The Wonder Wagon

Even Walmart's CEO admits his company's latest hybrid concept artic might never make it to the road, but it provides the perfect 'what-if' test bed for future truck technologies. Brian Weatherley reports

Ask any gathering of British road transport engineers who is furthest down the road, in terms of top-weight hybrid truck development – North America or Europe – and the chances are many will answer 'Europe'. They'd be wrong. When it comes to hybrid tractive units, US truck makers and operators are streets, if not freeways, ahead of their European counterparts.

Should you doubt that statement, I'd direct you to one outstanding exhibit at the recent Mid America Trucking Show (MATS). The ultra-slippery Walmart Advanced Vehicle Experience (WAVE) concept artic is the latest step in the US supermarket giant's ongoing journey, started in 2005, towards doubling the operating efficiency of its massive North American truck fleet by 2015. It's already well on the way. As of last year, the company claims to have achieved an 84% improvement in fleet efficiency over its 2005 baseline.

Having seen Walmart's prototype tractor and trailer, some engineers on either side of the Atlantic will remark: 'It's all very impressive, but I can't see us ever running a truck like that in our fleet.' And they're not alone. Commenting on the company's website in February this year, Walmart president and CEO Doug McMillon said: "When Walmart began our sustainability journey, I never thought it would lead us to trucks like this." However, he continued: "We're just beginning formal testing, but this WAVE concept truck will be 20% more aerodynamic than our current trucks and have a micro-turbine hybrid powertrain that can run on diesel, natural gas, biodiesel and probably other fuels still to be developed."

While conceding that the WAVE may never make it to the road, McMillon insisted that it will allow the organisation to test new technologies and approaches. And that, in a nutshell, is what the WAVE hybrid artic is all about – a one-off 'what-if' cutting-edge technology demonstrator that will provide data on the potential for future trucks.

Hybrid development

Not that Walmart is any stranger to hybrid tractors. Since 2009, it has been evaluating vehicles from Freightliner, International and Peterbilt – based on Arvin Meritor or Eaton parallel-hybrid systems – with the electric drive providing supplementary green power for starting off and hill climbing. However, the WAVE project takes the concept to a new level, as Elizabeth Fretheim, Walmart's director of logistics

sustainability, confirms. "We've built technology trucks [that] have conventional engines, but we pair them with very sophisticated systems, which increase both the efficiency and the safety of those vehicles. All of these are potentially game-changing technologies and we'll continue to work on them, but we wanted to push ourselves and our vendor partners just a little bit further."

It's certainly done that. Among the suppliers contributing to Walmart's wonder wagon are Peterbilt Trucks, Roush Engineering, Great Dane Trailers and Capstone Turbine Corporation. Starting at the front, the futuristic Peterbilt tractor's striking cab profile is the result of many hours of CFD (computational fluid dynamics), resulting in a shape delivering a 20% cut in aerodynamic drag, compared to Walmart's traditional Peterbilt 386 tractors. That reduction, says Peterbilt, leads directly to a 10% improvement in fuel economy.

Micro-turbine power

Underneath the fully-tilting, streamlined sleeper cab (which, for good measure, also sports sliding doors, a fold-out step, an unusual central driving position and a customisable electronic dash) sits the power plant – a Capstone micro-turbine. Unlike the diesel engine in a conventional bonneted US tractor, the micro-turbine (along with the rest of the hybrid drivetrain) is located directly below the cab, thereby reducing its wheelbase and aiding manoeuvrability. With the micro-turbine being air cooled, there's also no radiator to get in the way, so Peterbilt's designers have been able to maximise the tractor's bullet profile design.

Whereas previous Walmart hybrids retained a diesel engine drivetrain, albeit with the additional hybrid kit, the latest concept truck is described as a 'range-extending series hybrid'. The 65kW micro-turbine runs at a constant speed, providing electrical charging to the Corvus energy system, based on lithium nickel manganese cobalt oxide (LNC) cells. Seven battery modules have been used, each weighing 70kg. The turbine spins at an optimum 96,000rpm at full power, continually topping up the battery pack, while an electric motor delivers the power for acceleration and driving.

Dimensionally, the micro-turbine certainly lives up to its name, measuring 89cm long by 66cm wide and 76cm high. Weight is just 136kg. There is also a small inverter, while the large electric traction motor has an equivalent power/torque of 400bhp/1,830Nm and delivers to both tractor drive axles.

