



Joining **forces**

to tackle  
the road transport  
CO<sub>2</sub> challenge

# JOINING FORCES TO TACKLE THE ROAD TRANSPORT CO<sub>2</sub> CHALLENGE

A multi-stakeholder initiative

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# ABOUT





## About the initiative

Identifying the best possible response to the challenge of reducing CO<sub>2</sub> emissions from road transport is a major priority for Europe. It is a key focus of the European Union's ongoing policy development in the context of the 2030 Climate and Energy Framework and is also important in relation to the continuing international climate change negotiations.

The EU has set the most challenging targets in the world for cutting vehicle CO<sub>2</sub> emissions. By 2021, manufacturers will have to reduce emissions to 95g of CO<sub>2</sub> per kilometre for passenger cars and 147g for vans – reduced from 186g of CO<sub>2</sub> per kilometre for passenger cars in 1995, and 181g for vans in 2010. But efforts have not only been driven by legislation: consumers demand increasingly fuel-efficient cars, and manufacturers understand their crucial role in driving down CO<sub>2</sub> emissions.

For all these reasons, the automobile industry has been contributing towards driving down road transport CO<sub>2</sub> emissions through massive investments in research and development. This has included investing in both vehicle engine technology and in innovative methods to reduce the weight of car components, from bumpers to seats. Significant steps have been made in car technology, including variable valve timing, turbocharging, stop-start systems and direct injection technology, as well as continued investment into alternative powertrains.

As a result, the average new car coming on to the road in 2021 will produce 42% less CO<sub>2</sub> per kilometre than a new car bought in 2005. As the 'fleet' is renewed (every time a new car arrives on the road and replaces an old car), the benefits of these new technologies become increasingly clear.

Yet additional future CO<sub>2</sub> emissions reductions require a more comprehensive approach. The evolving policy framework should therefore include and support a broader mix of technologies and approaches, including road infrastructure, alternative fuels, innovative in-car technologies and more environmentally friendly driving techniques. In order to better understand how the technologies and approaches available can deliver the greatest impact, ACEA has brought a wide range of stakeholders together to learn from their expertise and knowledge, and to capture their views in this report. This has led to over 50 stakeholders joining ACEA in launching the 'Joining forces to tackle the road transport CO<sub>2</sub> challenge' initiative.

The initiative is based around a consultation exercise involving businesses, trade associations, NGOs, research bodies and think tanks. Its purpose is to identify the technologies and approaches that, according to the various stakeholders, can have the greatest impact on reducing CO<sub>2</sub> emissions from cars and light commercial vehicles (by 2030) and to strive to quantify the potential benefits for each, bearing in mind that these are not accumulative. It also aims to map out key policy changes necessary for such technologies or approaches to deliver their fullest CO<sub>2</sub> emissions reduction potential.

This stakeholder initiative comprises four workstreams, which make up the major pillars that can contribute to a more comprehensive approach to reducing CO<sub>2</sub> emissions. These workstreams involved an extensive dialogue with

stakeholders, including two workshops which were led by external moderators (see Annex). Those four workstreams are:

- **Fuel options** (moderated by Graham Floater, London School of Economics): including electrically chargeable vehicles, liquid biofuels and methane (natural gas, biomethane and syngas).
- **Intelligent transport systems (ITS) and the connected car** (moderated by Annika Hedberg, European Policy Centre): the contribution of innovations in this field to further reducing road transport CO<sub>2</sub> emissions.
- **Road infrastructure** (moderated by Christian Egenhofer, Centre for European Policy Studies): how the design and operation of our transport infrastructure influences road transport CO<sub>2</sub> emissions.
- **Eco-driving** (moderated by Fabio Genoese and Arno Behrens, Centre for European Policy Studies): how changing driver behaviour can contribute to reducing transport CO<sub>2</sub> emissions.

The outcome of these workshops, as well as additional materials provided by stakeholders, are captured in this report. While no text can claim to be truly comprehensive, the report aims to provide an overview of the views of a wide range of stakeholders. All the stakeholders involved share an interest and bring to the table expertise and legitimacy in their fields. Cooperation between these stakeholders can contribute to lowering the carbon footprint of cars and light commercial vehicles, as well as delivering substantial CO<sub>2</sub> emissions reductions by 2030.

## DISCLAIMER

This report aims to provide an overview of the views of a wide range of stakeholders, in order to contribute to an informed debate on the potential of a comprehensive approach to reducing CO<sub>2</sub> emissions from passenger cars and light commercial vehicles.

The views expressed in this report are a collection of those of the different stakeholders involved in the initiative. As such they do not represent the positions of ACEA or its members. In addition, each individual stakeholder may not necessarily support all views expressed in the report. All the stakeholders involved do however share a common interest; finding out how to best reduce CO<sub>2</sub> emissions.

Finally, with regard to methodology, it should be noted that the various workstreams – and individual measures – have been analysed and evaluated in isolation. While they are not accumulative, together the workstreams present a promising outlook for the overall CO<sub>2</sub> reduction potential of a comprehensive approach. In addition, it is not always possible to add up figures from individual measures within a workstream, as the effects of certain measures can produce diminishing marginal returns.



## Let's make Europe ready for a new era in transport



During the COP 21 summit in Paris, many thousands from all around the globe joined forces and agreed on a common goal in order to tackle climate change. Politicians, scientists and experts created a positive spirit and found that, even if the formulated goal is tough, there are solutions.

Innovation is one of the key instruments we need in order to fulfil the goals we set ourselves in Paris for 2050. Innovation is a central theme of the Dutch EU Presidency. Europe must seize opportunities to boost its competitive strength and generate new jobs. A lot of new technology is already available. In January this year, I received the keys of a new hydrogen car. I am impressed by what technology makes possible for us today and I am even more hopeful of what it will deliver in the future.

Reducing the fuel consumption of vehicles is of importance to consumers, who will pay less for mobility, but even more important for the environment. Through European emission targets a level playing field is created. They are one of the main drivers for stimulating hybrid and electric power trains. To ensure a further decrease of real world CO<sub>2</sub> emissions and innovation on our way towards low and zero-emission transport, working together is necessary.

ACEA embraced the need to decarbonise transport and started the dialogue with its partners. There is still a long way to achieve the necessary decarbonisation of the transport sector, but I find this report encouraging. It provides an overview of the efforts up to now and it shows the future potential of various developments like intelligent transport systems (ITS), the connected car, traffic management, road infrastructure and alternative fuels. Your commitment is needed to develop a future-proof transport and mobility system, creating green growth and jobs.

In order to achieve the 2050 goals we need a transition towards zero emissions. The Commission announced its intention to publish a communication on the decarbonisation of transport later this year, focusing in particular on road transport. During the informal council of environment ministers, which was held in Amsterdam in mid-April, we shared views on how to open a new, green chapter in road transport. How can we reduce CO<sub>2</sub> emissions, improve air quality and reduce our dependence on fossil fuels, whilst at the same time recognising the importance of road transport in our daily lives?

I invite you to be brave and choose to deliver the cars we need. You deliver the technology, we deliver the policy. Together we can make the difference.

Sharon A.M. Dijkma

A handwritten signature in black ink, appearing to read "Sharon A.M. Dijkma", enclosed within a large, loopy oval shape.

Minister for the Environment  
Kingdom of the Netherlands



## Foreword



The automobile industry welcomes EU initiatives to explore how to further address decarbonisation across all transport modes and recognises that the road transport sector must play an important role in driving down emissions. Yet, as society, we face a real challenge: how do we retain the mobility that is so vital to our economies and our ways of life, and, at the same time, manage the impact of road transport on the environment around us?

Currently, the European automotive industry is the continent's number one investor in R&D, spending €41.5 billion on innovation each year to meet future challenges. As a result, Europe's carmakers have already made a significant contribution to reducing CO<sub>2</sub> emissions by developing ever more fuel-efficient vehicles and investing into alternative powertrains. In 2014, average new car emissions were 33.7% lower than two decades before. Moreover, CO<sub>2</sub> emissions per car produced dropped by 25.4% between 2005 and 2014, reflecting the industry's efforts to also reduce CO<sub>2</sub> from production.

However, on the ground new vehicles only make up 5% of Europe's motor vehicle fleet, resulting in a slow uptake of more efficient vehicles. At the same time, the average age of cars in the European Union is currently close to 10 years and is rising year-on-year. As a result, emissions targets which exclusively focus on new vehicles fail to address the bulk of vehicles already on the road.

Manufacturers are committed to driving down emissions in years to come by continuing to invest in new technology and exploring the potential of intelligent transport systems. But even though less CO<sub>2</sub> is emitted for every kilometre driven by new cars, emissions from road transport have not decreased as hoped. What this shows is that this challenge cannot be adequately addressed by focussing on the car alone. Therefore, if we are to combat CO<sub>2</sub> emissions from road transport, we need a fundamental rethink on how we approach this challenge.

After all, common sense suggests that there are many factors influencing emissions during the use of the vehicle. With a holistic approach, we can reduce CO<sub>2</sub> emissions more effectively by drawing on a full spectrum of solutions. It was on this basis that ACEA decided to seek the views of more than 50 key stakeholders, who share an interest in reducing road transport emissions. The aim was simple: let's listen to each other so that we can better understand the potential of all innovative solutions available, and how these can be best realised in the most cost-effective way.

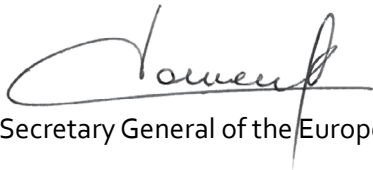
The 'Joining forces to tackle the road transport CO<sub>2</sub> challenge' initiative has involved hard work over a series of workshops and an all-stakeholder conference to validate the findings you are about to discover. The result of that is this report, which captures the different viewpoints of all the stakeholders who participated in the process.



Consequently, this is not an ACEA report: it belongs to those whose combined contributions show the enormous potential that joining forces could deliver for reducing CO<sub>2</sub> emissions. There are obviously obstacles to meeting that potential, which are frankly captured in this report. Yet, I am convinced that by working together, and with the policymakers here in Europe, we can make great strides to reduce the climate change impact of road transport and guard the mobility and freedom that it gives us.

I would like to thank all of the stakeholders who have contributed to this effort, and I look forward to working together in the months and years to come.

Erik Jonnaert

A handwritten signature in black ink, appearing to read 'Erik Jonnaert', written over a horizontal line.

Secretary General of the European Automobile Manufacturers' Association (ACEA)

# STAKEHOLDERS





## The stakeholders

A wide range of stakeholders from the public, private and non-profit sectors participated in this initiative, including businesses, trade associations, NGOs, research bodies and think tanks. An overview of all the stakeholders is provided below, listed by workstream.

### Fuel options

- Conservation of Clean Air & Water in Europe (CONCAWE)
- EURELECTRIC
- European Association for Advanced Rechargeable Batteries (RECHARGE)
- European Association for Battery, Hybrid and Fuel Cell Electric Vehicles (AVERE)
- European Association for Hydrogen and Fuel Cells and Electro-mobility in European Regions (HyER)
- European Association of Automotive Suppliers (CLEPA)
- European Automotive Research Partners Association (EARPA)
- European Biodiesel Board (EBB)
- European Biogas Association (EBA)
- European Green Vehicles Initiative Association (EGVIA)
- European Hydrogen Association (EHA)
- European Renewable Ethanol Association (ePURE)
- European Wind Energy Association (EWEA)
- FuelsEurope
- IFP Energies Nouvelles (IFPEN)
- International Fuel Quality Center
- Natural Gas Vehicle Association (NGVA)
- Norwegian Electric Vehicle Association
- SolarPower Europe
- Wuppertal Institute for Climate, Environment and Energy

### Intelligent transport systems (ITS) and the connected car

- DEKRA
- DIGITALEUROPE
- Eindhoven University of Technology
- ERTICO - ITS Europe
- European Conference of Transport Research Institutes (ECTRI)
- European Road Transport Research Advisory Council (ERTRAC)
- GSMA Europe
- German Aerospace Center (DLR) Institute of Transport Research
- Heich Consult (European Commission 7th Framework Programme ICT-Emissions Project)

- Huawei Technologies
- IBM Europe
- Polis - European Cities and Regions Networking for Innovative Transport Solutions
- TomTom

### **Road infrastructure**

- Conference of European Directors of Roads (CEDR)
- Eurobitume
- European Asphalt Pavement Association (EAPA)
- European Concrete Paving Association (EUPave)
- European Construction Industry Federation (FIEC)
- European Conference of Transport Research Institutes (ECTRI)
- European Council of Spatial Planners (ECTP-CEU)
- European Tyre and Rubber Manufacturers Association (ETRMA)
- European Union Road Federation (ERF)
- Forum of European National Highway Research (FEHRL)
- French Institute of Science and Technology for Transport, Development and Networks (IFSTTAR)
- International Council for Local Environmental Initiatives (ICLEI)
- International Road Transport Union (IRU)

### **Eco-driving**

- ERTICO - ITS Europe
- European Automobile Clubs Association (EAC)
- European Conference of Transport Research Institutes (ECTRI)
- European Driving Schools Association (EFA)
- European Express Association (EEA)
- European Road Transport Research Advisory Council (ERTRAC)
- European Transport Safety Council (ETSC)
- French Institute of Science and Technology for Transport, Development and Networks (IFSTTAR)
- International Road Transport Union (IRU)
- PostEurop
- RWTH Aachen University
- TomTom



# KEY FINDINGS





# Key findings and conclusions

## Introduction

With ongoing policy discussions around the 2030 Climate and Energy Framework, and in the context of efforts to reduce CO<sub>2</sub> emissions in years to come through the international Conference of the Parties (COP) process at the UN level, reducing CO<sub>2</sub> emissions from road transport is an increasingly crucial focus for the EU.

The role of the automobile industry in driving down road transport CO<sub>2</sub> emissions has been substantial. This has been driven in part by consumer demand and industry initiatives, but also by the toughest targets in the world for cutting vehicle CO<sub>2</sub> emissions. By 2021 manufacturers in Europe will have to reduce emissions to 95g of CO<sub>2</sub>/km for passenger cars and 147g for vans – down from 186g of CO<sub>2</sub>/km for passenger cars in 1995, and 181g for vans in 2010.

This has led to sizeable investments in research and development: in vehicle engine technology, new methods to reduce the weight of car components such as bumpers and seats, variable valve timing, turbocharging, stop-start systems and direct injection technology, but also continued investment into alternative powertrains. These investments have resulted in a reduction of average new car emissions by 33.7% in under two decades (from 186g CO<sub>2</sub>/km in 1995 to 123g in 2014).

However, future additional CO<sub>2</sub> emissions reductions require a more comprehensive approach, focussing on a broader mix of technologies and approaches, including road infrastructure, alternative fuels, innovative in-car technologies and more environmentally friendly driving techniques.

