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Batteries for… Rail

Q&A document

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- What are the most important aspects for rail energy storage from your perspective - safety? reliability? long shelf-life? cost? low maintenance?

In short all. Safety is always a key aspect on any rail project, however improving reliability and reducing maintenance also a key attribute to providing an attractive commercial proposition. Life cycle costs are important for knowing the investment required i.e. is the battery fit for the life of the vehicle? what life do we have in the vehicle is critical to this, so for a 35 year life how many changes of the battery are needed?

- Questions for Angel Trains: Does route profiling to determine Li-Ion battery capacity requirements account for environmental loading of ACUs and Heaters in passenger areas? Is the energy from braking scavenged back to charge batteries?

Route profiling incorporates not only the route, the topography but also the whole diagram i.e. the stopping times, and the requirement of auxiliary loads inc. lighting and heating. Where possible regen is looked at as a way to further improve the reliance on diesel or grid electricity but is dependent upon the traction type and if it can be harvested.

- Have you optimised the cooling of the batteries, and are there still opportunities to talk to you about Rectifiers and IGBT Chopper stacks for the Class 165?

Cooling is depended upon battery chemistry. For NMC we have liquid cooled electronics for the BMS, however air-cooled batteries, but for LTO I feel liquid cooling may need to be employed due to the fast charging opportunities.
At this time the equipment has been designed for the Class 165, so no opportunities there, but in future there could be for other projects.

- Question for Angel Trains: I would like to understand if thermal management of high-speed batteries is a challenge? If so, how do you see this being mitigated in future?

The suppliers BMS should be designed to ensure battery cells are appropriately managed from temperature, charge rates, discharge rates etc. Suitable design and cooling is an integral part of this and the whole system needs careful consideration including how the batteries are used.

- Question for RIA: You mentioned that different energy storage technologies need to be considered. I would like to understand - (1) what key factors determine the technology used/suitable (i.e. full electric, hybrid, diesel, HFC etc.)? and (2) specifically, which applications would be appropriate for Battery vs. Hydrogen, and why?

1) Rail is no different to any other industry in that it is highly price sensitive. What is different, however, is that the structure of the industry, and in particular the financial and leasing arrangements can cloud this somewhat. It may be worth reading up on the structure of the industry if you are unfamiliar.
2) different manufacturers and leasing companies are developing different solutions according to customer requirements, government policy influence, and technological capability. There is no 'one size fits all' answer like 'batteries up to 20km range, hydrogen thereafter' because there are just too many factors at play. I would recommend reading both the outputs of RSSBs DECARB workstream, and also the Traction Decarbonisation Network Study, which will shed a lot more. light on the why's and where's.

- BCIMO thinks the market for battery only VLR urban transport vehicles could be 3,000 vehicles in the UK alone - but the size of the market is very cost senstive and hinges on the whole-system, whole-life cost of implementation and operation. |What do the presenters think are the factors of cost and what can we do to minimise them?

The big cost of batteries is prohibitive to large scale roll out. Don't fultimately the traveller and taxpayer are funding the railways, so ticket prices cant simply increase to pay for batteries. Reducing the cost of these to a commercial level would assist here, however we still need to provide a whole vehicle life cost that is attractive to end users including reducing maintenance, increasing reliability to offset some of the additional cost.

- I'd be interested to understand your thoughts on using 2nd life batteries (following use in an automotive application, with 80% useable life) in a rail application, targetting reduced upfront cost for the rail industry. This could be either as on-train (BEV or Hybrid) or as off-train as grid support.

Using 2nd life onboard rail vehicles is not being looked at, as life is critical and 100% - 80% can be reasonably defined however 80% to 60% may not be as easy to define, leading to units not meeting diagrams etc. You cannot simply put more batteries on as contingency as axle load weight is critical to unit and braking performance, plus carting around more weight requires more power to move. Using 2nd life as off-train grid support is an option but requires Network Rail input.

- Are there any additional regulatory requirements for battery systems for rail applications, on top of, or in place of, conventional automotive safety regulations?

See standards EN 62864 and EN 62928. However, during the 165 hybrid concept proving design the latter was in draft and only finalised when our design was complete and going into production. Keeping pace with the technology is an issue not only on this project but all technology projects these days.