Using a turbine in place of a diesel engine offers several benefits, says Capstone's director of business development Steve Gillette, not least in terms of reduced maintenance (the turbine has

fewer moving parts and runs on air bearings) and lower emissions without after-treatment. Right now, the concept tractor's micro-turbine runs on diesel, but Gillette says: "Our micro-turbines can operate on a wide range of fuels, including natural gas [compressed or liquefied], biogas, kerosene and jet fuel."

Walmart's hybrid tractor operates in three modes. When the truck is started, it automatically detects the state of charge of the batteries and, if necessary, charges them using the micro-turbine. The charge mode can also be manually selected to top up the batteries prior to shutting down. In urban and environmentally-sensitive areas, the truck can switch to full electric vehicle mode, running on electric power only, until the battery charge hits 50% when the turbine automatically restarts charging. Finally, if maximum range is required, hybrid electric mode is selected and the turbine runs continuously.

WAVE is currently fitted with a 190-litre fuel tank, with Gillette stating that range depends strongly on the drive cycle – although for a typical stop-and-go urban environment 350 miles would be the expected envelope. "We will be doing testing to confirm our simulations and identify opportunities for improvement," he adds. Meanwhile, in electric-only mode, the artic's range is around 20 miles. While

Hybrid Axor?

Hybrid tractors are rare beasts in Europe. In 2008, Mercedes-Benz unveiled an Axor tractor with a parallel-hybrid system having a smaller 320bhp, 7.2-litre Atego engine under its cab, in place of the Axor's 12-litre straight-six. A 59bhp/420Nm electric motor provided power for pulling away and hill climbing.

Using lithium-ion batteries, the Axor hybrid was reportedly capable of cutting fuel consumption by 4–10%. But, by late 2011, the German truck maker admitted: "The focus in our engineering department has been to force the series-production readiness of the Mercedes Atego BlueTec Hybrid. So we've [ordered] no further activities."

Whether Mercedes will revive its top-weight hybrid tractor remains to be seen. While European manufacturers have restricted their hybrid truck activities to rigid chassis up to 26 tonnes for urban distribution, or refuse-collection, in the US hybrid tractors have been operated by some of America's biggest fleets, including Walmart and Coca-Cola.

that might not sound much, it's considerably greater than the electric-only range of most diesel-electric hybrids currently in Europe. Moreover, it's probably sufficient to allow a quick in-and-out mission to inner city stores or an LEZ (low emission zone).

The tractor was assembled by product development specialist Roush Engineering, and was not built with production components. Walmart says that the truck weighs about 19,000lbs (8,618kg), which is comparable to a conventional tractor, but adds that a production tractor could be 2,000–3,000lbs (907–1,360kg) lighter, "due to the simplicity of the turbine engine". The possibility of a future hybrid long-haul tractor weighing in at under 7.5 tonnes is certainly an attractive proposition.

Carbon fibre trailer

Behind the hybrid tractor sits a tandem-axle semi-trailer supplied by US trailer-maker Great Dane. Built almost exclusively from carbon fibre (including, for the first time, one-piece 16m carbon fibre roof and sidewall panels) it saves some 1,800kg in weight, compared to traditional designs. The trailer's convex nose also helps aerodynamically, while still allowing useable space at the front. Other features of the ultra-light trailer include low-amperage LED lighting strips, composite trailer skirts, aerodynamic wheel coverings, a Posi-lift suspension and a one-piece, fibreglass-reinforced floor panel with a practical 7,250kg forklift rating.

Having launched its futuristic hybrid artic at MATS, what does Walmart plan to do with it? The company concedes that the tractor is not approved for road use, so trials will be run on a test track. The intended duty cycle, it says, is a mix of highway and urban driving, "which we will be simulating". When it comes to fuel savings, Walmart comments: "This will be determined through further testing this summer." However, it also states: "The tractor is 20% more aerodynamic, which should equate to 10% fuel economy savings, and the trailer is [1,814kg] lighter, which will also improve mpg or allow us to carry more freight per load, so reducing fuel through fewer loads."

Transport Engineer will be watching keenly to see exactly which, if any, elements of the Walmart concept truck make it into production. But without the ability to trial the kind of technologies built into this aerodynamic, ultra-lightweight concept artic, fleet engineers would have a much harder job predicting the best fuel-saving inventions for the future.

As Walmart's senior vice president of transportation Tracy Rosser says: "Walmart is continually looking for innovative ways to increase our efficiencies and reduce our fleet's emissions. The WAVE is a bold step in transportation technologies that, although not on the road in its current form, will serve as a learning platform for the future that will accelerate our progress. It's important that we continue to work collectively on innovations and challenge ourselves to look boldly at fleet efficiency in new and different ways."

Walmart's wonder wagon certainly demonstrates that approach, and then some. TE