To better understand how to deliver such a comprehensive approach in the best possible way, more than 50 stakeholders have come together to contribute to the 'Joining forces to tackle the road transport CO<sub>2</sub> challenge' initiative. Throughout 2015, this consultation process facilitated by ACEA, has explored ways in which a comprehensive approach can be used to reduce the overall CO<sub>2</sub> footprint of cars and light commercial vehicles, through four workstreams (Fuel options, ITS and the connected car, Road infrastructure and Eco-driving). The findings from this initiative have been captured in this report, which provides an overview of the contributions of the stakeholders involved.

## CO<sub>2</sub> reduction potential

By looking at the potential of alternative fuels, intelligent transport systems (ITS) and the connected car, improvements to road infrastructure and the impact of eco-driving training and techniques (in addition to the continued cost-effective efficiency improvements to vehicles by manufactures), it seems the CO<sub>2</sub> footprint of road transportation can be cut significantly with a comprehensive multi-track approach.

## Fuel options – alternatives to conventional fuels

Alternative fuels will feature more and more in reducing CO<sub>2</sub> emissions. These include electrically chargeable vehicles (ECVs), liquid biofuels (including biodiesel and bioethanol) and methane (natural gas, biomethane and syngas). As the European Road Transport Research Advisory Council (ERTRAC) points out, all alternative fuels are needed in the mix in order to contribute to a lower-carbon future.

Within the ECV sector, this report includes not only battery-powered cars, but also hybrid vehicles and hydrogen fuel cell vehicles. What they have in common is a power source that is partly or entirely derived from the electricity supply (either by charging a battery or by using electricity to produce hydrogen) – meaning they are as ‘green’ as the electricity used to charge them. As Europe’s electricity supply gradually becomes less CO<sub>2</sub>-emitting and the percentage of low carbon power in the mix increases, CO<sub>2</sub> emissions of ECVs per kilometre driven will decrease as well. In addition, the costs need to further decrease, such that vehicles are competitive for consumers, manufacturers and society, which would allow the phasing out of current subsidies and incentives.

Liquid biofuels like biodiesel and bioethanol are derived from plants or biomass. These biofuels produce less CO<sub>2</sub> per kilometre than petrol or diesel and reduce Europe’s reliance on fossil fuels while being compatible with modern conventional cars. They are mainly used today as additives to traditional fuels: for instance, the E10 petrol mix used in some European countries today contains 10% bioethanol and 90% petrol, and diesel fuel can be blended with up to 7-8% of biodiesel. Cars can also be powered by methane, which exists in different forms, including natural gas, biomethane and syngas. All of these are produced in different ways, but are all lower-CO<sub>2</sub> alternatives that can contribute to greening transportation, according to the stakeholders involved.

Altogether, although the different fuel options have been analysed and evaluated in isolation and therefore are not additive, it seems their CO<sub>2</sub> reduction potential is significant. According to EURELECTRIC and other stakeholders, on a tail-pipe emission basis, ECVs (electric cars and fuel cell electric vehicles) could bring CO<sub>2</sub> emissions reductions of up to 15% by 2030 compared to 2015. Based on assumptions by the European Biodiesel Board (EBB) and other stakeholders, biodiesel could produce CO<sub>2</sub> emissions reductions of up to 15% across the car fleet by 2030, if we were able to take advantage of advanced biodiesel. Bioethanol could cut CO<sub>2</sub> emissions by 10% if E20 fuel were to be developed commercially, according to estimates made based on ePURE figures. Methane, meanwhile, could produce 7% of CO<sub>2</sub> reductions by 2030.

## Intelligent transport systems (ITS) and the connected car

ITS in general and more specifically connected car technologies, are instrumental in empowering drivers to make optimal decisions with regards to driving: real-time information that helps drivers make better decisions about routes to take, where to park and other driving decisions that are based on data provided by public and private providers. ITS and connected car technology can help lower fuel consumption, reduce costs and lower CO<sub>2</sub> emissions.

These technologies appear to have major CO<sub>2</sub> reduction potential, which is shown by multiple recent projects and studies. They bring together technologies that include adaptive cruise control, eco-routing, intelligent parking management and coordinated traffic control mechanisms. They use traffic data to advise individual drivers on routes that are shorter, quicker and use less fuel. Depending on the number of drivers using them, they can therefore also contribute to reducing congestion. This means overall CO<sub>2</sub> emissions of cars on the road would decrease, as idling, and stopping and starting, use considerable amounts of fuel and thus produce sizeable quantities of CO<sub>2</sub>.



It is not straightforward to calculate the total CO<sub>2</sub> reduction potential of these technologies, as the applications produce CO<sub>2</sub> reductions under specific conditions – for instance, traffic light control is effective in urban areas. In addition, it is not possible to add up figures from individual applications, as the effects of different applications can produce diminishing marginal returns. However, based on an assessment by ERTICO of recent European studies and trials, it seems that an annual CO<sub>2</sub> reduction of 5-15% by 2030 (compared to 2015) is feasible.

## Road infrastructure

The road network and infrastructure can also play a sizeable role in cutting CO<sub>2</sub> emissions from road transport. CO<sub>2</sub> emissions from cars and light commercial vehicles vary substantially depending on the types of surfaces used and frequency of maintenance, but also on the planning and design of future roads and upgrades to existing routes.

The stakeholders involved in this workstream report that one of the key drivers for CO<sub>2</sub> emission reductions is ensuring Europe's roads have low-resistance and well-maintained surfaces – as increased friction means greater fuel consumption and thus greater CO<sub>2</sub> emissions. Maintenance of roads keeps them smooth and reliable, meaning lower resistance and overall CO<sub>2</sub> emissions. But further reductions can be achieved through upgrades to road surfaces, such as the use of low rolling-resistance asphalt, smooth concrete surfaces and noise-reducing asphalt or concrete.

New technologies such as the integration of ITS technologies into roads, using renewable energy to power signs and lights, and combining drainage and carbon sinks planted alongside roads, can also contribute to cuts in CO<sub>2</sub> emissions, say the stakeholders. Roads bringing together these technologies are known as 'smart roads'. They can be combined with greater investment in new and upgraded road infrastructure, including road-widening as well as building bridges and tunnels. This must all be part of a more general coherent spatial strategic vision when dealing with road infrastructure.

The overall conclusion was that maintaining and upgrading roads surfaces can have a substantial impact on CO<sub>2</sub> emissions. At the renewal speed as recommended by several stakeholders, all of Europe's roads could be resurfaced with lower-rolling resistance surfaces within 20 years, resulting in CO<sub>2</sub> reductions of up to 5% by 2035 and 3.75% by 2030 (compared to 2015), according to the European Asphalt Pavement Association (EAPA).

## Eco-driving

Driving behaviour is also essential to cutting CO<sub>2</sub> emissions, stressed the participants in this workshop. 'Eco-driving' is a set of techniques and behaviours that drivers can use to prepare their vehicle before a journey, plan their journey and drive in a more ecologically-friendly way to lower fuel use. Some of these methods include car maintenance, reducing vehicle weight, planning trips to avoid congestion, but also reducing engine idling and driving at more appropriate and stable speeds.

Many of the most effective training initiatives in terms of CO<sub>2</sub> reduction potential have centred around teaching, as proper eco-driving training can have a substantial impact on CO<sub>2</sub> emissions. Public information can help increase awareness among the general population – such as programmes in the UK which aimed to communicate eco-driving to a wider audience. Alongside this, individual companies have also engaged in initiatives to promote eco-driving among employees.

Technologies that provide data and driving advice to drivers can also help them make better decisions in real-time.

On-board tools can provide recommendations on different aspects, including idling, speed fluctuations, optimal 'green speed' and gear shifts, which can all help drivers make more environmentally-friendly driving decisions (even those without training).

Assuming that eco-driving is learnt and maintained over the long term, via regular training 'top-ups', the potential for CO<sub>2</sub> emission reduction is up to 10% in a best-case scenario, according to the RAC Foundation. Combined with growth in technologies built into cars that help drivers lower their CO<sub>2</sub> emissions, an annual eco-driving-based reduction in CO<sub>2</sub> emissions of 10% (compared to 2015) is realistically achievable by 2030, according to the European Driving Schools Association (EFA).

## Realising the potential of a comprehensive approach

To realise the potential of a comprehensive approach to reducing CO<sub>2</sub> emissions from road transport, Europe must recognise the economic, political, administrative and behavioural obstacles to the roll-out of these technologies and approaches. It must put in place a framework and instruments that will enable and accelerate the impact of a comprehensive approach. Some of these obstacles and policy approaches, as identified by the stakeholders, are cross-cutting, touching on several of the areas covered in this report, whilst others are specific to individual areas like fuel options or eco-driving.

### A need for greater investment

Whilst the CO<sub>2</sub> reduction potential of the different technologies and approaches outlined above is clear, the consensus among stakeholders was that this potential cannot be realised without increased investment. The conclusion was that this would be needed in the following areas:

- **Research and development** – science and innovation are key to developing technologies and approaches that can help fuel the decarbonisation of road transport. To unlock their potential, greater investment is needed in the science that can help them succeed.

In terms of developing alternative fuel options and making them more viable alternatives to traditional fuels, more research and development is needed to make them even more sustainable and better-functioning to provide the same performance as cars with conventional engines. For electric cars, there is a clear need for increased investment in the development of batteries that can be charged more quickly, with increased performance and at a lower cost. For hydrogen vehicles, support for more research and development in fuel cell technology to allow for longer stack life and cost reduction is needed, as well as in electrolyser development and hydrogen large scale storage and distribution systems. Regarding liquid biofuels, there is a need to develop engines that can cope with new biofuel mixes, but research should also focus on boosting second generation biofuels that do not create competition with food crops.

- Research and development is also important in terms of ITS and eco-driving technologies that can reduce CO<sub>2</sub> emissions from cars and light commercial vehicles. These technologies can already produce CO<sub>2</sub> reductions, but many are still in their early stages and need further investment in order to be fully scaled up.
- **Renewable energy** – regarding ECVs, the carbon footprint of these vehicles is directly related to the source of electricity generation. That is why greening the power supply is key, as wind, solar, biomass and other renewable

or low-carbon energies ensure a very low emission electricity and hydrogen supply chain. On hydrogen especially, development of wind-to-hydrogen and similar techniques is a sine qua non for fuel cell vehicles to be truly low- (or zero-) carbon.

- **Infrastructure** – investment in road infrastructure is currently not taking place to the extent that many stakeholders believe it should. It is estimated that, for example, some countryside roads in the UK have not been upgraded in 70 years, whereas stakeholders believe maintenance cycles should be closer to 20 years. There is a need for an ‘asset management’ approach that views road infrastructure as an economic and environmental asset that requires constant investment over time, rather than a burden that only requires spending when things go wrong.

The total cost for Europe’s 28 Member States to resurface the entire European road network spread over a 20 year timeframe is between €520bn and €780bn, according to the European Asphalt Pavement Association (EAPA). This is on average roughly €26-39bn per year for Europe as a whole for the next 20 years. Here, funding streams such as the Juncker Investment Plan can play a positive role, various stakeholders underline.

Infrastructure investment is also crucial to enabling the development of alternative fuel options, ITS and eco-driving, the stakeholders reported. Europe currently lacks sufficient charging points for electric cars and fuel stations for hydrogen and methane (natural gas, biomethane and syngas). There is also too little investment in sensors for traffic monitoring and telecoms infrastructure, essential to the success of ITS and eco-driving technologies.

### Accelerating take-up of alternative fuel options

To encourage take-up of alternative fuel options, stakeholders underlined the importance of a stable and positive tax and regulatory framework that fully takes into account the CO<sub>2</sub> emissions reductions generated by their use. This framework must encourage innovation through subsidies, tax breaks, market liberalisation and other incentives that will improve technology, lower prices for consumers, and increase access.

In addition to investment in battery technology and charging infrastructure outlined above, the growth of ECVs in particular requires better promotion of charging at work and public places, stakeholders underlined. This should be combined with an effort to build smart charging into driver behaviour, which is essential to ensure that the growth of the ECV market has as low an impact on the power grid as possible. Educating drivers on smart charging techniques will reduce overall pressure on the grid, meaning lower CO<sub>2</sub> emissions.

Regarding liquid biofuels, it is important to promote sustainability and limit Indirect Land Use Change (ILUC), as far as it can be measured. The debate around bioethanol and biodiesel has led to a directive which limits at 7% the use of biofuels grown on agricultural land. This is based on debated concerns regarding the possible consequences of higher CO<sub>2</sub> emissions due to land-use changes around the world induced by the expansion of croplands for biofuels production, in response to the increased global demand for biofuels. This is why work by all stakeholders to develop more sustainable biofuels as well as second generation biofuels is so important.

The development of a truly European market for methane as a fuel for vehicles is essential to stimulate its uptake, argued the stakeholders. At the same time, there must be a level playing field for alternative fuels, particularly when comparing electricity and methane and how the energy is produced. More should also be done to promote power-to-gas technologies that would harness renewable energy to synthetically create low CO<sub>2</sub>-emissions methane.

## ITS and connected car technologies: data sharing, privacy and interoperability

According to several stakeholders, improving the quality of data and access to it is essential to realising the full potential of ITS. Data is however a difficult issue, because policy makers must balance concerns over individual data protection with a recognition that there is not currently enough data sharing between public authorities, technology and online service providers, and the public. Unless this is addressed, the full potential of ITS cannot be unlocked.

A related issue is the need for better interoperability between data sets from different sources, and connected technologies used in different cars. Public authorities can play a role in encouraging more standardisation in terms of measurements and guidance, as well as common data formats.

## Improving road infrastructure

On top of investment, several stakeholders believe there is a need to set standards for road infrastructure investment. This includes Strategic Environmental Assessments (SEAs) and certification, which would serve as a quality benchmark for future investment and encourage new projects to aim higher.

Stakeholders believe that increased harmonisation and the creation of a stable European regulatory framework could be helped by the creation of a European Road Authority on the same model as the already existing European Railway Agency. Such an agency could play a major role in better coordinating European policies on road infrastructure maintenance and development, meaning a more strategic overview of European-level priorities, as well as the sharing of expertise.

## Education and behavioural change

Drivers themselves can play a positive role in cutting CO<sub>2</sub> emissions, according to several stakeholders. Environmentally unfriendly driving behaviour can have a significant impact on carbon emissions. That is why there is a need to change driver behaviour.

For eco-driving, public information and education is essential for ensuring that people understand the impact of their driving behaviour on fuel consumption and CO<sub>2</sub> emissions, and in providing them with the tools to reduce the environmental impact of their driving. One key element therein is the integration of eco-driving behaviour into driving training and tests, so that all new drivers will have had to learn some basic eco-driving techniques. This should be supplemented by ongoing training.

