



Energy storage in the subsurface: an important component of transition to low carbon energy

Role of energy storage in future energy systems

The transition towards a clean and low carbon energy system will be accompanied by far-reaching changes in energy production and consumption patterns due to a strong foreseen growth of intermittent renewables in the energy system. These changes require solutions in order to ensure reliable, clean and affordable energy for all citizens and industries of Europe. Besides the development of flexible forms of power/heat production, improved grid interconnectivity, smart grids and demand-response functionalities, energy storage (Fig. 1) will play a pivotal role in providing the needed flexibility and offering balancing options to the integrated energy system.

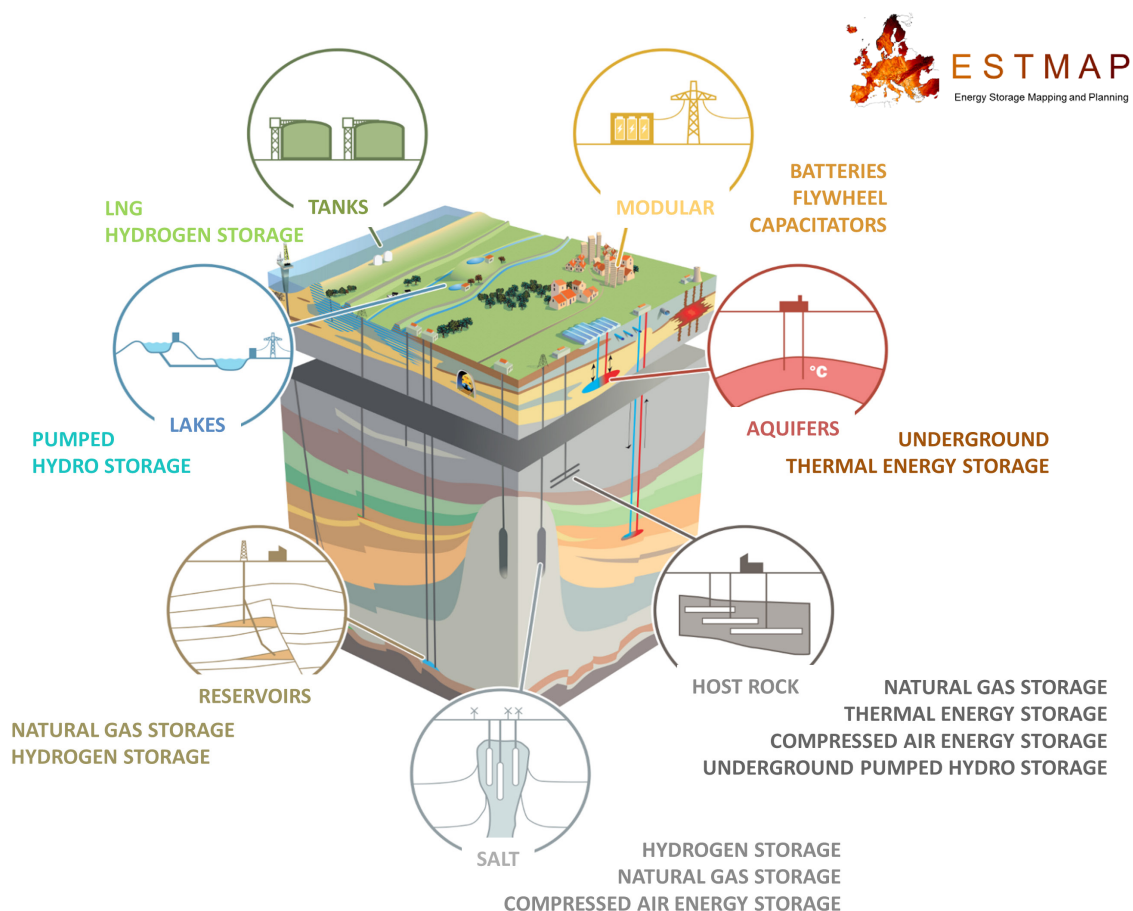


Fig. 1 Main types of above ground and subsurface energy storage

Greater deployment of energy storage is required at different scales, i.e. from low power (kW to MW level), fast response (seconds to minutes) solutions, to high power (towards GW), longer-term (hours and far beyond) balancing needs for the grid. Large-scale and centralized energy storage can provide flexible bulk power management services for electricity, gas and heat commodities. In addition to flexibility, large-scale energy storage offers essential services to society in the form of strategic energy reserves and balancing solutions for unavoidable seasonal variations. The growth of these services to sufficient scale is key to ensuring a reliable and secure energy supply at lowest system costs.

