48V and automotive electrification - systems, performance and opportunity

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Fuel economy and CO₂ emissions

Figure 6: Comparison of global CO₂ regulations for passenger cars, in terms of NEDC gCO₂/km.

Source ICCT

International CO₂ reduction commitments from Europe, the US and Asia, coupled with the promulgation of legislation have forced vehicle manufacturers to produce cost-efficient alternatives whilst driving markets toward an increasing environmental consciousness.

While the environmental problem is seen as global, the solutions are being managed in a variety of different ways within each of the vanguard triad jurisdictions. However, overall the global CO₂ target range is beginning to converge.

The movement to set fuel economy standards was launched by the US following the first OPEC oil shock of the early 1970s, although the Corporate Average Fuel Economy (CAFE) standards that were introduced in 1975 were increased gradually for a few years and then allowed to relax once the global oil price stabilised.

However, since the end of the twentieth century, the EU and Japan have also developed fuel economy standards for the new light vehicle fleet.

The EU opted to use grams of CO₂ emissions per kilometre (g/km) as a unit of measure, Japan adopting kilometres per litre (km/l) of fuel and the US retaining miles per gallon (mpg) using the US gallon (3.7854 litres). China has also now set standards that are expressed in litres per 100km (l/100km).
“Stop-start vehicles strike an attractive balance between cost and fuel efficiency improvement”, Said Pike senior analyst John Gartner

Figure 23: Penetration of stop-start systems 2011 - 2017

Source: Pike Research

To date Europe has seen by far the greatest selection of vehicles with stop-start technology and the greatest volume of vehicles sold. North America has experienced a relatively slow penetration of the technology due to less stringent emissions reduction goals and a US Environmental Protection Agency (EPA) testing cycle that underestimates the benefits of the technology. In Europe, around 25 models featuring stop-start were available in early 2011, while in the United States, only three models were for sale in early 2012.

By the end of the decade, according to a number of commentators, the minority of models likely to have an engine idling when drivers are stopped will include very small fuel-efficient sub-compacts and larger performance vehicles for which momentarily shutting off the engine is perceived as a negative. Interestingly the research from Pike argues that the battery market will be dominated by enhanced flooded batteries (EFBs) and valve regulated lead-acid (VRLA) batteries, along with a small number of Li-ion batteries. Ultracapacitors, although more expensive, have almost unlimited cycle life and will compete with batteries as stop-start energy solutions.

Stop-start, however, does not necessarily mean 48V and current systems in Europe are 12V based. The following comments from the president of Johnson Controls Power Solutions, Alex Molinaroli on mild hybrids illustrates the terminology now being used around progressive electrification where the addition of 48V and the functionality that this enables is labelled as mild hybridization.

“Johnson Controls sees opportunities for the development of evolutionary energy storage systems that offer even more fuel efficiency than stop-start at less cost than a hybrid or electric vehicle,” said Molinaroli.
This means that there is considerable motivation for AMTs to be developed that can boast a higher shift quality, the single real impediment to their widespread use. The availability of a 48V power-net enhances this development path and it is likely that the enabling the shift quality in automated manuals to be comparable to ATs and DCTs will bring about changes in the direction of the transmission sector.

This will be particularly true in Europe where manual transmissions remain popular because it is easier to utilize existing MT manufacturing capacity for AMT manufacture and there are therefore significant cost benefits to this development route.

In the past, despite the technological progress made and the potential for both fuel and cost efficiency, AMTs have continued to suffer from poor or inconsistent shift quality under all driving conditions compared with ATs and DCTs.

While there have been several attempts using innovative technology solutions to rectify this, the single-clutch AMT has never really been accepted by consumers apart from in low-cost A and B segment cars in which shift quality has been less of an issue, and some very high performance vehicles.

There have been a wide range of exercises designed to benchmark AMTs against both MTs and DCTs because, despite shortcomings the overall concept is highly attractive.

To this end electrification, to be further enhanced with 48V, has begun to provide the solution using an electric machine to infill torque during the gearshift. In addition, this development solution lends itself well to progressive hybridisation solutions.
Figure 51 illustrates the progress made in terms of X-by-wire systems as additional functions in both chassis performance and safety are integrated through electronic control systems. The availability of a 48V power net is a key enabler to more integrated vehicle control systems and enhanced active safety. An example of the increasing use of electrification and mechatronics in vehicle dynamics is the introduction of active stabiliser bars.

Active Stabiliser Bar Systems are a family of products that improve vehicle comfort and handling, particularly during cornering manoeuvres. When the vehicle is cornering, lateral acceleration is measured and the anti-roll torque required to keep the vehicle flat and stable is calculated. The Electronic Control Unit (ECU) determines the magnitude and direction of the hydraulic pressure and provides signals to a control module that regulates the pressure in the actuators. The hydraulic actuators then provide a force that counteracts the roll moment induced by the lateral acceleration, thus reducing vehicle roll angle. Such systems can drastically reduce vehicle roll while cornering. The roll angle reduction improves both the driver and passengers’ comfort. It also improves the vehicle steering feel, agility and stability, and more improvements to this system can be made through using dual channel systems and adapting the front/rear roll torque distribution depending on the driving conditions. For example, the anti-roll torque can be applied on the rear axle of a front-wheel driven vehicle when accelerating in a curve in order to limit its under-steer characteristic. Furthermore, anti-roll torque can be applied to counteract body oscillations that occur when the vehicle is driven over low frequency road inputs. This results in improved comfort.

BMW’s Dynamic Drive (Figure 53) uses active stabilisers on the front and rear axles to counteract the vehicle’s tendency to roll in a corner. Working together with acceleration and position sensors, a management system and other components, the system ensures balanced reactions to load changes and precise steering.

The stabilisers continually adapt to suit the driving situation and the changes to the vehicle’s self-steering behaviour. For example, when driving in a straight line, Dynamic Drive reduces the pressure of the stabilisers, treating them individually, so allowing for a more comfortable ride; a particular benefit for rear-seat passengers.

When cornering or making sudden changes of direction, the stabilisers increase the rigidity of the suspension relevant to the intensity of the lateral forces to prevent body roll. Roll distribution between the front and back axles also helps in difficult situations.
There are a number of influences on the future of NiMH including the volatility of both Nickel pricing (fairly stable at the moment) and the pricing and availability of rare earth metals, which is improving despite the designs of the Chinese producers, which dominate supply and seek to heavily control exports. However, NiMH is reaching the limit of its technological usefulness while lithium-ion is far from mature, therefore the majority of OEMs are shifting their attention to lithium-ion and this is where the heaviest resources in terms of both research and development and manufacturing are being deployed.

Clearly the winning business model will vary depending on the OEM. Some prefer to outsource as much as possible to a vertically integrated battery manufacturer (A123, Valence technologies) and to leave the research and development risk at arms length in this fluid area of development.