## Conclusion

The automobile industry continues to play a key role in driving down CO<sub>2</sub> emissions from cars and light commercial vehicles, and it accepts and embraces that responsibility. However, it is clear from the contributions of the stakeholders across the four workstreams that a comprehensive approach bringing everyone to the table is not only common sense – it also has enormous potential.

Delivering a significant shift downwards in CO<sub>2</sub> emissions from road transport requires a multi-faceted and multi-stakeholder approach. Whilst the potential to reduce CO<sub>2</sub> emissions has become clear through the discussions and contributions that have taken place in each of the workstreams, it is also clear that the barriers to this potential are very real. Harnessing the potential CO<sub>2</sub> emissions reduction power of fuel options, ITS and connected cars, infrastructure and driving behaviour will deliver huge societal benefit, but it needs some common support.

One of the most crucial obstacles, which cuts across all of the pillars of the initiative, is the lack of investment in the drivers of CO<sub>2</sub> emissions reduction. This certainly applies to research and development, where stakeholders agree the EU and its Member States must do more to develop alternative fuel options, more high-performing batteries, drive fuel cell stack life improvement and electrolyser efficiencies, and push development of new biofuel mixes and ITS and eco-driving technologies. In addition, this discussion also applies to investment in renewable energy, road infrastructure, and charging and refuelling infrastructure, where additional spending is essential.

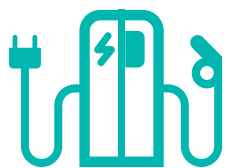
Alongside this, there is a cross-cutting need for a stable and supportive regulatory and tax regime that nurtures and encourages innovation through greener fuel options, technologies and infrastructure. Stakeholders underlined a particular need for subsidies, tax breaks, market liberalisation and other incentives that will improve technology, lower prices for consumers, and increase access.

Furthermore, clearer data sharing and privacy policies must strike a balance between individual data protection and the need to share more data to improve ITS technologies. This should be combined with common standards for ITS technology and road infrastructure investment; and more proactive efforts to boost eco-driving techniques and training.

No one organisation, industry or institution can tackle all of these challenges alone. The conclusion across all of the four workstreams, and of this initiative on the whole, is that the CO<sub>2</sub> reduction potential can only be unlocked by joining forces. By combining the ongoing work of the automobile industry to improve vehicle technology and fuel efficiency with the work of all the other stakeholders to drive efficiency and CO<sub>2</sub> emissions reduction, the 'Joining forces' initiative demonstrates the importance of the comprehensive approach.

# FUEL OPTIONS

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# 1. Fuel options

## 1.1 Introduction

As part of a drive to cut CO<sub>2</sub> emissions from cars and light commercial vehicles, automobile industry players continue to improve the conventional internal combustion engine, which is a key driver for CO<sub>2</sub> emissions reduction as well.

The stakeholders that have been consulted for this chapter believe that CO<sub>2</sub> emissions of cars and light commercial vehicles could be further reduced. One of the ways to do this is by working to better develop alternative, low-carbon fuels – a move which can be as beneficial for Europe's economy as it is for the planet.

This chapter will focus on a variety of alternative fuel options for cars and light commercial vehicles, which can be divided in three categories:

- Electrically chargeable vehicles (electric cars, hybrids and fuel cell electric vehicles);
- Liquid biofuels (bioethanol and biodiesel);
- Methane (natural gas, biomethane and syngas).

For each of these technologies, this chapter looks at the CO<sub>2</sub> reduction potential by 2030 – based on the potential CO<sub>2</sub> emissions per vehicle (in grammes CO<sub>2</sub> per km) and the uptake of the specific technology. In addition, this chapter studies how this potential could be realised, including identifying practical obstacles, as well as policies and other enablers to overcome these obstacles.

The European Road Transport Research Advisory Council (ERTRAC) underlines that we need to allow all alternative fuels to succeed in order to contribute to a low carbon future – as only time will tell which are best-adapted to take the transportation revolution forward. Yet, FuelsEurope underlines the need for caution. The task of transitioning from petroleum to other fuels is a substantial one, following which their view is that we need to be realistic about the speed with which this can be achieved. Many alternative fuels have significant costs and currently require subsidies. Consequently, there should be no let-up in efforts to ensure conventional engines become even more efficient.

## 1.2 Electrically chargeable vehicles

There are many different definitions of electrically chargeable vehicles (ECVs). For this report we follow McKinsey's definition, which describes ECVs as "all vehicles for which an electric motor is the primary source of propulsion," including plug-in hybrid electric vehicles (PHEVs), range-extended electric vehicles (REVs), battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs).<sup>1</sup> For this subchapter ECVs are split into two subcategories:

- Electric cars (EVs) – which includes plug-in hybrid electric vehicles (PHEVs), range-extended electric vehicles (REVs) and battery electric vehicles (BEVs);
- Fuel cell electric vehicles (FCEVs).

<sup>1</sup> [http://www.mckinsey.com/~/media/McKinsey%20Offices/Netherlands/Latest%20thinking/PDFs/Electric-Vehicle-Report-EN\\_AS%20FINAL.ashx](http://www.mckinsey.com/~/media/McKinsey%20Offices/Netherlands/Latest%20thinking/PDFs/Electric-Vehicle-Report-EN_AS%20FINAL.ashx)

Thus when the term ECVs is used, it refers to the entire category, whereas EVs cover only battery-powered and hybrid cars.

These types of cars have different advantages. BEVs are entirely powered by electricity, meaning that their CO<sub>2</sub> emissions reduction potential is greater. But because of limits in battery capacity and long recharge times, they are mainly used for short, urban trips.<sup>2</sup> PHEVs have a smaller battery capacity than BEVs, but also have conventional internal combustion engines (based on liquid or gaseous fuels), meaning a greater total range.<sup>3</sup>

ECVs as a technology have existed for many years, yet it is only recently that they have been developed commercially as a serious alternative to traditional petrol and diesel powered vehicles. As the European Commission points out, “electricity as an energy vector for vehicle propulsion offers the possibility to substitute oil with a wide diversity of primary energy sources. This could ensure security of energy supply and a broad use of renewable and carbon-free energy sources in the transport sector which could help the European Union targets on CO<sub>2</sub> emissions reduction.”<sup>4</sup>

According to AVERE (European Association for Battery, Hybrid and Fuel Cell Electric Vehicles) technologies around ECVs have now developed to an extent where they are clearly commercially viable and a serious option for drivers.

Yet, much must still be done to fully unlock the potential of ECVs in terms of CO<sub>2</sub> emissions reduction, focusing on two key drivers: the commercialisation of increasingly high-performance ECVs fuelling a growing market share, and the ‘greening’ of the power supply.

### 1.2.1 Electric cars (including plug-in hybrids)

#### A growing market, offering huge potential for decarbonising road transport

Global sales of EVs have doubled in each of the past three years. According to McKinsey, although global and European sales figures are still small (below 1% of total new car registrations), there seems to be a gradually increasing momentum behind EV adoption – both from the side of the consumer and the automobile industry – suggesting that electrified powertrains will play an important role in Europe’s mobility going forward.<sup>5</sup>

The European electricity industry, represented by EURELECTRIC, has the same message: the EV market (including plug-in hybrids) is set to grow exponentially over the next 20 years. Depending on scenarios, in 2030 the market share of EVs could be between 8.6% and 17.7% of the total European car market, reaching roughly 22% of market share by 2035. This will be driven by several factors, most importantly increasing battery capacity, but also ensuring that these EVs with longer ranges become more price competitive compared to conventional cars.

#### Greening power – the CO<sub>2</sub> reduction potential

EVs rely on electrical power, meaning they can only be as ‘green’ as the electricity used to power them. Europe is making significant progress in reducing the carbon intensity of its electricity supply. According to EURELECTRIC, in 2013, more than half of the electricity generated in Europe came from low-carbon facilities (mostly wind, solar and nuclear energy) and in addition more than 70% of the new power capacity installed in 2013 was renewable. EURELECTRIC forecasts that more than 70% of electricity produced in Europe will come from low carbon sources by 2030 (of which 47% would be renewables). But production varies from country to country. In Denmark 40% of energy

<sup>2</sup> <http://www.going-electric.org/assets/Uploads/Documents/cen-cenelec/charging-priorities-for-ev-users.pdf>

<sup>3</sup> <http://www.hybridcars.com/who-makes-the-most-useful-plug-in-hybrid/>

<sup>4</sup> [http://ec.europa.eu/transport/themes/urban/vehicles/road/electric\\_en.htm](http://ec.europa.eu/transport/themes/urban/vehicles/road/electric_en.htm)

<sup>5</sup> [http://www.mckinsey.com/-/media/McKinsey%20Offices/Netherlands/Latest%20thinking/PDFs/Electric-Vehicle-Report-EN\\_AS%20FINAL.ashx](http://www.mckinsey.com/-/media/McKinsey%20Offices/Netherlands/Latest%20thinking/PDFs/Electric-Vehicle-Report-EN_AS%20FINAL.ashx)



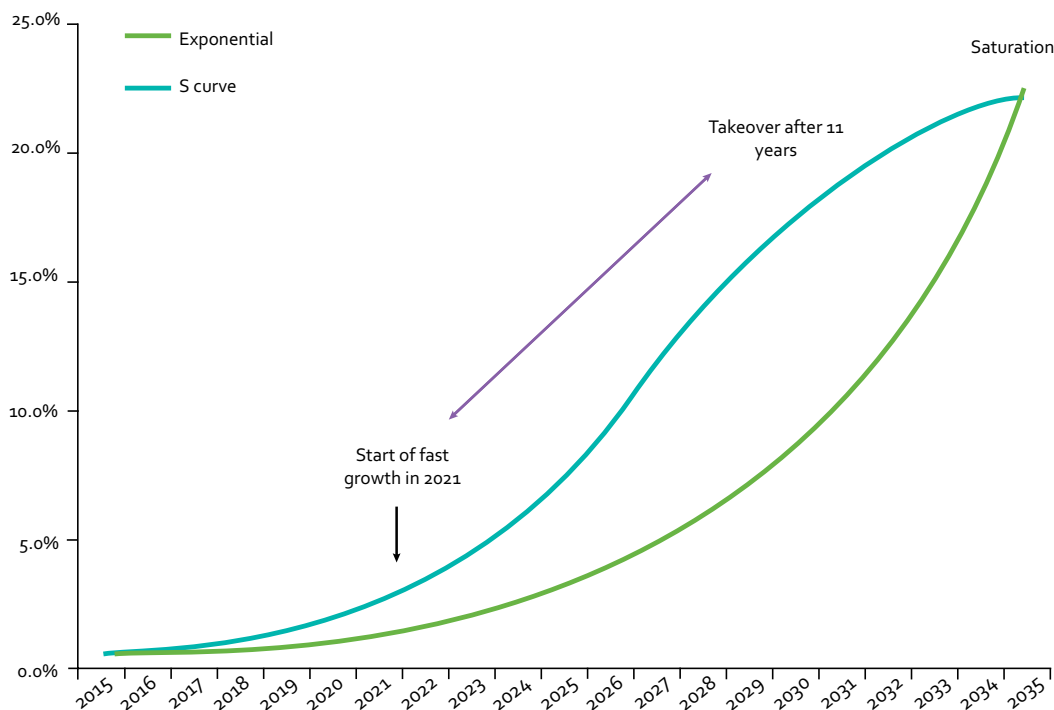


Figure 1: EV market uptake in a transition scenario (%) (theoretical approach S-curve vs exponential curve)  
Source: EURELECTRIC smart charging and e-mobility survey

already comes from wind. In Poland, however, over 75% of the power mix is coal (hard coal plus lignite), though this is projected to decline significantly by 2030.<sup>6</sup>

Wind energy can play an important role, according to the European Wind Energy Association (EWEA). Today, the wind power capacity installed in Europe can already cover 10% of the EU's total electricity consumption. Offshore wind has been described by the European Commission as the 'energy of the future',<sup>7</sup> while recent forecasts suggest that it could generate up to 18% of the world's electricity by 2050.<sup>8</sup> In 2014, wind energy allowed Europe to reduce CO<sub>2</sub> emissions by 190 million tonnes.

Solar power can also feed into the electrical system and reduce the overall CO<sub>2</sub> emissions of the electricity used to power cars. As SolarPower Europe points out, the potential of solar energy is already being unlocked today (covering 3.5% of the EU's electricity demand). The cost-competitiveness progresses faster and faster every year, and there are no technologies that can match the continued and considerable cost reductions for power generation.<sup>9</sup>

<sup>6</sup> [http://www.agora-energiewende.org/fileadmin/downloads/publikationen/CountryProfiles/Agora\\_CountryProfile\\_Poland\\_022014\\_web.pdf](http://www.agora-energiewende.org/fileadmin/downloads/publikationen/CountryProfiles/Agora_CountryProfile_Poland_022014_web.pdf)

<sup>7</sup> <http://www.ewea.org/policy-issues/offshore/>

<sup>8</sup> <https://www.iea.org/newsroomandevents/news/2013/october/wind-power-seen-generating-up-to-18-of-global-power-by-2050.html>

<sup>9</sup> [http://www.solarpowereurope.org/fileadmin/user\\_upload/documents/Media/2506\\_SolarPoweredEurope1.pdf](http://www.solarpowereurope.org/fileadmin/user_upload/documents/Media/2506_SolarPoweredEurope1.pdf)

## Smart charging

An important factor influencing the carbon intensity of EVs is that the need for additional electrical production varies depending on when electric cars are charged. Indeed, were all charging to take place outside peak times, the electrical system could cope with EVs without any additional investment, according to EURELECTRIC.

They believe that because most cars, including EVs, are parked for about 90% of their lifetime, there is scope for valuable flexibility. The combination of the significant storage capacity of EVs and the fact that batteries are not generally used entirely on an average day, means EVs could be charged at times when the system is capable of producing more electricity but currently does not. Through smart charging<sup>10</sup> this available capacity could be used in a much more efficient way.

Smart grids could enable EVs to provide flexibility services to the power system in two ways:

- With load management for EV charging, the charging process can be controlled by shifting the charging period to times of lower demand, reducing or increasing the charging power, or interrupting the charge of the car's battery in case of emergency situations. Additionally, it can be combined to coincide with available renewable energy sources such as wind or solar.
- In the longer term, EVs could bring even greater flexibility by supplying power back to the grid or home in a vehicle-to-grid (V2G) or vehicle-to-home (V2H) scenario – essentially meaning that EVs could function as portable batteries for the power grid or the home.

Driving an EV saves, on average, 5000 kWh per 10,000km, or 700 litres of fuel, compared to a conventional car, according to AVERE.

