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steam power technology

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Energy Storage

Steam Accumulation

***David Oakland describes a sometimes overlooked option in the utility scale energy storage mix.**

Energy storage for power generation and grid resilience has undergone significant development since the beginning of this century. Establishing a low carbon electricity grid requires the disparity between electricity demand and power supply generated from burning fossil fuel or the harnessing of renewable energy sources to be managed. To this end there already exists grid-scale direct electrical (battery), indirect thermal (molten salt) and mechanical (flywheel) storage technologies deployed commercially and the available choices in the future will undoubtedly expand as a result of fervent R & D in this field. It is only a matter of time before other technologies such as compressed air and liquid air storage, and hydrogen storage technologies are of sufficiently developed and comparable commercial size to join the list.

Efficient electrical power production from fossil-fuelled and concentrated solar power (CSP) plant which involves raising steam to drive a turbo-generator suffers from an imbalance between supply and demand and in the case of CSP power output cannot be maintained during periods of cloud cover and through the hours of darkness without some form of energy storage. In the case of new-build projects, conventionally fuelled or solar, this can impact detrimentally on economic justification and investment decisions.

Following the climate change summit in Paris last December, Government's among the signatory countries are starting to impose legislative requirements on power producers to ensure stipulated amounts of energy storage are available within a given time-frame. The focus of the US Energy Storage Association's activity at State level is to *"advocate for a prudence review of all transmission, generating capacity, and distribution proposals, to ensure that energy storage-based options are properly and routinely considered by buyers of electricity".* The State of California has already led the way toward this resolve when in 2010 the legislature passed Assembly Bill 2514 which required the California Public Utilities Commission (CPUC) to determine targets for each investor-owned utility to procure viable and cost-effective storage to be available to the State by 2020.

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Energy storage can balance intermittency to overcome the economic and operational problems of operating power plant. Various electrical and thermal technologies are available. Of the latter, one already long established energy storage solution that is often overlooked is 'steam accumulation'. Steam accumulation can provide large-scale indirect storage of electrical power by accumulating excess steam produced by the steam generator for later release to drive the turbine. Industrial size accumulators can be very large but there is no practical limit to size, storage capacity or operating pressure of the storage vessels to balance demand variations or maintain electrical power output at the levels required.

The early development of large storage installations for power generation began at Berlin-Charlottenburg power station in the early 1900's and which consisted of 16 steam storage vessels totalling 5,000m^3 in volume and holding a steam storage capacity of 610 tonnes of steam. The latest large saturated water storage plant recently built and now operational is the 50MW 'Khi 'Solar One' CSP plant situated in the Northern Cape Province of South Africa. This comprises multiple steam accumulator vessels which in combination can supply up to two hours of thermal energy (integral superheated steam) back to the power plant to maintain full output of clean energy to 45,000 households.

The term 'steam accumulator' is a misnomer and a more apt description would be 'heat accumulator'. This is because water (not steam vapour) is used as the storage medium in the storage vessel. The reason becomes evident when the greater heat storage capacity of water is compared with that of steam vapour by volume at any given state of temperature and pressure. Most accumulators work on the 'pressure drop' or 'sliding pressure' principle whereby steam from the generator is charged at high pressure into the water – thus raising its temperature (and pressure), and the steam for power production is discharged from the water as 'flash' at low pressure under demand.

Steam accumulation is not limited to power generation applications, indeed its widespread use in industries that are reliant on steam for its manufacturing processes extends back through the 20th century and its relevance today is still just as important. However, there is an important distinction to be made between the purpose of a steam accumulator to provide (1) industrial energy storage or (2) utility energy storage. The correct design in terms of the required storage capacity and charge/discharge functions is important for both types but in the case of (1) equally careful attention must be given to incorporating the steam accumulator into the steam supply system in such a way as to optimise, possibly maximise by means of suitable control, the efficient use of energy in the boiler house whilst at the same time securing the needs of production and safeguarding, even improving, product quality. In the case of (2) the stored energy is basically required to make available a supply of supplementary steam to the power generation plant to balance intermittency and if necessary to take over completely (for a finite period) the steam supply to the power generator during periods of interruption to the energy supply as (for example) in the case of solar power generation plant.

The utilisation of steam accumulation as an effective grid-scale energy storage solution can fit equally with new build or retro-fit applications for solar and fossil fuel fired turbo-generator power plant alike. The commercial and economic arguments for the choice of steam accumulation in the power generation storage mix have to be made in each individual case but technological viability need not be seen as a barrier to further investigation of the potential for this proven technology.

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