ECONOMIC EVALUATION OF AN UNDERGROUND PUMPED HYDROELECTRIC STORAGE IN DECOMMISSIONED HARD COAL MINES

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(1) Overview

The increasing share of non-dispatchable and fluctuating renewable energy sources brings several technical and economical challenges to the German energy system. Large scale power storage systems could play a key role in overcoming these issues. A number of power storage technologies are already available for commercial application; others like Underground Pumped Hydroelectric Storage (UPHS) are still under research and development. In Germany, UPHS has become an interesting technology for the energy system´s flexibility. Furthermore, Germany´s hard coal mining phase-out by 2018 represents a big challenge for the mining sector, which accordingly seeks new uses for the existing infrastructure.

The aim of this study is to carry out an economic evaluation of an UPHS system. Two technical variants differentiated in their storage volume are considered: variant 120 (120.000 m³) and variant 200 (200.000 m³). Variant 200 has larger underground storage cavities than variant 120, which in contrast to those of variant 120 are not fully available and therefore have to be partly drilled. The underlying data for the variants come from the coal mine Auguste Victoria of the German hard coal mining company RAG.

(2) Methods

For the execution of the economic evaluation an Excel based deterministic techno-economic model that simulates a market driven operation of the UPHS in the spot market is developed. The input data for the model are mostly obtained from research partners of the Duisburg-Essen University. The calculation method used in this study corresponds to the methodology of the dynamic investment appraisal. To take account for data uncertainty, a sensitivity analysis with respect to the discount rate and the lifetime is carried out.

(3) Results

This study shows that under the given conditions and assumptions, the sum of the payouts are not covered by the revenues in the spot market during the entire service period of the facility.

The net present value of the considered variants attains neither in the best-case nor in the worst-case scenario, a positive value. Investing in an UPHS is therefore disadvantageous for each one of the variants. When both variants are compared in terms of the energy storage costs, the variant 120 turn out to be more competitive. Comparing the variant 120 to alternative storage technologies, it shows also competitiveness. If the future development of the costs of the alternative storage technologies is considered, the variant 120 is still competitive. However, when the energy storage cost in the best-case scenario (9 € cents / kWh) is compared with those of conventional pumped hydroelectric storage, it shows not competitiveness.

(4) Conclusions

Due to the negative results obtained in this work, an investment in an UPHS with a pure market application on the spot market cannot currently be recommended.

It should be noted that an economic evaluation of new systems in early stages of development is usually done using an inadequate data base. Due to the lack of references this economic evaluation contains large uncertainties. Accordingly, this work cannot present definitive results, but merely provides a first estimation of the profitability of an UPHS in decommissioned hard coal mines.

In future work it is essential to enhance the data base for the calculations. For the remaining uncertainties a risk analysis could be carried out with the support of the Monte Carlo simulation.

As noted, the operation of the UPHS was limited for this study to the spot market. Since the balancing energy market also represents one of the most attractive power markets, it should be analyzed how this affects the economic performance of the UPHS.

Aspects related to storage optimization, such as the optimum storage capacity should be also examined. Therefore the UPHS design parameters should be optimized in order to maximize long-term profit, given a certain electricity market development scenario. This requires therefore spot and balancing energy market price forecasting based on selected scenarios for the future development of the German energy market.

References

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