Based on EURELECTRIC projections on the growth of the market and on the 'greening' of the power supply, CO<sub>2</sub> reductions could be substantial. Assuming power sector CO<sub>2</sub> intensity of 330g CO<sub>2</sub>/kWh in 2010, a typical EV emits around 66g CO<sub>2</sub>/km, compared to an average of 126g CO<sub>2</sub>/km for new cars in 2030. As the electricity supply becomes less carbon intensive, EVs could emit as little as 28g CO<sub>2</sub>/km by 2030 – in other words, less than a quarter of emissions from conventional cars. **From that perspective, based on estimates by relevant stakeholders, including EURELECTRIC's assumption of EV market share reaching 8.6 to 17.7% in 2030, total CO<sub>2</sub> emissions reduction potential of EVs across the European car fleet could be between 6% and 14% in 2030.**<sup>11</sup>

<sup>10</sup> [http://www.eurelectric.org/media/169888/20032015\\_paper\\_on\\_smart\\_charging\\_of\\_electric\\_vehicles\\_finalpsf-2015-2301-0001-01-e.pdf](http://www.eurelectric.org/media/169888/20032015_paper_on_smart_charging_of_electric_vehicles_finalpsf-2015-2301-0001-01-e.pdf)

<sup>11</sup> EURELECTRIC, at 'Joining forces' workshop

## NORWAY – LEADING THE WAY FOR ELECTRIC CARS

- Norway is a major success story in terms of EVs – there are now about 75,000 EVs on the road, and 22% of new car sales in Q3 2015 were electric. This growth is as impressive as it is swift.
- To stimulate EV penetration, charging infrastructure is essential. Norway has worked to make charging points widely accessible.
- In addition, Norway's cross-political agreement on managing climate change from 2012 was an important milestone in efforts to reach national decarbonisation goals. This includes a car import tax that has proven to be a key tool: the country has a levy calculated on the basis of a car's CO<sub>2</sub> emissions, NO<sub>x</sub> emissions, effect and weight. By gradually tuning the system to reward cars with low emissions, and penalise cars with higher emissions, the import tax plays a vital role in making low-emission cars attractive to consumers.
- This is fuelling significantly increased use of electric vehicles. Without zero emission vehicles and plug-in hybrids, 2020 targets are not attainable. Therefore, nudging consumers to buy low-emission cars will be the key to achieving those goals.
- Thanks to policies in place, CO<sub>2</sub> emissions of new cars in Norway have already gone down significantly and will continue to do so: by 2020, the fleet-average CO<sub>2</sub> emissions from new passenger cars in Norway should be 85g per kilometre. For comparison, fleet-average emissions in 2012 were 130g per kilometre.
- According to the Norwegian EV Association, effective policies to support EVs in Europe could lead to a market share of EVs in Europe which would be similar to the level in Norway, and therefore they believe the potential for CO<sub>2</sub> emissions reduction is around 30 % by 2030.

### Realising the CO<sub>2</sub> reduction potential of electric vehicles (EVs)

As outlined, the CO<sub>2</sub> emissions reduction potential from EVs is substantial, but there remain many formidable challenges. The two key ones are battery technology and charging infrastructure.

On batteries, cost and performance are still significant challenges to the commercialisation of EVs. Technology is becoming better and cheaper, with longer lifespans, but this is a long process, according to RECHARGE (European Association for Advanced Rechargeable Batteries). The graph on the next page shows the optimum and minimum scenarios for capacity, cost and range of batteries between 2015 and 2035.

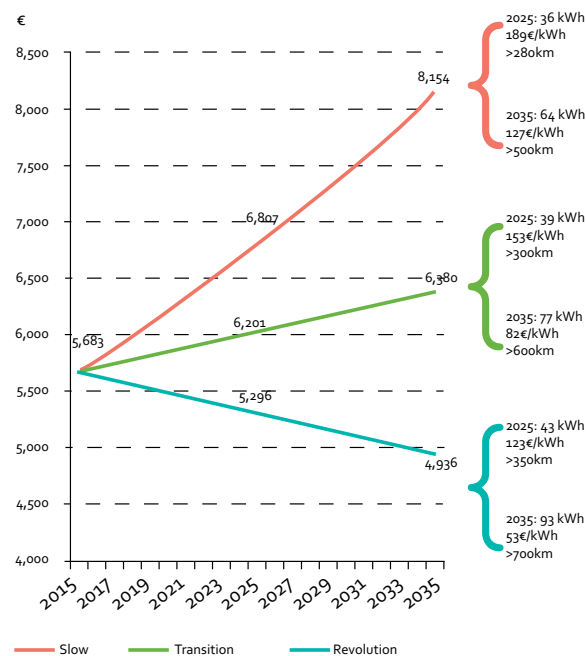


Figure 2: Development of battery cost (€) and capacity (kWh) in the three scenarios  
Source: EURELECTRIC smart charging and e-mobility survey

RECHARGE indicates that each battery generation is likely to be in production for four to five years at least to recoup capital investments and research and development costs: so the 2011/2012 introduction of the first generation of automotive lithium-ion batteries implies that the second generation batteries would be commercialised in 2016/17 and third-generation batteries only in the early 2020s. As generations of batteries improve, battery life improves too. This makes electric vehicles a more attractive option for drivers. As batteries are the most expensive single component of an EV, lessening the need to replace them makes them more economically viable. By 2020, average battery life might be in the 13 to 15 year range.<sup>12</sup>

This is vital because, as CLEPA underlines, consumers will only switch to alternative fuels if they face no incremental cost or if they are convinced of the added value. The lower the price of fossil fuel, the less likely it is that consumers and manufacturers will fully embrace alternative fuels like electric vehicles, liquid biofuels or methane.

Batteries are also seen as a challenge in terms of their sustainability and particularly how they are treated at 'end of life'. However, the European Commission believes it is generally understood that, unlike cadmium and lead based batteries, current known formulations of the rechargeable Li-Ion battery, which is increasingly used in ECVs, do not present significant environmental concerns. In addition, battery recycling will most likely require government mandates or subsidies to be economical.<sup>13</sup>

In addition to smart charging and home charging, developing charging infrastructure is also essential. One of the most important drivers in growing EVs is ensuring charging infrastructure exists – and Norway has been particularly good at this. In Norway, 95% of electric car owners have charging access at their homes, and almost 60% of the country's EV drivers have access to charging stations at their places of work, meaning that finding a place to charge

<sup>12</sup> [http://ec.europa.eu/clima/policies/transport/vehicles/docs/summary\\_report\\_en.pdf](http://ec.europa.eu/clima/policies/transport/vehicles/docs/summary_report_en.pdf)

<sup>13</sup> [http://ec.europa.eu/clima/policies/transport/vehicles/docs/summary\\_report\\_en.pdf](http://ec.europa.eu/clima/policies/transport/vehicles/docs/summary_report_en.pdf)

one's EV is rarely a problem. Yet, public charging is also needed. While home and office charging stations remain the most popular, these are not necessarily practical for city-dwellers who often do not have their own garages and park on the street. In London, for instance, two-thirds of homes have neither a garage nor off-street parking.<sup>14</sup> Electric cars are also not yet practical for long-distance travel. McKinsey underlines that while increasing battery capacity can help alleviate some of these issues, limited ranges mean that "most drivers would have an occasional need for additional charging outside of their homes or workplaces".

With this, there is also need to ensure 'fast charging' becomes ever faster. For full battery EVs, even fast-charging a battery to 80% will require 20-30 minutes (depending on battery size and fast-charging speed), and slow-charging a BEV usually takes multiple hours.<sup>15</sup> This makes long-distance travel difficult.

FuelsEurope warns that advocates for EVs should proceed with caution, as EVs still remain dependent on subsidies, which is not necessarily a sustainable model in the long term.

### Policies and other enablers

As the carbon footprint of EVs depends on the way the electricity is generated, more needs to be done to encourage low carbon uptake to fully unlock their potential. As EWEA and Solar Power Europe underline "investing in European renewable energy projects will be critical to the cost-effective realisation of our decarbonisation targets... a greenhouse gas target alone will not be sufficient to drive the investments in renewable energy and infrastructure which are necessary to decarbonise the power sector by 2050."<sup>16</sup> The organisations call for a binding renewable energy target for 2030. In addition, several other stakeholders pledge for a strong EU Emissions Trading Scheme (EU ETS), as the main driver to decarbonise the power sector.

EURELECTRIC believes much needs to be done to continue fuelling EV development. In particular, the electric industry group believes that there is a need to fully understand the new customer load and try to flexibly facilitate it, including the development of smart charging technologies as part of future smart grids. Several stakeholders believe that standardisation in charging is vital in boosting EVs.

RECHARGE underlines the need to couple the promotion of charging at working and public places with the implementation of home and office renewable energy. More homes with their own renewable energy (like solar panels), would increase the amount of clean energy used to power electric cars.

Many stakeholders have underlined that incentives, such as a favourable tax regime, need to be put in place to in order to continue to promote the growth of the EV category. EV penetration targets should not be thrown out the window, says EURELECTRIC, which underlines that while ultimately market forces must be the driver, without targets the market for EVs would not have developed as far as it has today.

Stakeholders also stressed that there is a need to provide stable legal, regulatory and tax frameworks for the 2020-2030 period to attract investment. EWEA in particular believes that countries must come forward with national plans for the roll-out of EVs, including market design, market integration and development of smart charging. EWEA also believes that the European energy market must be completed, ensuring the market is truly a single market. In so doing, it will be easier to work towards a system where renewables are the base load and are supplemented by variable production of other energy, and not the other way around.

<sup>14</sup> [http://www.mckinsey.com/-/media/McKinsey%20Offices/Netherlands/Latest%20thinking/PDFs/Electric-Vehicle-Report-EN\\_AS%20FINAL.ashx](http://www.mckinsey.com/-/media/McKinsey%20Offices/Netherlands/Latest%20thinking/PDFs/Electric-Vehicle-Report-EN_AS%20FINAL.ashx)

<sup>15</sup> [http://www.mckinsey.com/-/media/McKinsey%20Offices/Netherlands/Latest%20thinking/PDFs/Electric-Vehicle-Report-EN\\_AS%20FINAL.ashx](http://www.mckinsey.com/-/media/McKinsey%20Offices/Netherlands/Latest%20thinking/PDFs/Electric-Vehicle-Report-EN_AS%20FINAL.ashx)

<sup>16</sup> [http://epiadev.epia.org/fileadmin/user\\_upload/News/Joint\\_industry\\_letter\\_on\\_2030\\_RES\\_target.pdf](http://epiadev.epia.org/fileadmin/user_upload/News/Joint_industry_letter_on_2030_RES_target.pdf)

In terms of batteries, more investment is needed to develop lighter, longer-lasting and higher-performing batteries that can be recycled more easily. This should be a central focus of any transportation decarbonisation policy, according to RECHARGE.

### 1.2.2 Fuel cell electric vehicles

Fuel cell cars (FCEVs) are based on simple technology. Hydrogen atoms are stripped of their electrons to generate electricity and then combined with oxygen to form water as a by-product. The use of hydrogen as a fuel is thus carbon neutral, though its overall CO<sub>2</sub> footprint depends on the fuel used generate it, including electricity and methane.

FCEVs are being developed by many European, American and Asian auto producers. According to several stakeholders, fuel cell car roll-out is about to accelerate, as there is significant public funding for hydrogen and fuel cells in many countries – including at least \$100 million per year in the US, Germany, Japan and South Korea. Commercially, the technology is still in its infancy. Only California has installed a sizeable network of fuelling stations, though several European countries are planning to grow their networks.

#### Fuel cell electric vehicles – the potential

FCEVs have the potential to be almost completely carbon-neutral, depending on the energy mix used to produce hydrogen. Yet, FCEVs are currently not widely commercialised in Europe, with the first model available in Europe only released in autumn 2015.<sup>17</sup> However, there is cause for some enthusiasm. Cost for fuel cell vehicles have dropped by 50% since 2006 and 30% since 2008, according to the US Department of Energy.<sup>18</sup>

The potential for FCEVs to contribute to CO<sub>2</sub> emissions reduction could be substantial, as fuel cell engines are highly energy efficient. They use 40-60% of the energy available from hydrogen, compared to internal combustion engines, which currently use only about 20% of the energy from petrol.<sup>19</sup> Secondly, unlike EVs, they have a comparable vehicle range and refuelling time to petrol vehicles.

The most detailed projections suggest a FCEV today would produce 200g of CO<sub>2</sub>-equivalent per mile or 124g of CO<sub>2</sub> per km, using methane to produce hydrogen. This could be even lower in Europe, as the electricity produced in Europe, which is required to produce hydrogen, is 'greener' than in the United States.<sup>20</sup>

One recent market study projected that worldwide annual sales of FCEVs could reach 2 million by 2030, of which roughly 750,000 would be in Europe.<sup>21</sup> Based on 2025-2030 annual sales targets, it could reasonably be projected that the total fuel cell car fleet in Europe could reach 2 million by 2030.

**Assuming hydrogen produced entirely by renewable electricity (feasible when market share is still small), 2 million FCEVs in 2030, and a stable overall European passenger car fleet of 285 million,<sup>22</sup> stakeholders believe that total CO<sub>2</sub> reductions across the European car fleet could be up to 1%.**

<sup>17</sup> [http://www.greencarreports.com/news/1095511\\_2016-toyota-mirai-priced-at-57500-with-499-monthly-lease](http://www.greencarreports.com/news/1095511_2016-toyota-mirai-priced-at-57500-with-499-monthly-lease)

<sup>18</sup> <http://www.fueleconomy.gov/feg/fuelcell.shtml>

<sup>19</sup> [http://www.c2es.org/technology/factsheet/HydrogenFuelCellVehicles#\\_edn2](http://www.c2es.org/technology/factsheet/HydrogenFuelCellVehicles#_edn2)

<sup>20</sup> <http://www.c2es.org/technology/factsheet/HydrogenFuelCellVehicles>

<sup>21</sup> <http://www.greencarcongress.com/2013/05/fcvs-20130527.html>

<sup>22</sup> <http://www.acea.be/statistics/tag/category/vehicles-in-use>

## Realising the potential of fuel cell electric vehicles

The production of hydrogen requires electricity, and therefore can potentially itself be a source of CO<sub>2</sub> emissions. However, its storage and transportation is a challenge, as hydrogen has a very low volumetric energy density at ambient conditions, equal to about one-third that of methane. Were hydrogen to become a commercially widely available fuel, considerable investment would have to be made in storage facilities. These investments should also focus on promising developments with regards to on board hydrogen storage, as well as increasing deployment of power to gas solutions that could use the gas grid as 'storage' for hydrogen produced by intermittent renewable sources.

Cost is also a major challenge. Hydrogen fuel cells are expensive to produce, as they require expensive catalysts such as platinum. In 2002, the US Government estimated that the cost of a fuel cell for a vehicle was approximately \$275/kW, which translated into each vehicle costing an estimated 100,000 dollars.<sup>23</sup> By 2010, the cost had fallen 80% and it has been estimated that in the future automobile fuel cells might be manufactured for \$51/kW.<sup>24</sup> In 2015 the first commercially available affordable hydrogen fuel cell car was unveiled, at a consumer price of \$45,000.<sup>25</sup> However, FuelsEurope believes that hydrogen is not yet economically viable or sustainable, despite its potential.

