OEMs put a price on every gram of potential CO2 to be saved

By Graham Heeps

The US car and truck market isn’t always synonymous with fuel economy, but in 2012, the US Department of Transportation (DOT) and Environmental Protection Agency (EPA) issued corporate average fuel economy (CAFE) standards that will see the average economy increase to 54.5mpg in 2025 – about a 40% improvement on today’s level. Over the same period, the EPA’s new Tier 3 emissions standards mandate a roughly two-thirds cut in the sum of non-methane organic gases and nitrogen oxides (NMOG+NOx) and particulate matter (PM).

Despite the tougher targets, experts believe that gasoline-powered vehicles will continue to dominate the US passenger car and light-truck markets for the next decade or more.

“I think ICEs will keep making it hard for electrification to ‘take over’ by providing cost-effective solutions,” says Dan Nicholson, vice president of General Motors Global Propulsion Systems. “Customers want inexpensive transportation, including the operating costs. For CO2 reduction, we’re always working on combustion, friction reduction, mass reduction and managing heat loss.”

“I think that the ICE powertrain as a whole still has a lot of growth and opportunity to improve,” agrees Geoff Duff, gasoline engineering manager for the Americas at turbo maker, Honeywell Transportation Systems.

Duff adds that the recent trend for downsized, boosted gasoline engines – which reduce fuel-consumption/CO2-emissions particularly in highway driving – looks set to continue, but perhaps in a “right-sizing” form, with small increases in downsized engine capacity to provide more torque off-boost so that the turbo isn’t required as often.

“We’re getting closer to the sweet spot,” he says. In the longer term, aerospace-derived air-bearing technology or electric power could both increase the efficiency of turbos in certain applications, although electric turbos are not without their challenges in terms of the electrical systems available to drive them. “48V is pretty close to a prerequisite,” according to Duff.

Image: Geoff Duff, Honeywell Transportation System

Conventional three-way catalyst technology is well established and effective at reducing the NOx emissions of gasoline engines. According to Dr Dean Tomazic, executive VP and CTO of FEV North America, a rapid catalyst light-off is crucial. “Besides minimizing the duration until light-off is complete it is also important to minimize all legislated emissions generated during that period,” he says. “Many SULEV applications have shown that this is technically feasible, but the main challenge for 2025 – and the significant increase in production volume – will be how to lower the cost to achieve the SULEV emissions level.”
Tomazic believes that a number of technologies will help to minimize NOx in gasoline engines in the coming decade. As turbocharged engines with direct-injection come to the fore, it is crucial to optimize the cooling of the fresh air downstream from the compressor via an intercooler. He thinks there will be a shift from air-to-air charge air coolers to liquid-cooled ones, while other technologies such as cooled EGR, which lowers NOx emissions by diluting the fresh intake charge, will also find their way back into the market.

“Advances in aftertreatment technologies that enable higher conversion rates at lower temperatures, as well as increased overall conversion rates in conjunction with reduced thermal substrate inertia to further shorten the light-off duration, will be additional means to minimize NOx emissions,” he says.

Gasoline particulate filters (GPF) could be a notable addition to the gasoline emissions control armory in the next decade. In contrast to Europe, where particulate mass and number are regulated in combination with a continuously increasing market share of gasoline engines with direct injection, the USA only legislates particulate mass until 2025.

Tomazic thinks that in most cases, the legislation can be met without a GPF, “but the OEMs might face a similar scenario to the diesel one many years ago, when pressure from the public rose to a level where customers preferred a diesel particulate filter-equipped vehicle to ensure a higher resale value in the future. With that in mind, it seems likely that the industry will see an increase in GPF applications over time.”

**Diesel on the rise?**

In 2015, Audi, VW and Porsche together had about 75% of the US diesel sedan and SUV market. With many models off-sale in the wake of the Volkswagen scandal, US diesel sales – already under pressure from low fuel prices – and the image of diesel power are taking a hit.

