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The dedicated hybrid engine combining e-fuel compatibility, product cost and production boundaries

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The increasing number of different PT architectures with partially complex hybrid solutions on one side and stringent greenhouse gas (GHG) and emission legislation on the other side are boundaries for future ICE development.

The competition of different technologies and variabilities, from electrified components, variable cam timing, variable valve lift, advanced boosting technologies, EGR, advanced ignition, high pressure injection up to even variable compression ratio, as well as add on measures such as water injection require significantly increased efforts in both development and investment for the OEMs.

The compatibility for E-fuels, in particular Ethanol, Methanol and especially Hydrogen is a requirement for GHG neutral operation of combustion engine powertrains at least midterm. The engines need to be protected for dedicated fuel injection and combustion concepts, hydrogen resistant material selection, minimized oil consumption at the piston-Bore interface, active engine ventilation, specific aftertreatment requirements for lean operation as well as safety requirements.

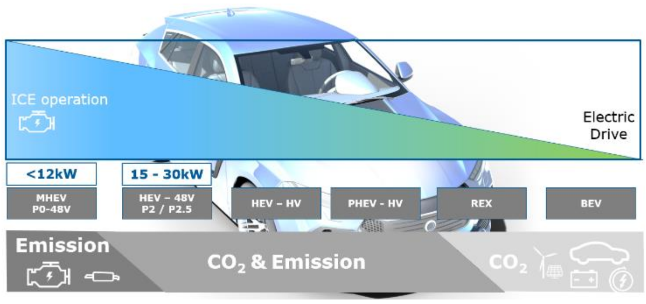

Figure 1 Powertrain electrification from pure ICE to BEV

An approach for an affordable lineup of powertrain versions is a modular common engine family architecture, with common machining and assembly concepts, as well as the feasibility to integrate different technology packages. This options are essential in particular for electrified powertrain architectures where the requirements on the subsystems are quite different to those in conventional powertrain solutions (Figure 1).

Dedicated hybrid engines, characterised by a better overall efficiency and a wider load / speed area of good efficiency, will significantly improve vehicle fuel consumption in combination with all architectures compared to today's technology and reduce the effect of the implemented architecture. The CO2-reduction potential of parallel hybrid, power split or other dedicated hybrid transmissions is on a quite comparable level in this combination. Beside CO2 reduction other factors such as performance, drivability and cost are decisive for the determination of the powertrain configuration.

Based on the different operating regime of a DHE engine in combination with a HV-hybrid system, compared to a Mild Hybrid or ICE only application, the priority of the evaluation criteria for concept choices needs to be reevaluated.

For down speeding operation in a DHE application, elimination of the balance shaft can be considered, at 1,5L 3-cylinders for example, to gain further efficiency.

For TC engines considering future EU7 emission limits, a direct injection system is clearly the preferred solution. For low-cost NA-Atkinson DHE variants, an MPI solution may be considered as well. A dual MPI solution represents an intermediate variant in terms of achievable mean effective pressure and maximum BTE. The electrification variants, including 48V- and high voltage mild- and full hybrids, up to serial hybrids, allow a partial and gradually increasing simplification of the ICE with the goal of a tailored dedicated hybrid engine (Figure 2).

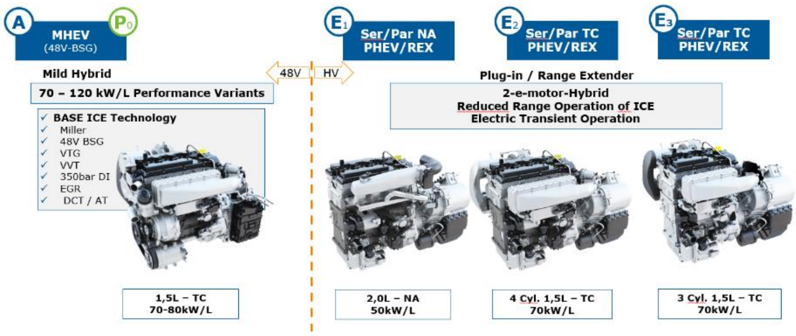

Figure 2 Dedicated Hybrid Engines based on a Modular Platform

Balancing overall powertrain complexity in regard of technology cost impact versus CO2-reduction and emission compliance with tailored technology modules on the ICE dependant on the degree of electrification allows significant cost reduction for highly electrified variants compared to the baseline ICE and at least partially compensates the cost penalty of the additional electric components.

A modular technology component box is the consequence to cope with future requirements, in particular when considering an uncertain distribution of variants in future vehicle platforms.

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