As well as the costs of the cars, charging infrastructure is also a major issue, as there is currently no distribution network anywhere close to what would be needed to commercialise hydrogen vehicles. It is estimated that there are fewer than 95 hydrogen refuelling stations in Europe.<sup>26</sup>

## Policies and other enablers

The European Hydrogen Association (EHA) believes that, to encourage the growth of hydrogen fuel cell-powered vehicles, a key priority is the realisation of a dedicated hydrogen infrastructure, as "the market will not cater for a change to a low carbon transport system by itself, especially where high initial investments in infrastructure are at stake and imply disadvantage for the first movers."

In addition, a coherent and predictable long-term strategy, regulatory framework and financial support mechanism is also needed to attract the necessary (private) investments in both hydrogen infrastructure and vehicles.

Finally, the EHA believes that a public-private approach and better pooling of available public and private resources are also essential.<sup>27</sup> This would require more coordination and cooperation between the automobile industry, infrastructure providers, renewable energy suppliers, energy companies and local authorities.

<sup>23</sup> [http://www.greencarreports.com/news/1068346\\_toyotas-fuel-cell-car-for-2015-gets-a-whole-lot-more-expensive](http://www.greencarreports.com/news/1068346_toyotas-fuel-cell-car-for-2015-gets-a-whole-lot-more-expensive)

<sup>24</sup> <http://www1.eere.energy.gov/hydrogenandfuelcells/accomplishments.html>

<sup>25</sup> <http://www.extremetech.com/extreme/198231-test-drive-hydrogen-fuel-cell-toyota-mirai-cruises-300-miles-costs-45k-can-your-ev-do-that>

<sup>26</sup> <http://www.tuev-sued.de/company/press/news/54-new-hydrogen-refuelling-stations-worldwide-in-2015>

<sup>27</sup> <http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetailDoc&id=3087&no=1>

## 1.3 Liquid biofuels

By the European Commission definition, biofuels are “fuels such as biodiesel and bioethanol which are made from biomass. They serve as a renewable alternative to fossil fuels in the EU's transport sector, helping to reduce greenhouse gas emissions and improve security of supply.”<sup>28</sup> Europe's goal is to reach 10% of transport fuel from renewable sources such as biofuels by 2020, with an additional requirement to reduce the greenhouse gas intensity of the EU fuel mix by 6% by 2020 (compared to 2010).

Liquid biofuels – biodiesel and bioethanol – are for the moment mainly considered to be additives to traditional fuels. However, they can also be used as fuels themselves. The potential of biofuels has already been recognised by two European directives:

- The Renewable Energy Directive (2009/28/EC) introduced a mandatory target of 10% renewable energy in the EU transport sector, which can be met through eg renewable electricity, hydrogen and sustainable biofuels, including biomethane;
- The Fuel Quality Directive (2009/30/EC) mandates that lifecycle greenhouse gas emissions per unit of energy supplied should be reduced by 6% in 2020 (compared to the average level in 2010).

To be taken into account with regards to the targets of these directives, biofuels must meet sustainability criteria set by EU legislation.

### 1.3.1 Biodiesel

Biodiesel is produced from plant oils – such as rapeseed and sunflower – as well as recycled vegetable oils, recovered fats and tallow. Biodiesel is made by a reaction between lipids (eg vegetable oil, soybean oil, animal fat) and an alcohol producing fatty acid esters. Algae could also be used in theory, but its development is still in a pilot phase. EN14214 standard<sup>29</sup> biodiesel can currently be used in blends with conventional diesel of up to 7-8% by volume, and in captive transport fleets in a 30% by volume concentration. Readily available since the 1990s, biodiesel can be used in limited concentrations with existing fuel infrastructure and vehicle diesel technology.

#### CO<sub>2</sub> reduction potential of biodiesel

Currently, biodiesel reduces direct greenhouse gas emissions from road transport by at least 35% compared to fossil fuels as required by EU legislation, and in 2017 it will do so by at least 50%.<sup>30</sup> Considering that 25% of total EU greenhouse gas emissions comes from transport and given that 41% of all cars run on diesel fuel, there is significant CO<sub>2</sub> saving potential in the use of biodiesel to achieve EU climate goals, according to the EBB.

Today, the European biodiesel industry produces approximately 11Mtoe per annum of sustainable biodiesel and it remains the most widely used form of biofuel in the EU transport sector with a 78.2% share of total consumption (by energy).<sup>31</sup>

According to a report<sup>32</sup> of the European Climate Foundation (ECF), advanced biofuels from wastes and residues could deliver greenhouse gas reductions of 60-90% if sourced sustainably, and these figures are supported by the European Automotive Research Partners Association (EARPA).

<sup>28</sup> <http://ec.europa.eu/energy/en/topics/renewable-energy/biofuels>

<sup>29</sup> The standard for FAME – fatty acid methyl esters – the most common type of biodiesel.

<sup>30</sup> Fuels Quality Directive, 2009/30/EC. <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009L0030>

<sup>31</sup> European Commission DG for Internal Policies - The impact of biofuels on transport and the environments, and their connection with agricultural development in Europe, 2015

<sup>32</sup> <http://europeanclimate.org/wp-content/uploads/2014/02/WASTED-final.pdf>



In the view of the EBB, the CO<sub>2</sub> reduction potential of biodiesel can easily reach 60% for conventional biodiesel and go up to 90-95% for advanced biodiesel, which is based on wastes and residues. In addition, they believe biodiesel could make up to 16% of road transport fuel in 2030, if all the wastes and residues that are sustainably available in the EU were converted only to biofuels.

**Assuming that 16% of the car fleet could run on sustainable biodiesel from wastes and residues, from now until 2030, stakeholders believe that the development of biodiesel from this source alone could produce CO<sub>2</sub> emissions reductions of around 9 to 15% across the European passenger car fleet.**

### Realising the potential of biodiesel

One of the main challenges with regards to the development of biofuels, including biodiesel, is the debate around indirect land use change (ILUC), which is about the possible consequences of higher CO<sub>2</sub> emissions due to land-use changes around the world induced by the expansion of croplands for biofuels production. The debates have resulted in Directive 2015/1513<sup>33</sup> (adopted in 2015), which sets a limit of 7% for the use of biofuels grown on agricultural land, while allowing Member States to set lower national limits.<sup>34</sup> In the view of the EBB this directive recognises the importance of the EU biofuels sector, while acknowledging the existing doubts around the concept and measurement of ILUC.

Following a study from the University of Illinois<sup>35</sup>, which shows serious concerns in the methodology used to calculate ILUC-related emissions, several stakeholders urge caution on ILUC. Their view is that the aim should be to safeguard not just jobs and investments, but also the CO<sub>2</sub> emissions-reduction, by protecting existing biofuels production from ILUC factors.

The new Low Carbon Fuels Standard (LCFS<sup>36</sup>), which was recently adopted by the California's Air Resources Board (CARB), includes an analysis of the ILUC impact of biodiesel and shows significantly lower ILUC figures than used in EU legislation. Therefore, several stakeholders believe that these findings should be taken into account with regards to the EU post-2020 biofuels policies. In addition, post-2020 policies should include specific transport and greenhouse gas targets, building on what is already achieved to date with present legislation (the Renewables Directive and the Fuel Quality Directive).

In the view of the EBB, a specific target for renewable energy in transport, possibly combined with greenhouse gas emission saving requirements, would be preferred. This would ensure that future growth in the biofuels market should come from the best performing biofuels in terms of greenhouse gas performance, irrespective of whether these biofuels are conventional or advanced.

However, FuelsEurope believes that technology mandates are not cost-effective, as they often result in market distortion and sub-optimal allocation of resources. Therefore whenever technology mandates are used, they should aim at creating consistency to maintain the single market, based on achievable targets and have established science based sustainable credentials based on a well-to-wheel basis (which is a life-cycle assessment used for transport fuels and vehicles).

<sup>33</sup> <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015L1513&from=EN>

<sup>34</sup> <http://www.euractiv.com/sections/transport/parliament-rubber-stamps-eu-biofuels-reform-amid-final-controversy-314196>

<sup>35</sup> <http://www.ebb-eu.org/studiesreports/GTAP%20Report%20ILUC%20Aug%2030%202013%20Final.pdf>

<sup>36</sup> <http://www.arb.ca.gov/newsrel/newsrelease.php?id=760>

## 1.3.2 Bioethanol

Ethanol – or bioethanol – is also known as ethyl alcohol, and is produced by fermenting sugars into alcohol, using cereals, sugar beet, potatoes, or organic waste materials. In the face of considerations over land use, second generation bioethanol is often cited as a natural response, as it is produced by using agricultural residues such as straw, non-food materials and waste. While bioethanol is used by some cars as a fuel, it is mainly used as an additive to petrol. Widely used in countries like the United States (up to 10% of the petrol market) and in Brazil (up to 40%), it only represents about 4% of the total fuel consumption in petrol vehicles in the EU.<sup>37</sup>

### CO<sub>2</sub> reduction potential of bioethanol

Industry groupings like ePURE point out that bioethanol produces potentially substantial CO<sub>2</sub> emissions reductions, with up to 90% fewer greenhouse gas emissions than fossil fuels, and in 2014 an average greenhouse gas emissions reduction compared to petrol of 61%<sup>38</sup>, which is more than any other liquid transport fuel. Since 2003, the use of European bioethanol has led to greenhouse gas emissions reductions equivalent to taking 4.6 million cars off the European roads for one year.<sup>39</sup>

Most petrol in Europe contains up to 5% ethanol without causing any problems for cars.<sup>40</sup> In addition, almost all cars produced after 2000 can consume petrol with up to 10% ethanol (E10). E10 is currently available and labelled as such in France, Finland and Germany, while other European countries are considering its introduction. The share of E10 in Germany has increased continuously, reaching roughly 20% of sales.<sup>41</sup> In France E10's share is now 32% of petrol sales<sup>42</sup> and in Finland it is 61%.<sup>43</sup> FuelsEurope underlines, however, that bioethanol needs innovation to fuel second generation biofuels from non-food sources.<sup>44</sup>

The next step would obviously be to move towards E20 – 20% ethanol content – which would provide opportunities for car manufacturers to optimise the combustion process in the engine, allowing lower fuel consumption, reduction of CO<sub>2</sub> emissions and other pollutants even further. FuelsEurope underlines the need for an appropriate transition to E20 optimised engines, to facilitate customer acceptance.

**Under a scenario where 100% of passenger petrol cars run on E10, and assuming that ethanol reduces CO<sub>2</sub> emissions by an average of 60%, CO<sub>2</sub> reductions across the car fleet by 2030 could reach up to around 5% according to stakeholders. This could rise to a reduction of up to 10% or more with E20 in combination with optimised engines.**

### Realising the potential of bioethanol

One of the main challenges regarding the development of bioethanol has been the debate around ILUC, which has stalled the implementation of the Renewable Energy Directive and the Fuel Quality Directive in most Member States, hence delaying E10 roll-out across the EU. Presently the roll out of E10 across Europe is still slower than expected, but there are several good examples, eg in France and Finland, where E10's market share in petrol has increased since its introduction.

<sup>37</sup> <http://epure.org/media/1227/european-renewable-ethanol-statistics-2015.pdf>

<sup>38</sup> <http://epure.org/media/1227/european-renewable-ethanol-statistics-2015.pdf>

<sup>39</sup> <http://epure.org/about-ethanol/ethanol-benefits/innovation-and-advanced-biofuels/>

<sup>40</sup> <http://epure.org/about-ethanol/fuel-market/>

<sup>41</sup> <http://hveiti.dk/en/news/german-e10-sales-rise-overall-gasoline-sales-fall>

<sup>42</sup> [http://www.bioethanolcarburant.com/communique\\_presse/paris-le-11-fevrier-2015-croissance-du-bioethanol-en-france-en-2014-10-de-consommation-de-sp95-e10-et-200-nouvelles-stations-pour-le-superethanol-e85/](http://www.bioethanolcarburant.com/communique_presse/paris-le-11-fevrier-2015-croissance-du-bioethanol-en-france-en-2014-10-de-consommation-de-sp95-e10-et-200-nouvelles-stations-pour-le-superethanol-e85/)

<sup>43</sup> <http://www.e10bensini.fi/en>

<sup>44</sup> <https://www.fuelsEurope.eu/knowledge/how-refining-works/biofuels>

In addition to ILUC considerations, another block on E10 roll-out has been some poor experiences with regards to industry communication. This has in particular been the case in Germany, where there was widespread fear of engine failure when using E10 – even though most new petrol cars which came on the market after 2000 are E10 compatible. This is now being addressed by the Alternative Fuels Infrastructure Directive, which mandates the placing of clear information on compatibility at different points, including on the car itself and at the pump.

According to ePURE, a rapid implementation of the new biofuels policy framework is needed together with incentives for biofuels with no or limited ILUC risks, such as European ethanol.<sup>45</sup> The main reason for this is that many Member States are at risk of not reaching their targets because they have not sufficiently developed their biofuels markets.<sup>46</sup> In addition, the full roll-out of E10 is essential, regarding which Europe has currently enough ethanol production capacity to provide 83% of the ethanol needed for full penetration of the petrol market by E10. As a next step, the focus of the bioethanol industry is on the development of E20, which would not be constrained by sustainability concerns.<sup>47</sup> However, this must be coupled with a long term stable and ambitious decarbonisation policy for transport up to 2030, as well as a dedicated ramping up target for advanced biofuels, combined with intelligent financing.

In the view of FuelsEurope, the potential role of advanced biofuels, including bioethanol, should be better understood. In terms of decarbonisation, it points out some parts of the fuel industry are engaged in research and development, aimed at unleashing the full potential of advanced or second generation biofuels, which are produced from sources that do not compete with food. These may offer a long-term sustainable supply at a large scale, with lower greenhouse gas impact, and have the potential to be cost-competitive, along with avoiding competition with food production.<sup>48</sup> ePURE points out that the greenhouse gas savings credentials of European-derived ethanol are not in doubt, as with its average certified 60% savings against fossil fuels, ethanol is recognised as having low ILUC impact, making it, according to ePURE, the best tool to decarbonise transport fuels at scale.

Alongside this, all players agree that more must be done to deploy second generation bioethanol that do not have the ILUC impact of first generation ethanol. FuelsEurope advocates for greater research and development to create advanced biofuels that can be scaled up in a substantial way.<sup>49</sup>

Finally, ePURE stresses that policy is the main blocking factor for sustainable biofuels deployment and uptake. What is needed going forwards is an energy product taxation, based on the energy content and carbon footprint of the fuel, that would allow for a level playing field between fossil and non-fossil energy sources, and between alternative fuels, as well as an ambitious and long term decarbonisation policy for transport fuels.

