



Electric *breeze*

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Sweeping regulation changes, and a push from OEMs to appear more environmentally friendly, is leading to increased application of mild-hybrid and 48V systems

Back in 2016, Audi became the first OEM to use an electrically powered air compressor to boost the output of a production engine. Its SQ7 high-performance SUV is powered by a 3,956cc diesel, with forced induction provided by a pair of turbos as well as a Valeo electric supercharger (or e-charger).

Gasoline engines seem set to follow suit, with the 3.0 V6 of Audi's Q8 concept shown in Geneva this year boosted by twin turbos and an e-charger.

In both applications, the e-charger improves the engine's transient response, providing high pressure boost at exceptionally short notice. Driven by a powerful electric motor, the SQ7's e-charger can hit 70,000rpm in just 220ms, explains Michel Forissier, research and development director at Valeo Powertrain Systems.

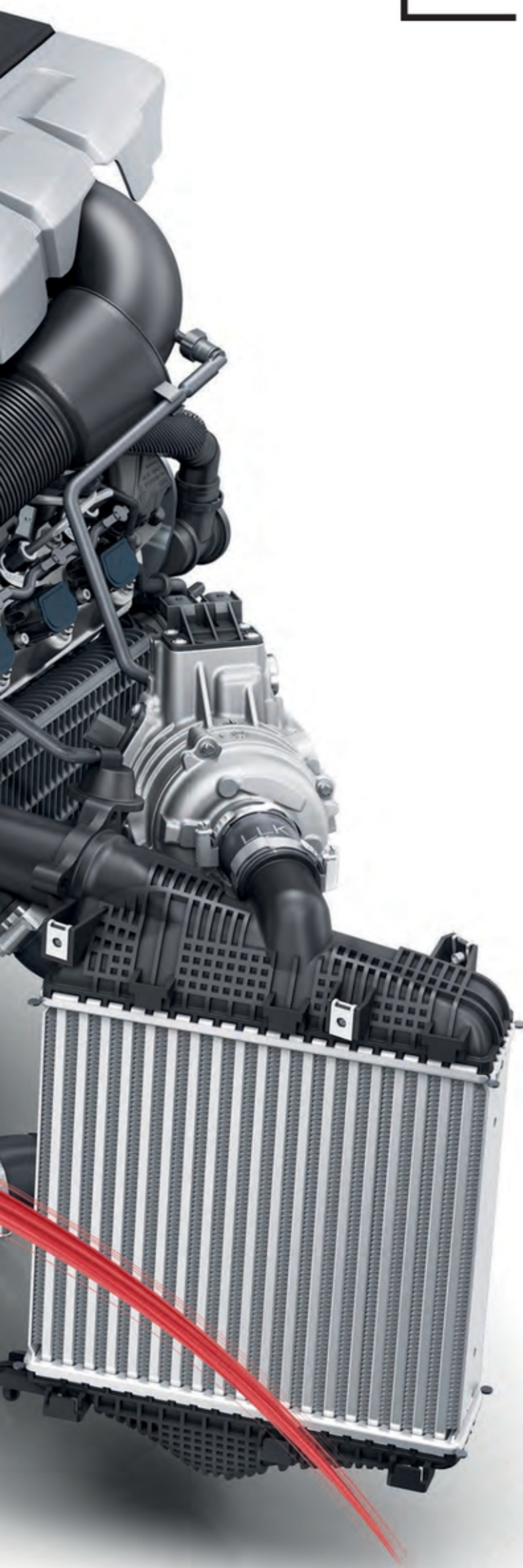
As a result, the SQ7's V8 can reach full torque in about a quarter of a second,

less than 25% of the time required with turbochargers alone, Forissier says. "So there is a big difference in engine elasticity and engine response. And therefore it makes a real difference for the end user," he adds.

The result is a real possibility to cut capacity, even in the realm of 4.0-liter V8s. "When we can replace a V8 with a V6, this could be called downsizing," Forissier observes. In the case of an SQ7, or its Bentley Bentayga sibling, an e-charged V8 offers the response of a V12, he argues.

Quick reactions make e-chargers ideal for boosting torque at low revs. But once up to speed, a turbo is more efficient, not least because it extracts work from the exhaust.

Supplier Mahle has employed an e-charger as part of a technology demonstrator, a 1.2-liter gasoline engine producing 193kW peak power. Mike Bassett, chief research engineer at Mahle Powertrain, points out that the energy needed to compress large volumes



1. A conventional turbocharger's compressor wheel is designed to take much higher loadings than a modern e-charger's

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of air can be considerable. For this reason, Mahle uses a beefy conventional turbocharger during high-rev running.

"The mechanical shaft of a turbo is a really cheap and efficient way of transferring power," Bassett notes. "If you look at the kind of power that the turbine is transferring to the main compressor, you're up at 20-odd kilowatts for this kind of engine, so you wouldn't want to do that electrically."

