

### MAHLE Powertrain Modular Hybrid Powertrain

Powertrain modularity in multiple applications

Reduced complexity for lower costs

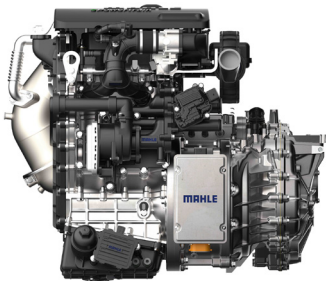
Low, weighted drive cycle CO2



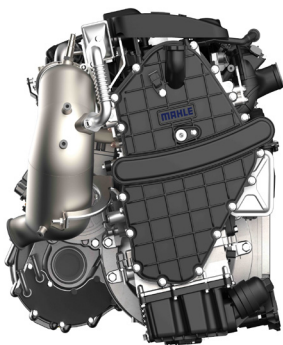
#### Modular Hybrid Powertrain

Electrification and hybrid technologies are now widely accepted as the preferred approach to achieving future vehicle emissions targets. In Europe, for example, OEMs must comply with a fleet average CO2 emissions target of <60 g/km by 2030.

So, there is an urgent need for the rapid adoption of appropriate, scalable solutions across a broad spectrum of vehicle segments to meet these objectives. In response, MAHLE has developed the Modular Hybrid Powertrain concept using a dual-mode (series and parallel) configuration to provide the best features of both series and parallel architectures.



>> Powertrain front view



>> Powertrain left view

- Dual mode plug-in hybrid (PHEV) powertrain
- Integrated series - parallel hybrid electric drive
- Dedicated Hybrid Internal Combustion Engine (DHE)
- Scalable across multiple vehicle applications
- Improved emissions & reduced after treatment complexity
- Seamless torque delivery provided by the traction motor
- Low, weighted drive cycle CO2 (< 2030 proposed target)
- Increased efficiency with parallel hybrid direct drive mode

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## Benefits

- IC engine, traction motor, generator & transmission arranged in compact, fully integrated package
  - › Vehicle operates in different modes according to battery charge & driving speed
- Traction motor connected directly to wheels
  - › Engine de-coupled by transmission & so runs at limited speed / load range ensuring low fuel consumption & CO2 emissions
- Engine, motor & HV battery all scaled easily to different outputs
  - › Caters for wide range of vehicle applications from B- to J-segment across multiple platforms
- MHP offers several advantages:
  - › Scalability
  - › Fuel efficiency
  - › Low emissions
  - › Reduced weight
  - › Easier packaging & low production costs

## Hybrid Electric Drive and transmission

- Direct drive HV MAHLE traction motor with optimised cooling
- HV MAHLE generator mounted on transmission input shaft
- MAHLE Inverters integrated into motor and generator housing
- Simplified transmission - no torque interruption
- Traction motor provides full vehicle dynamic performance
- No clutch as neutral selection decouples DHE from driveline
- 1, 2 and 4 speed transmission family use common ratios & main casing for modular approach
- Low cost, compact & adaptable unit



>> Dedicated hybrid engine

## Dedicated Hybrid IC Engine (DHE)

- Parallel twin cylinder, with contra-rotating balancer shaft
- 2 valves per cylinder, SOHC, fixed valve event timing
- Port fuel injection with MAHLE Jet Ignition (MJJ<sup>®</sup>)
- Turbocharger with MAHLE electronic wastegate actuator
- Miller-cycle operation with high geometric compression ratio
- Limited speed / load range operation for fuel efficiency
- Minimum BSFC = 207 g/kWhr (target < 200g)
- Compact, light weight & low cost engine
- Low technology requirement
- Very low specific fuel consumption & emissions
- Readily scalable for multiple vehicle applications
- Potential for higher efficiency with ultra-lean MJJ<sup>®</sup>



>> Hybrid electric drive & 2 speed transmission

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