Global light vehicle engine technologies market- forecasts to 2029

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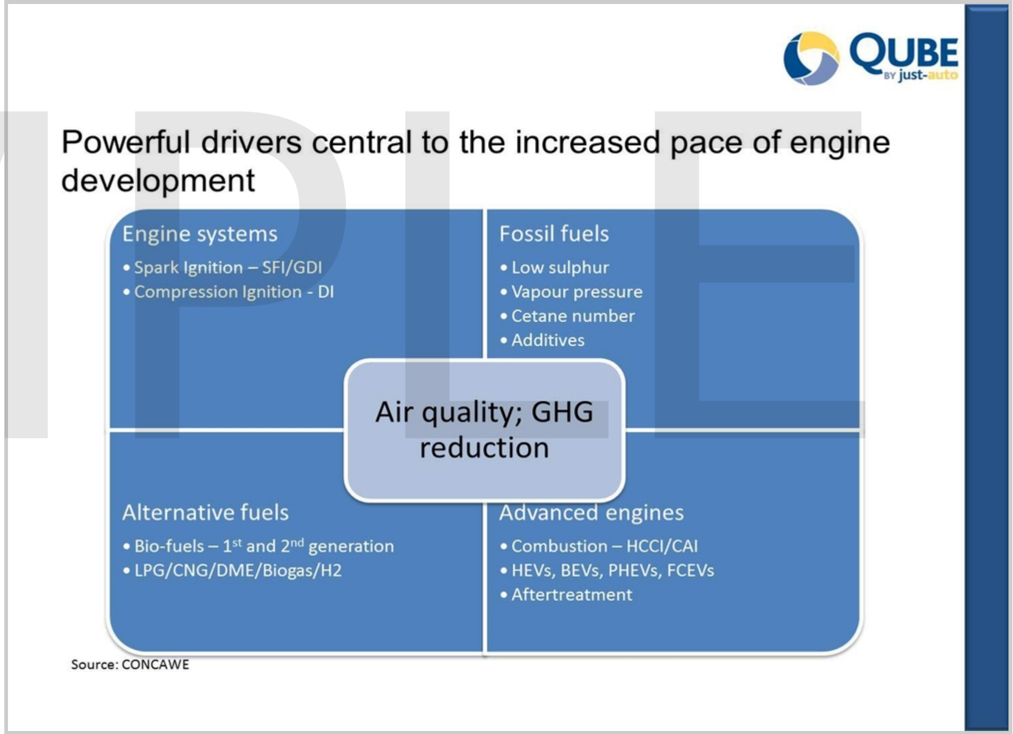
Introduction

The automotive sector's requirement to meet future emission and CO2 regulations sees engine technology at the centre of most automakers' R&D efforts at present. While other elements such as the drivetrain, body materials, aerodynamics and tyres can all be further optimised for fuel economy – the engine is by far the biggest contributor to energy losses in a conventional driveline and, therefore, the biggest target for reducing CO2 emissions. Depending on operating load conditions, the engine contributes anywhere between [redacted] and [redacted]% of the energy losses in a vehicle. ZF, the transmission and driveline supplier, estimates that the engine contributes [redacted]% of losses followed by the driveline ([redacted]%), rolling resistance and aerodynamics (each with [redacted]%), weight ([redacted]%) and auxiliary systems ([redacted]%). While work on improving driveline losses, reducing vehicle weight etc. is all ongoing in automakers' R&D departments, engine development remains key to meeting future emission legislation and also for maintaining automakers' brand attributes in terms of performance, driver feedback, comfort and control.

While meeting legislative requirements is a necessity for automakers, the legislation has to be met on a commercially viable basis - i.e. legislation cannot be met at any cost. Currently, it is estimated that the internal combustion engine is the single biggest cost contributor to a vehicle's Bill of Materials, accounting for anything between [redacted] and [redacted]% of material cost depending on the vehicle and engine type. Clearly, adding further cost to this reality is a consideration that has to be undertaken very carefully. Therefore, considered cost-benefit analyses have to be conceived by each automaker for the multiple technological paths that are available for meeting legislative and competitive requirements.



