Pumped Storage Hydropower International Forum

Policy and Market Frameworks Working Group

United Kingdom – Europe

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Overview of the UK electricity market

The UK Government has set a target of bringing all greenhouse gas emissions to net zero by 2050, with the devolved Scottish Government setting an even more ambitious target of 2045. Successive UK governments have put in place and supported policies since the 1990's to incentivise the development of renewable generation capacity within the UK electricity system. This shift is set to continue with both the UK Government and the devolved nations making a strong commitment to tackling climate change.

In November 2020, the UK Prime Minister, Boris Johnson set out his 10-point plan for a green industrial revolution, which the UK government hopes will generate 250,000 jobs and allow the UK to reach its 2050 net zero target. This recognises the vital role of renewable energy and in particular offshore wind, with a target to deliver 40GW by 2030. The importance of renewables in the future energy mix was further reinforced by the UK Government's long-awaited Energy White Paper published in December 2020.

Reforming the market to align with new low carbon policy requirements is a key challenge for the UK Government and one which is recognised in the White Paper. It involves the technical challenge of adapting to the new and different generation characteristics of a rapidly changing generation mix, while still ensuring high levels of energy security and undertaking the transformation in a cost-effective manner. For example, the government have acknowledged that increasing amounts of low marginal cost renewable generation will impact prices, and the implications this is and will continue to have on longer-term investment signals.

In July 2021, the UK Government published an update to their Smart Systems and Flexibility Plan which explicitly recognised the role that energy storage, and in particular long duration energy storage will play in providing the system flexibility needed to integrate increasing levels of variable renewable energy[1]. The government stated that long duration storage will be "essential for achieving net zero" and alongside the plan published a call for evidence on how the deployment of large-scale and long duration storage technologies could be facilitated by government policy[2].

Current status of pumped storage & development potential

The UK electricity system changed from a government owned and vertically integrated system to fully unbundled liberalised market with all key assets owned and operated by private developers and investors in the 1990's. The market is government regulated to allow competition between generation suppliers to provide power, to energy supply companies who in turn compete to sell that power to industrial and domestic users. The transmission and distribution assets operate as regulated regional monopolies to provide power distribution services between the power generators and users. Storage, and this was only pumped storage hydropower (PSH) at the time on market unbundling, was defined as a subsection of generation and conforms to generation market rules.

Over the last 20 years, the UK's electricity generation mix has undergone a significant shift away from fossil fuels to low carbon forms of generation. In 2000, fossil fuels made up roughly 75% of electricity generation in the UK. By 2020 this had dropped to less than a quarter, almost all of which comprises gas-fired generation. In contrast, renewable energy now provides more than a third of electricity generation. The UK currently has around 4GW of electricity storage in operation, 3 GW of which is PSH and 1GW of which is lithium-ion battery storage[3]. The existing PSH stations, all located in Great Britain (GB), were built before the liberalisation of the energy market with none having been built in the decades since.

[1] https://www.gov.uk/government/publications/transitioning-to-a-net-zero-energy-system-smart-systems-and-flexibility-plan-2021
[2] https://www.gov.uk/government/consultations/facilitating-the-deployment-of-large-scale-and-long-duration-electricity-storage-call-for-evidence
[3] National Grid Electricity System Operator (2020), Future Energy Scenarios, http://fes.nationalgrid.com/fesdocument/

Table 1 Current PSH pipeline in Great Britain

	Consent Granted	Estimated consent date	Target date for operation	Installed capacity (MW)	Storage capacity (GWh)	Developer
Coire Glas	2020		2028	1500	30	SSER
Red John	2021		2027	450	2.9	ILI
Glenmuckloch	2016		2027	400	1.5	Buccleuch
Glyn Rhonwy	2017		2027	100	0.7	Quarry Battery Company
Halviggan		2024	2027	150	0.2	SSER
Cruachan Extension*		2022	2030	600	0	Drax Power Ltd
Balliemeanoch		2023	2029	1000	28	ILI
Corrievarkie		2023	2029	600	19	ILI
Dorothea Lakes		2024	2029	450	2.1	Cirrus
Total				**5,250**	**85.4**	

*This is an extension to an existing project with no new storage added

Currently existing PSH stations earn revenues from the following sources:

1. **Market arbitrage** on day ahead and longer energy contracts.

