Unite response to the OfGem Window 1: Minded-to decisions – Long Duration Electricity Storage

1. Introduction

1.1. This submission is made by Unite, the UK's largest trade union with over one million members across all sectors of the economy, including manufacturing, financial services, transport, food, agriculture, construction, energy, utilities, information technology, service industries, health, local government and the not-for-profit sector. Unite also organises in the community, enabling those who are not in employment to be part of our union.

1.2. Of particular interest to this inquiry Unite represents almost 40,000 Energy and Utilities workers including engineers working to maintain the power distribution network throughout Great Britain and Ireland.

1.3. Unite has no financial interest in any of the projects and hence this response is drafted solely with the safety of any workers involved in any of the facilities, and with an eye to ensuring that the principal of utilising a diverse range of technologies as possible. This is especially true in an area where there is very little reliable information to go on, with respect to things like the longevity of the technology, as opposed to the assumptions made in the assessment.

1.4. Unite is interested in employment opportunities but only ones in industries where the risk to the individual and community are minimised.

2. Questions

1.11 We welcome views on our minded-to decisions and the reasoning set out in this document. This consultation seeks your views on whether the approach, methodology and evidence have been applied appropriately, including the proportionate, fair and consistent use of submitted evidence and standardised assumptions in reaching these decisions.

2.1. Unite's view is that of the technologies being utilised in these projects the storage method with the longest proven record is that of Hydro Pumped Storage given that there is a proven record of reliability[1]. The Ffestiniog Power Station in Gwynedd, Wales has been operational since 1963 and it continues to provide a reliable method to store excess electrical generation[2]. The only issues with pumped storage are :-

[1] See, for example, International Hydropower Association materials describing pumped storage as a long-established and widely used form of energy storage.

[2] Ffestiniog Pumped Storage Power Station entered service in 1963; see the operator's history page or official project documentation.

- the availability of geographic locations in the UK with the capacity to hold large volumes of water[3];

- the evaporation over periods of drought and capacity issues when it is subjected to heavy rains over extended periods[4];

- the frictional losses in the process of pumping the water up to the upper reservoir and frictional losses when the water is passing through the turbines to generate power[5];

- The maintenance of the concrete structure over long durations;

- Greenhouse gas releases from the flooding of an area filled with land dwelling vegetation (unless this is removed)[6] and

- The removal of debris that falls into the reservoir before it reaches the turbines.

Therefore, stating that Pumped Storage has a lifespan of an estimated 40 years is very conservative[7].

2.2. Unite has concerns over pumped Liquid Air Energy Storage, (LAES) given:

- the cryogenic temperatures that the pressure vessels will be subjected to and the issues of liquid air boil-off. Even at temperatures well below the boiling point of the various gasses, that make up air, the gas molecule evaporates and returns to a gaseous state[8].

- The increases and decreases in pressure to the containment vessel will probably require a safety valve to release the excess pressure to the

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[3] This is a general planning and geography constraint for pumped hydro developments, especially in densely populated or topographically limited areas.

[4] Reservoir performance can be affected by hydrological conditions, including drought and heavy rainfall.

[5] Round-trip efficiency losses are inherent in pumped storage due to pumping and turbine/generator conversion losses.

[6] Vegetation and reservoir inundation can cause emissions from decomposition (producing methane CH_4 a powerful greenhouse gas that is over 80-86 times more powerful as CO_2 at warming the planet over a 20-year horizon window or 28 to 34 times over a 100-year policy window according to the IEA and UNFCCC) unless cleared prior to flooding

[7] Lifespan estimates for pumped storage assets often exceed 40 years, subject to design, maintenance, and refurbishment cycles. The challenge is not so much the facility as the lifespan capabilities of the turbines themselves.

[8] Cryogenic storage systems face boil-off and thermal management losses because liquid air must be kept at very low temperatures to remain in liquid form also requiring specialised valves and pipework.

atmosphere, even if the pressures in the storage tanks are low. Such ventilation will reduce the volume of energy stored of course[9].