PESTER analysis

Political

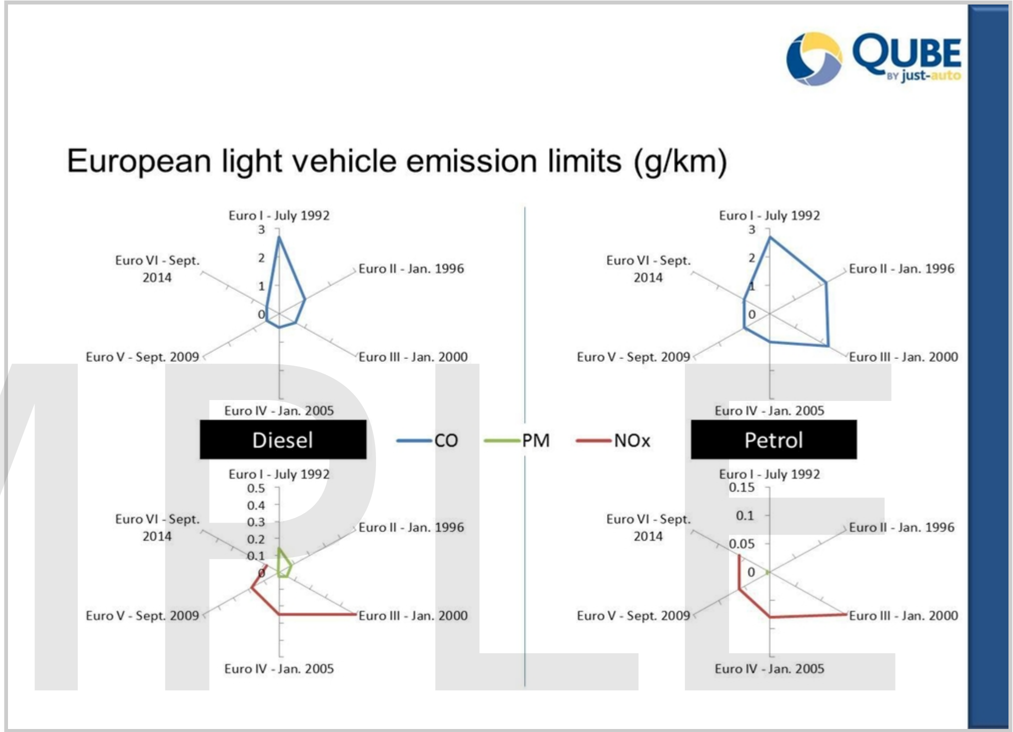
- *The two over-riding political or policy drivers, which have determined much of the direction of the automotive industry in recent years, surround the need to reduce fuel consumption and emissions.*

In terms of fuel economy, the political drivers are two-fold, i.e. the need to reduce harmful greenhouse gas emissions, but also energy security. China for example lacks its own major oil supplies so it would not be surprising to see an eventual political driven shift to full electric vehicles in China as the government seeks to reduce its dependence on external supplies of energy.

The more long-standing emission based driver of engine technology development is tailpipe (or criterion) emission regulations which first attracted political action due to their effect on urban air quality and associated health issues (a 2013 MIT study estimated [redacted],[redacted] deaths a year a caused by vehicle emissions alone in the US). Tailpipe emissions were first legislated against on a national basis in 1966 in Japan, but more widely known is the US's 1970 Clean Air Act, which was following California's lead after the state legislated in the 1950s.

A comprehensive reference for worldwide tailpipe emission, GHG emission standards and much more has been compiled by the automotive supplier Delphi and is linked to **here** **[ ]**, while EU light emission regulations are summarised on the slide.

