

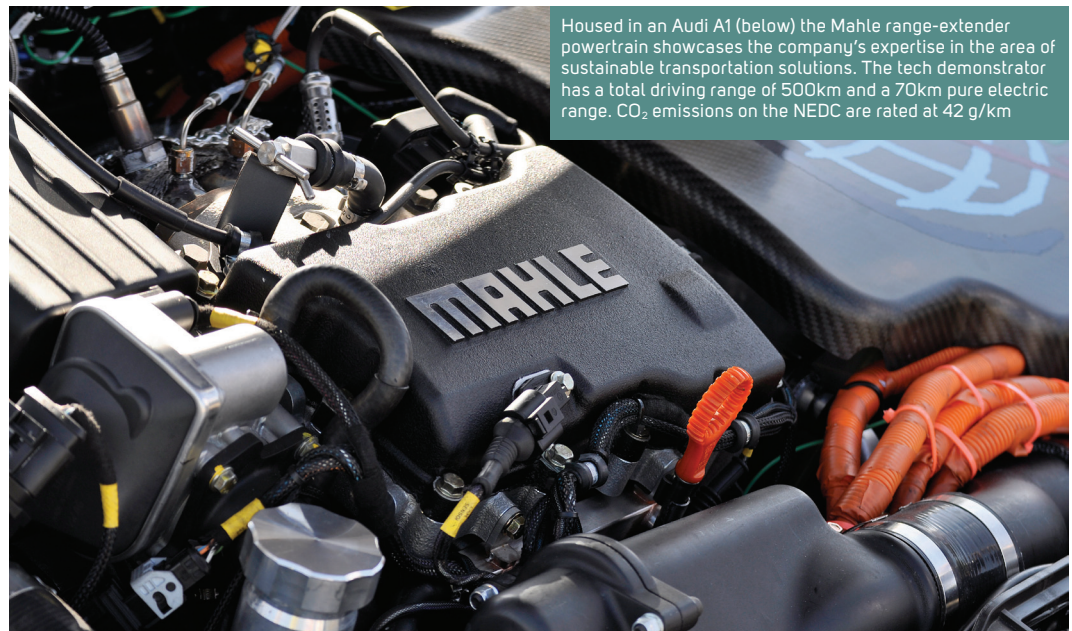
Range extender optimization

A dedicated range extender powertrain has been developed from a clean sheet and applied to a standard production vehicle in an effort to prove the technology's maturity and potential

▶▶ Following the success of its advanced engine-downsizing project, the engineers at Mahle Powertrain's Northampton headquarters have turned their attention to the growing vehicle hybridization trend. Recognizing the obvious technical and commercial limitations of battery electric propulsion, the decision was made to develop a bespoke, dedicated range-extender engine targeted at light EV applications.

The prime objective of the project was to create an auxiliary power unit, comprising both IC engine and generator, in the smallest, lightest and most cost-effective package. Gasoline fueling was chosen at an early stage to reduce total engine weight and exhaust aftertreatment complexity as well as to enable a broader range of potential vehicle applications in all global regions.

With the engine driving only the generator, and no mechanical connection to the wheel, transient operation was minimal, thus permitting a low-cost approach to the engine's components and subsystems. A simple two valve per cylinder arrangement was adopted, with fixed timing and lift, and port fuel injection was employed in a 900cc, four-stroke, parallel-twin configuration. The overall package dimensions were minimized in the early design phase by incorporating specific design features, including



Housed in an Audi A1 (below) the Mahle range-extender powertrain showcases the company's expertise in the area of sustainable transportation solutions. The tech demonstrator has a total driving range of 500km and a 70km pure electric range. CO₂ emissions on the NEDC are rated at 42 g/km

an intake system feeding air into the combustion chambers from underneath the fire face, and directly mounting the generator rotor to the end of the crankshaft.

To maximize installation flexibility and vehicle packaging options, the engine lubrication system was specifically designed with additional baffle plates and oil galleries to allow operation when mounted at any angle from vertical to horizontal. The latest Mahle component technology was incorporated within the engine, including a low-friction piston ring pack and polymer-coated main bearings, to ensure durability during the expected long periods of inactivity.

The optimization of the engine's NVH characteristics was another key consideration during the initial design process. Typically, twin cylinder engines display unfavorable NVH due to poor primary balance. This was directly addressed by adopting an

uneven firing order with a crank configuration of 180° (one piston at TDC when the other is at BDC) to achieve primary balance. This approach results in a cyclic torque output due to the uneven ignition events/power strokes. However, this effect could be mitigated by synchronized switching of the generator load to provide full dynamic torque control.

Following further development work on the in-house transient dyno (complete with a high-voltage battery emulator), the engine was installed in the selected donor vehicle. The Audi A1 was chosen to clearly demonstrate that all necessary hardware could be successfully packaged in a compact-class vehicle without sacrificing passenger or luggage compartment space. The entire process of converting the vehicle to electric drive, including installation of the engine, generator, inverters, traction motor, gearbox, 14kWh

battery pack and all associated control and cooling systems, was carried out at Mahle Powertrain's dedicated vehicle workshop facility. The project was an ideal showcase for the company's vehicle integration and control system development capabilities.

The Mahle RE-EV demonstrator vehicle is now fully operational and has already been driven at a number of OEM sites and industry events across Europe. The vehicle attracted great interest at the Frankfurt IAA motor show and went directly from there to participate in the Bertha Benz Challenge event. ©



CONTACT

Daren Mottershead at
 Mahle Powertrain
 T. +44 1604 738 226
 E. daren.mottershead@gb.mahle.com
 W. www.mahle-powertrain.com

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