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CIGRE UK Study Committee C1 Technical Liaison Meeting

Potential Role of Energy Storage in Networks

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Working Group C1.51: The potential roles of energy storage in electric power systems

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Power System Development & Economics

The challenge

Tackling climate change is truly the challenge of our generation; addressing energy security, sustainability and affordability for everyone is at the forefront of the global agenda and drive to meet net zero

Decarbonising the world's electricity supply will need to continue developing clean energy sources and grid-scale energy storage to manage and balance energy and load demand and mitigate the weather-dependent nature of renewable generation

1. This working group explored the role of energy storage in decarbonising the electric power system

2. Aimed at establishing a reference for state-of-the-art energy storage in the electricity sector

C1.51 Working Group on Energy Storage:

- Run between Feb. & Dec. 2024
- 40 experts from 20 different countries
- Six key chapters
- Serves as foundation for additional working groups on storage and its role in power system development & economics

Many thanks to Mark Kent, Keith Bell and Colin Ray from the UK

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Energy storage introduction

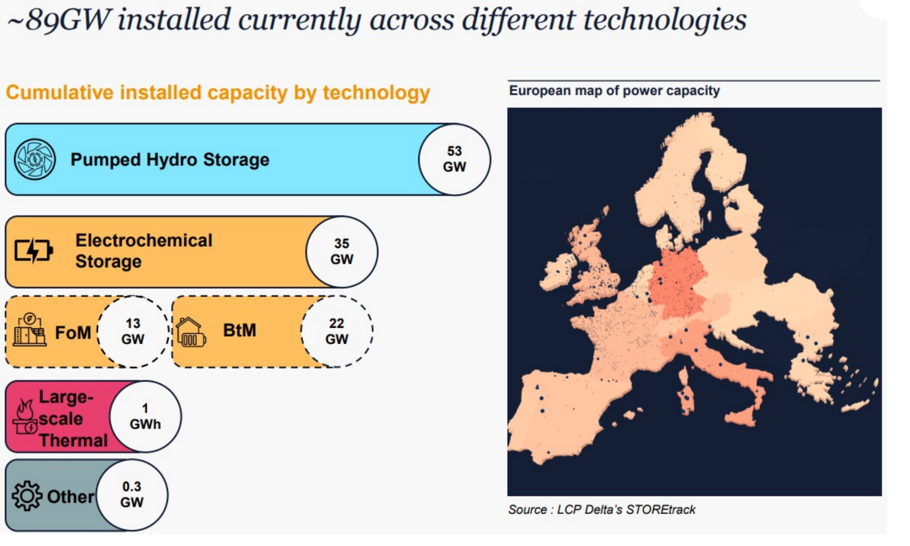
In its purest form, energy storage is a system, process, or device designed to routinely store and release energy as an integrated part of the electric power system

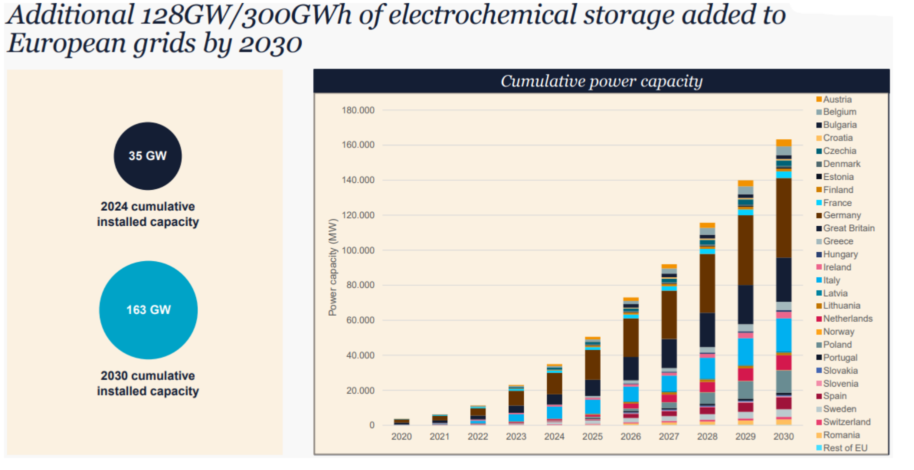
Successfully decarbonising the electric power system will need a range of roles for energy storage, from covering short-term variations, intra-day balancing and long-term system adequacy