- *The increasing global focus on fuel economy and CO2 emissions regulations is a key driver of developments in almost all automotive sectors presently and "behind the scenes" it is undoubtedly a key driver of change in engine technology.*



Technology overview

HCCI/CAI

It could be said that given the operating environment for internal combustion engines that the overriding development goals are to make the diesel engine as clean as the gasoline engine, while making the gasoline engine as efficient as the diesel engine. HCCI (Homogeneous Charge Compression Ignition) or Controlled Auto Ignition (CAI for gasoline engines) engines bridge diesel and gasoline technologies by combining the homogenous mixture injections from gasoline engines and diesel-like compression ignition of lean burn fuel-air mixtures. For HCCI, the fuel-air mixture is auto-ignited by the pressure and temperature of the diesel mixture, while for CAI the gasoline mixture is ignited by residual burned gases.

Using these methods instead of a spark plug means that the fuel-air mixture burns at a lower temperature, and homogeneously, rather than heterogeneously as in a conventional spark-ignition (SI) gasoline engine. Therefore, the exhaust gases from an HCCI/CAI engine contain only trace amounts of harmful compounds such as nitrogen oxide (NOx) and soot (PM) as combustion temperature does not exceed [redacted],[redacted] degrees Celsius when such emissions can form. As a result, the HCCI/CAI engine offers high thermal efficiency and, when operating at part loads, excellent fuel economy and a reduction in CO2 emissions.

However, while HCCI or CAI is very appealing due to the inherently lower NOx emissions due to lower combustion temperatures mapping the ignition points of the fuel precisely has been difficult to achieve. Additionally while a high compression ratio would seem the logical path to achieve auto-ignition, research has shown that compression ratios above [redacted]:1 cause knocking issues during full-load operation. Therefore, many solutions are now looking at using high-levels of EGR to provide the thermal energy required for auto-ignition and one way of providing this is through valve actuation strategies including early closure of the exhaust valve to cause recompression.

OEM overview

The following section details the engine manufacturing facilities worldwide of the major OEMs, describing the level of integration, production volume and engine types produced.

BMW

BMW has three major engine manufacturing plants in Europe. They are located at Steyr, Austria; Hams Hall, UK and Munich, Germany. Additionally, there is a major new engine plant in Shenyang, China to support its Brilliance JV. Furthermore, BMW has a major castings plant at Landshut, Germany.

Steyr, Austria

- *Capacity = [redacted].[redacted]mn engines per year; petrol and diesel units, 4- and [redacted]-cylinder units*
- *2013 output = [redacted],[redacted] engines, split [redacted],[redacted] petrol and [redacted],[redacted] diesel*
- *Produces all diesels for Mini and is BMW's diesel R&D centre; additionally the plant is the source of the [redacted].[redacted]L and [redacted].[redacted]L diesels supplied to Toyota's Auris and Avensis models.*
- *Also manufactures crankcases ([redacted].[redacted]mn units in 2013), crankshafts ([redacted],[redacted]mn), cylinder heads ([redacted].[redacted]mn) and con-rods ([redacted].[redacted]mn)*

Munich, Germany

- *Main petrol engine plant, including high performance M engines*
- *Machining and assembly of c[redacted],[redacted] engines per day, mostly [redacted]-cylinder petrol units, but also: V[redacted]s for M[redacted] and V[redacted] turbos for M[redacted], X[redacted], X[redacted] and [redacted]-series and V[redacted] for BMW [redacted] and Rolls Royce Phantom and Ghost*
- *In 2013, 4[redacted],[redacted] engines were built at Munich, with [redacted],[redacted] being [redacted].[redacted]L four cylinder Twin Power units*
- *In June 2014, the plant produced its one millionth four-cylinder petrol engine just three and a half years after production start*

Hams Hall, UK

- *New plant, first engine produced January 2001*
- *Output has risen from [redacted],[redacted] units in 2001 to 2011 peak of approx. 4[redacted],[redacted]; 2013 output was [redacted],[redacted]*
- *Produces [redacted].*

Supplier overview

Behr Gmbh & Co. KG

Overview

In late 2013, Mahle became a majority shareholder in the Behr Group, a global manufacturer of vehicle air conditioning and engine cooling for passenger cars and commercial vehicles. This business has since been integrated into the Mahle Group as the Thermal Management business unit.