2. **Capacity Mechanism** payment based on station installed capacity to ensure GB has adequate capacity available to meet forecasted demand based on year ahead and year plus four auctions of capacity.

3. **Flexibility services** procured by the NGESO (National Grid Electricity System Operator) including:

    a. Power flexibility – capacity for ramping up or ramping down power output as needed to meet highly variable levels of demand, including holding output for use in reserve. Power flexibility is normally managed through wholesale market trading, but the NGESO will manage real-time imbalances in markets and ensure sufficient flexible output is always available. NGESO also use power flexibility market to help manage local and national level transmission constraint issues.

    b. Frequency and grid stability services:

        i. Frequency - support through rapid changes in output,
        ii. Stability flexibility - providing sufficient levels of system inertia, dynamic voltage control, and short circuit management to maintain stability, including holding power capability in reserve in case loss of infeed from other generators,

iii. Voltage flexibility - providing the capability to generate or absorb reactive power to manage voltage levels, including holding capability in reserve,
iv. Restoration - black start capability to restore the power system.

All of the potential revenues above within the GB system are awarded on a competitive basis with the vast majority based on real-time or short-term trading or contracts (1 to 2 years). NGESO has made clear that its future policy is to not have long-term contracts as the NGESO believes the supply of these services from short-term markets will bring best value to consumers.

However, future low carbon market design and lack of long-term price signals bring a high level of revenue uncertainty. While it is anticipated that there will be a large increase in overall electricity demand as other sectors such as transport and heat decarbonise by using low carbon electricity, the timing and scale of these changes lead to high uncertainty on specific future revenue values. For example, future markets are likely to see low or zero marginal costs when renewables are available, yet unknown and increased price volatility when renewables are unavailable. Capacity and balancing markets do not provide adequate long-term price signals either. Uncertainty about future GB market design to meet government targets net zero carbon targets also will act with the revenue uncertainty to deter large-scale private sector investments such as long duration storage. These barriers for deploying large-scale and long duration storage were recognised in the government's recent Smart Systems & Flexibility Plan.

In addition, future increased penetration of non-synchronous, intermittent renewables with the retirement of large thermal plant (who provided these services in the past) will not provide the level of critical security of supply and ancillary services an expanded GB electricity system will need, such as inertia, voltage flexibility and restoration. These will have to be predominantly provided by dispatchable flexible resources, such as long duration storage, but again there are currently no long-term price signals to ensure future new capability will be built-out over and above existing capacity.

Challenges, barriers and emerging opportunities for pumped storage development

The major barrier to the deployment of PSH in the UK is building a viable investment case, due to the lack of revenue certainty and long-term market signals for these long lifetime assets.

Clear government policy objectives and market reforms are required to unlock investment in PSH which will be needed to meet the challenges in the transition to a low carbon energy system. For the UK, PSH is a proven and reliable existing technology and future revenue streams should be sufficient if the market evolves in line with the path to net zero targets. However, from a private investors perspective there is a high level of revenue uncertainty as long-term contracts cannot be secured prior to construction commencing. This is further exacerbated by the NGESO moving more services to be contracted on a short term or daily basis.

Current energy markets also do not fully value and remunerate the system benefits that PSH provide. These uncertainties are currently holding back longer time-scale investments and favouring short-duration storage solutions which may not be the most cost-effective or efficient for UK consumers or allow PSH to support other low carbon solutions which already receive government de-risking of their revenue streams e.g., wind generation.

Future electricity markets will need to give both long and short-term price signals for investment in the resources that are needed, and to optimise operation. If they do not provide clear pricing signals, then the market risks becoming increasingly inefficient, putting net zero and security of supply at risk, and consumers will be paying more than they need to. Therefore, it is vital that the UK Government and regulator Ofgem put in place a de-risking mechanism to create the necessary investment signal for longer duration storage. Just as the Contracts

for Difference (CfD) mechanism has been very successful for renewables, PSH (and other long duration storage technologies) requires a revenue stabilisation mechanism.

