“Batteries in Buses”
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Batteries in buses are not a new phenomenon!

1993 – 4 buses deployed on “City Circuit” service as joint project between OBC, OCC and Southern Electric

Vehicles needed to receive top up charge at the end of each cycle, using a charger at Oxford Rail Station. The driver was paid to stay with the bus, making the route very inefficient.

The vehicles were withdrawn within 5 years, following withdrawal of subsidies from OCC and concerns over long term battery life....
Energy storage in buses in Oxford more recently

2010 / 2011 – series hybrids
- Bus driven by diesel engine
- Engine boosted by small L-ion battery and electric motor to assist in accelerating from standstill
- Kinetic energy recovered under braking and stored into battery
- Enables smaller engine than normal – up to 30% fuel savings
- Long term issues with battery degradation, weight and vehicle complexity reduce savings over time
- Cost was high at c.£350k / bus and did not reduce despite kick start subsidies

2012 – parallel hybrids
- Bus driven by electric motors but with diesel generator to charge small L-ion battery
- Allowed the vehicle to move away from stop using electric power only
- Kinetic energy recovered under braking and stored into battery
- Enables smaller engine than normal – up to 35% fuel savings
- Long term issues with battery degradation, weight and vehicle complexity reduce savings over time
- Cost was high at c.£350k / bus and did not reduce despite kick start subsidies

2012 – flywheel hybrids
- Bus driven by diesel engine
- Engine boosted by electric motor and to assist in accelerating from standstill
- Flywheel used as a battery to recover and store kinetic energy under braking – idea being that this would be cheaper, lighter weight and not suffer from degradation
- System cost was circa £40k per bus, meaning complete vehicle for £260k rather than £220k.
- Fuel savings of up to 25% targeted. In reality did not exceed 17% and was highly specialized to route geography
- Adoption across the industry was low due to cost / benefit and reduced subsidies available by this time
Why are large quantities of batteries difficult on a heavyweight bus?

The additional weight of batteries vs diesel means more energy needed to move the vehicle, and comes at the expense of carrying passengers, which a bus is there to do!

The additional volume of batteries vs diesel is challenging to package in the envelope of bus bodywork – hence single deck EVs are easier to achieve than double deck.
Why is electric charging difficult for bus operators?

On-route charging infrastructure requires space and intrudes visually

Issues if roadworks / diversions cause charging stations to be unavailable – cannot operate

Routes need to be designed around charging rather than passenger needs

Infrastructure is very costly and installing it on the public highway, on land not owned by the operator is very difficult. Pear Tree P&R - £600k quote for charging plates in 2015.

Depot charging requires very large supplies, as buses all need to be charged at more or less the same time. For OBC an 8-10MW supply would be needed.

Traditional DSO model will either not be able to provide a supply or would charge many millions for grid reinforcement, meaning no business case

Space requirement for infrastructure likely to lead to issues with planning, increased requirement for land use for bus parking – or both

However buses with smart charging intuitively offers an interesting way to help balance the grid at times of high wind generation / low demand. “Private wire” supplies such as the Superhub project offer an interesting way to potentially exploit this.
Where is the market at currently? Some positive progress....

Waterloo bus garage – 50 x EV single decks operating since late 2016 and performing well in what is Europe’s largest all-electric bus depot.

Vehicles run on a heavily peaked commuter service network which allows vehicles to be brought back to depot in the off-peak to be top up charged.

Vehicles used cost double the price of standard diesel equivalent (£350k / bus) and infrastructure involved was several million pounds.

London now starting to introduce electric double decks with over 100 deployed or to be deployed

Range is limited to 150 miles / day and heating reduces this by as much as 25%

382kwh Iron Phosphate battery – high weight meaning reduced passenger capacity.

Cost is high at £430k / bus

Brighton & Hove bus company – 30 x “extended range” hybrids

32kwh Lithium NMC battery with additional E6 diesel generator, allows ZE running for up to 3 miles, with geofencing.

Allows full day operation without range anxiety or issues with heating.

However vehicle is expensive at £320k / bus and much more complex than standalone EV or standard diesel.

These vehicles still emit large amounts of tailpipe CO2 from the generator system.
...but uncertainty over direction of travel causes serious issues

Wrightbus collapsed into administration last week, blaming the transition from diesel to ZE vehicles as a factor.

1,500 redundancies have resulted.

Registrations in the UK have fallen 30% this year - after many previous years of similar falls - due to:
• Austerity reduced funding for bus services
• Fuel duty policy related issues
• Operators not sure which technology to back, or whether buses ordered today will be able to be used for their full lives
• Availability of funding for ZE buses is lumpy and timing uncertain
Possible future developments

Hydrogen fuel cell EV double deck was developed by Wrightbus pre-collapse and can achieve 220 miles range with heating. Cost was >£500k / bus but flexibility in operation is comparable to diesel

Orders in progress for London, Birmingham, Brighton and Aberdeen

Bus operators may invest in depot batteries to help minimise infrastructure and electricity costs

May even become players in flexibility services at local level – “LEO” project