The role of the underground for massive storage of energy: a preliminary glance of the French case

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The question of storing energy in France has become of primary importance since the launch of a road map from the government which places in pole position this topic among seven major milestones to be challenged in the context of the development of innovative technology in the country. The European objective to reach 20% of renewables in the energy market, from which a large part would come from wind and solar power generation, raises several issues regarding the capacity of the grid to manage the various intermittent energy sources in line with the variability of the public demand and offer. These uncertainties are highly influenced by unpredictable weather and economic fluctuations. To facilitate the large-scale integration of variable renewable electricity sources in grids, massive energy storage is needed. In that case, electric energy storage techniques involving the use of underground are often under consideration as they offer a large storage capacity volume with a adapted potential of confining and the space required for the implantation. Among the panel of massive storage technologies, one can find (i) the Underground Pumped Hydro-Storage (UPHS) which are an adaptation of classical Pumped Hydro Storage system often connected with dam constructions, (ii) the compressed air storage (CAES) and (iii) the hydrogen storage from conversion of electricity into H2 and O2 by electrolysis.

UPHS concept is based on using the potential energy between two water reservoirs positioned at different heights. Favorable natural locations like mountainous areas or cliffs are spatially limited given the geography of the territory. This concept could be extended with the integration of one of these reservoirs in an underground cavities (specifically mined or reuse of preexisting mines) to increase opportunities on the national territory. Massive storage based on compression and relaxation of air (CAES) requires high volume and confining pressure around the storage that exists naturally in the underground and which increases with depth. However, the move to an interesting efficiency requires that the heat generated during compression can be stored and used during expansion. This storage can be also underground. H2 underground storage is part of the “Power to gas” concept which allows for converting electricity into a gas available for either electrical or gas grid. Each of these techniques requires the selection of appropriate geological formations which contains specific characteristics in agreement with several criteria under consideration when choosing electric energy storage methods for application (lifetime, life cycle, discharge rate, environmental impact, public acceptance …). We propose in this paper a preliminary review of the potential massive electric energy storage capacities in France of using specific geological formations (salt, basement) and the various physical phenomena linked to the couple geology/technology. Several approaches and methodologies developed formerly with other applications (geothermal, CO2 storage, heat storage …) will be used to investigate rock mechanical integrity, geochemical and thermal environmental impacts associated to these innovative technologies.