Cost trajectories for electrical energy storage and their impact on CO_2 mitigation

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Overview

Electrical energy storage could play a pivotal role in future low-carbon electricity systems. By balancing inflexible or intermittent supply with demand it would enable higher penetration of low-carbon baseload generators and, as a result, a lower long-run carbon intensity of the power sector. But, the extent to which increasing levels of storage influence the carbon intensity of the power sector is unclear. Similarly, the investments required to install sufficient storage capacity, in particular in light of rapidly reducing costs, are uncertain.

We simulate the impact of electrical energy storage on carbon emissions in the British power sector up to 2060. While levels of storage are set exogenously, power generation investment decisions are optimised for least-cost capacity dispatch to meet hourly electricity demand. We also compile experience curves to project future prices for 11 electrical energy storage technologies. These experience curves enable us to calculate the corresponding investment requirements for sufficient storage capacity to minimize the carbon intensity of the British power sector.

The paper is organised as follows: First, we give a brief introduction of electrical energy storage, experience curve theory and power system modelling. Then, we present our first-of-its-kind compilation of experience curves for electrical energy storage technologies and analyse the overarching cost trajectory. The third section investigates the impact of storage on the long-run carbon intensity of the British power sector, and the costs to private investors and in public subsidy that may be required to achieve this level of storage.

Methods

- Experience Curve Analysis (Wright's Law) compiling data from 50+ sources for 11 technologies.
- Investment and Dispatch Modelling of the Power System using a merit order stack for least-cost operating decisions and a profit-maximising investment model (MOSSI: Merit-Order Stack with Step Investments)

Results

First, based on the experience curves for electrical energy storage technologies (Fig. 1) we find an overarching cost reduction trajectory for installed stationary systems as a function of cumulative installed capacity. Bottom-up assessment of material and production costs indicates this price range is not infeasible.

Second, electrical energy storage has a material effect on the future evolvement of the British power sector (Fig. 2), the associated reduction in carbon intensity and wholesale power prices.

Third, we quantified the cumulative investment required in electrical energy storage to enable the decarbonization of the British power sector.

Conclusions

The costs of promising stationary electrical energy storage technologies are falling rapidly. These technologies are key enablers to decrease the carbon intensity of the power system. The cumulative investment required to install sufficient levels of electrical energy storage are likely to be small (<5%) relative to all investments in generation capacity. Therefore, the evolutionary, experience-based cost reductions in electrical energy storage appear to be a key driver towards sustainable power systems.