Some roles for storage are clear, while others require further clarity

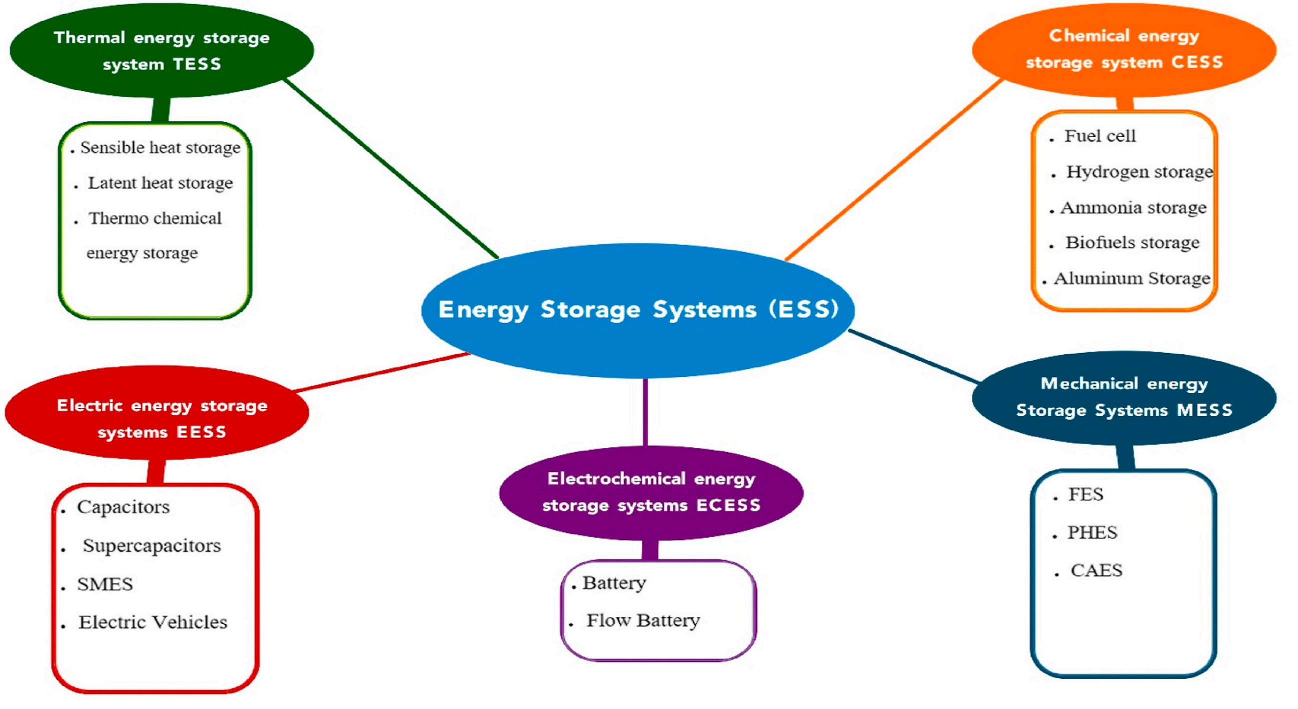
Up to today, storage needs have been covered mainly by gas; low carbon options need to be explored

In some cases, the system operator has direct control over the operation of energy storage. In other cases, the system operator has indirect control using price signals for independent owners to buy or sell energy