- Repeated changes in pressure in the tank will undoubtably form microfractures over time as the walls of the pressurised containers flex, and if this is not regularly inspected there is the potential for a container vessel or pipeline rupture, distributing extremely cold liquids over any unfortunate worker that happens to be in the area[10].

- The first working example was operated between 2010 and 2013 to contain 350 kW /2.5MWh, but the first grid scale demonstration version was not opened until 2018 at Pilsworth near Manchester therefore we have only got at best seven years of practical experience of operation.

- The low round trip electrical efficiency at around 50% to 60%[11].

- The high capital cost for the specialist low temperature infrastructure and the significant energy losses during air liquefaction.

- Global warming potential tied to thermal fluid leakage (like diathermic oils)[12]

2.3. Therefore, of the only operational examples of LAES, we can only be sure that the method works over an eight-year period. It is recognised that steel scuba tanks which similarly hold compressed air can typically last twenty to thirty years but they are not subjected to cryogenic temperatures. A typical cryogenic tank has a physical lifespan of fifteen to twenty-five years, but they are not subjected to rapid changes in pressure and temperature. Steel Liquid Nitrogen tanks may only last between five and eight years in cryogenic freezers. Therefore, given the size of the tanks used it may mean that they may only have a lifespan of less than ten years before they need to be replaced, on safety grounds.

- The same goes for the expansion tanks and hoses where the gasses are allowed to warm up and compress cylinders, that in turn will cause turbines to turn. We simply have not had the technology operational long enough to be sure the equipment can take the rapid changes in temperature and pressure

[9] Pressure management and venting are standard safety considerations for stored gases and cryogenic systems and can affect usable storage capacity.
[10] Fatigue, thermal cycling, and fracture risk are recognized engineering concerns in pressurized containment systems and associated pipelines.
[11] See the Renewable and Sustainable Energy Reviews Critical review of Liquid air energy storage.
[12] Over time, thermal stress breaks down the oil. Leaks or improper disposal pollute soil and local water systems, creating ecological damage alongside carbon costs, of their initial manufacture.

that will occur in order to store electrical energy as the type of kinetic potential compressed gas that this storage method utilises.

2.4. That said once the storage and expansion tanks and other components are replaced as required the rest of the infrastructure can be maintained, and you do not have to incur the expense or building the infrastructure again as you would with lithium-ion batteries.

2.5. Unite has concerns about the use of Lithium-ion and Vanadium chemical storage batteries in that:

- There are the safety concerns of having such a large store of a chemical that can self-sustain a fire indefinitely if there is access to oxygen[13].

- As anyone will know, if you charge up a lithium-ion battery and leave it for some time it will lose charge, apparently to the ether[14].

- Finally, there is the issue of crystalline dendrites that form in any chemical battery that grow from one electrode to the other creating a dead short that ends the life of that rechargeable battery cell. Over time these batteries will lose storage capacity especially if more and more charge is forced into the cell. It is recommended that Lithium-Ion batteries are therefore not charged beyond 80% of their capacity to reduce the growth of dendrites and extend battery life but grid storage may push the limits for short term gain[15].

2.6. The first early industrial-scale vanadium redox flow battery (VRFB) was installed in 1995 at a power station in Japan by Mitsubishi Electric and Kashima-Kita Electric Power Corporation with a proof-of-concept 200kW battery but its first Modern Gigawatt scale facility (200MW /1,000 MWh) was not switched on until 2025, unsurprisingly in Xinjiang, China. Thus, while this is a proven technology, we know that may last between 20 and 30 years providing between 15,000 to 20,000 charge discharge cycles, even if the lifespan storage capacity will slowly decline over time, as the charge retention slowly dissipates.

2.7. Unlike Lithium, Vanadium poses less of a fire risk as it's non-flammable water-based electrolyte forms the basis of its cells. However, the chemical toxicity of the chemicals and severe acid corrosion risks from sulphuric acid solutions,

[13] Large lithium-ion battery fires are difficult to extinguish and may self-propagate through thermal runaway, especially if oxygen is available

[14] All batteries experience self-discharge over time, though the rate varies by chemistry, temperature, and state of charge.