<sup>45</sup> ILUC Prevention Strategies for Sustainable Biofuels, University of Utrecht, 2015, [http://epure.org/media/1231/synthesis\\_report\\_iluc\\_prevention.pdf](http://epure.org/media/1231/synthesis_report_iluc_prevention.pdf)

<sup>46</sup> [https://ec.europa.eu/energy/sites/ener/files/documents/SWD\\_2015\\_117\\_F1\\_OTHER\\_STAFF\\_WORKING\\_PAPER\\_EN\\_V5\\_P1\\_814939.PDF](https://ec.europa.eu/energy/sites/ener/files/documents/SWD_2015_117_F1_OTHER_STAFF_WORKING_PAPER_EN_V5_P1_814939.PDF)

<sup>47</sup> High ethanol blends - fuel ethanol demand-supply scenarios 2017-2035, AGRA CEAS Consulting & E4tech, 2015 (<http://epure.org/media/1245/high-ethanol-blends-demand-supply-scenarios-report-for-epure-by-agra-ceas-consulting-and-e4tech.pdf>)

<sup>48</sup> <https://www.fuelseurope.eu/knowledge/how-refining-works/biofuels>

<sup>49</sup> <https://www.fuelseurope.eu/knowledge/how-refining-works/biofuels>

## 1.4 Methane (natural gas, biomethane and syngas)

Methane exists in different forms, including natural gas, biomethane and syngas, which are produced in different ways, and which all have the same chemical composition and energy content. This section focuses on these different forms of methane separately and combined.

Methane is considered to be a low-carbon fuel, because its use generates significantly lower CO<sub>2</sub> emissions than other hydro-carbon fuels, such as oil and coal (due to its molecular structure). Methane also emits 90% less particulate matter and up to 50% less NO<sub>x</sub> compared to the very strict European emission standards for new vehicles (Euro 6).<sup>50</sup>

### Natural gas

Natural gas is a major source of energy, including for generating power, heating and cooling. In addition, natural gas as a vehicle fuel continues to develop in cars, vans, buses and trucks, including distribution and freight transportation. The fuel burnt in a natural gas engine mainly consists of methane. This can either be in the form of CNG (Compressed Natural Gas) or LNG (Liquefied Natural Gas). CNG is methane stored at very high pressure and is used for passenger cars, buses and trucks. LNG is natural gas which has been liquefied at very low temperatures (-162°C) for storage or transportation purposes and is widely used for trucks, but also for ships.

### Biomethane

Biogas can be used for heating, power generation and when upgraded to biomethane (which has the same qualities of natural gas) as a fuel for road transport. As the European Biogas Association (EBA) points out, biogas is produced during anaerobic digestion of organic substrates, such as manure, sewage sludge, and the organic fractions of household and industry waste, as well as of energy crops.<sup>51</sup>

Presently, 12 countries in Europe use biomethane together with natural gas, regarding which the majority is injected into the natural gas grid. Biomethane has the same tailpipe CO<sub>2</sub> emissions profile as natural gas. However, when taking into account its life cycle emissions, biomethane is a carbon neutral fuel, like green electricity.

The biogas market continues to grow as technologies spread, according to the EBA. In 2013, biogas energy output, estimated at almost 13.4 million tons of oil equivalent, enjoyed double-digit growth (up 10.2% on 2012). Regarding biomethane in particular, the EBA believes that up to 48-50 billion Nm<sup>3</sup> of biomethane could be produced per year by 2030.<sup>52</sup>

### Syngas

Syngas, or synthetic gas, is generated via gasification of surplus electricity (wind or solar). In such a power-to-gas system, renewable electricity is converted into hydrogen (through electrolysis) and then, by adding CO<sub>2</sub>, into synthetic methane. This is called synthetic natural gas or syngas, which could be injected into the natural gas grid. According to several stakeholders, using syngas in an NGV could significantly reduce CO<sub>2</sub> emissions.

Several European energy companies are active in this field. On the OEM side, Audi has even invested in its own power-to-gas plant in Northern Germany, in order to provide a solution to customers driving CNG cars.

<sup>50</sup> <http://www.ngva.eu/ng-vehicle-catalogue>

<sup>51</sup> <http://european-biogas.eu/wp-content/uploads/files/2013/10/EBA-brochure-2011.pdf>

<sup>52</sup> <http://european-biogas.eu/wp-content/uploads/2013/11/GGG-Biomethane-roadmap-final.pdf>

## CO<sub>2</sub> reduction potential of methane

According to the NGVA, methane could reduce tailpipe CO<sub>2</sub> emissions with 30%, compared to petrol in state of the art CNG cars. Further significant reductions can be achieved via blends of CNG with biomethane or hydrogen, and by using direct injection technology, which is not yet applied to CNG and LNG.

When also taking into account the high octane number of the methane, which is 130, providing the opportunity for higher compression ratios, as well as the possibility to use direct injection technology, future CNG engines can realise a 40-50% CO<sub>2</sub> reduction. This is also shown by a joint CNG project of Bosch and Daimler.<sup>53</sup>

Presuming that 10-20% of the methane mix will come from renewables (biomethane and power-to-gas) by 2030, total reductions of up to 70% in CO<sub>2</sub> emissions are achievable compared to conventional vehicles. In addition, hybridisation of CNG vehicles would be the logical next step, once the infrastructure is fully deployed, which will further reduce CO<sub>2</sub> emissions.

At the end of 2014 there were more than 1.2 million NGVs on the roads in Europe, which was less than 1% of the total amount of vehicles.<sup>54</sup> The industry believes it could reach a 5% market share of the total European vehicle fleet by 2020 (about 4-5 million vehicles), and a market share of about 10% by 2030 (25-28 million vehicles).

**Assuming a 10% market share and an average CO<sub>2</sub> emissions reduction of 70% compared to conventional cars, stakeholders are of the opinion that methane vehicle growth could produce a total CO<sub>2</sub> saving of around 7% across the European car fleet by 2030.**

## Realising the potential of methane

Methane is already commercially viable in some countries, but several challenges and obstacles remain. While some countries are experiencing significant growth rates for gas-powered vehicles (eg 96% in Czech Republic),<sup>55</sup> the lack of readily available LNG and CNG in enough service stations remains an issue. In addition, there is currently no standardisation of fuel stations (although this situation is expected to change end 2016) and differing national tax regimes frustrate the development of a gas-powered car market.

Methane is the most cost-effective way to reduce CO<sub>2</sub> from transport within a quick timeframe, says NGVA. In fact, when comparing the CO<sub>2</sub> emission reduction potential related to production costs per powertrain, NGVs will comply with the 2020 target of 95g/km with a price advantage of minimum €2.000-3.500 (for hybrids) or €12.000 (for BEV) per car.<sup>56</sup>

On biomethane in particular, the lack of a single European market is a major issue. According to the European Biogas Association, the fact that biomethane is currently not allowed to be traded across borders via the grid, meaning biomethane is now produced and used within country, is a serious obstacle to the growth of this fuel source. In addition, biomethane is more expensive than natural gas, depending on the feedstock used and the national support schemes in place, which often favour 'green' electricity.

Beyond this, there is a more fundamental problem; natural gas and biomethane are low-carbon fuels, but are too often 'lumped in' with other fossil fuels. Therefore, according to several stakeholders, they are often not given the same consideration by policy makers as a serious alternative to petrol and diesel, as are electricity or liquid biofuels.

<sup>53</sup> <http://www.bosch-presse.de/presseforum/details.htm?locale=en&txtID=7385>

<sup>54</sup> <http://www.ngva.eu/co2-and-air-quality>

<sup>55</sup> ACEA sales statistics alternative fuels 2015

<sup>56</sup> CAR study, University Duisburg-Essen

## Policies and other enablers

Several stakeholders point out that in order to develop a truly European market for methane as a fuel for vehicles, there is a need for a single market with the same rules across Member States. In addition, taxation should acknowledge the contribution of methane to CO<sub>2</sub> reduction. As methane produces significantly lower CO<sub>2</sub> emissions than petrol, it should be incentivised via the tax system. On top of this, life-cycle CO<sub>2</sub> emissions should be acknowledged in the homologation of new vehicles.

Several stakeholders are also in favour of strong European and national roadmaps with a clear project on how to encourage the growth of refuelling stations and vehicles, in line with Directive 94/2014/EU.

At the same time, in the view of the NGVA, more can be done to promote power-to-gas technologies that would harness renewable energy to synthetically create low-emissions methane.<sup>57</sup> Regarding biomethane, significant work needs to be done to boost biogas production, biomethane upgrading and also trade across Europe, aiming at making the use of biomethane more economically sustainable.

In the view of several stakeholders, there must be a level playing field for alternative fuels, particularly when comparing electricity and methane and how the energy is produced. They believe it is unfair to homologate electric vehicles carbon neutral, as the source of electricity can produce significantly higher CO<sub>2</sub> emissions, when at the same blends of natural gas with biomethane and syngas lead to significant CO<sub>2</sub> reduction, which is not taken into account by European legislation.

## 1.5 Conclusion

While the car industry continues to innovate to make conventional combustion engines more environmentally-friendly, most commentators seem to agree that alternative fuels are essential to producing substantial additional CO<sub>2</sub> reductions. While ECVs, liquid biofuels and methane are often seen in competition with one another, they are all lower-CO<sub>2</sub> fuels that can contribute to greening transportation.

Based on the input of the stakeholders involved, the CO<sub>2</sub> reduction potential of the different fuel options seems very substantial. Although it should be noted that these numbers have been analysed and evaluated in isolation and while they are not additive, together seem to paint a very positive picture regarding the overall CO<sub>2</sub> reduction potential of alternative fuel technologies. ECVs could altogether produce reductions of up to 15% of CO<sub>2</sub> emissions by 2030 compared to 2015. Biodiesel could produce CO<sub>2</sub> emissions reductions of up to 15% across the passenger car fleet by 2030 if we were able to take advantage of advanced biodiesel; while bioethanol could cut CO<sub>2</sub> emissions by 10% if E20 fuel were to be developed commercially. Methane could produce another 7% of reductions by 2030.

However, according to the stakeholders involved many barriers exist – both ones that are specific to individual fuel types, and more general issues that cut across all alternative fuels. Probably the most important of these is the infrastructure for charging or refuelling. This is crucial to developing a critical mass of cars using alternative fuels. If drivers are not able to easily recharge or refuel their cars, they will not switch; but also, if the fuels are not available, they cannot switch. It is a circular problem; if these alternative fuels are to replace some conventional-fuelled vehicles, much more needs to be done to develop Europe-wide networks of refuelling and recharging points for electricity, hydrogen and methane.

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<sup>57</sup> <http://www.ngvaeurope.eu/use-of-synthetic-natural-gas-in-transport-reduces-co2-emissions-more-cost-effectively>

More research and development needs to also be done to make these fuel options even more sustainable – and also better-functioning to provide the same performance as cars with conventional engines. For electric cars, this means better and cheaper batteries providing greater range that can be charged more quickly. On liquid biofuels, it means developing engines that can cope with new biofuel mixes (for instance, anticipating the arrival of E20).

For electric cars and fuel cell vehicles in particular, greening the power supply is also key, while also building smart charging into driver behaviour to ensure that the growth of ECVs has as low an impact on the power grid as possible. On hydrogen, especially, the development of wind-to-hydrogen and similar techniques is a *sine qua non* for fuel cell vehicles to be truly low- (or zero-) carbon.

Liquid biofuels face additional political challenges, around Indirect Land Use Change (ILUC) and impacts on crop use and hence price. It is essential that these questions are resolved if biofuels are to play a greater role than currently. Methane can play a more prominent part if it is recognised as a low-carbon fuel alongside the other fuel options listed here – again a political question. To put all of this into perspective, a transparent debate on CO<sub>2</sub> abatement costs is required, in order to achieve clean mobility in a cost-effective way.

None of these problems seem insurmountable. However, as identified by the stakeholders, they involve difficult challenges around tax, regulation and investment framework. This framework must be stable and sustainable, and structured in a way that encourages innovation through intelligent subsidies, tax breaks, further market liberalisation and other incentives that will improve the technology, make it cheaper for consumers, and make it easily accessible.

# Intelligent transport systems (ITS) and the connected car

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## 2. Intelligent transport systems (ITS) and the connected car

### 2.1 Introduction

This chapter looks at how intelligent transport systems (ITS) and connected car technologies can contribute to reducing CO<sub>2</sub> emissions from passenger cars and light commercial vehicles. It brings together insights from stakeholders, including technology organisations and manufacturers, urban and road planning bodies, academics and experts. These stakeholders include the International Road Transport Union (IRU), DEKRA, TomTom, the French Institute of Science and Technology for Transport, Development and Networks (IFSTTAR) and the German Aerospace Centre (DLR).

The first part of this chapter outlines all ITS and connected car technologies and their CO<sub>2</sub> reduction potential, looking at various relevant projects, including an estimation of the possible CO<sub>2</sub> reduction by 2030.

ITS technologies and advanced applications can provide drivers with services and information that empower them to make better informed decisions about using different modes of transport, the best routes to take, and take more advantage of traffic management decisions. This helps lower fuel consumption, which will in turn cut costs and CO<sub>2</sub> emissions.

ITS also includes 'cooperative' applications relying on communications between different vehicles or between vehicles and infrastructure; for example, traffic management systems. Connected cars (or other vehicles) are equipped with communications devices, eg internet access, satellite GPS and Direct Short-Range Communication (DSRC). This means that the car is able to share data with other devices, both inside and outside the vehicle. It can be combined with other specialised technologies to provide benefits like automatic warnings of crashes, notification of speeding and safety alerts, and driver information and feedback.

This chapter focusses on all systems, applications and services that fall under these concepts. Specifically, it will look at the different application fields as outlined in the ERTICO thematic paper on 'ITS for Energy Efficiency':

- Predictive map-based applications;
- Traffic and travel information;
- Traffic management and control.

Several of the application fields outlined in this chapter also relate to 'eco-driving', which is about smarter and more fuel-efficient driving. In order to minimise overlap, the eco-driving chapter focuses specifically on behavioural aspects like driver training and pre-trip measures including maintenance, trip planning and tyre pressure.

## 2.2 CO<sub>2</sub> reduction potential

The unanimous view of the stakeholders taking part in the initiative is that the CO<sub>2</sub> reduction potential of ITS and connected car technologies is significant. According to the iMobility Support Forum<sup>1</sup>, ITS could improve the energy efficiency of car transportation by 20% (between 2011 and 2020), taking into account all possible technologies and their likely market penetration. In addition, it seems there are potential additional benefits regarding ITS, as reported by the iMobility Support Forum:

- 30% reduction in the number of fatalities across Europe;
- 30% reduction in the number of seriously injured persons across Europe;
- 15% reduction of road traffic related congestion;
- 50% increase in availability of real time traffic and travel information.

