



With several variants on the hybrid theme already in service, PSV operators are seeing a lot of diesel-electric powertrains. John Challen investigates some newer technologies

Hybrid buses have become a familiar sight on UK roads as fleets choose to operate diesel-electric powered vehicles, thanks in large part to the money available from the Department of Transport's Green Bus Fund. May 2013 saw the fourth round of funding – £12 million for 213 low carbon buses split between 83 single-deck and 130 double-deck vehicles, with Alexander Dennis, BYD, Optare, Scania and Volvo the key suppliers.

The cost and emissions savings from running these vehicles have been well publicised – hence the interest and investment. But engine and vehicle manufacturers are not standing still, and we can

goes into serial production by the end of 2015, and we have projects starting in Stockholm [August 2014] using eight pre-series vehicles." Morelissen also reveals that he is speaking with operators in Hamburg, Germany, and Luxembourg.

Plug-in bus trials might be confined to mainland Europe, but it might not be long before the technology arrives in the UK. "There are several interested parties looking at recharging electric or hybrid vehicles in service, rather than in the depot – notably a proposal in Milton Keynes for battery buses, and Transport for London, which is part of another consortium, for hybrid buses," says Adrian Wickens, product planning manager at Volvo Bus.

# Bus stop-start

expect further technology introductions soon. As part of a field test, Volvo Bus, for example, introduced plug-in hybrids to Gothenburg in May, claiming that the technology will reduce fuel consumption by 75%, compared to today's diesels.

Its trial vehicles are based on Volvo Bus' 7900 Hybrid. In those, a 5-litre engine is coupled with a 120kW electric motor and a lithium ion battery pack. With the plug-in variant, this configuration has been changed to enable recharging from the grid (in six to 10 minutes), via a collector on the bus roof.

Additionally, the battery pack has been enlarged (size wasn't confirmed by the Swedish firm), making it possible to drive up to 7km on electric power only.

"When we introduced our hybrids, we were questioned about the possibility of driving further in electric-only mode," recalls Erland Morelissen, Volvo's hybrid team leader. "This set-up was not [envisaged] at the time, because the main aim was to reduce emissions and improve fuel economy. But another target was cutting noise, using start-stop innovations and silent starting. We felt we could develop these with a plug-in hybrid bus."

This will happen. Morelissen states that all of the company's low-entry vehicles – articulated and 12m variants – will be equipped with hybrid drivelines within two years, making Volvo's diesel and CNG-powered bus options obsolete. "This is a big focus for us and, by driving our volumes, we believe our costs will come down," he reasons. "The plug-in

"In both cases, the teams are studying inductive charging, where coils are buried beneath the road surface and also fitted to the vehicle. The vehicle coils are then lowered to reduce the air gap."

Based on likely equipment suppliers, Wickens calculates that four coils will be needed on each vehicle (to give a charging rate of 120kW) and that transfer efficiency will depend on accurate alignment of the coils with the charging unit. Operators should not expect too much, too soon though: "60kW for one minute is only 1kWh [3.6MJ] of energy, and that will not take a bus too far," he points out. "Plus, fitting four coils in a typical UK bus will not be easy in the low floor area, where London buses also have the wheelchair ramp."

