changes in the market mechanisms.

Business model for FTM 2nd life batteries systems:

- In the past, second life batteries were seen as a liability. Over the course of the past 1-2 years, this has changed, and their sustainability value is now being recognised as an opportunity.
- Connected Energy (CE) has the ambition to develop an investment-ready business model for utility-scale FTM second-life battery storage systems. This contractual model is designed to allow second-life batteries to be integrated into a system, used for a certain period of time and realise their maximum value before being recycled. The batteries are offered on a "service-basis" which will enable the CAPEX:OPEX ratio and the related merchant risk to be reduced.
- If investors or OEMs want to retain the ownership of the battery, CE will treat them as customers and help them unlock the full potential of second-life battery storage systems. The same happens if the customer is an infrastructure developer.
- The uncertainties mainly relate to the performance of second-life battery systems compared to new batteries and their ability to provide reliable services to the grid, developers and investors. CE reduce these uncertainties by monitoring their systems and using the value of data to optimise their performance and maximise their value. The value of data is used to provide performance guarantees and to be transparent regarding degradation and response time so that a proper comparison with new batteries can be made.
- CE focuses on developing bankable projects with shared risks and rewards so that no actor bears a disproportional amount of risk alone or seeks to extract a disproportional amount of value.

Speakers Presentations
Roundtable 3

Energy Storage Ireland (ESI): Bobby Smith

FTM storage - trends in Ireland:

- Ireland has set a target to achieve 80% renewable energy penetration by 2030
- Storage is key to providing the flexibility of services required for the reliable and efficient operation of a system with high penetration of intermittent RES (up to 75%).
- The battery storage project pipeline comprises 2393 MW, mainly Li-ion batteries, of which 578 MW have to get grid offers and 467 MW are under construction and will be operating within the next 6 months. 356 MW are already operational.
- Most of the projects under development are stand-alone systems. Hybrid projects (battery + RES) are increasing but still face some regulatory obstacles that hinder their development.
- The ancillary services market was established by the TSO in 2017 to openly procure system services from market participants. These 12 services (inertia, ramping, voltage control, etc.) are necessary to ensure system stability. This framework will end in April 2024, leading to great uncertainties regarding the next market mechanisms and payments.

FTM business model and revenue streams:

- The ancillary services markets (DS3 market) are the main driver for the business case of FTM energy storage projects. For 60% of ESI members, DS3 arrangements are the main revenue stream and only 6% base their business case on energy arbitrage (merchant projects).
- The value is unevenly distributed across system services. The main value for FTM storage comes from fast-acting services such as frequency response → 2/3 of the value accessed by FTM battery comes only from 5% battery state of charge →systems are built for 30 min. duration.
- The TSO have a budget of €235M/year for DS3 services. The remuneration of DS3 services is based on this cap and the number of contracts. With the increasing number of FTM e- storage projects, the market is "overheating" with an increasing number of service providers that could lead to the reduction of tariffs, challenging the battery business case.
- The largest investment barriers are 1) the uncertainty around future DS3 revenues (after 2024) 2) permitting and connections.
- New mechanisms should reward long-duration FTM storage systems

Energy System Catapult: Paul Jordan

Energy System Catapult (ESC) mission:

- ESC supports the UK in achieving net-zero targets and overcoming the barriers that hinder the growth of the green sector and technologies such as e-storage. This includes supporting traditional players in the transition but also innovative SMEs that can make an important contribution with their solutions.
- E-storage is a key technology for ESC's mission as it represents an important opportunity to connect the demand and supply side to the green energy systems of the future.
- ECS is pioneering a "whole-system" approach that enables the transition to a net-zero energy system

ECS's "whole-system approach":

- In order to create an integrated, multi-vector digital system based on intermittent renewable energy resources, a new legacy infrastructure, market structure and regulatory environment are needed as well as a deeper understanding of consumer needs and behaviour. For this reason, ESC applies a "whole system" approach to ensure optimal system design and operation.
- On the other hand, ECS also focuses on optimising individual components/technologies such as storage to ensure an overall optimal operation of the energy system as a whole: time variability (Flexibility) + location (evaluating the geographical impact of the storage on the network, demand and generation)

Roundtable 3 discussion

What are the key challenges for the development and integration of front-of-the-meter energy storage projects?

The current market framework and tariffs are not designed to fit FTM e-storage systems

Current electricity tariffs are quite flat and do not yet properly reflect the demand peaks where congestion occurs in the system. This does not incentivise flexibility, so neither the full potential of e-storage nor its value can be realised. The greater granularity of tariffs at node level would allow flexibility to properly be rewarded where and when needed in a particular area of the network. Nodal-level pricing incorporating carbon pricing would provide a clear "market signal" that rewards local flexibility provided by e.g. FTM e-storage whilst supporting optimal system balancing and reflecting actual local marginal costs.

Regulatory uncertainty and a rapidly changing market pose a challenge to the resilience and predictability of FTM e-storage business case

European policymakers and regulators are currently working on the development of a new regulatory framework to enable the energy system of the future. Changes in market mechanisms and tariffs can have a major impact on FTM e-storage business case and its long-term viability and resilience. To mobilise investments in FTM e-storage projects, project developers and investors need to be able to predict revenue streams throughout the lifetime of the project. Currently, the risks associated with market changes are too high and there is a general lack of confidence. New risk-reward models are now emerging to overcome these uncertainties. The development of merchant projects is indeed increasing as some project developers are more willing to accept uncertainties associated with price volatility.

