Electric dreams

With a wide variety of **power sources** available, which is the right one for the job? And what are the power sources of the future?

Ruari McCallion listens to the discussion.

The transfer away from diesel power within confined spaces, including large warehouses, is now so entrenched that people may wonder why there was ever a fuss about it. But the drive towards cleaner power lower emissions is unrelenting and it seems that, no sooner is one debate settled than another takes its place. Electric lift trucks are currently powered by lead-acid batteries but they are not without their issues – not least, the length of time it takes to charge them. Talk now is of lithium-ion, nickel-cadmium, nickel-hydride and hybrid – and let's not forget the long-promised hydrogen fuel cells. How big can they go – and is it always a good idea to reach for the max?

The state of play today

Electric trucks are, gradually, getting bigger. While the most familiar use is as indoor workhorses for relatively light loads the limit for loading is, in theory, around 40 tonnes – all you need are enough lead-acid batteries and a big enough chassis, to lug its own weight around and still be able to do something productive. The power source load would be very large, however. A single lead-acid cell can generate just two volts of electricity, regardless of its size. You get a 12v battery by linking six individual cells together,120v by linking 60 of them, and so on. UPS (uninterruptible power supply) systems, used for power backups in offices, will often be made up of large collections of batteries. However, they're static – an office building isn't going anywhere. A lift truck has to be able to move. As well as voltage, it needs current – amperage – to operate its engine and the lift mechanism itself. The more amp-hours you need, the larger the individual cells have to be – but you will still only get two volts per cell, maximum.

"We can now recharge lead-acid batteries in around two-and-a-half hours, by pumping air through them as they are on charge,"

Anyone who runs a fleet will know that lead-acid batteries take a while to recharge. As a general rule, each eight-hour shift will be followed by eight hours of charging and then by eight hours resting, in order to get the battery to its optimum capacity. Historically, the faster a battery is charged the more it will be damaged and the sooner it will fail. But there are technologies that can speed up the process without being destructive.

"We can now recharge lead-acid batteries in around two-and-a-half hours, by pumping air through them as they are on charge," said Piet Rohs, of Hoppecke Batteries. The air mixes up the electrolyte and makes the charging process faster. But it is not a zero-sum game: there is a price to pay for high-speed charging. "It is definitely possible to charge faster but you won't get the normal six to seven years of battery life; it will be less, maybe as little as two to three years."

Li-on king?

So the question is: does the application require fast charging? Would it be a more efficient use of financial resources to replace sooner (but still in a few years time) or invest now in more batteries, so they can be trickle-charged? The answer is: it depends on needs, loads and availability. But lead-acid isn't the only type of power available. Rohs reports that there is rising interest in nickel-cadmium and nickel-hydride, which can be charged quickly. Lithium-ion is the technology in your mobile phone battery, and in the Kaz-Style experimental automobile, which whizzed round Mugello test track, in Italy, at 300kph.

"Lithium-ion is lighter than lead-acid but it's ten times as expensive," said Mika Taans, Management assistant with Celectric. "We believe it is very important to develop the company and to be part of [innovation and progress] but we expect traditional batteries to stay. Lithium-ion doesn't last as long as traditional power sources and the technology for charging them is complex. The highest capacity is about 100A/hr so they need more amperage – more power. It will be some time before they are used in business."

Weight advantage

One of the drawbacks of lead-acid batteries in non-logistical operations – their weight – is actually an advantage in lift trucks, which need a counterbalance. Lead-acid batteries deliver the dual function of energy source and counterweight. Remove them, or replace them with lighter batteries or a fuel cell, and the trucks will have to be redesigned. There are drawbacks to lead-acid – it's not the most efficient means of generating power, they take a long time to charge and they use up a lot of space but, in lift trucks at least, their established infrastructure, simple plug-in charging and their weight are all on their side. It may be that, in the future, these advantages will be seen as a reprieve rather than positive attractions but they work very effectively for now; there is no overwhelming clamour for something new – rather, the customer demand is to get more out of existing technology, extend truck lifetimes and ensure performance.

There is also a need for flexibility. The number of companies that can afford fleets of specialised vehicles for every application is pretty small. The demand is for trucks that can perform more than one function and do so well.