[15] Dendrite formation, capacity fade, and cycle degradation are recognized battery-aging mechanisms; charge limiters and battery-management systems are commonly used to reduce these effects, but these only prolong the inevitable need to replace the cells.

can cause contamination risks[16] and potential electrical shock hazards from conductive liquid spills. There is little to no chemical hazard data for the electrolyte mixtures, and hence any hazard assessment therefore can only be based on chemical reactivity and toxicity data for the individual electrolyte components.

2.8. If the vanadium batteries are over charged it is possible that they could produce amongst other things a toxic cocktail of Clorine, Sulphur Oxides, Hydrogen Sulphide and Phosphine (Phosphorus Trihydride). In combination and even on their own these chemicals pose a significant hazard to human health. Therefore, at the very least a full health and safety assessment would be advisable.

2.9. Even sodium-ion batteries have a far better predicted development potential than both of the above growing from US$ 0.67 billion in 2025 invested to US$ 2.01 billion by 2030 especially in Europe as it has a far better potential for grid scale charge/ discharge cycles[17]. Even so no sodium battery solutions have been provided with the opportunity in this round of strategic energy storage solutions to prove their capabilities.

2.10. Unite would stress that the only proven long duration stable storage method that it is aware of, involves the conversion of electricity to hydrogen, (via electrolysis or pyrolysis[18]) and its long-term storage as a metal hydride[19]. In that form the hydrogen can exist indefinitely before its release, requiring the hydride to be heated (in the majority of metal alloy hydrides) to be released. The metal hydride storage cylinders may at most need to be pressurised to about the same pressure as a typical car tyre or even less rather than the extreme pressures and cryogenic temperatures needed with respect to liquid hydrogen. There are some metal hydrides that are stable at room temperature and pressure, enabling blocks of the hydride to be handled. Once discharged both the storage metal and cylinders can be reused to store more hydrogen.

2.11. As no other element is able to insert its nucleus into the crystal structure of a metal, the process results in the separation of gases[20] leaving it in a near pure state when it is released, even if the hydrogen entered the hydride from a natural gas source, with all its impurities. And if then passed through a bank of

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[16] from any leaks or seepage from the cells

[17] though market forecasts vary by source Sodium-ion batteries are widely discussed as a lower-cost alternative for certain stationary storage applications

[18] Pyrolysis is the heating of a substance to a level which destroys the molecular bonds turning the molecule into a collection of elements. When applied to hydrocarbons, the result is black carbon powder and hydrogen gas (plus a trace of elements that were found in the hydrocarbon or its trace pollutants).

[19] A hydride is a standard metal crystalline structure where the gaps between the metal nuclei is used a storage facility to hold the nuclei other various isotopes of hydrogen (standard Hydrogen, Deuterium and Tritium).

[20] Not filter in the conventional sense but separate the hydrogen from its impurities given the hydrogen can be absorbed but the impurities are too large to be absorbed into the crystal structure of the metal.

hydrogen fuel cells, the process could also yield a supply of drinkable quality fresh water, which could be very useful in drought prone areas[21].

2.12. While it is recognised that there are considerable losses with the conversion of water to hydrogen and back again, these are outweighed by the long duration storage potential of the technology, which could receive generated capacity now for release any time, in this century, the next or even the one following, etc. until it is required. Unite is not aware of any process that comes close.

2.13. The concept of using metal hydrides as a power source is nothing new given it has been used to power submarines[22] and hydrogen fuel cells were used on the Apollo missions to provide electricity and fresh water.

2.14. Unite notes that of the chosen projects that Ofgem has selected, eleven of the sixteen are lithium-ion grid scale battery storage facilities, one Vanadium battery, one compressed and liquified air, plus three pumped hydro schemes.