This sub-chapter looks at the CO<sub>2</sub> reduction potential of each of the application fields (ie predictive map-based applications, traffic and travel information, and traffic management and control) and highlights the most relevant projects, which together provide an estimation of the overall CO<sub>2</sub> reduction potential by 2030.

### 2.2.1 Predictive map-based applications

On-board maps and navigation have been features of many cars for years, providing drivers with real-time route information. However, this has moved on substantially in recent years, with the development of more intelligent map systems, meaning that more can be achieved in terms of predictive capabilities for on-board systems.

New systems can not only plan out routes, but also interact with the car to help anticipate changes in driving conditions, such as approaching uphill slopes, stoplights, roundabouts and sharp bends. All of this contributes to better calculations of optimal paths, speeds and gears, resulting in greater fuel savings and lower CO<sub>2</sub> emissions.

Eco-routing is the use of GPS systems to calculate the most fuel-efficient routes possible, based on traffic conditions, road types, hills, weather conditions and, in some cases, even the weight of the car. This can be coupled with predictive cruise control, which maps out the road ahead and adjusts engine output to uphill and downhill gradients, meaning the car can reach optimum speeds for fuel savings. For electric and hybrid cars, there are also powertrain management systems, where the car reconfigures the power supply and sources based on road and traffic conditions.

These can all be done in absolute terms, or on a constant basis, through simpler systems like advanced driver assistance systems (ADAS)<sup>2</sup> where the car's map-based system searches ahead of the car in a radius of a few kilometres, judging features such as hills and road types in order to constantly update recommendations on driving, rather than just mapping out a whole route. The low-cost solution for ADAS, consisting of some form of vehicle positioning, a stored digital map and some simple car-based sensor technology (as vehicle-to-vehicle (V2V) or Vehicle-to-Infrastructure systems are currently more costly) could be installed in large numbers of vehicles and provide the necessary critical mass to lower CO<sub>2</sub> emissions.

These systems have been developed both by vehicle manufacturers and portable-device manufacturers, the former being more comprehensive and the latter often more affordable.

<sup>1</sup> <http://www.imobilitysupport.eu/imobility-support>

<sup>2</sup> [http://adasis.ertico.com/wp-content/uploads/sites/13/2014/09/ADASIS\\_Brochure.pdf](http://adasis.ertico.com/wp-content/uploads/sites/13/2014/09/ADASIS_Brochure.pdf)

The eCoMove project, featuring both public and private sector partners (including DLR, RWTH Aachen University and TomTom),<sup>3</sup> looked at building eco-routing into passenger and freight transport systems, developing solutions such as:

- Pre-trip planning: advice on optimal departure time and the greenest route, combined with energy-relevant information about vehicle functions;
- Smart driving: dynamic green driving and route guidance as well as tips to tune vehicle functions for maximum fuel efficiency;
- Monitoring: information from vehicles' post trip eco record sent anonymously to traffic control centres;
- Adaptive balancing and control: strategies for energy-optimised traffic distribution, such as traffic signal optimisation;
- Adaptive traveller support: information on traffic, route recommendations and speed profile data.

The eCoMove project focused on maximising use of efficient routes to destination considering the traffic situation and vehicle properties. It provided a reduction of up to 20% in CO<sub>2</sub> emissions (5% margin of error), based on a simulation in the Munich region.

In addition, there are several projects which show that the use of predictive map-based applications can contribute to reducing CO<sub>2</sub> emissions. These projects looked at the potential of various ITS and connected car technologies on a small scale, and are extrapolated based on estimations by ERTICO, providing potential CO<sub>2</sub> reductions (in high and low scenarios) by 2030:

Category	Projects	Description	Estimated annual CO <sub>2</sub> reduction potential by 2030, compared to 2015
Eco-routing	eCoMove (simulation in northern Munich urban area)	Use of efficient route to destination considering traffic conditions and vehicle properties	0.2-1.4% CO <sub>2</sub> reduction (depending on penetration)
Eco-routing	eCoMove (simulation in Helmond, The Netherlands)	Simulation of optimised routing combined with 'green wave' (a succession of green traffic lights along a stretch of road)	1.3-1.5% CO <sub>2</sub> reduction (over whole road network)
Navigation and eco-routing	ICT-Emissions Project	Real-time in-vehicle navigation for eco-routing by personal digital assistant (PDA) or mobile phone	4.7-7.2% CO <sub>2</sub> reduction (with 25% of cars equipped)
Adaptive cruise control	ICT-Emissions Project	Automatic velocity control subject to the distance between vehicles	2.5% (with 40% of cars equipped) 5.1% (with 80% of cars equipped)

<sup>3</sup> <http://www.ecomove-project.eu/about-ecomove/consortium/>

## 2.2.2 Traffic and travel information

Bringing real-time traffic and travel information (RTTI) into cars can provide significant CO<sub>2</sub> emissions reductions, according to Polis.

Traffic message channel (TMC)<sup>4</sup> technology was developed more than 30 years ago and is now widely used and keeps drivers informed in real time about traffic events and road conditions on their planned route, contributing to improving traffic flows and reducing traffic congestion and therefore CO<sub>2</sub> emissions. This has now been built on by newer specifications like Transport Protocol Expert Group (TPEG) technology,<sup>5</sup> providing richer content, such as parking, weather and fuel price information.

As traffic and road condition information becomes more widely available and more precise, using information from public authorities and live traffic flow data, the time taken to make journeys will continue to shrink. Such an approach has been adopted by the TM 2.0 ERTICO Innovation Platform which groups together almost 30 European ITS stakeholders from all sectors (OEMs, service providers, ITS hardware providers, road authorities, road users) at a European level and which works on enabling vehicle interaction with traffic management centres and procedures. The exchange of personalised routing data and traffic management plans provides for the next step in managing traffic flow using ITS and automated mobility. This type of traffic information can enable reduction of CO<sub>2</sub> emissions by optimising the deployment of traffic management and control measures such as traffic lights and traffic flow.

Route calculation can also build in 'multimodal' options. For instance, suggesting a drive by car to a train station parking facility, a train connection to the destination city, and a public transport ride from the train station to the final destination.

One key innovation is the inclusion of information on parking, fuel and electric charging points. A significant amount of congestion is caused by drivers searching for parking spaces or a fuel station. This can be wedded to dynamic parking pricing and management (prices changing in real time based on supply and demand) to improve the overall parking and congestion strategy. Information on e-charging points for electric vehicles (EVs) is also vitally important at a time when the number of charging points and mileage is still limited.

The projects below illustrate the potential benefits of systems such as intelligent parking management, dynamic pricing and dynamic parking management:

Category	Projects	Description	Estimated annual CO <sub>2</sub> reduction potential by 2030, compared to 2015
Intelligent Parking Management / Dynamic pricing	LA Express Park (Los Angeles)	Dynamic parking pricing to tackle congestion caused by circling traffic seeking spaces. Information via a smartphone application and a variable message sign (VMS)	10% CO <sub>2</sub> reduction (but only in big cities)
Dynamic Parking Management	COSMO (University of Salerno campus)	Service giving indications on parking space status, showing them on on-board units (OBUs), a smartphone application and a variable message sign (VMS)	3-4% CO <sub>2</sub> reduction (in urban areas, assuming 50% penetration)

<sup>4</sup> ISO 14819-1/-2/-3

<sup>5</sup> ISO 18234 and ISO 21219-series

## ICT-EMISSIONS PROJECT (2011-2015)<sup>6</sup>

The EU-funded ICT-Emissions project, coordinated by the Aristotle University of Thessaloniki, focused on assessing the impact of information technology on road transport emissions for different penetration rates and in different traffic conditions (free flow, congested).

Results of the project demonstrated that ITS can help reduce CO<sub>2</sub> emissions, but that reductions varied substantially based on local conditions like traffic, infrastructure and fleet composition. Advanced vehicle types like hybrid and plug-in hybrid vehicles could provide additional benefits.

Vehicle and driving related ICT Systems can bring substantial reductions – over 15%, depending on traffic conditions. The reductions are greatest when many cars have such systems and can interact with one another. In addition, traffic and routing related systems can have an impact of up to 8% CO<sub>2</sub> emissions reduction, based on factors like traffic light timing which can affect local driving and road capacity.

### 2.2.3 Traffic management and control

Better controlling and distributing traffic flows contributes to a more efficient drive, less congestion and lower CO<sub>2</sub> emissions. There are three key areas where action can be effective in managing traffic: increasing efficiency (minimising stop-go traffic and better utilising the available road space), reducing the environmental footprint (lowering fuel consumption) and improving traffic safety (reducing the number of accidents).

#### Traffic lights

Traffic lights are essential to controlling traffic in cities, but a lack of efficient traffic light control contributes to increased fuel consumption and thus CO<sub>2</sub> emissions due to time spent waiting for lights to change. Improved pre-timed traffic light control can reduce the frequency and length of stops to favour the most trafficked arteries. As acceleration produces the greatest quantity of CO<sub>2</sub> emissions, it should be reduced by cutting out stops and improving traffic flow. Traffic light coordination and management, known as urban traffic control (UTC), is already an established feature of most urban networks in developed countries. However the level of effectiveness varies considerably due to local factors (network characteristics, traffic density and mix, modal split, traffic management policies) as well as the systems used (age, flexibility, operational strategy).

Using real-time information and adapting traffic light control to control and improve traffic patterns can reduce CO<sub>2</sub> emissions by around 10%. Further emphasis on reducing stops provides additional reductions of 8%.<sup>7</sup>

A study by the German Automobile Club (ADAC) and the Technical University of Munich (TUM) in 2013 on reduction of emissions using 'green waves' – meaning using traffic information to create successions of green lights for smooth flows on specific roads – showed 15% less CO<sub>2</sub> emissions and 33% less nitrogen oxides thanks to adaptive traffic management.

Providing speed advice for vehicles can have varying effects depending on the situation. On average, advising drivers on optimum speed can produce a reduction of around 7%, but in combination with network adaptive control and

<sup>6</sup> <http://www.ict-emissions.eu/>

<sup>7</sup> ITS for Energy Efficiency, ERTICO, November 2014

signal coordination, it can reduce CO<sub>2</sub> emissions by up to 14%, thanks to more efficient fuel use rather than abrupt stopping and starting.<sup>8</sup> Integrating real-time information and speed advice with eco-driving advice has been shown to bring reductions in CO<sub>2</sub> emissions of up to 25% in urban corridors with traffic lights, for equipped vehicles.<sup>9</sup>

## Traffic flow routing

In addition to helping individual drivers make their trips more fuel efficient, routing of traffic flows via route advice can help balance traffic load more evenly over the road network, optimising the overall network efficiency and reducing CO<sub>2</sub> emissions. Generally, the most fuel-efficient route is also the shortest time route (in 80% of cases) but uncoordinated vehicle routing can also spread congestion from one specific road to a whole area, meaning that while a road may be eased up, overall congestion may increase.

The table below summarises some key projects that have shown particularly promising CO<sub>2</sub> reduction potential. It includes the ADAC/TUM study mentioned above, as well as elements of the eCoMove and ICT-Emissions projects mentioned elsewhere in the chapter that are directly relevant to traffic management and control:

Category	Projects	Description	Estimated annual CO <sub>2</sub> reduction potential by 2030, compared to 2015
Green wave	ADAC/TUM study on reduction of emissions using green waves	Drivers with simTD technology equipped vehicles can get recommendations regarding the optimum speed needed to ride a 'green wave'	11-17% CO <sub>2</sub> reduction
Traffic signal control	eCoMove	Dynamic green wave for traffic lights	2-3% CO <sub>2</sub> reduction (in urban areas)
Traffic signal advisory	eCoMove	In-vehicle advice on approach speed to traffic light depending on traffic light status	3.3% CO <sub>2</sub> reduction (with 10% penetration rate) 3.6% CO <sub>2</sub> reduction (with 30% penetration rate)
Urban Traffic Control (UTC)	ICT-EMISSIONS	Synchronised traffic signals on five intersections in Turin	5.1% CO <sub>2</sub> reduction (in urban areas)

### 2.2.4 Total CO<sub>2</sub> reduction potential

The results of the projects outlined in this report clearly illustrate the CO<sub>2</sub> emissions reduction potential of the main ITS technologies. The projects undertaken show considerable promise.

The eCoMove project showed that eco-routing technologies could have a reduction potential of up to 1.5% if spread widely among the passenger fleet. The ICT-Emissions project shows even greater potential reductions for real-time in-vehicle navigation for eco-routing, by mobile device, of between 4.7-7.2%. Adaptive cruise control could also provide substantial reductions of between 2.5-5.1%. Traffic signal advice and control, according to the results of the eCoMove project, could produce up to 4% reductions. Meanwhile, intelligent parking management could bring up to 10% CO<sub>2</sub> emissions reductions in urban areas, while 'urban traffic control' could bring a 3.6% to 8% reduction in fuel

<sup>8</sup> ITS for Energy Efficiency, ERTICO, November 2014

<sup>9</sup> BMW ecoAssist trial in Helmond, eCoMove project, 2013

consumption and thus CO<sub>2</sub> emissions.

To better understand the total CO<sub>2</sub> reduction potential, but also obstacles, it should be recognised that:

- Many applications produce significant CO<sub>2</sub> reductions under certain specific conditions – traffic light control is effective in urban areas, and in-vehicle eco-driving advice is best in areas where there is less congestion rather than situations where driving dynamics are determined by the vehicle in front;
- Cars are becoming more efficient and less polluting, so even without additional ITS deployment, emissions per car will fall by 2030; this means the net benefits from some ITS solutions could diminish over time;
- The effects of different applications can produce diminishing marginal returns;
- ITS technologies that reduce congestion, increase road capacity or make it easier to find parking space, are likely to have the effect of generating extra traffic.

Based on an assessment by ERTICO of recent European studies and trials in a report entitled 'ITS for reducing CO<sub>2</sub> emission of passenger cars'<sup>10</sup>, most of which are described in this chapter, as well as in a report by the iMobility Working Group for Clean and Efficient Mobility (WG4CEM),<sup>11</sup> annual CO<sub>2</sub> reduction of between 5-15% by 2030 are feasible.<sup>12</sup>

## 2.3 Realising the potential

### 2.3.1 Obstacles

The CO<sub>2</sub> reduction potential of various ITS and connected car applications are very significant. But as outlined by the stakeholders involved, there are many obstacles to overcome, most notably on research and deployment.

#### Research and methodologies for calculating CO<sub>2</sub> reductions

In terms of research, some of the main challenges are that trials are often local and short-term, and that wider trials or real deployments are rare and complicated. This means that most data are generated from modelling and predictions based on observations. Alongside this, results are often not consistent, data is sometimes in percentage, other times in grammes CO<sub>2</sub>/km.