Products

- *Complete HVAC systems, condensers, evaporators, storage evaporators and evaporator coatings, heater cores, blowers, air vents, fragrancing units. Control panels for passenger car and commercial vehicle air conditioning systems. Cooling plates and chillers for lithium-ion battery cooling*
- *Cooling modules, expansion tanks, high- and low-temperature radiators, exhaust gas coolers, direct and indirect charge air coolers, power steering oil coolers. VISCO® clutches and fans as well as Visco coolant pumps for commercial vehicle applications*
- *Wax elements, thermostat inserts, integral thermostats, housing thermostats, operating map thermostats, bypass thermostats, transmission oil thermostats, water valves, thermoswitches, coolant regulators, oil temperature regulators and inserts, sleeve valve thermostat inserts (since October 2014)*

Organisation

Mahle's Thermal Management business unit employs [redacted],[redacted] people at facilities in [redacted] locations.

Acquisition of Delphi's thermal business

In February 2015, Mahle revealed it is to acquire Delphi's thermal business reducing the size of the once huge supplier business, built up under General Motors ownership, still further. Delphi, which was spun off from GM around [redacted] years ago, then employed around [redacted],[redacted] people in the US in [redacted] factories. The latest sale will reduce this down to about [redacted],[redacted] in five plants. Its thermal business has approximately [redacted],[redacted] employees with annual sales last year of US$[redacted].

Market forecasts

Diesel engines

Europe

We estimate that diesel currently accounts for a little over [redacted]% of all passenger car and light truck assembly in Western Europe, up from around [redacted]% in 2004.

Diesel's acceptance within Europe – which is in marked contrast to its reception in both North America and Japan – is attributed to a number of different factors, but a key driver has always been assumed to be the differential in excise duty between that levied on diesel and that levied on gasoline. However, the impact of incentivisation at the pump needs to be examined carefully, as the correlation between excise duty and market penetration is by no means a perfect one. Indeed diesel is now more expensive than petrol in many markets, especially the UK.

Diesel's significance in the European market is being progressively reduced by the development of smaller, more fuel-efficient gasoline engines. Turbochargers and other fuel efficiency technologies are seeing increasing application in petrol engines and this, plus the rise of hybrids, is likely to have a negative impact on European diesel sales. Furthermore, a forthcoming tightening of European NOx regulations with Euro [redacted] from September 2014, is set to add considerable cost to the diesel aftertreatment systems. To meet Euro [redacted], and iterations down the line, most automakers will elect to adopt Selective Catalytic Reduction (SCR) DeNOx systems whereby urea is dosed into the SCR catalyst breaking NOx emissions down into nitrogen and water. Automakers are not willing to absorb the additional costs, so it's likely that diesel will increase in price and erode their competitiveness in the market. Ironically, while Euro [redacted] is threatening diesel dominance in Europe it is providing European automakers an easier path to selling diesels in the US market as being fit for sale in Europe will mean little rework for US sale due to emission legislation convergence.

Market volumes of turbochargers fitted to newly-assembled passenger cars and light vehicles, 2[redacted]-2[redacted], ('[redacted]s units)

Market	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2024	2029
North America	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Mercosur	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Western Europe	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Central Europe	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Russia	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Japan	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
China	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
India	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Korea	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Thailand	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Other Asia	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Iran	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
South Africa	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Australia	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total [redacted] markets	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Source: *just-auto, LMC Automotive and industry sources*

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