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Coalmines as Underground Pumped Storage Power Plants (UPP) – A Contribution to a Sustainable Energy Supply?

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In Europe, electrical power generation from renewable energy sources rose by about 50% in the last 20 years. In Germany, renewable electricity is mainly provided by wind power and photovoltaic. Energy output depends on weather conditions like wind speed or solar radiation and may therefore vary considerably. Rapid fluctuations in power generation already require regulation of conventional power plants by the distribution network operators to stabilize and ensure grid frequency and overall system stability. In order to avoid future blackouts caused by intermittent energy sources, it is necessary to increase the storage capacity for electric power. Theoretically, there are many technologies for storing energy, like accumulators, hydrogen storage systems, biomethane facilities (hydrocarbon synthesis) or compressed air storage. Only a few technologies combine sufficient capacity, fast response, high efficiency, low storage loss and long-term application experience. A pumped storage power plant (PSPP) is a state of the art technology which combines all of these aspects. Energy is stored in form of potential energy by pumping water to an upper reservoir in times of energy surplus or low energy costs. In times of insufficient power supply or high energy costs, the water is released through turbines to produce electric energy. The efficiency of state-of-the-art systems is about 70-80%.
The total head (geodetic height between upper and lower reservoirs) and the storage capacity of the reservoirs as given in a mountainous terrain, determine the energy storage capacity of a PSPP. An alternative is the use of man-made geodetic height differences as given in ore, coal or open cast lignite mines. In these cases, the lower reservoir of the plant is located in the drifts or at the bottom of the mine. Energieforschungszentrum Niedersachsen (EFZN) has already explored the installation of a PSPP in abandoned ore mines in the Harz-region/Germany (Beck 2011). In 2011/2012 a basic research project, funded by Mercator Research Center Ruhr has been performed to investigate the field of application of coal mines for underground pumped storage plants (UPP). In further research, in co-operation with the Ruhrkohle AG coal mines in the Ruhr Area will be investigated (Niemann, 2011).
The coal mine “Prosper-Haniel” is located in the northern part of the Ruhr Area and shafts have a maximum depth of 1,159 m. It will be closed in 2018. In principal two different designs had been investigated (Luick 2011). The first is a closed system in which water circulates isolated from surrounding groundwater in drifts and shafts supported by casings. The second one is an open system, with a varying groundwater table at a defined depth. Problems resulting from this are the stability of the surrounding rock, its porosity and fissurization, composition of mine waters, the necessity of new drifts and shafts or the upgrading of old ones. In addition, the configuration and arrangement of turbines, pumps and ventilation shafts play an important role.
The presentation gives an outline towards problems and challenges which have to be solved in order to establish an innovative contribution for future energy storage.

References

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