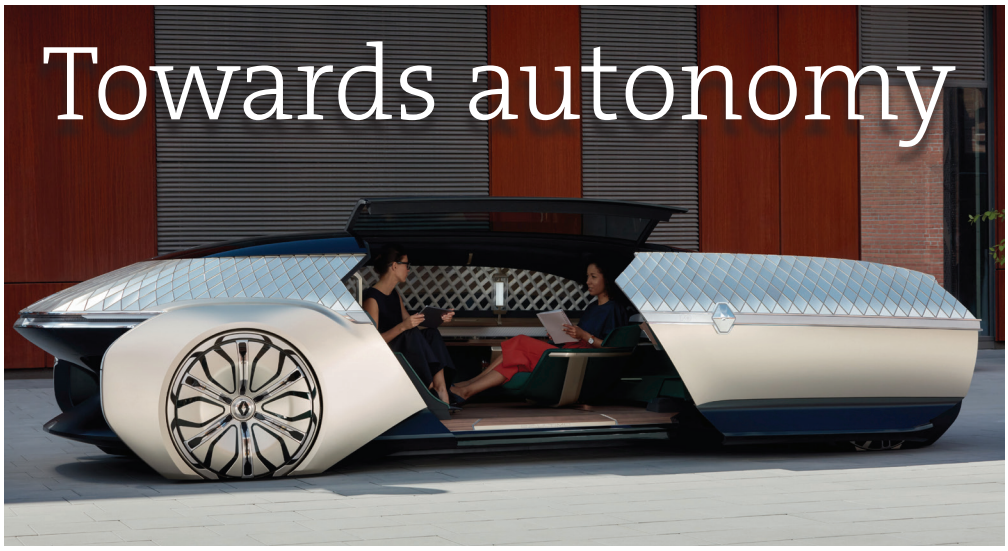
AUTOMATION

Towards autonomy



Leading automakers are looking at the potential of self-driving connected and autonomous vehicles (CAV). Though it may be a decade or so before we see many CAVs on the road, experts are already questioning the energy and emission implications. *Brian Davis* reports.

Driverless cars, vans and trucks are heading our way. Last month at the Paris Motor Show, leading carmakers like Renault unveiled a concept self-driving car with Level 4 autonomy (see **Figure 1**) called the EZ-Ultimo. The car looks more like a travelling diner with luxury seating and a table. While Mercedes-Benz, Audi, Ford, Tesla and BMW offer competing electronic and potentially driverless options.

Despite a recent BBC News report that suggests people will stop owning cars within 20 years, it is not yet time to throw away the car keys. The internal combustion engine still has a lot of mileage, with improved energy efficiency and emissions performance. Moreover, automation features are increasing across the board in vehicles with conventional drive trains, as well as electric and fuel cell options.

The ultimate idea is that that self-driving vehicles will be organised into an Uber-style network offering such cheap transport that you won't need a car any more. However, Dr Zia Wadud of the Centre for Integrated Energy Research (CIER) and Institute for Transport Studies (ITS) at the University of Leeds, is eager to dispel the myth that 'car ownership will vanish'. He argues that autonomy could be positive or negative from an energy perspective.

'While some energy benefits can occur through vehicle automation, there are large energy and carbon implications. From an energy and carbon perspective, it is the total energy or carbon emissions from the transport sector that are the primary concern,' he says. This can be expressed in the equation:

Energy use = Energy efficiency of travel x Travel demand

While improved energy efficiency can help reduce energy use in the transport sector, travel demand may well increase. Furthermore, vehicle automation may result in a radical change to the way people travel, possibly resulting in a 50% or more increase in energy consumption.

Uncertain scenarios

A new report published in May 2018 by the US Energy Information Administration, entitled *Autonomous vehicles: Uncertainties and energy implications*, emphasised that the effect of autonomous vehicles on transportation energy consumption is 'highly uncertain'. It cites a report by Tom Stephens and colleagues at the National Renewable Energy Laboratory (Nov 2016), which suggests that energy use by autonomous vehicles (light-duty passenger car and trucks) could decrease by 60% or increase by 200%, depending on various scenarios.

Researchers have developed a ripple diagram[1] that identifies the primary and secondary effects of full vehicle automation and their potential impact on energy use and carbon emissions, developed by Dr Wadud, Professor Jillian Anable, the Low Carbon Vehicle partnership (LowCVP) and the IMechE.

Wadud *et al*[2] suggest energy consumption could be reduced by a number of factors:

- Travel flow could be streamlined with fully automated vehicles connected to the road infrastructure, for traffic and speed control.
- On motorways, automated trucks could drive close and safely in platoons; sometimes driving at high speed to reduce aerodynamic drag and cut fuel consumption.
- Eco-driving mode could optimise passenger vehicle energy consumption.
- Safety could be significantly improved as over 90% of traffic fatalities are attributed to human errors.
- Lighter materials for CAVs could also improve fuel efficiency.