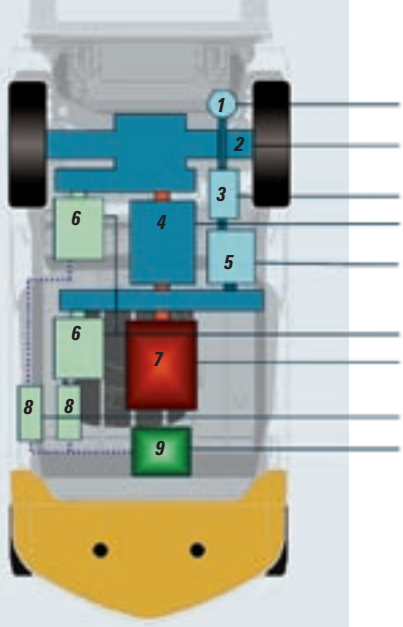
"We are evaluating diesel/electric hybrid power," said Willem de Jong, Assistant Program Manager (APM) with Cat Lift Trucks. "The pilot project we are running is an extension of a four tonne diesel lift truck, supplemented with electric motors and lithium-ion batteries. We will be testing with potential customers during the second quarter of 2010." The hybrid truck is a series-parallel powertrain (see illustration) that stores regenerative braking energy drawn from the braking system into the batteries – which has raised a potential lifecycle cost benefit. ➔

1. *Eight hours charging, eight resting and eight working is the established rule for optimising lead-acid battery capacity.*
2. *…but HOPPECKE trak© power premium charge units can recharge lead-acid batteries in just two-and-a-half hours, with the application of pumped air. (Image courtesy of Hoppecke Batteries)*
3. *Hybrid trucks' powertrains are series-parallel units, similar to the technology adopted in the Honda Insight. (Image courtesy of Honda)*

Operation of a 'series-parallel' hybrid powertrain

This hybrid forklift uses a new powertrain consisting of two power sources, one internal combustion diesel engine and two electric motors powered by a lithium-ion battery. Depending on various conditions, including vehicle speed, vehicle acceleration, load, battery state, etc, the most efficient combination of these powersources is used. When decelerating, the electric motors operate as generators transforming kinetic energy (movement) into electric energy. The electric energy is stored in the lithium-ion battery, to be used later again for acceleration.
This hybrid powertrain can drastically reduce fuel consumption, while overall truck performance remains excellent.

Please note that a typical forklift application consists of many short acceleration and deceleration cycles -very different from a car- and therefore a forklift qualifies as very suitable for this type of hybrid technology.



1 Hydraulic cylinder
2 Front axle
3 Valve
4 Transmission
5 Hydraulic pump
6 Electric motors/generators
7 Diesel engine
8 Inverters
9 Li-ion battery

Traveling

Motors ON **Engine OFF**

In normal operations, the electric motors will power the vehicle at steady speeds and under gentle, low-load acceleration.

Accelerating

Motors ON **Engine ON**

IC engine activates and works with the electric motors under heavier acceleration.

Lifting

Motors ON **Engine ON**

IC engine and electric motors work together to power lifting operations.

Regenerative braking kinetic energy recovery system captures energy when the truck is braking and stores it in the lithium-ion battery.

→ Hybrid developments

"It reduces the level of regular brake maintenance required," said de Jong. "Standard trucks use drum brakes; the hybrid truck seems to have hardly any wear on the brakes. This could be a service advantage." Every little helps but the core is fuel saving and flexibility. "Depending on the test cycle, we have been seeing diesel fuel savings of 25-40 per cent. That's a major advantage in itself. And, in electric mode, the truck can be used in low-speed areas and it's also capable of going indoors." As with any new technology, there are always going to be questions of cost.

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According to de Jong: "the general trend in lift trucks is similar to the auto industry: a drive to lower emissions".

"In the past we saw discussions about acid rain and unhealthy working areas, caused by emissions from IC (internal combustion) vehicles, especially indoors. That led to tough legislation in Europe," he said. "Engines now are getting very clean – in a couple of years we could see the air going into the engine being dirtier than that coming out!" Surprisingly, though, that doesn't mean the engines are using less energy; consumption is about the same but some is going to remove emissions before gases are vented. In some cases, energy use can actually increase. So manufacturers are looking everywhere they can for other means of saving.

"The auto industry has been downsizing engines and making them more efficient. In that respect, lift trucks are a bit behind – but with counterbalance and warehouse products, the auto solution of reducing weight is a trend we cannot follow," he explained. So the search and drive is for greater efficiencies, in the fleet and its support infrastructure.

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"The hybrid truck represents one solution, with a downsized engine and massive energy savings," said de Jong. Data logging, effective warehouse layout and management and considered fleet makeup all have their part to play, as well. "In energy consumption I expect the trend to electric vehicles to continue – but the maximum size of an all-electric vehicle within our range is five tonnes. Our company strongly believes that there remains a longer-term future for IC trucks, especially in larger capacities, which are not suitable for electric vehicles. They will be cleaner and more efficient but they also need to perform and be durable". ■

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