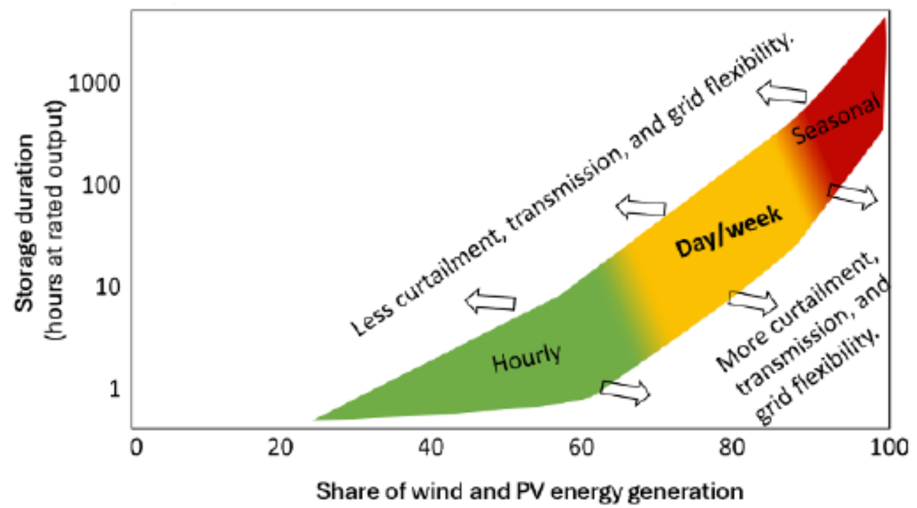
Types of energy storage



1. Electrochemical (e.g., lithium batteries, flow batteries, electric vehicles)
2. Electrical (e.g., supercapacitors, superconducting magnetic devices)
3. Mechanical (e.g., flywheels, compressed air energy storage, pumped hydro storage)
4. Thermo-mechanical (liquid air energy storage)
5. Chemical (e.g. hydrogen, biofuels, ammonia, fuel cells)
6. Thermal (e.g., molten salt, sensible/latent heat)

Applications of energy storage

	Generation		Network		Consumption	
	Front of the meter				Behind the meter	Mini-grid & off-grid systems
	Dispatchable	Variable	Transmission	Distribution	Customer load	Access
Ancillary services (essential grid services)	Black start	Renewable smoothing to correct forecast errors	Frequency regulation	Voltage support	Power quality	Grid support
			Inertia services		Power recovery following outage	
			Contingency response		Backup power	
			Ramping reserve			
			Grid forming			
Short-term flexibility & optimising use of existing assets	Wholesale arbitrage	Renewable integration via energy shifting	Congestion relief		Increased self-consumption	Enable first-time electricity access
					Fixed charge reduction	
					Variable charge reduction	
System adequacy	Wholesale arbitrage	Renewable firming				
Infrastructure planning			Transmission upgrade deferral	Distribution upgrade deferral		



Potential applications:

1. Short-term variations
2. Intra-day balancing
3. Long-term system adequacy

Network upgrade deferral across transmission and distribution

Implementation issues and challenges

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1. Markets: "Perfect foresight" common issue in energy market modelling that risks overstating the effectiveness of energy storage by assuming that can operated in an ideal fashion, trading off present and future needs

How can markets facilitate the best use of storage?

2. Inverter-based resources: like many energy storage systems, introducing complexity and maintenance needs that are different and more complex than conventional resources

3. Cycling factors: charging/discharging speed, sustained response and cycle efficiency

4. Lifetime factors: environmental impact, lifespan and decommissioning

Trade-offs are needed across the different applications and the techno-economic models

5. Large grid-scale storage connected to the grid with diverse roles causing conflicting behaviours, such aim at minimising total system costs while potentially creating local congestion, creating the need for additional investment (all linked to overall market structure and role of storage in them)

Investment decision: generation vs transmission vs storage

Examples of energy storage applications

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Figure 17: Dalrymple Battery Energy Storage System

