TECH TALK

FOCUS ON | HYBRID BUSES FOR LOW-EM

Last month, the first of a fleet of 30 hybrid-electric buses began what is said to be the first use of geofencing combined with zero-emissions propulsion technology, meeting the emerging demands for clean air zones across our cities. The double-decker Enviro400ER buses, run by Go-Ahead in Brighton & Hove, are supplied by ADL (Alexander Dennis Ltd) and are powered by the BAE Systems Series Electric Range hybrid (Series-ER) powertrain. The buses automatically switch over to zero-emissions operation as they enter the city's zero emissions zone, and then back to normal operation as they exit.

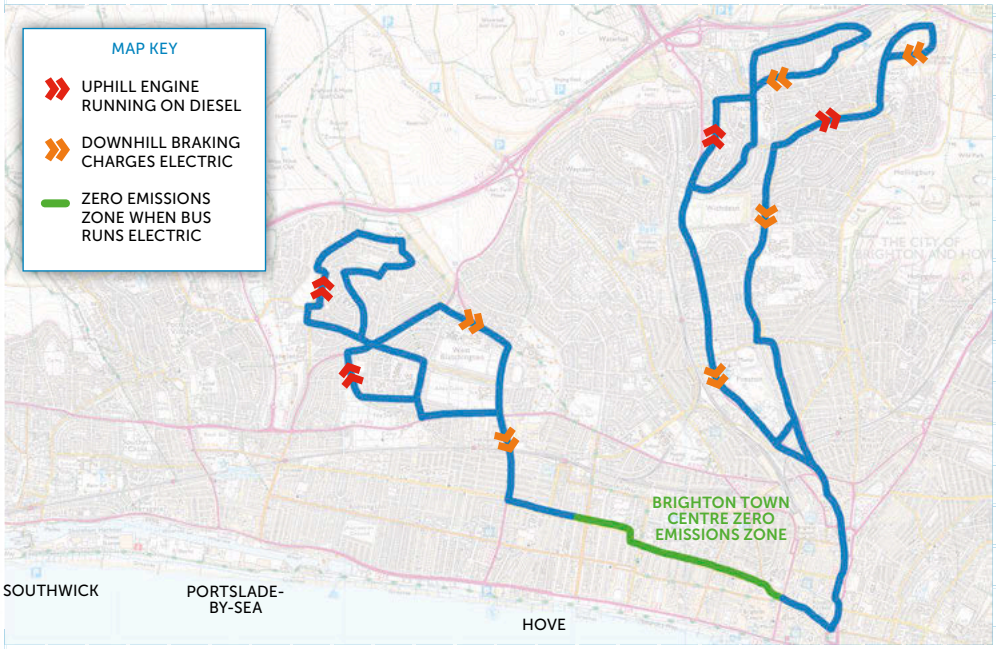
In Brighton this means that the buses run for about a mile and a half through the most congested part of the city, including along the high street, on battery power alone. Geofencing requires access to a GPS (global positioning system) signal on the bus. The switch-on and switch-off locations are pre-programmed to occur at certain points on the route. Actuation is carried out without any driver intervention, and the bus powertrain control system manages the battery and powertrain operation.

Inside and outside the zone, the bus's 32kWh battery is topped up by regenerative braking, converting kinetic energy into electricity by applying its traction motor as a generator. Outside the zone, the battery is charged by a four-cylinder, 4.6-litre Euro VI compliant Cummins range-extender diesel engine.

For other routes, the bus's engine-off range can extend as far as three miles. On any route, the system can be used multiple times, with the general requirement that as much distance again is required to recuperate the energy expended; so for example, at least 1.5 miles' engine-on travel would be required after a 1.5-mile zero-emissions stage. In addition, each route can be custom-calculated and optimised, taking into consideration other factors such as topography.

