TECHNICAL DESIGN NOTE

Project name	Newburn BESS
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The battery cell proposed for this Battery Energy Storage (BESS) project is a Lithium iron phosphate (LPF) cell which forms the main chemical component of the battery. It does not contain any nickel or cobalt both of which have allegedly caused challenges in the past regarding human and environmental impact. LPF batteries are safer than other lithium-based batteries during the charging and discharging stages. They are safer due to the addition of the iron ion which makes it difficult for a redox reaction to occur with the electrolyte.

A Redox reaction like many other chemical reactions involves the transfer of electrons from one chemical substance to another. The electron transfer reactions are termed oxidation reduction or redox reaction, or those reactions which involve oxidation. Oxidation is a process which involves the addition of Oxygen, removal of Hydrogen.

Therefore, in this context the environment for the charging and discharging process is safe. LFP batteries can also maintain the stability of the physical structure during charging and discharging which removes the hidden potential risk of battery combustion as a result of any increase in gas volume.

Furthermore, Tesla and Ford are transitioning the chemical composition of all production to LFP batteries instead of the previously used NMC batteries.

When compared to other lithium-ion cells in a thermal runaway experiment[1], the LPF battery had the best results regarding safety. It had the highest onset temperature (approximately 195 °C), the smallest temperature increase during the thermal runaway (approximately 210 °C), the lowest amount of gas produced (approximately 50 mmol) and the lowest percentage of toxic carbon monoxide in the gas (approximately 4%).

There are multiple protection and safely devices within the battery energy storage system (BESS) specification including fire detection in each container and over-temperature protection. The installation is such that each container is isolated by space and individual safety controls as part of the master control system.

1. THE BATTERY DESIGN

1.1 The individual cell

Safety features are designed into each layer of the battery, including the individual cells. Firstly, the battery cell has a prismatic shape which has multiple safety measures implemented. For example, the shape allows for easier heat dissipation and avoids deformation under adverse conditions such as an external short-circuit.

[1] Golubkov, A.W., Fuchs, D., Wagner, J., Wiltsche, H., Stangl, C., Fauler, G., Voitic, G., Thaler, A. and Hacker, V. 2014. Thermal-runaway experiments on consumer Li-ion batteries with metal-oxide and olivin-type cathodes. Rsc Advances. **4**(7), pp.3633-3642.

Furthermore, the cells are certified under UN38.3, GBT 31485 and RoHS/REACH/(2006/66/EC&2013/56/EU). UN38.3 is the United Nations standard for lithium batteries to meet for safe transport and there are 8 tests for the lithium battery to pass in order to receive this certification. These tests include a thermal test, a vibration test to simulate transport, an overcharge test etc.

The cells also undergo numerous safety tests instigated by the manufacturer including an over charge test, over discharge test, short circuit test, crush test, drop test, low pressure test, heating test, thermal runaway test and nail penetration test. The cell passed all these tests.

1.2 Battery Module

52 cells are connected in series and then two of these in-series connections are connected in parallel leading to 104 cells forming each module.

1.3 BESS container

The plates that make up the ESS container are three-layer structure composed of double steel plate and fireproof rock wool. Furthermore, the fire resistance rating is greater than 1h and the decoration materials used both internally and externally are all flame retardant and the fire-fighting grade of the materials is UL94-V0. Finally, the container is designed following the NFPA69, NFPA68 and NFPA70E standards. NFPA69 details explosion prevention using exhaust ventilation, NFPA68 requires deflagration management using blast panels and NFPA70E ensures safe work practices.

2. GENERAL SAFETY FEATURES

The fire safety system is designed to follow the NFPA855 installation standard for stationary energy storage system. There are also general safety features integrated into the design including a fire alarm control panel, automatic alarm system, ventilation system, aerosol fire extinguishing system and water spray system. The combustible gas concentration reduction system is provided with a minimum of 2 hours of standby power according to NFPA 855-2013 section 9.6.5.6.7. The gas detection system is provided with a minimum of 24 hours of standby power and 2 hours in alarm according to NFPA 855-2013 section 9.6.5.6.7. A secondary power supply is provided for smoke and fire detection systems in accordance with NFPA 72 capable of 24 hours in standby and 2 hours in alarm according to NFPA 855-2013 section 4.8.3.