2.15. While hydrogen has been toted as a potential solution the key concern is storage and transportation of the gas. Hydrogen has a property in that it can disassociate itself from all its electrons and insert its proton nucleus into the crystalline structures of metals, effectively turning the gas into a solid. This solid form can be stored at room temperature and normal atmospheric pressure (if the correct alloy is chosen), providing a non-flammable way of storing the gas in a chemically stable form. To access the hydrogen, just apply the right amount of heat or reduce the pressure (again depending on the metal hydride). There are many options out there from traditional intermetallic hydrides (such as Lanthanum Penta-Nickel ($LaNi_5$) or Titanium Iron (TiFe) other alloys absorb and release hydrogen easily at room temperature, but their storage capacity is low (typically under 2 wt%).

2.16. Lithium Borohydride ($LiBH_4$) offers a massive storage potential[23], but it binds to the hydrogen very strongly, meaning they require high thermal energy to desorb the gas and often suffer from slow reaction kinetics, and it has a non-stable nature over the longer-term.[24]

2.17. Standard uranium trihydride (UH_3) achieves a high volumetric hydrogen density of roughly 4.0×10^{22} hydrogen atoms per cm^3 storing hydrogen at twice the density of liquid hydrogen. It is already extensively used to handle and

[21] Final drinkability depends on the system used but water from fuel cells is extremely pure given there has been little time for contamination from its creation.

[22] The type 212A attack submarine as used by the German, Italian was the first example of the use of a fuel cell powered submarine for near silent subsurface propulsion, reportedly quieter than a nuclear vessel.

[23] Roughly **67 to 74 kJ per mole of hydrogen (H_2)** released. Unmodified LiBH4 needs temperatures **above 400ºC to 500ºC** to cause hydrogen to de-absorb efficiently despite this being above the melting point of LiBH4 (280ºC). – See the National Centre for Biotechnology Information.

[24] Lithium borohydride is a high-capacity hydrogen storage material by weight, but practical use is limited by stability and reversibility challenges

store tritium and deuterium in fusion research facilities as it releases the hydrogen on moderate heating and absorbs it again during cooling.

1.12 In particular, we welcome views on the following questions:

Question 1: Do you agree with the minded-to decisions set out in this consultation?

2.18. For the reasons set out earlier Unite questions the validity of supporting so many Lithium-Ion projects but wholey supports the construction of new pumped storage facilities, provided that the construction complies to standard building regulations and is frequently maintained. Unite is of the opinion that for grid scale storage facilities lithium-ion batteries cause more issues than they solve and while they offer a light-weight solution for transport, they will not provide the longevity nor provide the sustainable solution required given just how difficult the process is to recycle lithium-ion batteries.

Question 2: Do you agree with our minded-to capacity decision for Window 1?

2.19. As highlighted Unite would question the assumed lifespan of the projects named and would question the safety standards assessment of project technologies where there is very little actual evidence available in reality, when examining some technology solutions.

2.20. By way of example, with respect to LAES, it may be assumed that cryogenic containers can withstand the frequent pressure and temperature changes over time but until grid scale facilities are used, we simply do not know for sure. Unite suspects the growth of micro fractures will be enhanced by the cryogenic temperatures making the tanks far more brittle than has been assumed. We will not know until the system fails or survives the predicted lifespans, that have been claimed by supporters of the project.

2.21. While Unite is pleased to see that OfGem is not supporting the premise of putting all of the options based on a single technology, Unite is concerned about the number of that number rely on Lithium-ion batteries.

Question 3: Do you agree with our minded-to decisions on Regime Requests?

2.22. Unite does not wish to comment in this area.

Question 4: Do you agree with opening further application windows?

2.23. Unite agrees that further application windows should be opened with a mind to constructing a strategic reserve of energy which can be deployed at times of international turmoil on the energy markets. As has been seen by both the invasion of Ukraine and the attacks against Iran by the United States and Isreal, global tensions can severely impact prices at home while we are reliant on Natural gas and oil supplies.