The 48V Aeristech e-charger used by Mahle peaks at 9kW, or about 4.5kW in continuous use. It forms part of mild-hybrid setup with integrated starter-generator, and regenerated energy is generally sufficient to meet the e-charger's demands, Bassett explains. "When the driver kicks in we'll throw all 9kW at it to

pick the boost up," he says, adding that the ISG is on hand to ensure there's always sufficient electrical reserve.

Valeo's Forissier similarly suggests that an e-charger plus large turbo offers the best of both worlds. "We propose a simple e-compressor together with a simple turbo – there is no need any more for variable geometry or variable nozzle technology, which cost a lot of money," he says. "Twin turbos are also very expensive, and they are very difficult to package. Our solution is much more elegant, because a single turbo is easy to package properly, and the supercharger can go on the cold side of the engine, rather than needing a plumber's nightmare at the back." Keeping away from the exhaust can also ease the e-charger's own cooling needs, he adds.

Valeo's e-charger employs core technology originally developed by Controlled Power Technologies (CPT), which sold rights to Valeo in 2011 for vehicles below 3.5 metric tons.

While Valeo has since refined the technology for cars, CPT has developed e-chargers for commercial vehicles. It has created heavy-duty e-charger technology called COBRA (Controlled Boosting for Rapid Response Applications), which it aims to license to an OEM or supplier.

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**MICHEL FORISSIER, R&D DIRECTOR,
VALEO POWERTRAIN SYSTEMS**

2. Audi's RS5 TDi concept demonstrated the benefits of using electric assistance to boost performance

3. Aeristech's e-charger is used by Mahle, and can deliver an additional 9kW peak, or 4.5kW continuous power as part of a hybrid



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E-CHARGING FOR ECO-CARS

Many engine makers are adopting Miller cycles (leaving intake valves open for part of the compression stroke) to improve fuel efficiency. "One of the counter effects is a backflow of gases into the intake manifold," says Valeo's Forissier. "You need a compressor to push the gases back into the cylinder. The e-charger can do that very well, because it can do it with very accurate control," he adds.

That kind of application is one reason why Valeo expects to sell a million e-chargers in 2021 – a big jump from 50,000 units last year.

"Big V6 and V8 applications are nice, but they don't make a big business case," notes Forissier. "Any time you have a 12V or 48V mild hybrid, it is very easy to bring the supercharger on top because you use the same electric system."

Valeo aims to achieve price parity with turbochargers, or about a third of the cost of mechanical superchargers.

One stumbling block may be noise, with e-chargers producing a whistling noise as they zip from zero to 70,000rpm in the blink of an eye. Forissier says Valeo is working to cut noise, to ease installation in cars that lack the NVH sophistication of a Bentley.

"We've just been doing testing with an OEM in the Far East," says Andy Dickinson, CPT's senior manager for COBRA product development. "They have a 4.4-liter diesel engine with a fixed-geometry turbo, and its time to peak torque on a tip-in was three seconds, which is relatively quick. But with COBRA it's reduced to 1.1 seconds."


However, rapid response was not the only outcome. "Their base torque was 475Nm, but with COBRA, after 1.5 seconds, they'd peaked at 650Nm – a 175Nm lift. So they had to clip the fueling, because they weren't sure the engine was strong enough."

As Dickinson notes, an e-charger can supply air to match an engine's fuel delivery

even at low revs, avoiding the tendency to run rich. "Because you've got air available at every tip-in, it's a pure burn," he observes. "With a lot of heavy-duty vehicles and buses, where you get curbside smoke, it's because they reach a transient torque limit. The ECU is programmed to deliver a certain amount of torque, but there isn't enough air so it's laboring, you get a bit of a lag, and then it suddenly achieves it and you get this big slug of black smoke."

An e-charger can also avoid the laboring phase, helping to clean up emissions and extend the life of particulate filters, Dickinson adds.

E-chargers can also help battle NO_x, notes Forissier, by improving exhaust gas recirculation. "NO_x is mostly created when you accelerate a diesel engine – when you have a high load, a high temperature in the cylinder and a very high excess of air," he says. "With the supercharger we can enhance the flow of EGR, adding inert gases into the chamber during acceleration. So when you kick down, at the same time and in synchronicity we can have a special flow of EGR compensating the excess of air. And therefore we can suppress the creation of NO_x at source."

Bassett adds that e-chargers may also prove vital for future lean-combustion systems, citing Mahle's turbulent jet ignition system, used in F1 engines to allow running as lean as lambda 2. "If you need twice as much air for the same power output, then you need a way of supplying that, and you don't always have enough energy in the exhaust gas," Bassett observes. "So electric superchargers are quite attractive in those situations." 

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4. A conventional turbocharger can be supplemented by electric chargers, helping deliver a feeling of instant boost