## Bigger and better?

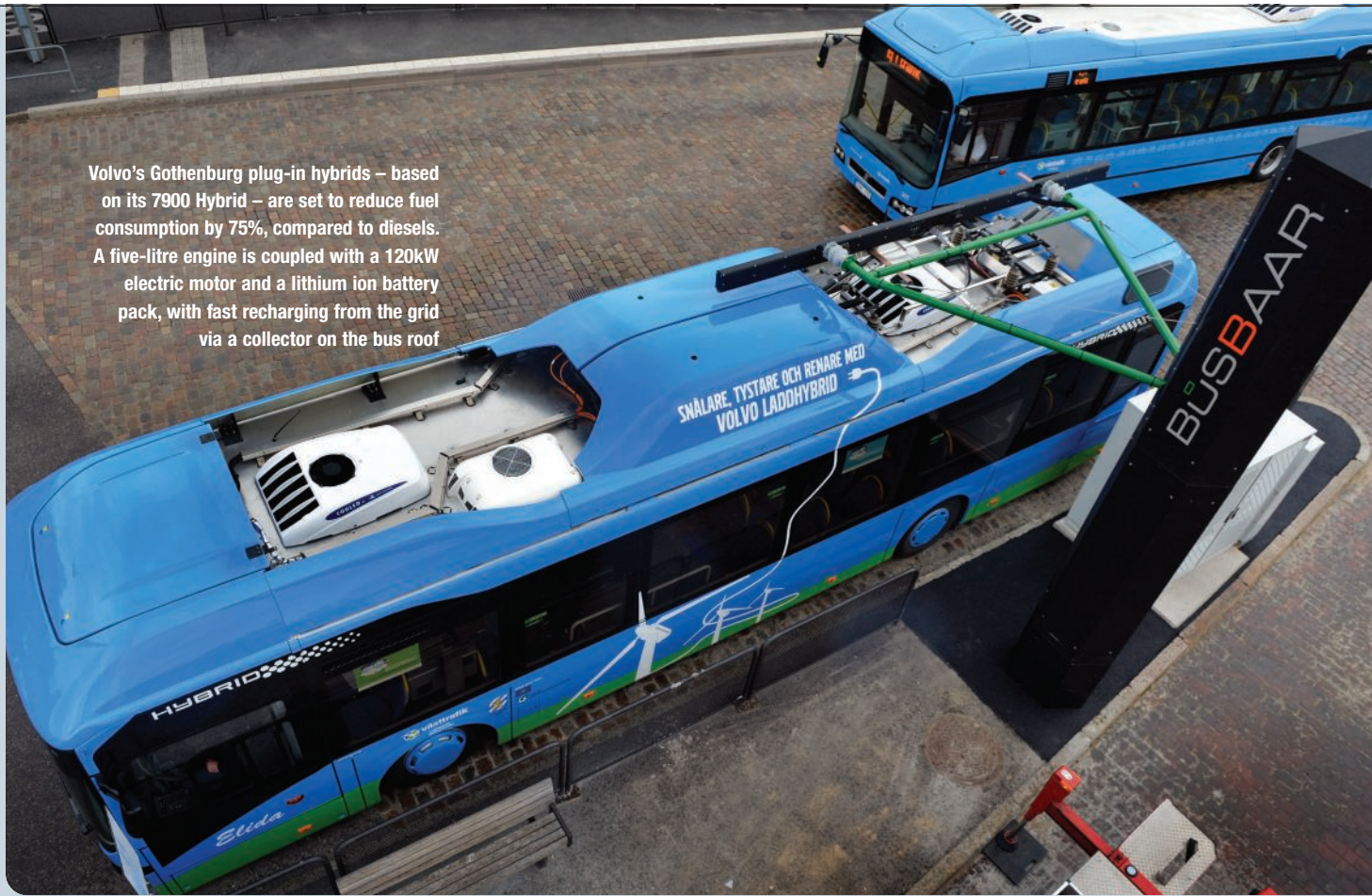
Over at bus manufacturer Optare, Glenn Saint, chief technology officer, is fully aware of the engineering challenges. "One of the difficulties we have with hybrid buses is the way the rules are written," he claims. "From January, the motive power unit has to be Euro 6, due to emissions regulations, but no account is taken of overall vehicle emissions."

That said, a problem with the current crop of hybrids is that they are "probably over-engineered", says Saint. He believes there is a gap in the market for engines designed with hybrids in mind. "Once you get below 4.5 litres, engines are designed for smaller LCVs and their duty cycles. Designs are

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Volvo's Gothenburg plug-in hybrids – based on its 7900 Hybrid – are set to reduce fuel consumption by 75%, compared to diesels. A five-litre engine is coupled with a 120kW electric motor and a lithium ion battery pack, with fast recharging from the grid via a collector on the bus roof



unsuitable for hybrid buses. Some operators have found, to their peril, the problems with putting a small engine in a hybrid. It won't work, because it won't stand the bus duty cycle."

Saint says the engine manufacturers are listening, but concedes he is yet to see new technology. Another thing he hasn't seen is a fall in component costs. "We were promised that, with volume, hybrid equipment would reduce in cost, but that hasn't become a reality at the speed we would like," he says. "The UK has invested heavily in hybrids, with the Green Bus Fund, but engines, motors and inverters haven't dropped in price enough. So hybrids are still a commercial challenge."

Nevertheless, Saint commits Optare to offering a full diesel-electric range. "While they may be an interim step towards zero-emission vehicles, hybrids are going to be with us for a number of years. As we've seen in London, they are a good solution to reducing emissions ahead of infrastructure changes."

And Optare's new vehicles will see developments that will help operators, he insists. "In the next generation of hybrids, the driveline equipment – generators, motors and inverters – will be lighter," he promises, hinting at further fuel savings from running at lighter gvw. "We'll also be using a direct-drive generator, as opposed to one mounted on the gearbox. And our electrical equipment is evolving all the time to help our buses be reliable and efficient."

Beyond hybrids – be they of the plug-in or standard variety – are fuel cells. It's a technology that

Mercedes-Benz has been very active in, but one that has also been hampered by infrastructure issues. Undeterred, the German manufacturer now seems to be moving, with more services – such as one at the Karlsruhe Institute of Technology – being run on hydrogen-powered vehicles. Mercedes-Benz says that at least eight more vehicles are planned for Bozen and Stuttgart before the end of 2013.

Its Citaro FuelCell hybrid bus (pictured right) uses an identical stack to that found in the company's B Class F-Cell vehicle – a 27kW, water-cooled, lithium-ion battery pack sufficient to power the electric motors at a constant 120kW (163bhp). On the bus' roof are seven cylinders, with capacity for 35kg of hydrogen. This represents a decrease of 50%, compared with the previous generation. "As a power supply, the fuel cell is intelligently linked with several components," explains a company spokesperson. "The battery and electric wheel hub drive, and also the integral braking energy recuperation system, are networked with one another."

Citaro FuelCell has a range of over 300km, and refilling the tanks takes less than 10 minutes. Mercedes-Benz also claims that the drive system is "virtually maintenance-free and highly durable". All good news in what could represent an important bridging technology on the road to pure electric driving. However, with infrastructure issues yet to be resolved, in the short- and mid-term, bus fleets are more likely to be saying hello to hybrids than they are to hydrogen. **TE**

**Above: back to the future with Volvo rapid bus charging**

