UNIVERSITY OF LEEDS

Mobility & Energy Futures Series

SELF-DRIVING CARS

WILL THEY REDUCE ENERGY USE?

Energy Leeds

Since Google's demonstration of the driverless car in 2012, it has attracted large interest from the media and the public, as well as from the transport academics. Self-driving, driverless or fully automated autonomous vehicles are often expected to solve transport's energy use and carbon emissions related problems.

The energy efficiency benefits of automation

Widespread adoption of self-driving can reduce energy consumption through various mechanisms, such as:

- Traffic flow can be streamlined and optimized for fuel consumption with automated vehicles connected to the network;
- On motorways, automated vehicles can drive very close to each other, creating platoons, thus reducing aerodynamic drag at high speed and fuel consumption;
- The automated vehicles can be programmed to run on an eco-driving mode (driving practices that can reduce fuel consumption);
- At very high level of penetration, automated vehicles can be light-weighted as crash risks fall dramatically (currently, nearly 90% of traffic fatalities are attributed to human errors);

All of these mechanisms improves 'fuel efficiency' of individual (self-driven) vehicles, and received attention from the media and grey literature as potential energy and carbon benefits. However, there are other such mechanisms that affect the energy efficiency, but the direction could be either positive or negative:

- Higher speed limits resulting from increased safety (increases consumption);
- Right-sizing of vehicles made possible by self-driving shared-cars (decreases consumption);
- Lower engine performance requirements for automated driving (decreases consumption).

But will automation lead to additional demand for travel?

Yet there is another aspect of vehicle automation with large energy and carbon implications that has not received much attention. From an energy and carbon emissions perspective, it is the 'total' energy or 'total' carbon emissions (from the transport sector) that is of prime concern, which can be simply expressed as:

Energy Use = Energy Efficiency of Travel × Travel Demand

While improved energy efficiency (assuming the net effect of above seven mechanisms is still beneficial) goes some way to reducing energy use from transport sector, the other half of the equation, travel demand is often missing in the debate about energy effects of vehicle automation. Yet vehicle automation is also likely to make a radical change to the way people would travel in future.

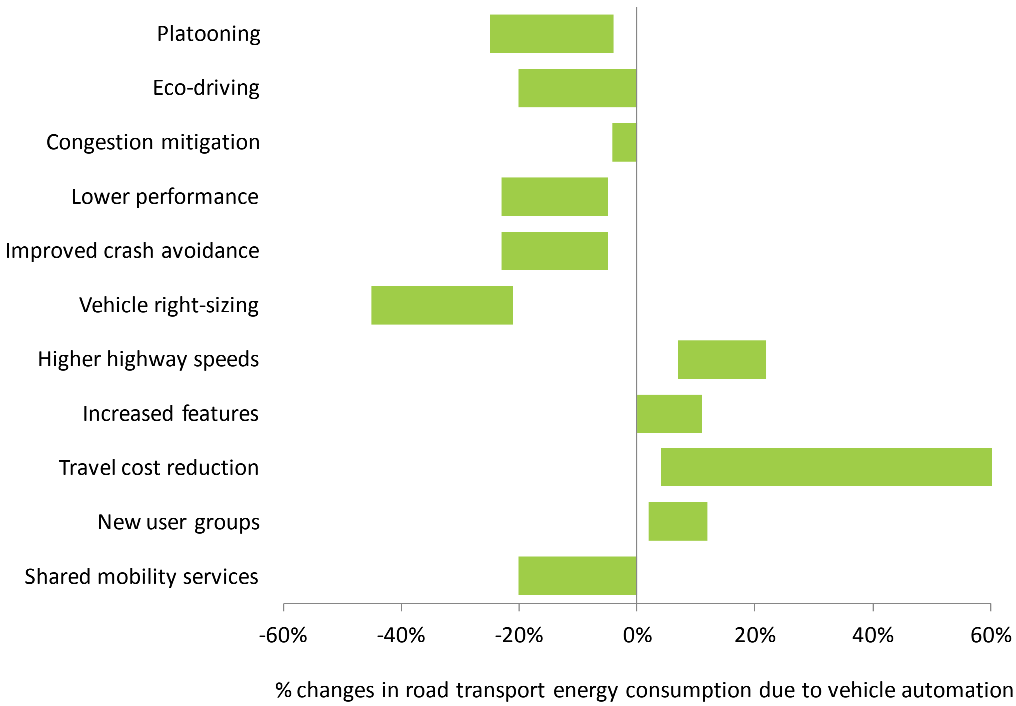
Take, for example, the potential for modal switch back to cars. During travelling, people generally prefer the privacy and convenience of car, but also appreciate the driving-free experience of public transport, especially since this time not driving can now be used in a productive manner due to the progress in information and communication technologies. Self-driving cars can combine these benefits by allowing hands-free, productive use of time in cars, making them relatively more attractive to the public transport modes. In transport modelling terminology, the value of time 'wasted' during driving/travelling is one of the major determinants of the choice of different transport modes and this value of time could be lowered substantially in a driverless car. This could substantially disrupt the perceived costs of travel could encourage a more car-centric life pattern, while people decide to live further from work. Research showed that car current modal share enjoyed by rail (and buses) in the UK in favour to personal self-driving car. The lower travel and concomitant energy use and carbon emissions, could increase by 5% from mid-level automation to up to 60% for a high penetration of self-driving cars in the USA.*