The development of successful FTM e-storage products and projects require clarity about future system requirements, which is currently lacking

In most European countries there is a lack of clarity from TSOs and regulators about future energy system requirements. These requirements set out the technical specifications that must be met to provide system services and, thus, access their revenue streams. E-storage products and projects should be developed to meet such requirements and capitalise market value, but lack of signals from regulators makes it difficult for product and project developers to respond and optimise the technical characteristics and configuration of their products and projects (e.g. duration, speed of charge – discharge, responding time). Therefore, there is a technology component that represents an additional risk due to the uncertainties in the marketplace.

Changes in service requirements over the course of the project/product lifetime not only affect the value generated but also create warranty issues that can be hardly be negotiated. For example, current FTM e-storage systems in Ireland are being designed to have a 30-minute duration as the most profitable service is frequency response. In the UK, there has already been a shift towards a 1-2 hours duration system.

Insights from the roundtable discusssion
By Bobby Smith, Matthew Lumsden, Paul Jordan

Insights

Roundtable 3 discussion

Interreg North-West Europe STEPS
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Can FTM storage support congestion management? What is the current status of congestion markets?

FTM e-storage can provide valuable services to solve congestion issues, but new market mechanisms are needed to procure flexibility locally

Congestion in distribution networks is a growing problem affecting large areas in several European countries. The current grid infrastructure has limited capacity, sometimes constrained by increasing electricity demand and renewable energy penetration at the local level. Upgrading the grid would require a significant amount of investments and would limit the pace of the ongoing transition to renewable energies. New local market mechanisms are needed to remove such bottlenecks and enable the energy system of the future**.** These local "ancillary services markets" could solve congestion issues by procuring flexibility from local assets such as FTM storage, thereby avoiding or deferring grid investments. Furthermore, remuneration from the provision of congestion services to the DNO would add an additional source of revenue for FTM e-storage and unlock its full potential. Nowadays there are very few trials from DNOs testing these congestion markets and further regulatory efforts and changes are required to guide this market modernisation.

Market modernisation should improve TSO-DSO interface to enable the effective provision of system services. The current FTM e-storage projects in Ireland can be connected to the transmission or distribution network depending on their capacity. However, all of these storage assets are operated to provide system services to the DS3 markets and therefore to the transmission network. Currently, there are no flexibility markets at distribution network level yet. The design of the future market framework should therefore focus on establishing an effective TSO-DSO interface and on the complementary of congestion and DS3 services as there is the risk that these would otherwise be competing. This integration between local vs national level markets is necessary to ensure an effective operation of the overall system.

Who are the current investors and asset owners of FTM energy storage projects?

High uncertainties characterising FTM storage projects do not meet requirements of traditional investors

In Ireland investments in FTM e-storage projects are mainly made by utilities and specialised project developers that have a large portfolio of renewable energy projects and a proven experience in the sector.

Traditional investors are not yet participating in e-storage investments in Ireland because they are risk averse and lack data from successful projects. Uncertainties are still too high for projects to meet traditional due diligence requirements which prevents the mobilisation of capital by traditional actors.

However, "niche investors" with a higher risk tolerance are now demonstrating a growing interest and participating in FTM e-storage investments by either co-developing the projects together with the renewable energy companies or by buying the projects after construction. Some of them are backed by the Government or offer hybrid financing instruments that reduce financing costs. Hybrid financing or Government backed financing is important to build confidence in the market, facilitate capital mobilisation and promote upscaling.

Insights

Roundtable 3 discussion

In the transition towards Community Energy Systems (CES), local authorities have a crucial role to play in supporting the development, financing and operation of local e-storage projects

Grid congestion is a major bottleneck to economic development in some regions of the UK. Local authorities are increasingly taking a leading role in guiding the transition to Community Energy Systems (CES) based on renewable energies and with active participation of citizens as prosumers. E-storage is a key component of such systems to offer the necessary flexibility for maximising local self-consumption of renewable energy and realising the pressure on the distribution network. Complexity of e-storage business case and uncertainties related to revenues hinder investments from citizens despite their interest and sustainability ambitions. Support from local authorities through funding or technical assistance is key to facilitate the development of citizens-led storage projects.

What are the challenges for the deployment of hybrid projects (storage combined with renewable energy generation assets e.g., PVs) or the combination of e-storage with EV charging infrastructure?

Technological innovations unlock the potential for hybrid projects, but planning and implementation issues still need to be overcome

When integrated into renewable energy projects, e-storage can optimise the feed-in of generated energy to the grid, avoiding e.g. congestion or imbalances issues and improving the business case by storing energy at times when electricity is cheap and abundant and discharging when price and demand are higher (energy arbitrage). Additionally, it has been proven that integration with EV charging infrastructure or with data centres can offer significant technical and economic benefits. However, despite the emerging technical innovations, there are still some planning and implementation barriers as explained below.

Current regulation hinders the integration of energy storage into renewable energy projects in Ireland

Under the current Irish regulatory framework, e-storage and renewable energy generation plants (such as wind or PVs) cannot share the same grid connection. Therefore, the two assets must have two different grid connections which might require an upgrade of the grid infrastructure. These additional connection and infrastructure costs are a major barrier as they strongly affect the business case and the overall project viability.

E-storage can be a key enabler for smart charging infrastructure deployment, but there are complexities

Fast chargers can place a significant load on the grid, so their connection can be delayed or denied due to network constraints. Integration with e-storage and the use of grid management software can facilitate their deployment as their operation is continuously controlled. However, implementation and economic viability is a challenge.

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