Role of batteries and fuel cells in achieving Net Zero

Written Evidence

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This evidence and the recommendations are based primarily upon findings derived from research activities conducted for Engineering and Physical Sciences Research Council, Standard Research Project EP/022049/1. The research project was focussed on utility-scale energy storage for low carbon electricity generation. The findings and recommendations are highly relevant to the call for evidence.

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Executive Summary

Recommendation 1: *Energy policy schemes should be enacted to support and protect the planning, development and operations of energy storage in related markets, in particular utility-scale energy storage in combination of low carbon electricity generation*[1] *incentives.*

Recommendation 2: *Generation Integrated Energy Storage (GIES) systems*[2] *have been demonstrated as technically and economically viable energy storage options in achieving net zero. On that basis, GIES systems can be considered for storage of thermal and mechanical energy produced by solar and wind power.*

Recommendation 3: *Price floor mechanisms as applied for carbon trading*[3] *can also enhance energy storage economic viability and reduce electricity market volatility. Upfront subsidies required to meet the high upfront costs and long lifetimes of energy storage is needed with regard to currently expensive battery technologies.*

Recommendation 4: *From a long-term (i.e., 5 to 20 years) perspective, mathematical models can be developed to analyse the technical and economic impacts on the wider energy system in terms of extensive installation of large-scale batteries.*

1. Department for BEIS, Policy paper Contracts for Difference Updated 2 March 2020. https://www.gov.uk/government/publications/contracts-for-difference/contract-for-difference
2. Department for BEIS, The future of UK carbon pricing, May 2019. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/815011/THE_FUTURE_OF_UK_CARBON_PRICING_-_04072019.pdf
3. Engineering and Physical Sciences Research Council, Generation Integrated Energy Storage - A Paradigm Shift: EP/P023320/1. https://gow.epsrc.ukri.org/NGBOViewGrant.aspx?GrantRef=EP/P023320/1

1. Is the right strategy, funding and support in place to enable the research, innovation and commercialisation of battery and fuel cell technologies in the UK?

1.1. *There were no policy and incentive schemes to promote the deployment of energy storage prior to the introduction of electricity market reform.* For example, energy storage was not defined within the legislation for the Renewable Obligation or feed-in tariff scheme.

1.2. From the commercialisation perspective, *the current energy policies in supporting energy storage (including batteries) for power grid applications are not well implemented.* Energy policies impact on the economic and financial viability of battery and thermal energy storage in the UK[4]. For example, with regard to a utility-scale battery system coupled with a wind farm, as the net present value reduces with increased energy storage capacity, low-carbon incentives can represent unintentional barriers to the development of energy storage due to: (A) current generator incentives give a favourable return on investment and energy storage would diminish it; (B) energy storage cannot participate in generator only incentives. Specifically, policy mechanisms (such as contract for difference, CfD) designed to support low-carbon technologies could affect the energy storage adoption. *There is a need for energy policy schemes to support and protect the planning, development and operations of energy storage in related markets.*

1.3. CfD for low carbon electricity generation can affect the procurement of energy storage in related markets depending on the strike price[4]. Renewable energy technologies, especially onshore windfarm and solar photovoltaic, have plummeted in cost. However, energy storage systems in particular batteries are still expensive and *there are no long-term policy mechanisms in place to promote energy storage growth.*

1.4. Recommendations to support grid-scale battery commercialisation include establishing:

1.5. **Price floor mechanism for energy storage:** A price floor is a regulatory policy, with the government to enforce price limit or control on how low a price can be charged for a good, service, product, or commodity[5]. Price floor mechanisms have been implemented for the

4 Lai, C. S. & Locatelli, G. Are energy policies for supporting low-carbon power generation killing energy storage? *Journal of Cleaner Production* **280**, 124626, (2021).