However, Wadud argues that some mechanisms that affect fuel or energy efficiency could have either a positive or negative impact.

- Increased safety due to full automation could result in relaxation of speed limits, resulting in higher vehicle speeds that boost energy use.
- In the shared car environment, described by some as 'Mobility as a Service' (MaaS), car sizes can be matched to vehicle occupancy. Energy per trip could go up because of empty running. Ride-hailing will probably increase energy consumption, and ride-sharing might reduce it.
- Engine performance could also be reduced in automated drive vehicles, with reduced energy consumption.

Travel demand

Self-driving cars could also allow passengers to pursue more useful pursuits for increased productivity. Wadud and co-researchers report that travel demand and concomitant energy use and carbon emissions could increase from 5% (for mid-level automation) to 60% for Level 4/5 self-driving cars. There could also be an increase of demand by new user groups, like the elderly and disabled, as well as younger people who are not currently allowed to

Renault's EZ Ultimo allows passengers to pursue more useful pursuits for increased productivity while the car drives itself

Photo: Renault

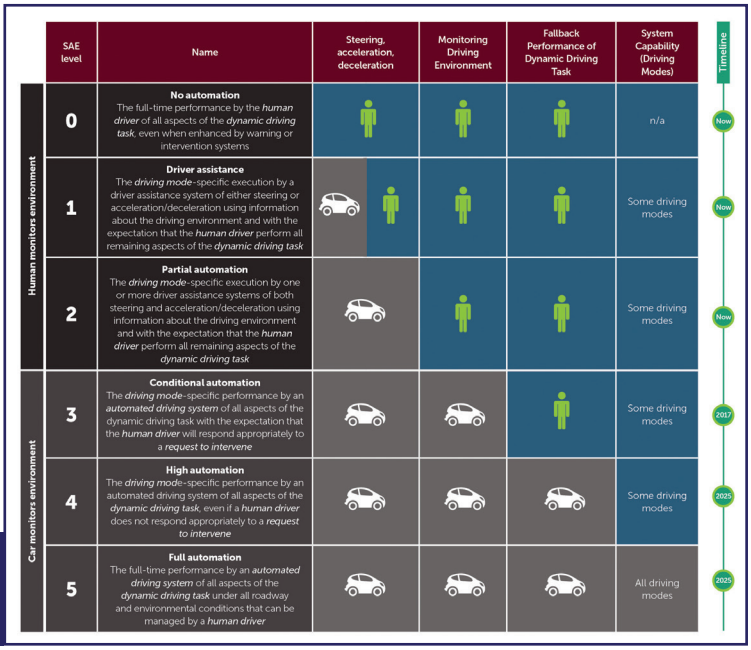


Figure 1: Different levels of automation (adapted from SAE and KPMG)
Source: LowCVP

drive – although this could boost energy use and carbon emissions by 2–10%.

The driver is said to represent around a third of the cost of a taxi or Uber-type ride-hailing service. Consequently, self-driven taxis or ride-hailing services could reduce costs significantly. Wadud estimates that ride-sharing (Uber pool type) could lower fuel consumption but warns that 'cheap, automated ride-hailing will likely increase energy consumption substantially due to both the demand effect, but also because of the empty running'.

Many people may actually resent the idea of giving up car ownership, and some mistrust the concept of driverless vehicles. A 2018 Gallup poll found that 54% of the public in the US said they were unlikely to use a self-driving car. However, these are early days. Global research by auto-component supplier Bosch suggests that despite significant progress made in the technology, two-thirds of Brits remain sceptical of fully automated vehicles. Dr Daniel Ruiz, CEO of Meridian, believes that as awareness and understanding increase, so scepticism will be reduced and acceptance will go up.

There is also the fear factor. Transport Research Laboratory (TRL) tests are underway to see how fast a passenger could take control of a Level 4 automated vehicle. Apparently, 75% of members of the American Automobile Association report feeling afraid to ride in a self-driving vehicle.

Weighing up the costs

The additional costs of automation technologies could also affect uptake. Wadud insists that 'the additional costs are not massive, although up-front costs can be high, since that cost is depreciated over the 10–12 years of vehicle life, so the annual cost increases will not be massively high.' According to the US Energy Information Administration (EIA), Level 1 and 2 systems are broadly available, Level 3 is increasingly found in high-end vehicles, while Level 4 is not considered affordable for the average consumer.

Cybersecurity is another major issue.

