High-Temporal-Resolution Analysis of GB Power System Used to Determine Optimal Amount and Mix of Energy Storage Technologies

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Different energy storage technologies suit different timescales. Batteries, for example, may be suited for short-term use, while hydrogen is well suited for long-term. Thus, the appropriate choice of storage technologies is very much dependent on the application, which in the case of this paper is grid balancing, and in particular, the balancing of the GB power system in a low-carbon 2050 scenario.

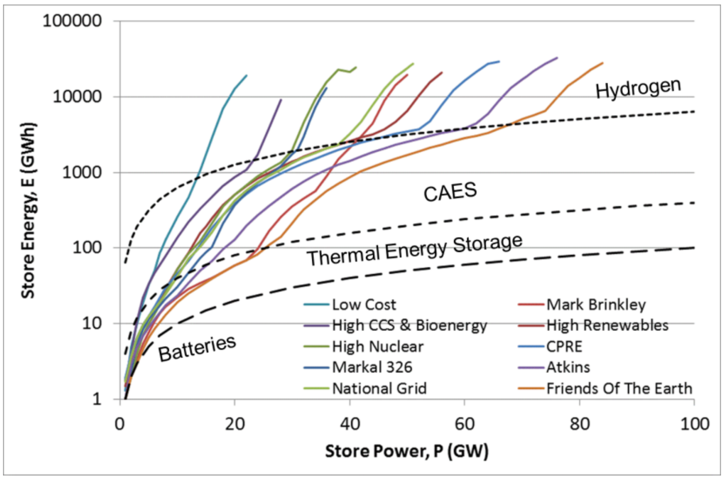
The role of energy storage in the GB power system is investigated through application of an hourly-time-step model of a whole year of operation. The model, FESA (Future Energy Scenario Assessment), has been described previously [Barton et al., Barnacle et al.].

The focus of this paper is to look at the temporal characteristics of how storage would be required to operate within this future GB scenario, and to align this with temporal characteristics inherent to various energy storage technologies.

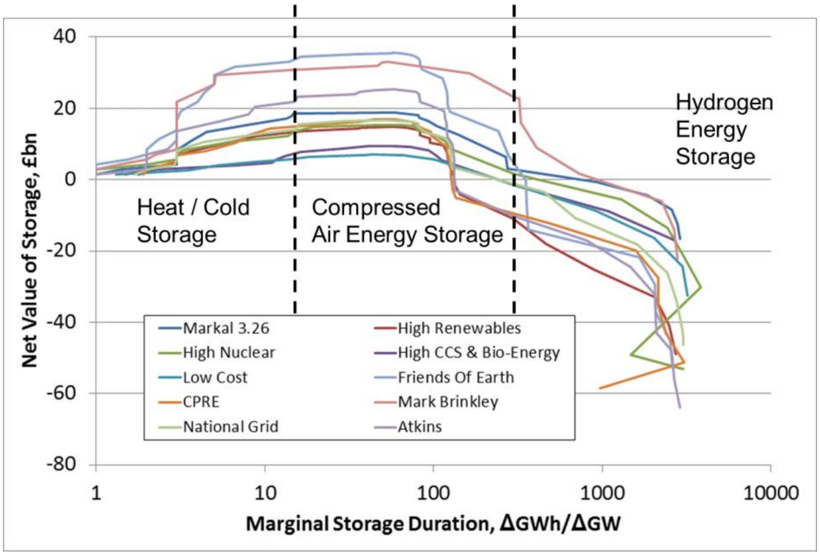
Using the 10 example low-carbon scenarios from the DECC Calculator [DECC], the study evaluates the economic value of energy storage to the GB system accruing in three ways:

1. Peak generating plant deferral, resulting in a saving in capital cost
2. Energy arbitrage, replacing unabated and fossil fuelled generators by CCS generators, renewable power and nuclear power. This results in savings of carbon emissions and fuel costs.
3. Curtailment avoidance. Output of renewable and nuclear power is stored for use later, again saving carbon emissions and fuel costs.

The study shows that as the penetration of storage increases (more is installed), the required storage timescales are increased and so the appropriate choice of storage technologies alters. That is to say, as the ratio of energy capacity to power rating (GWh/GW) of storage increases, the appropriate choice of storage changes, based on cost-per-power and cost-per-energy.



A combination of four different technologies is examined for progressively longer timescales: batteries, high-temperature thermal stores, compressed air energy storage (CAES) and hydrogen. In each scenario, each incremental increase in storage power and storage energy capacity is met by the economically optimum technology, based on the incremental ratio of energy to power (ΔGWh/ΔGW).



The results show a net positive value for storage up to an optimum level, after which the net value of storage declines with further increases in capacity. An optimum mix of technologies and total level is thus determined. In some scenarios the optimum is not much greater than today's (year 2015) level of storage. In other scenarios, with greater levels of renewable energy, the optimum is much greater, and with a different mix of storage technologies, but still less than the amount that would be required for inter-seasonal storage of energy. For example, in the friends-of-the-Earth scenario in 2050, the optimum amount of storage appears to be about 26GW and 110GWh of thermal storage, with a further 8GW and 326GWh of CAES.

References:

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