EERA JPs ES & e3s Scientific Joint Workshop

"ENERGY FOR THE FUTURE- Exploring not-technical factors for Energy Storage deployment"

16th June 2023 – CIEMAT, Madrid

Participants

	Name & Surname	Organization	Country
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3	Michael Belsnes	SINTEF	Norway
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10	Israel Herrera	CIEMAT	Spain
11	Holger Ihssen	Helmholtz association	Germany
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17	Witold-Roger Poganietz	KIT	Germany
18	Esther Rojas Bravo	CIEMAT	Spain
19	Esperanza	Ruiz Martínez	Spain
20	Alessandro Sciullo	UNITO	Italy
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Notes from the presentations and discussion

Yolanda Benito (*CIEMAT Director General)* and **Adel El Gammal** (*EERA Secretary General)* opened the workshop welcoming all the participants.

Myriam E. Gil Bardají (KIT - EERA JP ES coordinator) and **Alessandro Sciullo** (University of Torino – EERA JP e3s coordinator) introduced the speakers and explained that the aim of the workshop is contributing to build a multidisciplinary bridge through the promotion of a concrete dialogue and practical exchange of knowledge, information and perspectives among the members of the two EERA Joint Programmes Energy Storage and e3s-clean Energy tranSition for Sustainable Society . In addition to a comprehensive, although synthetic, reciprocal update about the state of the art on the most promising ES technologies and the most widely diffused social, legal and economic widely recognized factors affecting RES technologies development at the different scales of the energy system (EU, national, regional and local), the participants would have been engaged in a structured discussion aimed at identifying the main challenges and explore possible ES solutions to be diffused in the EU energy system.

1st session: an overview of ES state of play with a focus on not-technical aspects related to RES development;

Michael Belsnes (SINTEF Energy) delivered a presentation about mechanisms of the power market. First of all Belsnes provided an overview about the mechanism of power system balancing and then focused on the European Internal Energy Market (IEM) which consists of a number of market solutions in sequence:

- Long-Term Transmission Rights
- Single day-Ahead Coupling
- Single Intraday Coupling
- TSO-TSO trading and ancillary services

The energy market development with more renewables driven by the Clean Energy Transition raise two main issues. On the one hand, the surplus of renewables will give more hours with very low energy price and this will give incentives for electrolysis, boilers and storage. On the other hand the shortage of renewables will give more hours with high energy prices, incentivising storage, peak generation and demand flexibility. To face this challenges and adapt the power market to the CET, changes have been required. In this regard, the EU is working on the electricity market design reform which aims to:

- Enhance market access to more stable longer-term contracts and markets. **Power purchase agreements (PPAs)** - long-term private contracts between a generator (typically renewable or low carbon) and a consumer – can protect against price volatility. A barrier to the growth of this market is the credit risk that a consumer will not always be able to buy the electricity over the whole period. To address this, Member States should ensure that instruments to reduce the financial risks associated to off-taker payment default in the framework of PPAs, including guarantee schemes at market prices, are accessible to companies that face entry barriers to the PPA market and are not in financial difficulty.
- Some forms of public support guarantee the energy producer a minimum price by the government but allow for the producer to nevertheless earn the full market price even when this market price is very high. With the recent high prices much (cheap) publicly supported energy has been receiving these high market prices. To curb this and so stabilize prices, investment support should be structured as "two-way" (**two-way contract for difference**), which set a minimum price but also a maximum price, so any revenues above the ceiling are paid back.
- The proposal requires Member States to assess their needs for power system flexibility, establish objectives to deliver on these needs. Member States can design or redesign **capacity mechanisms** in order to promote low-carbon flexibility. Moreover, the proposal opens the possibility for Member States to introduce new support schemes for non-fossil flexibility such as demand side response and storage.
- Empower consumers by creating the right to share renewable energy directly, without the need to create energy communities. Greater **energy sharing** (e.g., sharing surplus roof top solar power with a neighbour)

can improve the use made of low cost renewable energy and provide greater access to direct use of renewable energy for consumers who might not otherwise have such access.

Belsnes highlighted that the assumed impacts on the generators, consumers and grids of the main changes foreseen by the reform are the following.

Contracts for Difference and Power Purchase Agreement:

- Generators: reduces the risk in investment in new generation
- Consumers: know their electricity bill but get weaker signals short-term savings but more predictability for long-term savings
- Grids: reduces the available flexibility in the grid

Energy sharing:

- Generators: weakens the price signal due to lower market volumes
- Consumers: increases investment incentives in renewables, positive social aspects.
- Grids: smaller markets volumes and flexibility, still needs to invest in grid to maintain reliability, so new incentives towards energy sharing are needed?