Of course there are already multiple routes in London and elsewhere running full-electric buses. However, this new fleet is the first of these Series-ER powertrain-equipped buses running in the UK, now helping operators in smaller towns and cities who may not need, are not ready for or cannot afford the potentially large-scale investments in electric charging infrastructure to switch to full-electric operation. They can really benefit from new buses of this type, argues Andrew Ashby, BAE Systems' business development manager, power and propulsion solutions.

Each Series-ER bus features its own generation and on-board charging, using



ISSION ZONES

the Euro VI diesel engine to charge the onboard battery when needed, outside the zero emission zones. The series configuration of the powertrain means that there is no direct linkage between the engine and the driven wheels. Instead, the engine's flywheel drives an electric generator, which in turn delivers power to the battery and/or direct drive traction motor via the power control system (PCS). BAE Systems also provides an accessory power system unit (APS) that handles power conversion and inversion, as well as voltage transformation for feeding a low-voltage line to power vehicle ancillaries such as air conditioning pumps and air compressors for braking. Downstream from the motor, the powertrain is conventional, in that the drive goes through a propshaft to a rear differential to the wheels.

There are two significant consequences for bus operations from this power architecture. First, the diesel engine never drives the bus and is never exposed to the full vehicle load. The bus is always driven by the electric DDTM (direct drive traction motor), while the diesel engine only powers the generator, and the powertrain system control unit (SCU) manages this fixed load to ensure the engine always runs at optimum efficiency.

For example, lowest fuel economy is normally experienced at pull-away from standstill, when large torques are required to get the heavy vehicle going. All internal combustion engines have to increase revolutions to reach maximum torque, because of inefficiencies in the compression phase at low revs. Of course, pull-away often occurs around bus stops, where passengers are likely to be present and so exposed to a cloud of exhaust. In the Series-ER hybrid architecture, this drive can be provided by electrical energy previously recovered from regenerative braking.

UNFAMILIAR TORQUE

That's not the only factor at work. Electric motors can offer full torque at zero revolutions. That is because torque is the effect of the interaction of magnetic and electric fields in the motor that are created by conductors and magnets in either the rotor or stator. While owners of a Tesla sports car might particularly enjoy the thrill of a speedy departure, passengers who are standing in a gangway on a bus cannot cope with much acceleration before falling over. For that reason, electric drivetrain control systems limit the amount of current delivered to the traction motor to control acceleration, and to obey operators' acceleration limits and requirements. TfL's limits, for example, are currently set at 1.3m/s² and BAE Systems adheres to this.

The second consequence is future-proofing. As the BAE Systems powertrain is essentially electric, its major components – including motor, inverter and control unit – are also used on other models in this low- and zero-carbon product range, regardless of the power input. That includes the Series-E electric hybrid powertrain, which comes with an ultra-capacitor energy storage system. This quick charge, quick-discharge system enables stop-start operation at road junctions, for example, to reduce emissions, and also offers engine-off operations during pull-away, as well as electrical power for hotel loads such as air compressors. However, it cannot match the extended engine-off driving distances offered by the Series-ER. (And the Series-ER offers a plug-in option for extra charging capability, too.)

Another model is the Series EV full-electric plug-in powertrain, which replaces the diesel engine with a battery pack for entirely zero-emissions operation, whether recharged frequently using opportunity charging or for longer periods overnight. BAE Systems' range even includes a hydrogen-powered model, which also generates a flow of electricity from the combination of hydrogen in tanks and atmospheric air into water. That unit requires a different control module, but the architecture is basically the same; it just swaps the diesel engine for a fuel cell.

There are many potential scenarios, and much uncertainty, about the way that public transport will be decarbonised over the next 20 years. Both the speed of that transition and the form it ultimately takes will differ from place to place. For some routes in large cities like London, that might include full-electric operations, alongside a major investment in charging infrastructure. In contrast, most of the smaller cities and towns in the UK currently planning air quality improvements, like Brighton, have fewer requirements. For these areas, other types of less expensive, less drastic electrification options, available now, might be more appropriate. TE