Solution Mining Research Institute Spring 2023 Technical Conference
Detroit, Michigan, USA 24-25 April 2023

Redox Flow Battery: Application to Salt Cavern

Cyriane Fournier, Geostock, Rueil-Malmaison, France
Florence Geneste & Didier Floner, ISCR, Rennes, France
Xavier Decotenie, Géosel, Rueil-Malmaison, France

Abstract

Rechargeable batteries have been recognized as promising candidates for stationary energy storage due to their ability to convert and store electrical energy. Among these batteries, redox flow batteries (RFB) which have been developed for over 40 years, have been identified as one of the ideal choices for large-scale energy storage due to their safety, high reliability and long-lifetime expectancy.

The use of salt cavern as a container for electrolyte for redox flow batteries has several advantages. The biggest one is the very large volume of electrolyte (salt caverns in the range 90 000 - 600 000 m^3 – 600 000 – 4 000 000 bbl) offering high electrical energy storage capacity. In addition, the salt caverns provide an electrolyte saturated with salt, which could solve the problem of the chemical instability of the water and stop side reactions from happening (decomposition of water). Finally, the temperature (between 40 and 45 °C, 104 and 113 °F) also improves the solubility of the redox couples in the electrolytes.

Based on these advantages, the feasibility of using salt cavern for RFB was examined, on the specific site of GEOSEL Manosque, on two thematics:

- Finding an electrolyte that is compatible with saturated brine at the required concentration
- Estimating the energy yield and the costs for such a system

The first works carried out demonstrated that some organic redox species are soluble in salt cavern brine and could achieve a solubility of 0.5 mol/l. Furthermore, the reversibility of these redox species in saturated brine was verified. Finally, redox flow batteries were tested at laboratory scale. In the best case, about 1500 cycles were performed. The loading capacity decreases significantly over the cycles. Therefore additional tests are required to stabilize the electrolytes over the time.

In terms of energy yield, it was calculated that two caverns of 100 000 m^3 (630 000 bbl) could provide an energy storage capacity between 400 MWh and 1 340 MWh depending on the concentration of the electrolyte. At least one week would be necessary to load or unload the total volume of electrolytes. Hence, the power of the battery can be estimated between 4 and 13 MW. The pressure losses of the process have been estimated (in casing, pipes and stacks) and a first energy yield of 51.5 % was estimated with the current technology. This yield could rise to 60 % with several optimizations.

Last, a first LCOS (Levelized Cost of Storage) was estimated and compared to other energy storage systems.

Keywords: Redox Flow in Salt Caverns, Energy yield of Redox Flow, Solubility of redox species, Reversibility, Laboratory tests