Figure 18: The Hornsdale Power Reserve BESS

Figure 27: Lithium-ion batteries used in Queensland

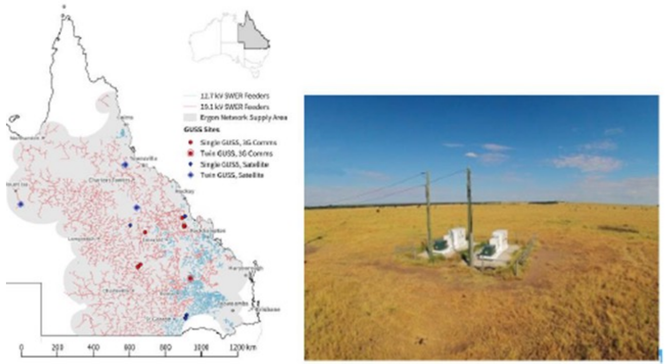


Figure 19: BESS locations in RINGO project

Figure 24: View of the Kapolei Energy Storage facility

Figure 33: Design of heat battery thermal energy storage

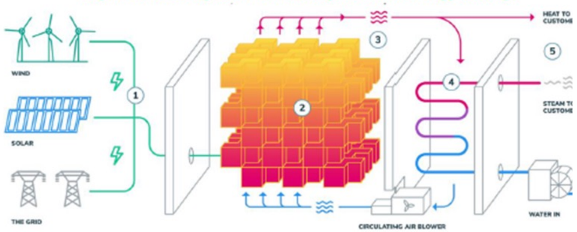
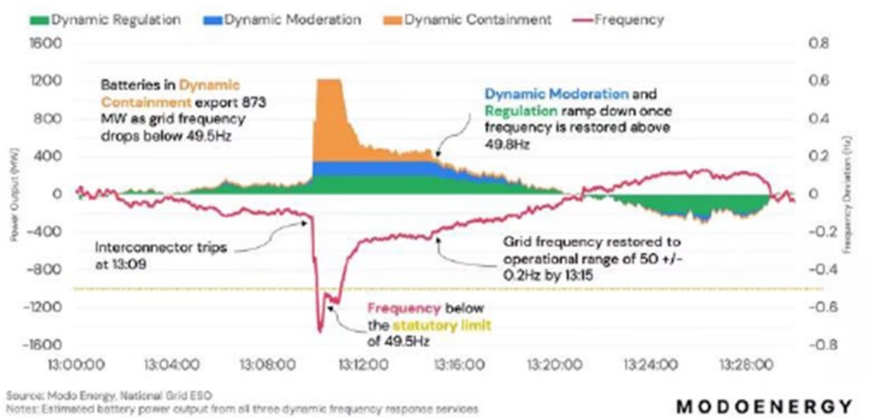


Figure 28: System response to 22 December 2023 event



Conclusions

Energy storage can support overall power system operation

Main observations from energy storage deployment globally:

1. Battery storage growing rapidly
2. Conventional pumped storage and synchronous condensers used but more limited deployment
3. Support needed for emerging technologies to develop technical capability

Mix of solutions needed across different timescales to overcome degrees of risk and initial investment

Deciding factors affecting deployment: duration and response time, efficiency, expected lifetime, costs, scalability, response time, safety and space requirements

Considerations around financing and policy support, as well as regional considerations for siting

The optimal energy storage mix will vary from system to system, depending on the renewable mix as well as baseload generation, the pattern of consumption, and the existing network topology and interconnected systems

Decision-makers, policymakers, engineers, and developers must consider all the above

Recommendations for next working groups

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1. Economic and technical analysis of energy storage compared to transmission investment and/or generation options, including ancillary services

2. Dealing with the new challenges energy storage presents to system planning methods, as opposed to tools and data

3. Planning for Vehicle-to-Grid applications with large-scale adoption of EVs. If widespread adoption of EVs becomes a reality, understand the potential split across grid-scale and/or distributed battery storage vs Vehicle-to-Grid

4. Joint challenges faced by TSOs, ESOs and DSOs. Storage located within the distribution network may present challenges for transmission and vice versa, and introduces the need in coordinating storage patterns across both

Public

Thank you very much for your attention!

Any questions?

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NESO
National Energy System Operator