Press Information

Feature: The hybrid future is here

Volvo Trucks took on the hybrid powertrain challenge as early as the 1980s. Years of research, development and testing has led to the cutting edge Volvo FE Hybrid. The solution: parallel hybrid technology using up to 30 percent less fuel.

One of the quintessential sounds of the city is the early-morning rumble of the diesel-powered refuse truck as it stop-starts up the street accompanied by the occasional tinkle of breaking glass from the trash in the compactor. But the backing track to urban life will start to change with the introduction of the hybrid engine. At low speeds the hybrid truck will replace the diesel's growl with a muted electric hum. The Volvo FE Hybrid, which will be available for distribution trucks and city buses as well as refuse trucks, will be a significant stride forward for environmentally-friendly automotive technology. Besides the considerable noise reductions, the hybrid will reduce CO2 emissions and fuel consumption by 15–20 per cent depending on the application. Volvo has achieved reductions of up to 30 per cent with a plug-in superstructure for waste compression.

"This is the way forward for inner-city stop-start applications," says Henrik Kloo, who coordinated the Volvo FE Hybrid project for Volvo Trucks. "As fuel prices increase and awareness of climate change grows, everyone is asking what they can do. This is part of the answer."

While the Volvo FE is right at the cutting edge of hybrid technology, the idea of combining an internal combustion engine with an electric motor is nothing new. Indeed, the first patent for a hybrid engine was granted in 1899 to a young inventor by the name of Ferdinand Porsche. Volvo Trucks has been involved with demonstrators and theoretical studies of hybrids since the mid-1980s and has tested various technologies, from mechanical hybrids to hydraulic hybrids to electric hybrids.

In 2002 an advanced engineering project got underway to investigate which sort of hybrid solution would provide the best combination of fuel efficiency, robustness and cost effectiveness.

"We ruled out quite a few configurations of hybrids because they were too expensive, and ended up with what is known as a parallel hybrid system, in which you use one electric machine and an automatically-geared mechanical gearbox," says Anders Kroon,

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who is director of hybrid technology at Volvo Powertrain, the Volvo Group's internal producer of powertrain systems.

In 2006 the project resulted in a FM9 hybrid truck, the first test of a parallel hybrid. Unlike the more traditional series hybrid approach, where an electric motor alone drives the wheels and a combustion engine charges the batteries, a parallel hybrid uses either the electric motor or the combustion engine – or both together. There is a normal diesel engine and a gearbox, but in between the clutch and the gearbox sits the electric motor. It is a reliable construction and the diesel and electric motors can be used independently of each other.

"These two power sources work on the same axle through the gearbox and that drives the wheels," says Henrik Kloo. "That means that when you start the truck from standstill you engage the electric motor because it is better when starting off with heavy loads from zero: higher torque at lower revs. Then when you get up to higher speeds the diesel engine is activated and these two work together, or if the control system feels it is better then the diesel engine can take over. When you are running at high speed it behaves like a traditional truck, but at low speeds is behaves more like an electric vehicle." During braking, the electric motor works as an engine brake, reducing brake wear and recovering braking energy.

While Volvo Powertrain has developed dozens of diesel engines over the years, the task of coming up with a hybrid solution for large-scale production threw up a number of challenges, several of them connected to the battery and its control system. The battery chosen by Volvo for the Volvo FE Hybrid is a lithium ion battery, with the same chemistry as the batteries found in mobile phones and laptops, but considerably larger – it weighs about 200 kg.

"The battery is the Achilles heel in all hybrids throughout the automotive industry," says Kroon. "Even though there has been significant development with nickel metal hydride technology, lithium ion technology and super-capacitors as energy storage, there is still a lot of ground to be covered before we have a completely robust system."

The 600-volt system used in the Volvo FE requires hundreds of lithium ion cells in series. "The challenge is how to manage this to make it act as a robust system," says Kroon. "To handle these kinds of electric energy levels we have incorporated protective systems that shut down the battery and isolate it from the rest of the vehicle in case of an accident or someone doing something wrong when working on the system."