Capacity mechanisms:

- Generators: reduces risk in capacity investment – risk of overinvesting
- Consumers: lower the price in the most expensive hours, but paying elsewhere
- Grids: Creates certainty of reserves and easier grid planning as capacity development and location is less uncertain.

Finally, Belsnes concluded by specifying that the CET is fundamentally changing the power system operation as it is known. Many changes in the electricity market design can be expected in the coming decades, and the development is closely connected to technology capabilities and if demand flexibility shall play a role or not.
The two main components that are needed to face the upcoming changes are storage solutions and consumer flexibility.

Manuel Baumann (KIT) firstly provided a brief overview on the state-of-play of energy storage application underlining how energy storage represents the centrepiece for building a decarbonised, flexible and cost-effective energy system, through electrification and energy system integration. The demand for energy storage will exponentially increase in the future due to larger use of Renewable Energy Sources (RES) which require higher flexibility. As concerns the development of the energy storage market, the market size in 2022 was about 429 Billion USD and several markets announced ambitious energy storage goals fort the near future (+130 GW storage capacity announced by 2030 with global cumulative capacity 508 GW/ 1,432 GWh by 2030). Applications of energy storage are many, mainly related to generation and grid support, consumer management and ancillary services. These different applications areas may require different storage technologies and business models. Then Baumann focused on 3 application of the energy storage pointing out that:

- Long Duration Storage
    - Large-scale, long-term energy-storage projects may require visible long-term revenue streams
    - Support research and innovation - in particular, long-term energy storage – and launch technology accelerator programmes and dedicated support schemes.
- Off grid Applications
    - Accelerate the deployment of storage facilities and other flexibility tools in islands, remote areas and the EU's outermost regions with insufficient or unstable grid capacity.
- Smart Mobility

- Member States should identify any specific actions, regulatory and non-regulatory, necessary to remove barriers to the deployment of demand response and behind-the-meter storage.

Vittoria Maria Garibbo (Sant'Anna School of Advanced Studies) delivered a presentation on the role of business networks into the energy transition with a focus on business ties to foster hydrogen economy. The research conducted by Garibbo aims to investigate the main implications and constraints for the green hydrogen development prospects according to market operators. Here below the main results are reported:

- **Utilities and energy companies**: they see H2 as a complement to the core business. They play a pivotal role in providing RE. They can become business integrator of potential users where electrification is not viable
- **Utilities gas distributors**: they are an important enablers of H2 diffusion because of the methane infrastructure they own. They could facilitate the scale-up of green H2 addressing distribution barriers. Current pipelines should be updated, and this is a significant investment.
- **Refineries: potential off-takers**: they see green h2 instrumentally for decarbonization. They already uses grey H2 in traditional production cycle, so it wouldn't be critical to use it. They suffer mainly economic constrains due to the green premium price of green H2 compared with grey H2.
- **Steel-Making companies:** potential off-takers of big volume. They see green h2 instrumentally for decarbonization. The use of H2 in the production cycle requires both significant capital expenditure (CAPEX) to modify the production process and equipment (ex. DRI) + and higher operational costs in the day-to-day operations.
- **Heavy duty Transports:** potential off-takers. A widespread usage require substantial investment in upgrading the fleet of vehicles, and higher operational costs comparing with traditional fuels. Moreover, it require advanced supply chain system (refilling stations).

Jens Peters (University of Alcàla) focused his presentation on the challenges for the comprehensive sustainability assessment of energy storage. Indeed large amount of LCA studies on batteries exist but with variable outcomes which make them hardly comparable due to discrepancies in assumptions and modelling, scope, functional unit and impact assessment. Peters highlighted that the future demand for critical raw materials necessary to the Clean Energy Transition will be huge and, considered that the overall availability of these materials might limit the deployment of energy storage system, an efficient use is needed. In this regard, the EU with Critical Raw material Act set specific targets for materials classified as critical or strategic raw materials (SRM) for 2030:

- EU's extraction capacity covers at least 10% of EU's consumption
- EU's processing capacity covers at least 40% of EU's consumption
- EU's recycling capacity covers at least 15% of EU's consumption
- no more than 65% of the EU's annual consumption from a single third country

Few publications apply s-LCA to the battery sector, most of them focus on the LIB sector as a whole, with no activity- or battery-specific approach. What seems to be the challenges for the Social Sciences and Humanities?