CAVs will also require significant investment in special road and smart signalling infrastructure if the transition to the fully autonomous future is to be made as smoothly, efficiently and safely as possible.

A legal framework will also be necessary to address future liability issues related to autonomous vehicles, when it comes to assigning fault for an accident. The liability could sit with the manufacturer, the infrastructure, and yes, still with the owner/operator of the vehicle. In fact, a UK Tesla owner has been penalised recently for sitting in the passenger seat while his Tesla was on 'auto-pilot', as this is not a fully-fledged self-driving function and is therefore illegal on UK roads.

Commercial transport

In the US, commercial light- and heavy-duty trucks accounted for 23% of energy demand in 2017 and are projected to account for 27% by 2050. According to the US Department of Energy, widespread adoption of platooning in heavy-duty vehicles, could reduce truck energy use by 4% compared to today's levels.

Automated trucks could operate almost continuously, potentially reducing downtime and changing the logistics for total truck demand.

Testing, testing

Gordon Telling, Head of Ultra Low Emission Vehicles (ULEV) at TRL, says there is a perception that autonomous vehicles are synonymous with ULEVs. 'No. It is quite possible to have an autonomous diesel or petrol car. But things are progressing towards an ultra-low emission drive train which autonomous vehicles will deploy.'

A series of Level 4/5 trials are underway around the UK in controlled urban environments.

Project GATEway started in 2015. Led by TRL, the project aims to demonstrate the use of CAVs for 'last mile' mobility, with seamless connection to existing transport hubs using a zero emission transport system. The GATEway project involved three trials, including automated valet parking, driverless grocery deliveries and a shuttle service. The GATEway programme has now ended, but led to the setting up in Greenwich, London, of the Smart Mobility Living Lab (SMLL).

Meanwhile, the UK Autodrive project is jointly funded by Innovate UK and industry, with total investment of £19.4mn. The three-year trial of CAV technologies will culminate in demonstrations on public roads in Milton Keynes and Coventry. Partners include Arup, Ford, Jaguar LandRover, RDM Group, Catapult Transport Systems, Thales and others. Self-driving pod trials began in spring 2018.

Further trials are planned from Oxford to London, on the M40, (with a safety driver onboard) in 2019. There is also a Low Emissions Freight and Logistics Trial (LEFT), looking at the potential to reduce emissions from freight vehicles.

Connected intelligent transport systems are to be trialled in the West Midlands, as a 5G (telecommunications) test-bed around the 'Coventry Box' (M40, M42, A45, A46).

A heavy-goods vehicle platooning trial called HELM aims to run a convoy of vehicles 'nose to tail' along stretches of the M6, where only the first vehicle has a driver controlling speed and direction. The vehicles will be hooked up electronically, but none will actually lack a driver. The technology is well established, but vehicles in the middle will save more fuel, as they run in the slipstream. There is also a question regarding EU driving hour

regulations in terms of those 'not driving'. The overall fuel saving is estimated to be 10–15%.

Numerous MaaS trials are also underway around Europe, particularly in Nordic countries. But the UK is trying to differentiate itself by putting legal frameworks in place that allow on-road trials for a real-world environment.

'MaaS does not necessarily imply low emissions,' says Telling. 'However, an autonomous pod may offer fuel savings as it is probably a better driver than most of us. There are also fuel savings because the vehicle is likely to be connected to local traffic infrastructure, so it will know the best way to avoid congestion. CAVs should give a smoother, more efficient ride with 10–15% fuel saving.'

Telling anticipates relatively quick take-up of MaaS in a controlled urban environment, but says operation in rural environments will be far more challenging.

Road to Zero

In accordance with the its 'Road to Zero' strategy announced in July 2018, the UK government has committed for all new cars and vans to be zero emission vehicles by 2040, and most vehicles to switch to low emissions by 2050. A new EV Energy Taskforce has been launched to pilot the initiative, and CAVs will have to comply.

'Whatever level of autonomy is rolled out, it is likely to be applied to electric or hydrogen vehicle platforms. By that logic, autonomous vehicles will have zero emissions, in so far that they are using energy from a zero emissions source. EV growth is typically doubling year-on-year. The determining factor will be affordability and which manufacturer produces the most appealing models,' says Telling. (Wadud disagrees. He claims the determining factor will depend on external factors. 'Most will pay for automation once they get over the trust issue,' he says.)

Telling believes that EV range anxiety should disappear in 18–24 months as batteries improve. 'The limiting factor will be charging infrastructure, but the energy companies have woken up to this. Recent initiatives, like BP's acquisition of Chargemaster, a leading electric infrastructure provider, is a move in the right direction.'

