TECH TALK

HOW TO | MOVE FORWARD IN BU

One of the themes of Glasgow's COP26 environmental congress last month was the global importance of reducing carbon emissions to limit the potential rise of world temperatures. Last month also marked 25 years since BAE Systems began reducing local emissions with hybrid electric propulsion systems for buses, coaches and other vehicles.

While running partly or fully-electric buses operating in city centres might now be commonplace, it is useful to consider how they got there. Two drivers have been most instrumental: government funding and real-world operating experience of advanced driveline technologies. Long before London's ULEZ (ultra low emission zone) came into effect, BAE Systems was putting hybrid, full-electric and fuel-cell buses on the roads.

Over the past quarter-century, BAE Systems has produced more than 14,000 reduced-carbon powertrains in battery-electric, fuel-cell electric and electric hybrid configurations for urban buses for North America and Europe. The environmental benefits of those vehicles have been huge; the OEM noted earlier this year that the combined fleet has travelled an accumulated total of more than 20 million miles in zero-emission service.

That journey began on Tuesday 26 November 1996. On that date, BAE Systems signed a contract to design and produce hybrid electric vehicle drivetrains for Orion Bus Industries, a Canadian bus maker. At that time, the defence manufacturer was adapting capability originally developed for military vehicles for civilian use: not just buses, but also light and heavy commercial vehicles, off-road vehicles and trains.

The first model promised 25% savings in diesel fuel (later models closer to 40%) compared with a traditional internal combustion engine thanks to a series-electric architecture (Series-E) that severed the mechanical connection between diesel engine and driveline, replacing it with a diesel-driven generator providing charge to batteries and an AC induction motor.

One of the first contracts for these buses was for ten low-floor Orion VI buses ordered by New York City. In 1999, Orion announced it would install BAE Systems' electric drivetrain on to the RTS chassis from Nova Bus, which was popular in the city. So significant was the new technology that in 2001 the MTA won the US Environmental Protection Agency's 2001 Clean Air Excellence Awards.

A few years later, this technology migrated to the UK, in the form of a collaboration with British bus manufacturer Alexander Dennis Ltd. That partnership proved very successful, as it eventually produced some 1,400 Enviro400H double-decker buses.

Another step to facilitate a further emissions reduction came in 2014, when BAE

Systems launched engine stop/start functionality for passenger boarding/disembarkation. The technology has been integrated with engine manufacturers specifically for hybrid systems based on the Series-E electric drivetrain. Tests showed it reduced engine idling by up to 40%.

Since then, the Series-E version of the hybrid system has launched with a lighter and more compact direct-drive permanent magnet traction motor, which also does away with the speed-reducing gearbox. Next was a switch to the use of ultra-capacitors instead of lithium-ion batteries on this platform. This provides many more cycles of micro-charging for the lifetime of the bus. Using the UK Bus test cycle from Zemo Partnership (formerly LowCVP), tank-to-wheel CO_2 equivalent emissions are 37% lower than those of a conventional Euro VI diesel

US DECARBONISATION

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bus, allowing the Enviro400H to be certified as an Ultra Low Emission Bus, according to ADL (see *www.is.gd/emolop*).

Another variant of the hybrid-electric drivetrain proved popular in Boston, Massachusetts, whose transport authority ordered nearly 200 in 2019. Dubbed Series-ER, it incorporates a larger battery to function as a range extender (see *www.is.gd/amover*). This enables buses to run for as much as five kilometres (three miles) at a time with the engine turned off. For towns and cities, this provides a significant tool in the fight to improve local air quality, as well as reducing carbon emissions by more than 30% when compared to a diesel-only vehicle. With intelligent controls and advanced geo-fencing, the bus can travel cleanly and efficiently on longer, inter-urban routes, and switch immediately to engine-off, zero emission operation when in city centre zero emissions zones.

FULL-ELECTRIC

As awareness of the importance of air quality in cities has improved – along with the funding to support infrastructure investments – so full-electric fleets have spread.

The newest full-electric platform is Series-EV. Using the same core components as Series-E and Series-ER, this system allows the operators to travel 100% of the time with zero emissions. As the driver accelerates, energy moves from the energy storage system to power the motor. To increase the vehicle's efficiency during braking, the motor takes on the role of a generator and recaptures braking energy, storing it in the energy storage system for use later (see also this article: *www.is.gd/etohes*).

By 2016, Heuliez GX Elec buses were using these systems in Paris, being powered by both plug-in and pantograph opportunity charging. Most recently, Nova Bus launched the LFSe+ battery bus, also with BAE Systems power electronics, that offered a range of 211-292 miles before recharging – either at the depot or on-route. Earlier this year, Milwaukee, Wisconsin ordered 15 of them for a new bus rapid transit (BRT) partially-segregated bus route.

HYDROGEN EXPERTISE

Hydrogen as a transport fuel has been much in the news lately, following the conclusion of several EU-funded research projects in the UK over the last few years, and there is much interest in its potential as an eventual replacement for diesel and natural gas. But fuel cells, which convert a stream of hydrogen into electricity (and waste product – water) to power an electric motor, are nothing new to BAE Systems, having integrated its first hydrogen fuel cell vehicle more than 20 years ago.

In 2011, SunLine Transit Agency of southern California took delivery of the first US fuel-cell bus, in a pilot project financed by local and national government agencies. It used a fuel cell module supplied by Ballard Power Systems as the power plant, combined with BAE Systems' drivetrain. As the vehicle prime integrator, BAE Systems also supplied the electric accessory system, power management systems and advanced lithium-ion-based energy storage system.

Ten years later, BAE Systems began a collaboration with hydrogen fuel cell provider PlugPower, in which BAE Systems integrates Plug Power's fuel cell engines with its electric drive systems to power the bus (see article via *www.is.gd/exojim*). In a world that is becoming ever more complex, this collaborative approach marks a new way forward by combining best-of-breed technology from leaders in the field.

During the COP26 conference, the UK confirmed its big-picture phase-out plans for diesel engines by 2040 for commercial vehicles. Meeting such targets is a daunting prospect for manufacturers and operators alike. Fortunately, it doesn't have to be one giant leap to reach the end goal. Many different technologies are available to assist them, at different levels of pricing and with different requirements for supporting infrastructure. Whether the configuration is hybrid, battery-electric or hydrogen fuel cell electric, BAE Systems has supplied them all, providing power electronics, control laws, systems integration and aftersales support. And it is not finished. BAE Systems continues to extend its range of competitive electric drive solutions.

In other words, BAE Systems is perfectly placed to help operators in the UK and elsewhere meet their carbon-reduction targets over the next 25 years. From advanced electronics to control systems, systems integration, batteries and motors, BAE Systems brings to bear the manufacturing capacity, people and partnerships to make a difference for the future. TE