The result is an advanced system which analyses what is happening and takes appropriate action if needed. "It has to happen blisteringly fast and it has to function in

all situations," says Kroon. "There are a lot of safety systems around the battery and the entire high-voltage system on board the truck."

As anyone with a three-year-old mobile phone or laptop can testify, lithium ion batteries have a limited lifespan. But Volvo is aiming for a lifespan of up to eight years for its batteries, depending on driving cycle. "That should resemble the lifetime of the truck, maybe with one battery change," says Henrik Kloo. "Here there needs to be a bit of a trade-off as you can have greater fuel savings if you compromise on the lifetime of the battery."

Once the issues surrounding the battery had been solved, the next step was finding suppliers. "This technology is new not just for us but for the supplier structure," says Anders Kroon. As there has been no large-scale production of these batteries, new factories have had to be built. "The major challenge facing the battery industry has been to stabilise production from these new factories to provide good reliability and good productivity to match that of the system integrator who provides us with the energy storage system."

Volvo Trucks is currently carrying out field tests with test hybrids in commercial operations together with selected customers. Although considerable progress has been made from the technical viewpoint, the global financial crisis has affected both product development and the haulage industry's investment potential, so small-scale series production of the Volvo FE Hybrid will not get under way until 2012. At the same time, a hybrid solution for long-haul applications is being investigated. Although the potential savings in percentage terms are not as great as for urban stop-start driving, the distances covered mean that considerable emission and fuel consumption reductions are also possible on the open road.

Anders Kroon declares himself extremely happy with the outcome of the Volvo FE Hybrid project. "The result for the customer will be great," he says. "Once functionality and reliability have been proven, we will gain trust for these new technologies. I think the Volvo Group has a great product coming."

FACTS

Here's how the Volvo FE Hybrid works
Volvo's solution utilises parallel hybrid technology, which means that the diesel engine and the electric motor can work both together and separately. The electric motor has three tasks: to power the vehicle, to serve as an alternator when the vehicle brakes, and to act as a starter motor to fire up the diesel engine. Energy from braking is used to

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recharge the batteries. On uphill gradients, the electric motor can step in to assist the diesel engine to provide added power. Peripheral equipment such as the servo pump, air compressor and power take-off, which in a conventional truck are driven by the engine, can in a hybrid use small electric motors instead. This gives greater freedom in positioning the relevant components and they only consume energy when they are actually being used.

Technical Specifications
Diesel engine: Volvo D7
Power output: 300–340 hp
Electric motor: 3-phase permanent magnet synchronous electric motor 600 volts
Max. power output: 120 kW
Max. torque: 800 Nm
Transmission: I-Shift
Batteries: Lithium ion 600 V

Pictures
future_hybrid1.jpg
Caption: Volvo FE Hybrid
Picture: Volvo Trucks

future_hybrid2.jpg
Caption: The Volvo FE Hybrid will be available for distribution trucks, city buses and refuse trucks.
Picture: Volvo Trucks

future_hybrid3.jpg
Caption: Henrik Kloo, coordinator of the Volvo FE Hybrid project for Volvo Trucks.
Picture: Nicke Johansson

future_hybrid4.eps
Caption:

1. D7 diesel engine
2. Clutch
3. Electric motor I-SAM (Integrated Starter Alternator Motor)
4. I-Shift transmission
5. PMU control unit (Powertrain Management Unit)
6. Batteries
7. Energy converter

For reference see picture: future_hybrid4_example_eng.pdf

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Volvo Trucks provides complete transport solutions for professional and business-driven customers. The company offers a full range of medium to heavy duty trucks, with a strong global network of 3,000 service points in more than 140 countries. In 2008 Volvo Trucks sold more than 106,000 trucks worldwide. Volvo Trucks is a part of the Volvo Group, one of the world's leading manufacturers of trucks, buses and construction equipment, drive systems for marine and industrial applications, aerospace components and services. The Group also provides solutions for financing and service.

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