TRL believes that autonomous vehicles will yield improvements in road safety, health and fuel efficiency, matched by savings from the shift to EVs or ULEVs. 'If connected systems are deployed in our towns or cities, one of the key benefits will be faster, more smoothly flowing traffic,' he says.

Lifecycle emissions

Professor Jillian Anable, at ITS, University of Leeds, is concerned about 'lifecycle emissions' as CAVs will require a vast amount of data processing. 'They will have a huge impact on the amount of server capacity involved, with significant energy implications. What's more, the built environment may have to be completely restructured, with dedicated sidewalks and crossing points, separating road users and pedestrians from robot-vehicles.'

She says MaaS using autonomous vehicles could encourage more travel but also abstract from conventional public transport operations. 'That could be good from an efficiency viewpoint but bad in terms of affordability. Energy costs might go down as CAVs are more efficient vehicles, but more mobility may be generated and they may be used more frivolously than conventional cars.'

Professor Anable also points to another anachronism: 'Many carmakers talk about more car sharing, but the last thing they want is to get rid of individual ownership.'

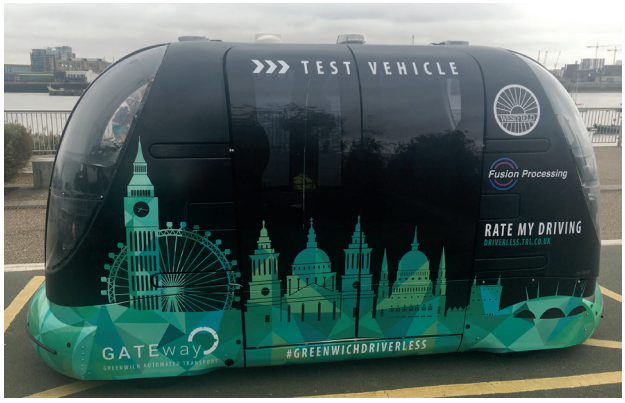
She forecasts that the degree to which CAVs decarbonise will probably follow the rest of the fleet, so it will have no net benefit. 'If affordable, CAVs could generate more mobility and higher energy consumption and will require significant infrastructure changes. There are also cybersecurity issues, and the likely damage to conventional public transport could lead to social exclusion.'

Meridian initiatives

In September 2017, the UK government and industry set up Meridian as a focus to develop UK capability in CAV technologies. Investment of £100mn has been committed by government and matched by industry to develop a coordinated national platform, focused on a potential global CAV market worth £907bn by 2035.

Meridian CEO Dr Daniel Ruiz says: 'There is consensus that self-driving vehicles will initially be deployed in relatively controlled environments in the next 5–10 years, like ports, airports, shopping malls and retirement communities.' In the longer-term they will be on public roads.

Meridian test and development initiatives include the Trusted Intelligent Connected Autonomous Vehicle consortium, TIC-IT, which is led by Horiba MIRA in partnership with Coventry University, under a £26mn investment in the testbed facility. Millbrook and the UKAEA's RACE also operate a testbed for CAV development, across two sites. The Midlands Future Mobility testbed, led by Warwick University's WMG, and the Smart Mobility Living Lab in London, offer significant CAV physical and virtual test facilities.



The GATEway project involved three trials, including automated valet parking, driverless grocery deliveries and a shuttle service, and led to the setting up in Greenwich, London, of the Smart Mobility Living Lab (SMLL)
Photo: TRL

Ruiz also believes that an increase in connectivity will precede the uptake of autonomy. This is because connectivity can be applied to any type of vehicle, with data flowing for application in enhanced mobility models for passenger vehicles and delivery of commercial transport services. 'In the next five years there will be a significant increase in the development of intelligent infrastructure. And we are driving to overcome most cybersecurity issues using expertise of GCHQ and the National Cybersecurity Centre,' he says.

Ruiz suggests that emissions could be reduced by 20–25% (Wadud claims 10% or less) if drivers were to adopt efficient driving techniques. He also mentions a Folsom Research report, which claimed that automated vehicles could reduce petrol consumption up to 18%, with US carbon savings reaching the equivalent of 100 coal cars daily.

He concludes: 'The auto-industry has been thrown into disarray as the paradigm changes in every area from speed of design and development, testing, sales and future transport models. We need to think about the transition towards CAV to ensure we evolve as rapidly as possible. But fundamentally, safety, control and cybersecurity are top of the list.' ●

1 *Automated vehicles: Automatically low carbon?* Z Wadud, JL Anable, IMechE report, 30 June 2016

2 *Help or hindrance? The travel, energy and carbon impacts of highly automated vehicles*. Z Wadud , DW Mackenzie, PN Leiby, Transportation Research Part A, Vol 86