ENERGY STORAGE SYSTEMS FOR ELECTRICAL ENERGY

by

B.B. Quist, H. Holscher and E. Verschuur

KONINKLIJKE/SHELL-LABORATORIUM, AMSTERDAM
(Shell Research B.V.)
Badhuisweg 3, 1031 CM Amsterdam, The Netherlands

In general, consumption of electricity is higher during the daytime than at night. As electricity is normally generated at the time of consumption, the total generating capacity of a public utility should at least be capable of coping with peak loads, leaving a considerable amount of capacity unused during a large part of the day. In order to keep the costs of electricity low, utilities would like to store electricity at night for delivery during the daytime. The only storage facilities that are in current use are based on the principle of Pumped Hydro or Compressed Air Energy Storage. Other storage systems such as batteries, fuel cells etc. are by no means economic at this moment.

We have developed a novel underground energy storage system, in which the electrical energy is stored as potential energy: two large down-hole cavities located at different depths in a salt dome are interconnected top-to-top and bottom-to-bottom. The cavities are both filled with brine and high-pressure gas. The gas pressure is sufficient to provide a suction head for a reversible pump-turbine (RPT), which is positioned at approximately the same height as, or above, the upper cavity. The configuration may be thought of as a huge siphon.

During power generation the brine flows from the higher cavern to the lower cavern via a turbine and in the charge mode the brine is pumped from the lower cavern to the higher cavern. The gas flows uninterruptedly in the opposite direction. A practical configuration in the Netherlands would involve twenty units of 100 MW each and cavern sizes of 700 000 m^3. We found that it is economically attractive to position the RPT underground, at the same depth as the upper cavern. In this configuration the required length of the high-pressure shaft is approximately 100 m per unit.

The Central Offices of the Royal Dutch/Shell Group have made a budget-type cost estimate for the system in a salt dome near Hengelo. This salt dome is large enough to accommodate a system with 2000 MW generating capacity. Costs are estimated to range from Dfl. 1400 to 1700 per kW installed capacity. For the Dutch situation these figures compare favourably with alternative underground pumped hydro systems.