There are several potential options for achieving this, and these have been outlined in the recent Scottish Renewables paper addressing these options[4]. But as an example, the existing Cap and Floor mechanism administered by Ofgem for interconnectors between the UK and Europe is an example of a possible mechanism to stabilise revenue risk for investors that could be adapted, as it ensures that there is an absolute minimum floor on project revenues rather than providing a fixed price.

If a suitable mechanism can be put in place for PSH within the next 2 years, then there is enough time for such an investment signal to enable for significant new PSH capacity to be operational by the end of the decade. In the government's recently published call for evidence on facilitating the deployment of large-scale and long duration storage, the Cap & Floor mechanism was highlighted as a suitable approach for intervention which requires further consideration.

In terms of planning, consent and environmental licencing issues are not a major barrier for PSH development unlike in some other countries, once an economically viable site from a power and storage perspective has been identified. Most geographical locations for PSH in GB are in Scotland or Wales and due to a long history of positive community engagement and local benefits from existing hydropower developments, there is general goodwill to hydropower developments. For the consenting process, all potential sites must submit a comprehensive environmental impact assessment (EIA) and engage with key stakeholders as part of this process. Three key areas to be addressed are water management, ecology management, and the impact on local communities for both project construction and operation. It is critically important though that planning agencies are adequately resourced to ensure decisions are made in a timely and cost-efficient manner.

As evidenced by a recent study carried out by modelling experts at Imperial College London, new long duration energy storage has a vital role and offers significant value in facilitating a cost-effective transition to a net zero GB energy system[5]. Key findings from the study included:

- An additional 4.5 GW of long duration pumped storage, with 90 GWh of storage could save up to £690m per year in energy systems by 2050.
- Of these system savings, 75% are from the avoided capital cost in higher cost, low carbon electricity generation technologies such as nuclear that would otherwise be needed to reach net zero whilst also meeting security of supply.
- New long duration pumped storage can reduce wind curtailment by up to 11 TWh a year by storing excess renewable output and discharging it when needed.
- New long duration pumped storage in Scotland could reduce the need for up to 2 GW of transmission between Scotland and England in 2050, saving up to £2bn in avoided capex.
- Long duration pumped storage can provide critical grid stability services needed for integrating a high penetration of renewable generation, e.g., frequency response, system inertia and operating reserves.
- Long duration pumped storage can reduce system emissions by displacing fossil-fuelled sources of flexibility such as gas-fired mid-merit and peaking plants.

Jacobs Engineering, in its recent independent report in 2020, also found that PSH is the cheapest storage technology for durations beyond four hours[6].

[4] https://www.scottishrenewables.com/assets/000/001/513/Realising_benefits_of_long_duration_storage_-_final_March_2021_original.pdf?1616492450
[5] https://www.imperial.ac.uk/energy-futures-lab/reports/Whole-System-Value-of-Long-Duration-Energy-Storage-in-a-Net-Zero-Emission-Energy-System-for-Great-Britain/
[6] https://www.jacobs.com/sites/default/files/2020-10/Jacobs-Strategy-for-Long-Term-Energy-Storage-in-UK-August-2020.pdf

Recommendations

1. As soon as practical after the conclusion of the call for evidence in September 2021, the UK government should launch a specific consultation on the design options on the most appropriate policy mechanism (e.g., Cap & Floor) to bring forward timely investment in long duration storage technologies. Given the speed and scale of the transition to net zero, the government should aim to have the mechanism established by the end of 2022, if not earlier.

2. The UK Government should consider establishing energy storage targets (GW and GWh) for 2030, 2040 and 2050 which supported by a best-in-class policy and regulatory framework would give both developers and investors to confidence to plan and invest in these long-term assets.

3. Other levels of government in the UK (devolved, regional, local) should ensure that planning policy agencies are both adequately resourced and recognise the importance of long duration storage to net zero - specifically pumped storage and associated infrastructure.

4. The wider societal benefits from the investment in pumped storage as part of green post-COVID economic recovery need to be recognised by government. The very nature of pumped storage as major civil engineering projects requiring high levels of investment that will be spent across GB, often in remote and rural areas, will directly support the government's levelling-up agenda.