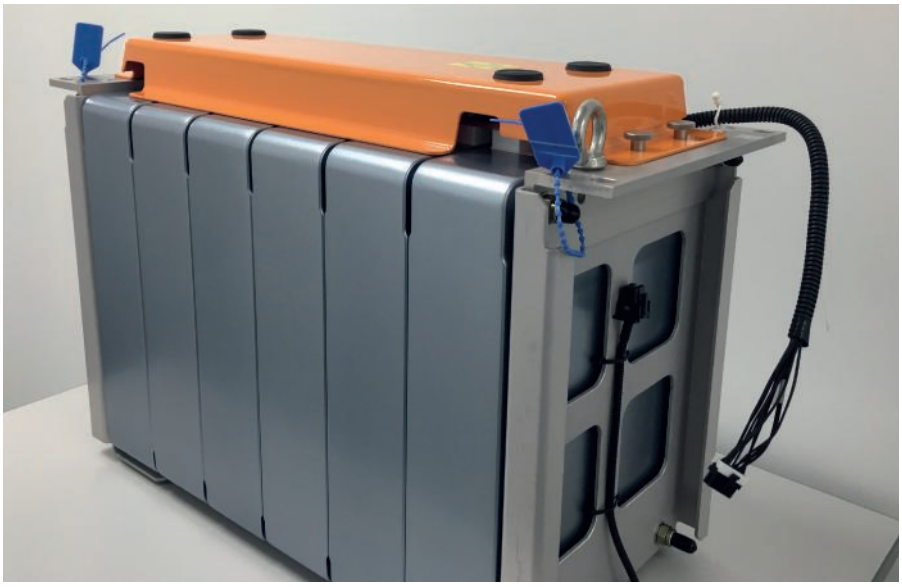
# The future of BATTERIES

**Why is lithium-ion the best choice for batteries in hybrid and all-electric trucks and buses? And what technologies are coming in the future? JMBS's chief electrochemist Allan Paterson explains the issues to Brian Weatherley**



*Typical single CV battery module based on 48 high-energy-density NMC cells. Up to 15 such module blocks could be used within a range-extender electric truck or bus for around 110kWh*

Look at the specification sheet of any electric van, bus or truck (whether hybrid or pure electric) and under the section 'battery type', you'll invariably see the words 'lithium ion'. One company that can explain what makes them so popular is Johnson Matthey Battery Systems (JMBS). It takes individual battery cells provided by 'cell vendors' and creates complete battery packs, along with controlling electronics, for automotive installations.

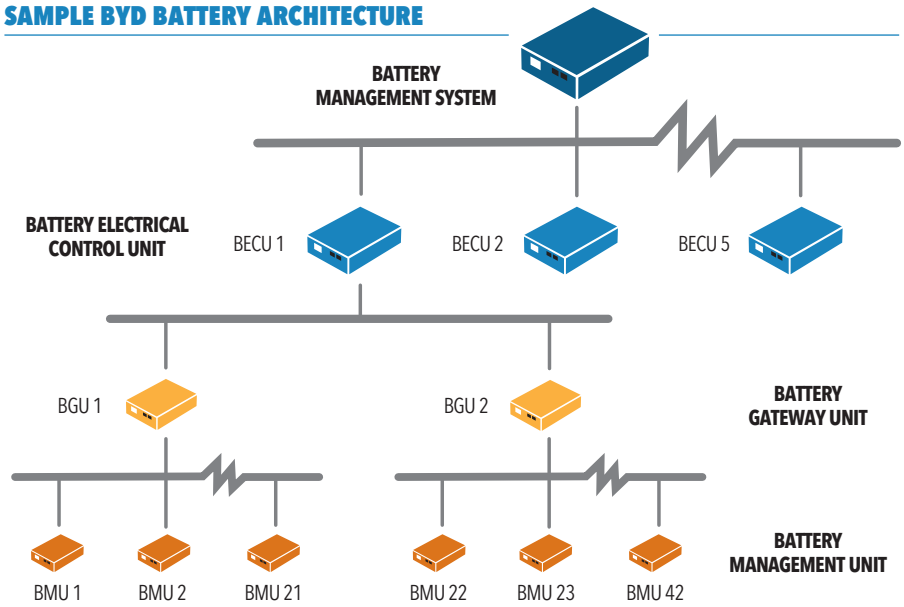
Chief electrochemist Allan Paterson explains: "Compared to all the other battery technologies, lithium-ion has the highest energy density." Based on the most common measurement of energy density in batteries and capacitors of Watt-hours per kilogram (W·h/kg), he confirms lithium-ion based batteries are the smallest and densest for a given amount of energy compared to other battery types. "They have very good power capability for acceleration or braking events, and they last a long time," he adds. The expression 'power capability' denotes a battery's ability to quickly discharge power and be recharged quickly, too.