5 Gissey, G. C., Subkhankulova, D., Dodds, P. E. & Barrett, M. Value of energy storage aggregation to the electricity system. *Energy Policy* **128**, 685-696 (2019).

energy sector, including for the carbon price [6]. In April 2013, the UK government introduced a carbon price floor to reduce carbon market price uncertainty and worked well with the emissions trading scheme[6]. The carbon price floor sets a minimum market price for carbon and was developed to deal with the low carbon prices in the EU emissions trading scheme, as a consequence by the oversupply of permits and the economic recession. The carbon price has been effective to reduce greenhouse gas emissions by increasing the economic viability of low carbon technologies.

1.6. Generators and energy storage systems influence the wholesale electricity market[5]. With greater uncertain power demand and generation due to larger penetration of intermittent renewables and reliance on electricity, wholesale market price volatility is a major challenge to be dealt with. Indeed, negative wholesale prices have appeared in recent years[7].

1.7. With a price floor mechanism, the government may pay the system operator a certain value (£/MWh) to store energy when the wholesale market reaches a level of the low market price. Consider that many system operators may store the energy driven by the price floor mechanism, the reduction in power generation will increase the wholesale price. The energy stored will be sold during a period of high prices, but given this availability of energy, there will be less shortage of electricity; therefore, the "peak period" will be reduced. In summary, creating a price floor would make battery economically viable and, at the same time, contribute to reducing the volatility of the electricity market. However, the price floor mechanism may not support off-grid energy storage systems or microgrids.

1.8. Upfront subsidies required to meet the high upfront costs and long lifetimes of energy storage is needed: The UK government does not provide direct subsidies for the deployment of large-scale or behind-the-meter energy storage systems[8]. However, upfront subsidies can promote the development of certain technologies. For instance, the Green Deal was a UK government policy initiative that let the domestic sector to pay for energy-efficient home improvements, including solar panels and heat pumps through the

6 Anuta, O. H., Taylor, P., Jones, D., McEntee, T. & Wade, N. An international review of the implications of regulatory and electricity market structures on the emergence of grid scale electricity storage. *Renewable and Sustainable Energy Reviews* **38**, 489-508, (2014).

7 N2EX day ahead auction prices. (NORDPOOL, [Online]. Available: https://www.nordpoolgroup.com/Market-data1/GB/Auction-prices/UK/Hourly/?view=table).

8 Battery promoting policies in selected member states. (N° ENER C2/2015-410, European Commission. June 2018 [Online]. Available: https://ec.europa.eu/energy/sites/ener/files/policy_analysis_-_battery_promoting_policies_in_selected_member_states.pdf).

savings on their energy bills[9]. Batteries could benefit from comparable initiatives due to the relatively high cost for energy storage and the balance of plant. However, fund raising to support upfront subsidy may increase electricity prices for consumers.

9. What are the costs and benefits of using battery and fuel cell technologies in their various applications, including when integrated into the wider energy system?

For energy storage including batteries, capital costs are the upfront cost consisting of 1) "hard costs" due to the physical system components and infrastructure (e.g., materials costs including electrolyte) and 2) "soft costs" which are intangible to the project (e.g., licensing fees and the engineering, procurement, and construction costs)[10,11].

9.1. Operation and maintenance costs occur during the system life cycle and include labour, repair, regular servicing, and electricity purchasing (energy storage charging cost)[10]. The Balance of System cost is associated with the auxiliary equipment (e.g., power converters) for a power system[11,12]

9.2. Grid-scale energy storage including batteries have been built with solar farms and wind parks to minimise electricity curtailment[13]. Considering the economic benefits, the developed sources of revenue streams for system operators with grid energy storage are:

9.3. Electricity markets: *Spot price/ wholesale market:* Electricity is a commodity that can be traded in the wholesale market from various energy technologies. For example, Nord Pool

9 Green Deal: energy saving for your home. (Gov.UK. [Online]. Available: https://www.gov.uk/green-deal-energy-saving-measures).

10 Li, X., Chalvatzis, K. & Stephanides, P. Innovative Energy Islands: Life-cycle cost-benefit analysis for battery energy storage. *Sustainability* **10**, 3371 (2018).

