Written Evidence Submitted by

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Energy storage allows production and consumption to be decoupled over time. Fossil fuels are excellent for this, given their high energy density and stability. However, new forms of energy storage will be needed to achieve net zero (carbon) targets, for the energy system and transport. Hydrogen can act as a store of energy and is therefore an attractive option to consider.

We hold the position that the role of hydrogen will be important but limited in scope. Other technological options may be more suitable to meet system needs as described below.

1 Technologies

Many technologies have been, or are being, developed that provide energy storage services:

Batteries: Lithium-ion batteries (LIBs) and (lead-acid) are already playing an important role in the electrification of transport, along with frequency regulation and short-term balancing of loads on the grid. As costs approach \$100 kWh^{-1} (at the cell level), and gigafactories are being planned globally (and nationally at Blyth in Northumberland), LIB prices are projected to fall as production is ramped up exponentially, at least in the short term. LIBs are ready to make significant inroads for back-up on the grid. The scale needed for storage is massive, and so a global race is on to develop cheaper and longer-lasting batteries for the grid, requiring different types of LIBs. Sustainability is also an overall driver, with efforts being made to replace the Co and Ni in the cathodes with other more sustainable and less toxic metals (e.g., Fe and Mn), and to replace Na for Li, in sodium-ion batteries. Redox flow batteries represent a method for decoupling electricity generation and storage of oxidised and reduced chemicals, allowing much larger batteries to be produced. The challenge now is to reduce cost of these next generation technologies so they can compete with the incumbent LIBs and provide back-up power for increasingly longer periods of time.

Other forms of storage: Technologies have been, and are being, developed that can store large amounts of electrical energy for long durations, potentially at lower cost than batteries. These include liquid air energy storage (with a 50 MW CryoBattery demonstrator being constructed in the UK), compressed air energy storage, flow batteries and devices based on gravitational potential energy. Compressed air can be stored in manufactured salt caverns but there are significant technical issues to be solved to cope with the heat generated during compression and heat needed during expansion of the air as well as ensuring the integrity of the overburden to the salt cavern during massive and rapid pressure cycling. Thermal storage technologies could also be important where heating or cooling is required, rather than power.

Hydrogen storage: Abundant storage options in the subsurface in depleted gas/oil fields (pore space storage) or salt caves. The latter need to be manufactured and locations in which to build are few, limited to NE England/Yorkshire, Cheshire and possibly. Monitoring of storage sites required but ultra-low expectation of induced seismicity or rupture caused by natural seismicity (UK already stores H_2, CH_4 and N_2 safely and has for decades). Different preparations and operations are required for cave and pore storage but both options for storage are already proven at small scale in the UK. There may also be opportunities for accumulations of molecular (gold) hydrogen on the UKCS. Such hydrogen is already in natural, geological storage.

There is a general need to be scaling-up all these technologies with technological innovation and supportive policy, to the level at which they can contribute to managing the energy system, integrated across heat, power and transport.

2 Role of hydrogen in the energy system

The UK needs energy storage, over multiple time-scales, to ensure energy security and integrate renewables. Scenarios indicate the scale required to meet net zero will be many times that what exists in the UK as pumped hydro.

Hydrogen is both a fuel and (secondary) energy store so has a potential role to play. It provides an option for inter-seasonal energy storage in particular. It could be used for electricity generation at times of extended low supply/high demand, especially in winter when there could be extended periods of low wind and high demand from heat pumps in domestic locations.

We do not see hydrogen, or synthetic fuels derived from hydrogen, playing a major role directly in the home. It is not so much the low efficiency that is the issue, as much as the opportunity cost, i.e. it limits the scale of the alternatives such as heat pumps that can meet a much bigger level of demand overall. Upgraded low and ultra-low, near carbon-zero geothermal heat could easily be used to meet demand across much of the UK.

Shorter timescale variation in supply/demand can be managed by other thermal or electrical energy storage technologies. In general, hydrogen should be targeted at niches where there are limited alternatives, e.g. high-grade industrial heat.

There is an urgent, no regrets, need to improve the efficiency of buildings for low-carbon heating by any means, as that will reduce the investment costs in either hydrogen production or electricity generation (and improve well-being for people in fuel poverty).

3 Transport

Batteries can currently be used to power light transport (cars and light trucks, motorbikes, scooters etc.). The challenge is to produce battery-powered HGVs with sufficient range. While research continues to develop batteries with much higher energy densities (e.g., lithium sulphur and lithium air batteries) there are still significant technological hurdles to be overcome.

Strategies that combine more local distribution of goods, with longer range travel via freight, or motorways with frequent charging points should be considered. Fuel + battery powered HGVs should be considered as possible alternatives, but these will also come with considerable infrastructure requirements, and a need to reduce cost of the fuel cell + associated onboard gas handling and storage. While large aircraft is likely better powered with a liquid fuel, batteries may find a role in light aircraft, providing new opportunities for UK PLC.

4 Other considerations

It is important to consider storage of all sizes and in multiple locations. The need for storage is so large on a grid that is powered by renewables; the need to increase the overall electricity use by a factor two by 2050 (if done smartly; and three if we do not), means that we will need many forms of storage. We need local storage in homes, in microgrids at the community level, or associated with a solar or wind farm. We need smart feed-in tariffs to encourage the purchase of storage, and we need smart metering to allow EV batteries to become a part of the grid (and to balance use of other heavy demands on electricity).

The dynamics, and the co-dependencies, of the energy system transition are important. Trying to predict/project the scale of deployment, or future costs, of hydrogen storage technologies by certain dates is not meaningful given the uncertainties (and how poor previous forecasts have been) of them, and other changes to the system. However, we can have quite high level of confidence that generation from wind will increase by 10s GW through the 2020s, fossil fuels will be diminished (but not eliminated) and there will be a mass commercialisation of EVs. That tells us that **there is a case for accelerating innovation in energy storage in particular, with research and opening-up market mechanisms to incentivise deployment.**

The key barrier to deploying new technologies that can manage the scale of variability expected later in the 2020s is the lack of value attributed to such services. Existing market mechanisms do not recognise the positive system externalities of storage, nor do they sufficiently penalise the negative externalities of alternatives.

When looking at costs, we should consider wider impacts, e.g. recycling/re-use, and manufacturing of batteries. Environmental issues associated with the supply of critical minerals needs to be considered, and all of these factors need to be included in the overall cost. Also, we need to rebalance energy costs to incentivise switch to low carbon electricity away from the higher carbon alternatives.

Importantly, natural gas markets have been such that seasonal storage has not been profitable in the UK. This may influence the approach used to hydrogen storage.

5 Conclusions

Interest in the hydrogen economy should not distract from the massive investment needed in all forms of energy storage. There is no clear roadmap or technology of choice for an HGV but batteries have already demonstrated that they are fit for purpose in lighter forms of transport. Cost remains a significant challenge, and raises questions as to who will pay for these new forms of transport or the electrification of the grid. Research is needed all the way from low TRLs through to advanced manufacturing of the devices. While conceptually an easy way out, fuel-cell powered transport is still not cost competitive to manufacture, has resource implications and there are multiple opportunities for optimisation of many of the components. (These concerns to not even consider the inefficiencies of making and using H_2).

We cannot engage in a hydrogen economy which neglects alternative (more proven) technologies and does not address the technology limitations (and resource issues) inherent to many of today's fuel cells.

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