

Energy storage for grid-scale applications: Technology overview, current technological options, and future challenges

One of the most direct and effective ways to decarbonise human society is to lower the carbon content of the electric energy we use, which is done by increasing the presence of Renewable Energy Sources (RES) in the energy mix. As headlines for transitioning towards a net-zero-greenhouse gas emissions economy, the EU countries set ambitious goals for 2030 and 2050.

In the future EU strategy, renewables will represent 50% to 70% of energy production, depending on the level of ambition we decide to pursue. We know very well that non-dispatchable RES will mainly represent such shares, and it is widely acknowledged that energy storage will play a decisive role in helping manage RES fluctuations. Different storage technologies are and will be required. Nowadays, the landscape is dominated by lithium-ion batteries for power-intensive uses (forecast errors, balancing actions, frequency regulation), while for energy-intensive uses (load shifting), the landscape is much more diverse. The emblematic energy-intensive storage technology is pumped-hydro, but most advanced countries have struggled to find suitable sites for new pumped-hydro facilities in the last few years. This sparked intense research and development efforts to produce various storage technologies, mainly based on various thermal and mechanical concepts.

In the seminar, the issues to be solved to advance the RES integration will be introduced and linked to the various storage technologies. The seminar will focus mainly on the energy-intensive uses of storage, and the newly proposed technologies to replace and complement pumped hydro will be reviewed. The pros and cons of each technology will be discussed, covering practical and technological limitations, the environmental and social impact and the replicability of the technology. Finally, we will try to identify the future outlook of each technology, also factoring in some economic considerations.

Agenda

- First lesson (2 h), 17th of February, 9:30 – 11:30, Room TBD
 - Introduction
 - The EU path towards decarbonisation
 - RES-related issues and their classification in power-intensive and energy-intensive
 - Storage technologies for grid-scale applications (part 1): classification of technologies, power-intensive technologies and pumped hydro
 - Classification of technologies based on charging and discharging times
 - Overview of technologies for power-intensive tasks
 - Pumped hydro: technology overview, overview, limitations and possible solutions
- Second lesson (2 h), 18th of February, 9:30 – 11:30, Room TBD
 - Storage technologies for grid-scale applications (part 2): Electrochemical and thermo-mechanical concepts, prototypical and commercial applications and economic outlook
 - Compressed Air Energy Storage (CAES)
 - Liquid Air Energy Storage (LAES)
 - Pumped Thermal Electricity Storage (PTES)
 - Electrochemical (Molten salt e Flow batteries): a brief overview
 - Future outlook and economic issues