Self driving cars could also encourage a completely new demographic group to own cars, e.g. the disabled and the elderly, and potentially those too young to drive now, as well. Whilst potentially important in advancing social inclusion, increased vehicle ownership and use would inevitably lead to increased energy use and carbon emissions. These new user groups could increase the energy consumption from personal vehicle fleet by 2% to 10% in the USA.* With the population growing older, such an increase is possible in the UK as well.

What would the impacts of a shift in how we own cars be?

One aspect related to travel demand that has received some attention in the UK is the move away from individual car ownership toward new models of mobility services such as car-sharing or on-demand service facilitated by driverless cars. The net energy impacts of such on-demand services are still uncertain: total car travel and energy consumption should decrease as the variable out-of-pocket costs per mile becomes more visible to the traveller, yet this reduction could be neutralized by an increase in car travel, as the driverless shared-cars or taxis travel empty shuttling from one passenger to another.*

Figure 1: Impacts of automation on energy use*



What would be the net effect?

Research done at the University of Leeds in collaboration with the University of Washington and Oak Ridge National Laboratory bounds the potential ranges of energy impacts of self-driving cars in the US through the energy efficiency and travel demand mechanisms mentioned above, and are reproduced in Fig. 1. While the numbers may differ, the general direction of the effects are expected to be similar in the UK, too.

The key messages are:

- Automation can result in substantial reduction in energy demand, but this reduction is not a direct consequence of automation per se, rather due to changes in vehicle design, vehicle operations, transport system optimization facilitated by vehicle automation.
- Some of the reductions in energy demand could be brought about by a higher degree of connectivity, even at a lower level of automation than self-driving cars. Yet, for fully self-driving cars, there is a substantial risk of increased travel and energy demand. Thus, stopping short of fully self-driving cars may be more beneficial from an energy perspective.
- There are large uncertainties in the quantification of net energy effects of self-driving cars. Therefore it is vital that the various mechanisms discussed here are aligned in the correct directions through appropriate policies in order to reap full energy and carbon benefits of automation.

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*Figure.1 and this briefing draws from Wadud Z, MacKenzie D and Leiby P (forthcoming) Help or hindrance? The travel, energy and carbon impacts of highly automated vehicles, Transportation Research Part A: Policy and Practice

Mobility & Energy Futures Series

Transport consumes a fifth of global energy and has a near-exclusive reliance on petroleum. As such it has an important role to play in the Energy Trilemma of reducing energy consumption and associated greenhouse gas emission, creating an energy system built on secure supplies and developing the system in ways which are affordable.

Addressing the Energy Trilemma in the transport and mobility sector is especially challenging due to the continued growth in demand for the movement of goods and people, the technical, regulatory and social challenges of moving away from an oil based system of mobility and a complex and fragmented set of stakeholders required to work together to deliver change.

Drawing on the expertise and opinions of the University of Leeds academics from different disciplines, this series will highlight the drivers, gaps and opportunities in reducing the energy consumption and carbon emissions from the transport sector in future. This is the inaugurating briefing in the series.

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