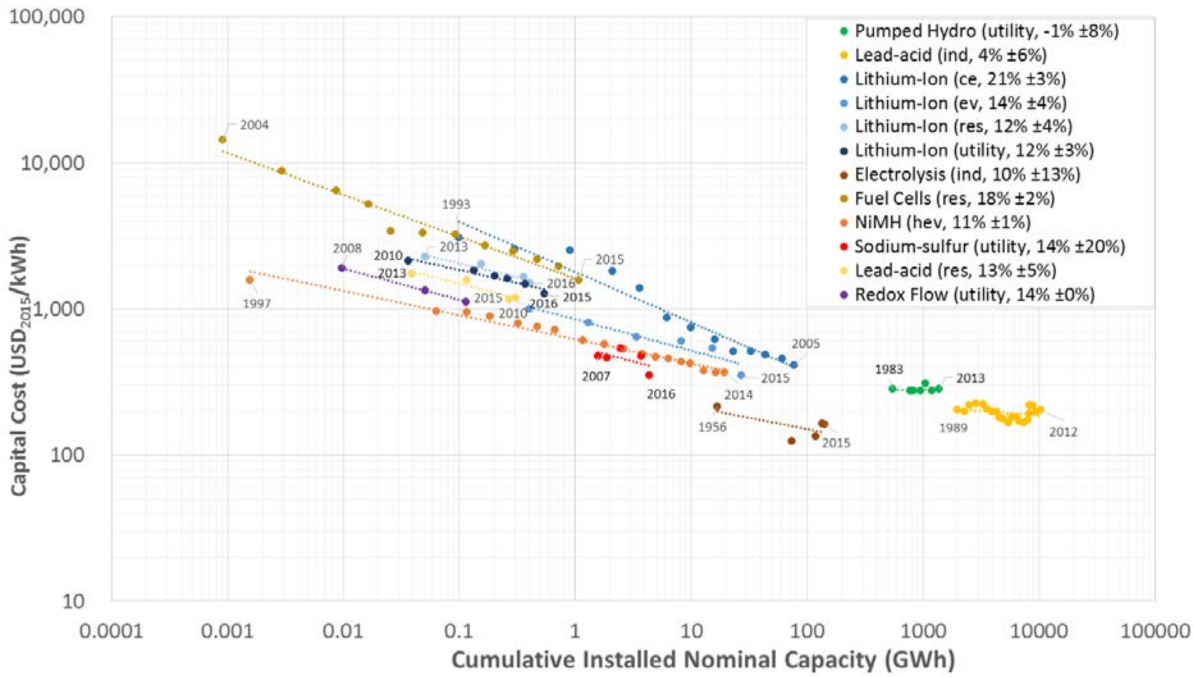

Figure 1 – Experience curves for EES technologies. *Results shown for product prices per nominal capacity in energy terms. Legend indicates application and experience rate incl. uncertainty.*

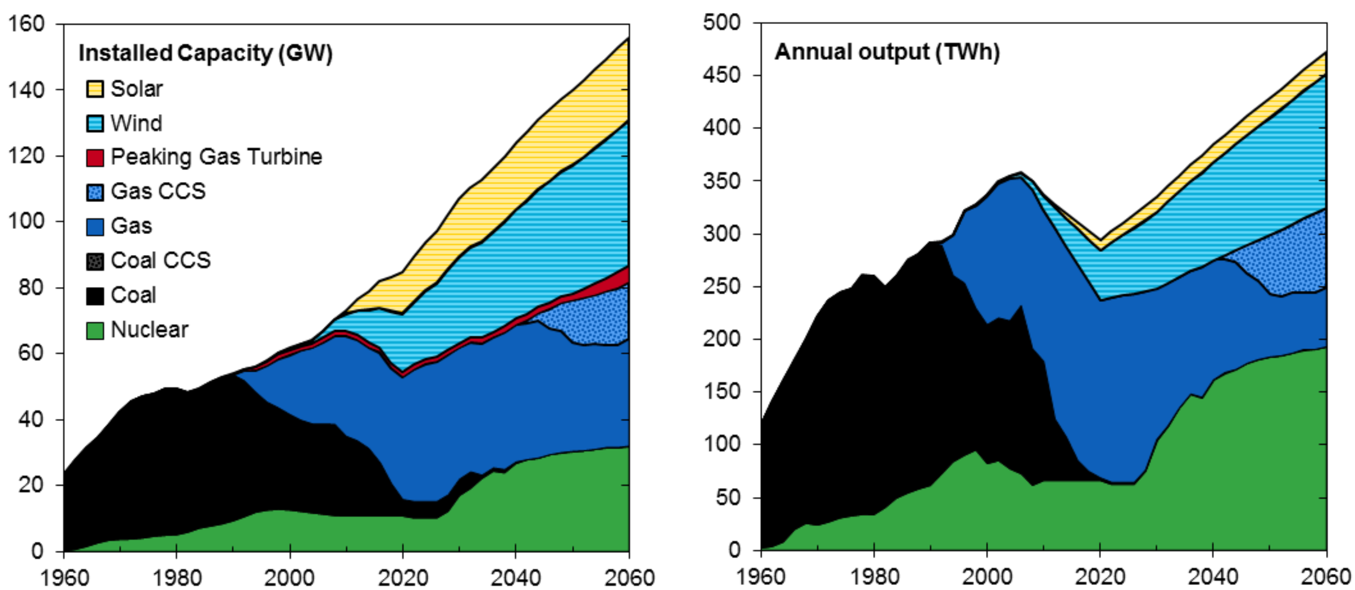

Figure 2 – Electricity generation projection for Great Britain. *Results obtained with least-cost operating decisions and a profit-maximising investment model, assuming doubling of pumped hydro storage capacity in this example.*

References

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