Past and recent investigations have revealed a broad potential for large-scale energy storage in Europe including existing and prospective sites both on the surface (especially pumped hydro storage) and in the subsurface (compressed air energy storage, underground thermal energy storage, synthetic/natural gas storage and hydrogen storage).

Analyses of the future energy systems, for example, the recently completed Horizon 2020 ESTMAP project (www.estmap.eu), demonstrate a substantial potential and indicate an important future role of large-scale energy storage in Europe. Subsurface energy storage is an important part of the solution.

Subsurface energy storage: research challenges

Subsurface energy storage represents a complex and broadly evolving field of research, as it covers multiple scales of application, a variety of end-user profiles, and different types of energy carriers. Subsurface storage capacities are present in many types of geological formations, each of which has its own criteria for identifying techno-economic viability. Some of the subsurface energy storage technologies (e.g. natural gas storage) have been applied at large scale for decades, while others have thus far been applied in pilot projects or at modest scale only (e.g. compressed air energy storage, hydrogen storage). It is crucial to further increase our level of understanding of subsurface energy storage potential on the basis of new geoscientific data, improved models and common agreed assessment principles.

The key to unravelling the full potential and effective implementation of large-scale subsurface energy storage lies in the integration of geological knowledge, engineering solutions, market-economy information and a comprehensive analysis of the entire energy system. Close cooperation between all actors from science, industry and policy areas is therefore essential to a successful development.

The ESTMAP project, with participation of many partners of the ENeRG and EuroGeoSurveys networks, made the first important steps towards the assessment of the subsurface energy storage potential in Europe. Based on collection and compilation of publicly available spatial information on existing energy storage sites and future storage potential, a harmonized spatial database (Fig. 2) has been developed and populated, capable of maintaining, integrating and disseminating the gathered information. Moreover, a demonstration of how the database can be used for pan-European and regional energy system modelling studies has been performed.

This is, however, not enough; further steps towards a comprehensive assessment of Europe's energy storage potential and its utilization in planning of future low-carbon energy systems are

needed. National geological surveys and geoscience research institutes of Europe hold the key to jointly establishing the information and knowledge that is required to improve the evaluation and identification of prospective sites for developing subsurface energy storage technologies (for gas, electricity and heat).