However, our experts believe that any damage to diesel will only be short-term and that diesel power will continue to increase its market share in the USA over the long term. At GM for example, which has just expanded production capacity for its fast-selling 2.8-litre Silverado diesel pick-up (the only diesel offering in the midsize segment), Nicholson believes the situation could present an opportunity to attract diesel customers who might otherwise have bought a VW. In early 2017, GM plans to introduce a Cruze sedan powered by a European-developed, whisper-quiet 1.6-litre ‘Fluster Diesel’ engine.

Sales of diesel passenger cars and trucks in the USA are starting from a low base, currently accounting for around 3% of the market – more than half of that attributed to heavy-duty pick-ups. But rapid growth is on the cards. Turbo supplier Honeywell, for example, expects the market share to double in five years, boosted by growing demand for diesels of around 3-litres capacity.

Allen Schaeffer, executive director of the Diesel Technology Forum – an advocacy group that represents numerous OEMs, automotive suppliers and fuel companies – agrees. The sales success of models like the Ram 1500 EcoDiesel (the USA’s highest-volume diesel vehicle, representing 15-18% of Ram 1500 sales, depending on spec) and the Jeep Grand Cherokee EcoDiesel (about 10% of Grand Cherokees sold, almost 20,000 vehicles in 2015) will likely encourage others into the market, according to Ram, Jeep and Schaeffer. Ford is rumoured to be readying a diesel version of its F-150 pick-up; as the USA’s best selling vehicle, it alone could have a huge impact on US diesel sales.
“Small-sedan sales are falling year on year,” says Schaeffer. “Crossovers and SUVs are where the action will be in the future; if that’s the case, some are going to be of a size and shape that makes compliance with future CAFE standards difficult without compromising a lot of things, which is why the diesel becomes attractive. You can maintain the balance of the vehicle size, performance and fuel economy better than you might be able to by continuing to tweak gasoline.”

Selectively catalytic reduction (SCR) systems have become the de facto option for ‘clean diesels’ in the US market. Occasional top-ups to the diesel exhaust fluid (DEF – urea) tank have become an accepted part of ownership, says Schaeffer. With incremental improvements to the catalysts, dosing systems and control systems in the next decade, SCR should be good enough to help vehicles meet 2025 emissions standards.

“We’re now in at least the second generation of SCR technology in passenger cars and heavy trucks are ahead of that,” he adds. “SCR is working well and the EPA is satisfied when the systems are properly programmed, so I think they’re the future for diesel engines under the new constraints of NOx and PM reduction.”

NEW TECHNOLOGIES

That’s not to say that existing emissions control systems might not be supplemented by new technologies in the future, for gasoline or diesel engines. FEV, for example, has developed a two-step variable compression ratio mechanism, which could be on a production vehicle in around two years. This technology is integrated into the connecting rod on a per-cylinder basis and is claimed to represent the least intrusive method of introducing a variable compression ratio mechanism into a combustion engine.

Meanwhile Faurecia, which has a market-leading 27% of the world market for light-vehicle exhaust systems, has a number of heat-to-heat and heat-to-power technologies in its portfolio that could become more common in the next decade. Exhaust heat can be recovered with up to 70% efficiency to warm up coolant or oil, for example, while its first Rankine system – in which a working fluid is vaporized in an evaporator by exhaust heat and the vapor drives a turbine/expander to generate electricity – is due on a production vehicle in 2018.

OEMs already put a price on every gram of potential CO2 to be saved so the big question to be addressed by these and all other emissions control technologies in the future will remain: “How much does it cost?”

“In the future, the mix of technologies will be highly application- and OE-specific, depending on the fleet mix and the associated sales by segment,” says FEV’s Tomazic.
“The mix will cover the areas of basic engine architecture (low friction, variable valvetrain, etc.), combustion systems (Miller/Atkinson cycles), controls, aftertreatment, transmissions, thermal management, and hybridization/electrification.”

The low price of fuel is currently hurting US sales of electric and hybrid vehicles in the same way that it’s affecting diesel sales. Nevertheless, it’s thought that such vehicles, including plug-in hybrids, will be key to OEMs hitting the 2025 CAFE targets.

“For 2025 the cost of electrification remains significant,” Tomazic assesses. “But is fair to assume that we will observe an incremental increase in hybridization over time, complementing the changes on the powertrain side that typically represent lower cost for the foreseeable future.”

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