- Chances and risks of EU technology development and deployment for third (and EU) countries
- Need for efficient use of resources and energy storage

In order to guarantee a sustainable energy storage, some regulations started to be put into place:

- Battery Regulation (mitigation of environmental impacts)
- Green Hydrogen Act (mitigation of environmental impacts)
- Due diligence act (regulation of social impacts)
- Critical Raw Material Act (regulation of demand)

2nd session: foresight exercise (future triangle methodology) to identify possible future scenarios based on diverse drivers respectively operating: in the future (pulling), in the present (pushing) and in the past (weighting).

In the second session of the workshop 3 working tables on different Energy Storage applications were created:

1. **Long-duration storage** – moderator Holger Ihssen - *Helmholtz Association*
2. **Smart mobility** – moderator Witold-Roger Poganietz – *KIT*
3. **Off-grid applications** - moderators Manuel Baumann & Myriam E. Gil Bardají – *KIT*

The methodology of future triangle was used in order to identify, for each Energy storage application, possible future scenarios and related drivers operating in the future (pulling), in the present (pushing) and in the past (weighting).

Working table on long-duration storage main results

PUSHING FACTORS

- Fossil fuels is the main long-term storage at the moment. By 2035 this is not going to change. So, 2045 is a better timeline to visualize fundamental future changes.
- Technology mix expected in the longer future: e-fuels, H2, reactive metals.
    - Aluminium storage: 60% electricity can be returned back.
    - Hydrogen (H2) has much lower efficiency: 22%. However, H2 has huge clean water requirements which will make this efficiency much lower than 22%. H2 is not easy to store.
    - Reactive metals: no business case.
- Technologies should be different for different national and geographical contexts (e.g. Spain has no Al but lots of sun). Storage strategy ang the economics are context dependent.

PULLING FACTORS:

- Europe could have a good 'map' of what can be provided by each country and rely on the interconnections between different countries.
- The only option for thermal storage is geothermal. Concentrated Solar Power (CSP) facilities are small but there are no technical issues. with the CSP is only a regulation obstacle. CSP has higher cost but it is dispatchable. Thermal losses are low. Combined circle power plants is a good solution for the countries that have fossil-fuel-based generation. There are many potential approaches with thermal storage but it remains a blind spot for policy-makers (and often for the researchers too).

WEIGHT FACTORS:

- Gas, oil, coal are still there which is a reference for the business case, and with the fossil fuel subsidies and low ETS non-fossil-fuels energy storage solutions will never be cheaper than fossil fuels options.
- Awareness on the thermal to power is an important leverage that can lead to investment of money, time and effort into the storage solutions.
- Energy policy should become European policy – a common one. At the moment, each country does its own thing. There is competition between the EU Members States. We need cooperation, all-over-EU policy. For example, France blocks access to their grids from the South of Europe countries. Germany lobbies against ban of the ICE in Europe.

- Transmission capacity: grid extension is another big problem. There are obstacles that are not only related to a physical infrastructure (e.g. transmission lines), there are also commercial and political reasons.

Working table on smart mobility main results:

PUSHING FACTORS:
- Attitude of young people to share cars and not willing to have their own private car.
- People's increasing fear and awareness about climate change.

PULLING FACTORS:
- In the future all cars will be shared and the majority of private cars will be on a sharing platform.
- Consistent increase in e-vehicles which will exchange power with the grid non only when parked but also while moving.

WEIGHT FACTORS:
- The marketing message is still to own your private car (sharing solutions are not advertised).
- Older people still have the idea that private mobility is the cheapest and quickest way to move.
- The automotive industry exercise lots of pressure via lobbying campaigns to preserve the status quo.

Working table on off-grid applications main results

PUSHING FACTORS:
- Creation of innovative business models to foster the deployment of energy storage technologies.
- Off-grid renewables energy technologies are increasingly becoming a competitive solution for sustainable energy access in a range of remote locations.
- Energy storage can enable time shifting at the time of excess low-cost generation and the release of energy in times of peak demand,
- Energy storage can mitigate the intermittency of renewables and balance the supply-demand mismatch.
- Hybrid energy storage system including heterogenous and supplementary energy storage technologies to enhance the regulated capability and reliability.

PULLING FACTORS:
- Energy storage can generate savings for grid systems under specific conditions.

WEIGHT FACTORS:
- Energy storage is strongly dependent on favorable regulatory conditions and it's not clear today whether storage is profitable, how much value it adds to the system in terms of technical rules, ownership, and market regulation .
- Great uncertainties about the scale at which power systems should be deployed. They bring new operation constraints and complexity and require the association of energy storage solutions to insure power quality and supply efficiency.
- Barriers to off-grid energy storage, providing a number of international examples. A couple of issues have been discussed. Costs of off-grid energy storage cannot be recovered directly by residents of rural

communities who normally have low-incomes. For such locations and communities, there is a need for support from governments.