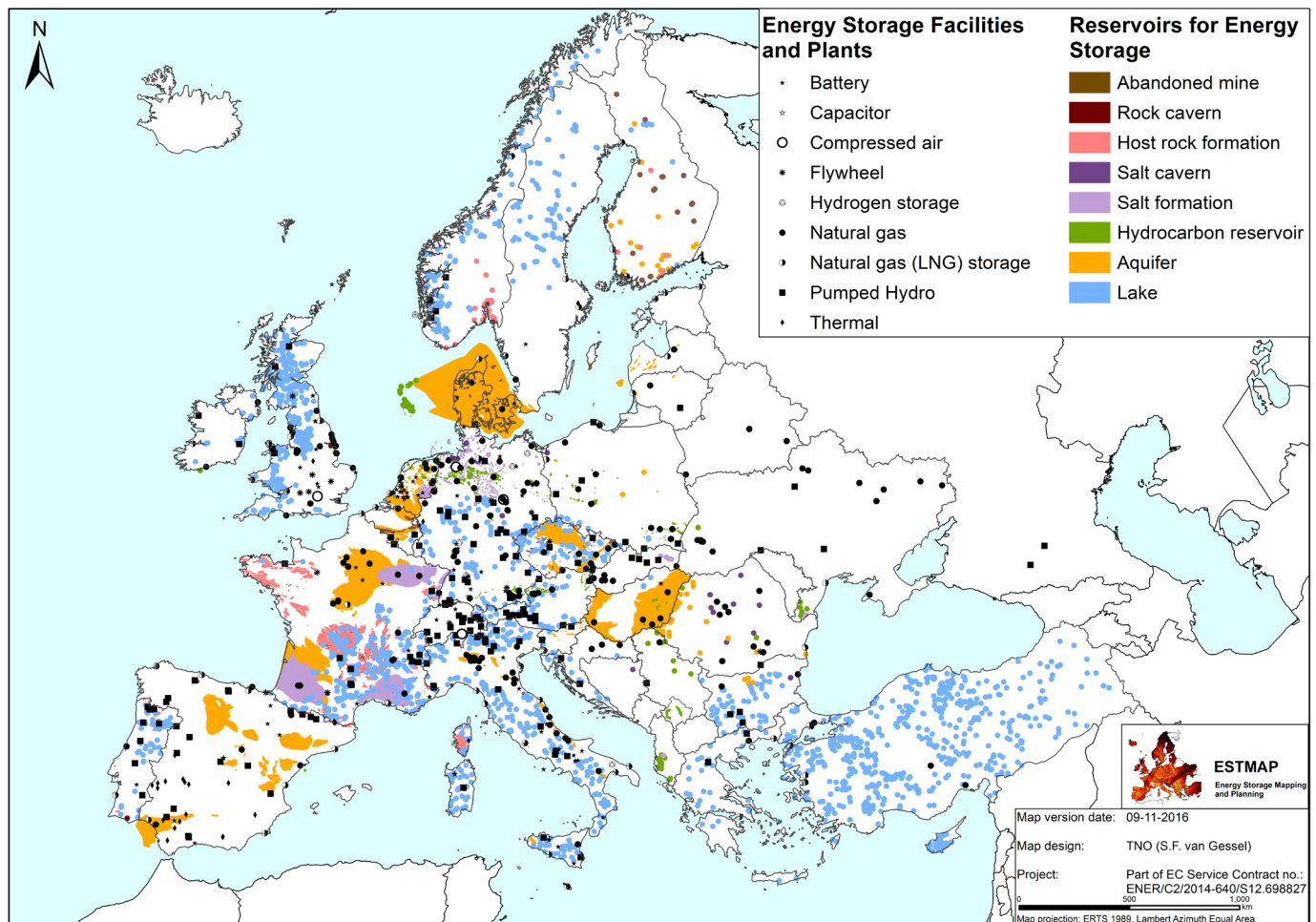


Fig. 2 Map of energy storage potential in Europe (based on ESTMAP results)

Critical actions involve:

- The development and application of methodologies and criteria to geological data in the less technically mature countries, especially in Central, Eastern and Southern Europe, in order to evaluate the European subsurface energy storage potential in a unified manner and bring it to a comparable cognition level.
- The identification of prospective areas that can be considered as a potential play opener for large-scale deployment of subsurface energy storage, and preparation of information that can be used as a basis for selecting and developing pilot storage projects.

- The exchange and transfer of knowledge between “forerunner” and “follower” countries (in terms of subsurface energy storage research, development and deployment) and raising awareness of subsurface energy storage potential and its competitiveness to other practical solutions in all countries.

Facilitation of future planning and policy support on subsurface storage developments will also require:

- Conforming and harmonizing capacity assessments to common classification systems and industry standards, and allowing for a better comparison of storage potential between various regions of Europe.
- Enabling an unbiased ranking of prospective sites based on technical, economical and societal criteria.
- Map the characteristics of large-scale energy storage vis-à-vis other flexibility and storage options in the energy system in terms of societal impact and acceptance.
- Identify main barriers and risks to the deployment and advantageous synergies with other technologies supporting the up-take of large scale energy storage in exemplary business and use cases.

Timing and cooperation

Action is needed on multiple levels. Large-scale energy storage capacities need to be ready for deployment in optimising the productive use of renewable energy sources and substantially reducing curtailment as part of a cost-effective energy transition. This technology can have a meaningful and substantial role in optimising the transition that can be realised only if proper preparations are done well before the share of renewable energy sources has grown towards targeted levels and the consistent supply from fossil resources has shrunk.

Currently, there is a key window of opportunity to rebuild momentum for research and development of subsurface large-scale energy storage, while benefiting from synergy with developments in adjacent research domains including geothermal energy and Carbon Capture & Storage. This synergy should include contributions from oil and gas industry as well as national and regional geoscience and technology institutes.

Energy storage is more and more becoming a prominent topic in various research programmes. To prevent fragmentation of knowledge and information, it is important to ensure that actions across these research programmes do have added value to each other. Geological research institutes can stimulate this by cooperating within and across the networks and programmes under which they are organized.

ENeRG, the European Network for Research in Geo-Energy (www.energnet.eu), was created in 1993 by European organisations involved in research and technology development (RTD) focused on fossil energy sources, especially oil and gas. The focus has been evolving towards all subsurface technologies for enabling low carbon energy transition, climate change mitigation and security of supply: geothermal energy, CO₂ geological storage, underground energy storage, etc.