11 Electricity storage and renewables: Costs and markets to 2030. (International Renewable Energy Agency, 2017. [Online]. Available: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Oct/IRENA_Electricity_Storage_Costs_2017.pdf).

12 Balance-of-system equipment required for renewable energy systems. (Energy Saver, energy.gov [Online]. Available: https://www.energy.gov/energysaver/balance-system-equipment-required-renewable-energy-systems).

13 Lai, C. S. *et al.* A comprehensive review on large-scale photovoltaic system with applications of electrical energy storage. *Renewable and Sustainable Energy Reviews* **78**, 439-451 (2017).

AS is an European power exchange and is responsible for delivering power trading across Europe[4]. The wholesale price increases with electricity demand.

9.4. National Grid (grid services):

- *Firm Frequency Response (FFR):* FFR complements other categories of frequency response (e.g., primary response) and provides firm availability. FFR can be from generators, energy storage, and aggregated demand response [14].
- *Short Term Operating Reserve (STOR):* The provider gives a contracted level of power when called by National Grid to achieve energy reserve requirement[15]. STOR provider must provide a minimum of 3 MW of steady demand reduction or generation for two hours minimum.
- *Fast Reserve (FR):* FR provides rapid active power by reducing the demand or increasing the generation, as requested by the National Grid Electricity System Operator[13], to participate in controlling frequency variations. FR provider needs to give power consistently for a minimum of 15 minutes.

9.5. Distribution network operators: *Super Red Credits (SRCs):* Distribution network operators provide SRC payments to non-intermittent generators for providing energy during peak demand times (i.e., super red periods). These generators allow the distribution network to defer the reinforcement or grid upgrade. To receive these credits, generators must be connected to the extra high voltage grid. *Participation in SRC payments is possible for renewable sources with batteries and enhanced as the need for providing dispatchable power* [14].

9.6. Electricity Market Reform: Capacity Market (CM) aims to create enough reliable capacity (both supply and demand-side) for secure electricity supplies, in particular during

14 Firm frequency response (FFR). (National Grid ESO. [Online]. Available: https://www.nationalgrideso.com/balancing-services/frequency-response-services).

15 Short term operating reserve (STOR). (nationalgridESO, [Online]. Available: https://www.nationalgrideso.com/balancing-services/reserve-services/short-term-operating-reserve-stor).

16 Fast reserve. (nationalgridESO, [Online]. Available: https://www.nationalgrideso.com/balancing-services/reserve-services/fast-reserve).

17 Distribution connection and use of system agreement (DCUSA) DCP108- Availability of the non-intermittent generator tariff. (Office of Gas and Electricity Markets, April 2012. [Online]. Available: https://www.ofgem.gov.uk/ofgem-publications/62523/dcp108d-pdf).

critical periods for the system (e.g., poor weather conditions)[18]. CM allows the market to determine a price for competitive capacity. Capacity agreements are given to providers of current and new capacity, from one year (T-1) to four years (T-4) ahead. This gives investors certainty and confidence about future revenues, under intermittent generation and uncertain market conditions. The CM provides revenue in monthly capacity payments. Capacity payments are paid monthly during the delivery years to capacity providers[18].

9.7. From a long-term (i.e., decades) perspective, there is a need to examine the technical and economic impacts on the wider energy system with prolific installation of large-scale batteries. Long-term electrical power system models support decarbonisation studies and energy technology assessments, including batteries and fuel cells[19]. There is no comprehensive study on the aforementioned revenue sources with regard to the technical and economic impacts to the UK energy system.

18 G17 - Capacity provider payments EMRS guidance. (EMR Settlement Limited, Electricity Settlements Company, March 2018. [Online]. Available: https://www.emrsettlement.co.uk/documentstore/guidance/g17-capacity-provider-payments.pdf).

19 Lai, C. S., Locatelli, G., Pimm, A., Wu, X. & Lai, L. L. A review on long-term electrical power system modeling with energy storage. *Journal of Cleaner Production* **280**, 124298, (2021).