- Is there still an industry appetite to refurbish end-of-life trains as opposed to building new ones?

Several years ago, wholesale fleet changeouts were the thing to replace and replenish an aging fleet life which was seeing close to 30 years average. Much of this has been done and the average fleet life has reduced considerably. This has ensured that much of the fleet now meets current passenger requirements for comfort (debatable term). As fleets have a 35-year life, simply replacing these every few years is not a green option when talking about embodied carbon and ensuring economical operation of the railway, therefore i still feel refurbishment offers huge benefits to the railway as a whole and see no reason why refurbishment should be part of the overall strategy.

- We've seen lots of statistics primarily focused on passenger trains. Is there an emissions breakdown broken down by passenger and freight rail we I believe we need to change focus somewhat? There is a very large programme of research work being carried out throughout the industry. RSSB, in particular, have a large volume of literature around this topic, generated as part of their DECARB workstream. You can find all the documents on their website, the recently close T1197 is a good place to start, and T1202 (incentives for decarb) is examining the differences between passenger and freight more closely with regards the economics.

- Are companies taking into account cost of materials for batteries and network upgrades with respect to the rate of network upgrade? Taking into account how investment markets for material demand is increasing rapidly and doesn't seem to be slowing down. How are they strategising for this?

All costs are taken into account when building a business case for battery use. With the high cost of batteries, the life of those batteries is taken into account and a decision is made whether to use the tech or not. Other schemes such as electrification or if there is a ready-made hydrogen supply which may lead to that technology being preferred at some point is taken into account.

- In additional to LTO, any other battery technologies you are considering / investigating for fast charging / regenerative braking?

We will respond to the supplier market with respect to which technology is best to use. This will be based on cost, life, C-rate etc. and how we intend to charge. Regen is looked at depending upon whether it can be undertaken due to the existing traction and costs involved to upgrade to employ its use. Basically, all options are on the table if they can be made to work.

- What about opportunity top-up charging at stations and terminals?

See above. If it can be made to work then it is an option. For some routes this may need to be a requirement if electification is not to happen and decarbonisation of the route is required.

- Performance etc. when in use is clearly important. What is the maturity of end-of-life management of batteries? Can we plan on the basis that the disposal/re-use options are available?

This is an issue that the DfT and Government should answer in my opinion. We can employ 1000 battery vehicles with average 500kWh of batteries giving us 500MWh of batteries to recycle, however automotive has 215k EVs and 455k PHEVs as of 2021 with an average battery size of 75kWh? giving 50MWh at present, and with this expected to grow to between 2.7m and 10.6m by 2030 and be as high as 36m by 2040, I think the automotive size will dwarf rail alone and therefore the Government need to address this as a whole.

- What is the impact of deep discharge on battery life e.g. in the case of perturbation?

In truth, we are not so sure on how these will be truly used. Suitable sizing of battery and BMS should ensure that the battery is not discharged to a point where it is detrimental to the life of the battery. When we have 10 or 20 years life data we will be better placed to answer.

- From a non-technical perspective, would battery-powered trains or battery-hybrid decarbonisation programmes in rail network translate to higher train fare to consumers?

In an ideal world no. We look at the whole unit for removing cost to make a case for the high cost of the battery, but with battery costs being high it is a difficult model to produce.

- Economics for passenger vs rail freight are clearly very different. Is the research considering both environments fully?

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- What is the typical life span of passenger and freight trains? if you were to design a new train from scratch that was optimised to be all electric, with aerodynamic design, minimised weight, regen braking, efficient battery cooling, fast charging capability if necessary etc., how long would it take to introduce those trains? Is a large percentage of the current fleet old and due for replacement in the coming years for example?

A passenger train has a typical life of 35 years. To introduce a train from concept to delivery and fault free running (You would have to ask a train manufacturer) however in practice from contract signed to introduction takes the best part of 3-4 years and then as MTINs show, new trains take time to bed in and achieve the reliability of mid-life trains. A large number of the current fleet has already been replaced over the past 5 years, with some fleets still due to be replaced for new.