# Analysis of the Hardware Requirements for a Heavily Downsized Gasoline Engine Capable of Whole Map Lambda 1 Operation

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**Abstract**

MAHLE has developed a heavily downsized demonstrator engine to explore the limits, and potential benefits, of engine downsizing. The 1.2 litre, 3-cylinder, MAHLE downsizing (Di3) engine, in conjunction with an Aeristech 48 V electric supercharger (eSupercharger, eSC), achieves a BMEP level of 35 bar and a specific power output in excess of 160 kW/litre. The eSupercharger enables high specific power output, good low speed torque and excellent transient response. The resulting heavily downsized engine has been installed into a demonstrator vehicle that also features 48 V mild hybridization.

At specific power output levels above 90 kW/litre the engine is operated with excess fuel in order to protect the turbine from excessive exhaust gas temperatures. In this analytical study, the boosting system requirements to maintain lambda 1 fuelling, via the use of EGR, across the entire engine operating map for the eSupercharged version of the MAHLE Di3 engine, have been explored. It has been found that a HP EGR system, with the eSupercharger located downstream of the main compressor, has the greatest potential to enable lambda 1 operation at maximum power output. At this point an EGR flow rate of 15 % is required, which would require about 38 kW of EGR cooling capability.