Over the past three decades, battery technology has come on in leaps and bounds from lead-acid 'milk-float' batteries that were big, heavy and inefficient. Paterson continues: "Everything is definitely moving into the lithium area, primarily because it's more energy-dense and lasts longer."

A number of different lithium ion-based chemistries are currently being explored by automotive companies (see also box, p32). For passenger car applications, lithium nickel manganese cobalt oxide (NMC) is favoured, not least due to its energy density capabilities. A similar alternative is lithium nickel cobalt aluminium oxide (NCA). "Tesla tends to use NCA chemistry in small cylindrical cells for its model S and model X," says Paterson. "Everybody else has used other versions of metal oxides and those are all NMC or higher nickel-rich versions of NMC as we go into the future. The new-generation Nissan Leaf uses NMC-based cells."

As all batteries degrade over time, the performance life of a battery pack remains a concern to potential EV buyers. As a battery pack ages, two things happen. The first is that its 'fuel tank' effectively gets smaller, reducing its range – the measure of how far the vehicle can go between charges. Secondly, its internal electrical resistance will rise, causing its power capability to drop. It's something that's more likely to be noticeable sooner in hybrid vehicles than other applications, according to Paterson. He adds: "So instead of being able to deliver [the equivalent of] 100bhp, the battery can maybe only

## SAMPLE BYD BATTERY ARCHITECTURE




## CUMMINS AEOS URBAN HAULER EV CONCEPT TRUCK

**In August, Cummins revealed a fully-electric demonstration eight-tonne 4x2 tractor unit. The class 7 US truck is intended for urban delivery and is said to offer a 20-tonne payload capacity. Range is 100 miles on a charge, using a 140kWh Li-ion battery pack. That powers a 225kW (continuous) traction motor built into the Cummins Integrated Electrified Powertrain that also includes automatic gearbox and regenerative braking. The engine maker will launch an all-electric powertrain in 2019; a range-extended version is to follow in 2020.**

deliver 80bhp through to the motor. So that's another condition that might define 'end-of-life' for an operator."

Another worry for would-be EV buyers is whether current lithium-ion battery technology will be overtaken in the next 10 years; fear of obsolescence continues to be a barrier to adoption. Not so, says the electrochemist: "We can see a route forward for the next 10 or even out to 15 years or so that will be an evolution of existing technology."

In the short term, passenger cars are the developmental focus, he points out. "At the minute, OEMs such as Daimler, Volvo, other Tier 1 and powertrain developers seem to be looking at what they can leverage from a mainstream passenger car," he says. "We could see the upscaling of all types of battery applications from mild-hybrid 48V systems all the way up to range-extended hybrids and very high capacity full-electric buses and trucks. It's something that JMBS is right now heavily involved in, looking at how we can leverage mainstream passenger technology but apply it in a scaleable modular way [to commercial vehicles]."

As for future EV adoption, Paterson believes the two key drivers will be fuel efficiency demands, and reductions in $CO_2$ and NOx. Air quality concerns – and requirements in cities such as London – are driving the technology. Among the early adopters will be PSV operators. States Paterson: "Transit bus is where we've seen the initial pull. One of the biggest players at the moment in terms of volume is China where they have clean-air polices and incentives – but it's starting to become a global thing."

Following the debut of electric 'heavies' from Mercedes and MAN at last year's IAA show, and from Cummins last month (see box above), Paterson expects more prototype electric HGVs to appear. He concludes: "You're starting to see a lot of the manufacturers and powertrain providers realising they need to offer electrified options within their range because of all of the economic and environmental drivers." TE

### FURTHER INFORMATION

*'What causes Li-ion to die?' by Cadex Battery University – https://is.gd/iboyuc*

*'Types of lithium ion [battery]' by Cadex Battery University – https://is.gd/oqujij*

*'Brighter sparks' – https://is.gd/ugifiv*

## LONGER-TERM ALTERNATIVES FOR LITHIUM BATTERY CHEMISTRY

**Oxis Energy is developing lithium-sulphur batteries, which are said to have higher energy densities than lithium-ion. Chief technical officer David Ainsworth says: "Sulphur is a very cheap feedstock material so at high production volumes lithium-sulphur batteries could be 20% cheaper than lithium-ion batteries."**

**In contrast, Faradion is extolling the virtues of sodium-ion, arguing that its material costs are lower than those of lithium-ion – sodium carbonate is 10% of the cost of the equivalent lithium salt, it states – but the technology offers comparable performance.**

**Lithium titanate has potential, too, suggests Allan Paterson of Johnson Matthey. It is faster-charging than its near-rivals he says, but tends to be more expensive. A limiting factor is scale of production; only lithium-ion and lithium iron phosphate batteries have so far been produced in large quantities. Vehicle manufacturers installing them in large quantities would need convincing before they switch from proven technologies, points out electric vehicle manufacturer BYD.**