2.24. The United Kingdom needs to once again become a net exporter of energy rather than one reliant on imported energy. Nations will always look after their citizens first and if that means overcharging the citizens of its neighbours to offer lower prices at home they will do it especially if they are supplying a captive audience like those in the UK. In turn, manufacturers will always favour nations that are energy rich with a stable energy network and sadly, that is not the UK thanks to over a decade of underinvestment.

2.25. Unite would highlight that there is a considerable list of projects in the queue for grid connectivity[25]. Unite is minded to suggest that where these projects are completed and awaiting a connection that they use this untapped energy source to power the creation of hydrogen. At least in that way the backers will realise some return on their investment before the grid connection is available. There are mobile modular electrolysis facilities available[26] on an industrial scale, which could be used to create a strategic store of energy. As highlighted if stored as a metal hydride this store of energy could be released at some later stage once the infrastructure is available.

2.26. As transport sectors like aviation move towards hydrogen as their preferred fuel option for domestic and trans-European flights[27], at least initially. The desire for secure hydrogen sources will become more apparent, meaning that the creation of a strategic, national or regional, reserve of hydrogen could provide a solution to multiple future challenges.

1.13 Our minded-to decisions are made with reference to the information available at the time of publication. To ensure fairness, consistency and comparability across projects, we do not intend to take account of new or materially revised project- specific information submitted after that point, nor do we generally intend to rerun the Project Assessment on the basis of updated project data.

2.27. Unite believes that Ofgem should consider all the facts, both positive and negative before making a decision and consider what would be best for the consumer. A system that is capable of more directly managing and storage of excess electrical generation, for the short term, one that looks to the strategic needs of the country as a whole over time or ideally both.

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[25] To see just how many visit the NESO website

[26] An example is the Stiesdal Hydrogen modular 3.1 MW and 6.5 MW HydroGen Electrolysers which after their two weeks after their two trucks arrive on site, they can be producing hydrogen. Combine this with MTC's modular metal hydride storage solutions, (other providers are available). And you have the basis of a way to realise the trapped potential of the projects waiting in the queue to create a strategic energy reserve that could be deployed via a bank of fuel cells, anywhere that clean renewable power is needed, at a time of your choosing to back up the grid or provide uninterrupted electrical supplies to a conference or other event. Increase the capacity of hydrogen stored and you have a reservoir that can be used or expanded, limited only by time and the supply of storage alloys. And it is not as though suitable metals are in short supply.

[27] Airbus is working on the development of their fully electric hydrogen fuelled, mass transport aircraft, capable of enough range to reach the majority of European destinations without refuelling but these are not expected to enter service until the early 2040's. See Airbus ZEROe project

3. Conclusion

3.1. Unite believes in not putting all one's eggs in one basket and feels that each option has a place in the mix, but the balance should not just be based on applications made from projects to go ahead but on the basis of commissions to build the infrastructure needed for the storage and use of electricity in the UK.

3.2. Unite feels that the number of options and speed of connections to the grid is heavily impacted by the lack of investment into not just the infrastructure but also the availability of staff trained to perform the vital functions of connecting the wires together. At present jointers are working unsustainable hours and performing an unprecedented number of tasks in the time they have in a day leaving little time for sleep or a social life. It comes to something when there is meant to be a hard stop after 16 hours of work and health and safety notices advising 20-minute power naps in their van followed by the consumption of a Red Bull before returning to work if they feel fatigued[28].

3.3. Unite is extremely concerned that workers tempted to drive after such extensive shifts, or worse over the course of a week of such activity, are putting their lives and the lives of other road users in danger. Yet the practice of allowing such activities to continue, to keep the lights on and keep the delays to the waiting list, of grid connection to a minimum.

3.4. There, undoubtably, are many other options for electrical energy storage not covered here but Unite would stress, whatever options are settled on, more investment is needed into the people to make the network operational and sustainable in the long term.

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[28] Health and Safety advice sent out to linesmen and jointers working in excess of 12 hour days by one of the electrical grid providers.