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Techno Economic Analysis of CAES Systems Integrated into Gas-Steam Combined Plants

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Abstract : The increasing utilization of renewable energy sources for electric power production calls for the introduction of energy storage systems to match the electric demand along the time. Although many countries are pursuing as a final goal a “decarbonized” electrical system, in the next decades the traditional fossil fuel fed power plant still will play a relevant role in fulfilling the electric demand. Presently, such plants provide grid ancillary services (frequency control, grid balance, reserve, etc.) by adapting the output power to the grid requirements. An interesting option is represented by the possibility to use traditional plants to improve the grid storage capabilities. The present paper is addressed to small-medium size systems suited for distributed energy storage. The proposed Energy Storage System (ESS) is based on a Compressed Air Energy Storage (CAES) integrated into a Gas-Steam Combined Cycle (GSCC) or a Gas Turbine based CHP plants. The systems can be incorporated in an ex novo built plant or added to an already existing one. To avoid any geological restriction related to the availability of natural compressed air reservoirs, artificial storage is addressed. During the charging phase, electric power is absorbed from the grid by an electric driven intercooled/aftercooled compressor. In the course of the discharge phase, the compressed stored air is sent to a heat transfer device fed by hot gas taken upstream the Heat Recovery Steam Generator (HRSG) and subsequently expanded for power production. To maximize the output power, a staged reheated expansion process is adopted. The specific power production related to the kilogram per second of exhaust gas used to heat the stored air is two/three times larger than that achieved if the gas were used to produce steam in the HRSG. As a result, a relevant power augmentation is attained with respect to normal GSCC plant operations without additional use of fuel. Therefore, the excess of output power can be considered “fuel free” and the storage system can be compared to “pure” ESSs such as electrochemical, pumped hydro or adiabatic CAES. Representative cases featured by different power absorption, production capability, and storage capacity have been taken into consideration. For each case, a technical optimization aimed at maximizing the storage efficiency has been carried out. On the basis of the resulting storage pressure and volume, number of compression and expansion stages, air heater arrangement and process quantities found for each case, a cost estimation of the storage systems has been performed. Storage efficiencies from 0.6 to 0.7 have been assessed. Capital costs in the range of 400-800 €/kW and 500-1000 €/kWh have been estimated. Such figures are similar or lower to those featuring alternative storage technologies.

Keywords : artificial air storage reservoir, compressed air energy storage (CAES), gas steam combined cycle (GSCC), techno-economic analysis
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