2.1 Automatic Alarm System

The automatic alarm system comprises of a fire alarm control panel, heat detector, alarm bell, horn/strobe, emergency button and manual release button. The strobe light on top of each container will ensure that the fire service can identify which container is going through a thermal runaway event.

2.2 Ventilation System

The ventilation system consists of a combustible gas detector, fan controller, air inlet electric shutter and exhaust fan.

2.3 Aerosol Fire Extinguishing System

The aerosol fire extinguishing system has 4 aerosols.

2.4 Water Spray System

There are sprinklers and pipes making up the water spray system. The DN65 quick connector will be reserved for connecting to an outdoor fire hydrant or truck.

3. PROCESS

3.1 Air inlet and Exhaust System

If the combustible gas detector detects the gas concentration above 10%LEL (lower explosion limit), an alarm is sent to the BMS (battery management system). The ventilation system emergency start button is activated and the fan controller receives the signal to activate the ventilation system. The system is then monitored and if all the combustible gas concentrations are below the safety threshold and the fan has operated for more than 5 minutes then the ventilation system is turned off, if not the ventilation system continues to operate until these conditions are met.

3.2 Automatic Fire-Fighting System

If a fire occurs, the smoke and heat detector are activated and the FACP receives the fire alarm signal level 1. This activates the alarm bell and sends the first level alarm signal to the BMS. The FACP then receives the fire alarm signal level 2 and sends out the gas fire extinguishing linkage control signal. This signal activates the horn and strobe, turns off the ventilation system and sends a secondary fire alarm signal to the BMS. After a 30 second delay, it is determined if there are any personal on site. If there are then the personal can manually determine whether to activate the firefighting, if there are no personnel, the automatic control process takes place. During this the aerosol is released and firefighting is implemented.

4. OUR DESIGN

Following conversations with individual fire officers we are going to:

- Ensure a water provision is on site by working with Northumbria Water to establish a water main and hydrant or install a water tank on site.
- We will have an emergency panel at the entrance of the development containing a telephone number to contact for 24/7 guidance on resolving a fire event.
- We are also keeping at least 3 metres between pairs of battery containers in line with the NFPA855 guidance. The safety features incorporated into the containers including internal cooling systems and module temperature monitoring justify this separation distance.
- Design the compound so there is adequate separation between the sides of the container that contain access panels, doors or deflagration vents, 1.5 m is the minimum recommendation[2].

5. LEGISLATION

There are currently no UK standards for fire safety regarding BESS, therefore we have been following the NPFA855 standard from the US and have chosen batteries that comply with these standards and have undergone NFPA855a testing.

6. PREVIOUS PROJECT

Similar projects have been approved for example in Cheshire where planning permission was approved for the installation of an energy storage system made up of sixteen containers and the associate infrastructure. This project was approved with conditions in 2019 and since energisation there have not been any health and safety incidents.

[2] FM Global (2017) Property Loss Prevention Data Sheets: Electrical Energy Storage Systems, para. 2.3.2.2

In December 2023, it was estimated that the UK battery energy storage pipeline consisted of 84.8 GW, which is a 68% increase compared to the previous year[3]. When considering these projects, 3.5 GW are in operational battery storage capacity, 3.8 GW are under construction, 24.5 GW have been consented, 27.4 GW have been submitted into planning and 25.7 GW are in an early stage of development.

A few notable consented projects include a 940 MW project in North-West England. This project was approved by Lancaster City Council in November 2023 and covers 72 acres of land but 1,880 MWh of storage capacity. There has also been a 500 MW/ 1,000 MWh battery energy storage project accepted in Leicestershire in January 2024.

To summarise, the battery energy storage system has been designed with safety as a priority. There are multiple components of safety measures within the system, such as features in the battery cells to prevent leakage which are highlighted in section 1. Section 2 goes into general safety features incorporated into the BESS design. The processes that would occur in the case of a fire is detailed in section 3 and specialised design features of our development are highlighted in section 4. Furthermore, comparable projects (section 5) have been underway for years with no reported incidents regarding safety or environmental impact.

[3] Norris, R. RenewableUK. 19th December 2023. Published: Pipeline of UK energy storage projects grows by two-thirds over last 12 months - RenewableUK