In terms of assessment, reductions are not uniform. Impact assessment and validation depend on traffic load, local topography, penetration rate, driver behaviour and road network characteristics. As roads are managed by many different public and private sector bodies, it also can be difficult to obtain joined-up information.

#### Lack of critical mass for better results

Researchers from Eindhoven University of Technology<sup>13</sup> underline that one key issue is critical mass in terms of market penetration of ITS technologies. That is, cooperative solutions must take into account the initial low degree of penetration of ITS technologies. Fewer vehicles in connected systems means less detailed information, which means lower-quality data.

<sup>10</sup> <http://erticonetwork.com/its-for-reducing-co2-emission-of-passenger-cars/>

<sup>11</sup> <http://www.imobilitysupport.eu/library/imobility-forum/working-groups/active/ict-for-clean-and-efficient-mobility/reports-4/2332-wg4cem-final-report-131308/file>

<sup>12</sup> All figures provided by ERTICO

<sup>13</sup> <http://www.tue.nl/en/university/departments/mechanical-engineering/the-department/staff/detail/ep/e/d/ep-uid/19970028/>

Additionally, the accuracy of maps and real-time GPS still needs more progress, as well as a need for more accurate energy meter information. Without much greater development of ITS and connected car technologies, this will not be possible. The issue of compatibility is also important here. If many different, incompatible systems are present in different cars, the effectiveness of ITS on a global level is greatly weakened.

### Data sharing and privacy

There is a need for greater data sharing between road operators, mobile operators and third parties in order for ITS technologies to be more effective. At present, limited cooperation means that traffic and parking data provided will often be patchy, and discourages take-up.

At the same time, privacy of personal data is a major concern. As the European Commission points out, “despite the many potential benefits of Intelligent Transport Systems, the associated increase in vehicle/infrastructure electronics and communications raises security and privacy issues which, if left unaddressed, could jeopardise the wider deployment of ITS. ITS technologies must ensure the integrity, confidentiality and secure handling of data, including personal and financial details, and show that citizens’ rights are fully protected.”<sup>14</sup>

### Lack of interoperability between systems

The Transport Research Centre (TRANSyT) of Madrid Polytechnic University focuses on the need for interoperability between electronic road systems in the EU. The worry of many is that the multiplication of systems will make coordination difficult, which will in turn hamper the potential to achieve substantial savings in fuel consumption and emissions.

### Insufficient cooperation between public and private sector actors

TomTom stresses that there must be a more holistic approach to management systems built on a collaborative approach between stakeholders. There is currently not enough cooperation between all relevant players – not only car and device manufacturers, but also road management bodies and public authorities, as well as groups representing drivers.

### Older cars are not ITS ready

Several stakeholders underline that greater integration is needed with legacy systems in older vehicles. This is key to ensuring penetration rates grow. While fleet renewal is essential, people will not replace their old cars purely to build in ITS and connected car applications. This means that there must be adaptable solutions that can be built into older cars.

### Too little compatibility with existing fleets and systems

It was stressed by many stakeholders that more needs to be done to foster innovations that are more user friendly and compatible with current infrastructure, taking into account product replacement life-cycles. The better the products, the more drivers will shift to ITS technologies.

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<sup>14</sup> [http://ec.europa.eu/transport/themes/its/road/action\\_plan/data\\_protection\\_en.htm](http://ec.europa.eu/transport/themes/its/road/action_plan/data_protection_en.htm)



## Insufficient knowledge among drivers

Drivers lack both the technical knowledge needed to maximise the CO<sub>2</sub> reduction potential of ITS and connected car applications, but also the necessary awareness of the cost of CO<sub>2</sub> emissions. Addressing these points is essential to further increase their uptake.

### 2.3.2 Policies and other enablers

Stakeholders pointed out that an EU-level Task Force could establish a list of priority ITS measures and their impact on CO<sub>2</sub> emissions. This group could explore possible mechanisms to promote technologies that could bring higher energy efficiency and lower CO<sub>2</sub> emissions. This could be combined with credit mechanisms to encourage the rollout of ITS, first to cars and then other modes of transport. This would be an investment which could potentially achieve significant CO<sub>2</sub> reductions in the long term.

## More funding for research and development

Many stakeholders pointed out that in order for ITS technologies to continue evolving in ways that can unlock their full CO<sub>2</sub> reduction potential, significantly more public and private funding is needed to fuel research and development into innovations that make ITS more effective.

## Data sharing and privacy issues

Stakeholders underlined that more needs to be done by policymakers to provide clarity on privacy protection, data security, as well as third party access. Currently, while national data protection laws exist, the framework around data sharing versus privacy is not clear and as a result both companies and individuals lack sufficient information and guidance. This lack of a proper policy and regulatory framework discourages investment and innovation.

The European Commission is currently reviewing rules on data protection more generally with the goal to better protect individuals while also ensuring data flows freely across the EU.<sup>15</sup> ITS needs to be a key component of this.

Alongside this, several stakeholders believe it is crucial to achieve better sharing of data between all stakeholders – drivers, manufacturers, application developers, local authorities and other bodies. Cooperation at EU level would be helpful in this regard.

## Improved communication and education

The ICT-Emissions project team adds to this that there is a need for more and better communication of findings and reports in order to build trust in the benefits of ITS. This must include open shared public database results for use by authorities and traffic stakeholders to better calculate the value of the CO<sub>2</sub> impact of different measures. It has to be combined with standardised assessment methodologies to interpret, compare and upscale results. The German Institute of Transport Research (DLR) calls for greater encouragement for early adopters of ITS technologies while also adapting roll-out to audiences both young and old, fuelled by greater communication and education.

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<sup>15</sup> [http://ec.europa.eu/justice/data-protection/review/index\\_en.htm](http://ec.europa.eu/justice/data-protection/review/index_en.htm)

## Increased cooperation and interoperability between systems

There is a need for a standardised assessment methodology and greater interoperability, which is why a common standard needs to be reached that can enable greater coordination between systems and improve data sharing.

### 2.4 Conclusion

According to the stakeholders involved, ITS and connected car technologies can play a major role in reducing fuel consumption, and thus CO<sub>2</sub> emissions from passenger cars and light commercial vehicles. Many technologies exist that contribute to reducing CO<sub>2</sub> emissions from cars and light commercial vehicles by using information technology and connectivity to help drive in a more efficient way, both individually and in terms of traffic and parking management.

The projects and studies provided by stakeholders involved show great CO<sub>2</sub> reduction potential. These bring together technologies that include eco-routing, adaptive cruise control, traffic signal advisory and control, intelligent parking management and 'urban traffic control'. The eCoMove project, for example, shows potential of up to 1.5% CO<sub>2</sub> reductions from eco-routing technologies, and also shows that traffic signal advisory and control could produce up to 4% CO<sub>2</sub> reductions.

The ICT-Emissions project additionally shows reductions generated by real-time in-vehicle navigation for eco-routing of between 4.7-7.2%. Overall, based on an assessment by ERTICO of recent European studies and trials, most of which are described in this report, as well as in a report by the iMobility Working Group for Clean and Efficient Mobility (WG4CEM),<sup>16</sup> annual CO<sub>2</sub> reductions of between 5-15% by 2030 are feasible.

Yet according to the stakeholders involved, many barriers still exist – for example, ensuring accuracy of maps with real-time GPS. On top of this, drivers do not know ITS and connected car applications well enough, nor understand adequately what the true cost of CO<sub>2</sub> emissions is.

In addition, much technology requires cooperation between a wide range of actors, from local authorities through road managers to car and app developers. This cooperation is difficult to set up and does itself also need incentives.

Several stakeholders argued that there are many fronts where progress is needed in order to fuel growth in ITS and connected car technologies. More research needs to be funded and undertaken on the different technologies. There is also the more fundamental issue of data, where a need to improve information sharing must be counterbalanced with privacy issues and therefore more clarity is required on EU data policies, in terms of security, privacy, protection, third party access and also improving cooperation and sharing. This must be combined with greater interoperability between ITS systems.

It was also underlined that there is a need to achieve a critical mass more quickly than the slow renewal rate of the European car fleets allow. Consumers are not naturally inclined to install ITS systems of their own accord. It is therefore necessary to provide more incentives to consumers, while at the same time offering more technological solutions that can be integrated into older cars.

<sup>16</sup> <http://www.imobilitysupport.eu/library/imobility-forum/working-groups/active/ict-for-clean-and-efficient-mobility/reports-4/2332-wg4cem-final-report-131308/file>



# ROAD INFRASTRUCTURE

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## 3. Road infrastructure

### 3.1 Introduction

Well-built and well-maintained roads can significantly contribute to reducing CO<sub>2</sub> emissions from passenger cars and light commercial vehicles. Bringing together the expert knowledge of key stakeholders from the world of road building and infrastructure design and development, as well as representatives of road users, this chapter provides insights from across the board on how shorter distances, different road surfaces and technologies can impact CO<sub>2</sub> emissions and performance.

The road network and infrastructure can play a sizeable role in cutting CO<sub>2</sub> emissions from road transport – from the types of surfaces used and the frequency of maintenance to the way roads are planned and designed.

### 3.2 CO<sub>2</sub> reduction potential

One of the key ways in which road infrastructure can contribute to cutting CO<sub>2</sub> emissions is through low-resistance, well-maintained surfaces. On top of that, the planning of future road upgrades and new road construction can have a major impact. Straighter, wider roads can mean more direct and efficient travel, and thus lower fuel consumption. This can also be combined with new technologies built into the road that interact with cars. All of this must fit into a more comprehensive spatial strategy; looking at the role of infrastructure in traffic management, parking, and urban planning.

#### 3.2.1 Materials and maintenance

##### The best materials

The materials used to surface roads are crucial in determining the overall CO<sub>2</sub> footprint of the cars using them. The choice of surfaces depends on a variety of considerations: cost, but also noise and safety. Yet in terms of CO<sub>2</sub> emissions reduction potential from road infrastructure, no single factor is more important than reducing rolling resistance. Rolling resistance, the friction resulting from an object moving along a surface, comes from both tyres and the road surfaces, and contributes significantly to CO<sub>2</sub> emissions. While some friction is necessary to ensure adequate grip on the road, its reduction can lower fuel bills and emissions. Reductions can come from better tyres, but also better surfaces.

Surfaces that have lower rolling resistance require less energy to move the same distance. Well-maintained, smooth road surfaces are important for low rolling resistance and reduction of fuel consumption and CO<sub>2</sub> emissions. This was confirmed through studies and projects including the MIRIAM Project<sup>1</sup>, coordinated by the Danish Road Directorate, which found better texture and evenness of roads leads to reduced rolling resistance.<sup>2</sup> The COOEE project<sup>3</sup>, also coordinated by the Danish Road Directorate, found that 25% of CO<sub>2</sub> emitted on roads is caused by rolling resistance.

<sup>1</sup> [http://miriam-co2.net/Miriam\\_brochure\\_ver\\_2.pdf](http://miriam-co2.net/Miriam_brochure_ver_2.pdf)

<sup>2</sup> [http://miriam-co2.net/Publications/MIRIAM\\_SP1\\_Road-Surf-Inf\\_Report%20111231.pdf](http://miriam-co2.net/Publications/MIRIAM_SP1_Road-Surf-Inf_Report%20111231.pdf)

<sup>3</sup> <http://cooee-co2.dk/Workshop/Workshops.htm>

Eurobitume highlights the example of Denmark. The total fuel consumption on Danish state roads is 1.7 billion litres of diesel and petrol a year, producing 4.6 million tonnes of CO<sub>2</sub> emissions per year. A 10% reduction in rolling resistance on Danish roads would reduce CO<sub>2</sub> emissions of road transport by 4% according to Eurobitume. This impact was also confirmed by a study by the Swedish Environmental Research Institute<sup>4</sup>, on the impact of road surface texture on fuel consumption, which showed a variation over a range of approximately 11% from the smoothest to the roughest surface tested. Another experiment in the Netherlands demonstrated fuel consumption savings can reach 7% depending on the type of road surfaces.<sup>5</sup>

As the European Asphalt Pavement Association (EAPA) underlines, there is significant potential for CO<sub>2</sub> reduction from certain more advanced asphalt surfaces: asphalts with low rolling resistance are already available. Split mastic asphalt (SMA) surface in particular shows a significant fuel consumption reduction potential.<sup>6</sup> SMA is a type of asphalt that is deformation resistant, durable and particularly well suited to heavily trafficked roads. The COOEE project estimated that 3-5% of fuel consumption can be saved thanks to SMA asphalt, delivering an 11-25% reduction in rolling resistance. This is equivalent to at least 48 million litres of fuel annually and could reduce CO<sub>2</sub> emissions by 45,000 tonnes.

Friction also means noise and many European countries and cities have been rolling out noise-reducing asphalt or concrete with the main goal to reduce road traffic noise. Noise-reducing asphalt or concrete is low-friction, meaning that it also reduces CO<sub>2</sub> emissions.<sup>7</sup>

Concrete surfaces can also contribute to the decarbonisation of transport, delivering up to 6% fuel savings compared to conventional surfaces, according to the European Concrete Paving Association (EUPAVE). The association also points out that smooth roads can provide additional benefits, including savings on vehicle maintenance, because less friction means less wear and tear.

The European Road Federation (ERF) also supports incorporating recycled elements and using materials that soak up CO<sub>2</sub> emissions (and additional pollutants like NO<sub>x</sub>). Ideally these materials, which are called 'sinks', should be lower in CO<sub>2</sub> emissions in terms of their production, application and maintenance, says the ERF. Carbon sinks are natural or artificial systems that take CO<sub>2</sub> out of the atmosphere. While oceans, soils and plants are generally cited, some materials also soak up CO<sub>2</sub> gradually with time. One example of a smart road using such sinks and materials is the Spanish 'ecological highway', the A 381 from Jerez to Los Barrios, which includes carbon and NO<sub>x</sub> sinks close to the road and CO<sub>2</sub> absorbing road surfaces.<sup>8</sup>

## Proper maintenance of Europe's roads

Making roads more efficient in reducing fuel consumption and CO<sub>2</sub> emissions is also about ensuring that existing roads are properly maintained. Eurobitume underlines that roads that are not maintained correctly result in more fuel consumption and therefore greater CO<sub>2</sub> emissions.

As Eurobitume points out, while asphalt roads should be resurfaced every 20 years or so to ensure smooth surfaces and avoid potholes, many rural roads in particular (but also highways) are resurfaced far less often than that. For example, some countryside roads in the UK have not been upgraded in 70 years. The Asphalt Industry Alliance's (AIA) annual ALARM study for the UK, which looks at shortfalls in road infrastructure spending as seen by local authorities, shows the total shortfall in road maintenance spending in the UK was £548.6m (over €750m) with a 13-year backlog. The estimated one-time catch-up cost for maintenance works in the UK, according to the survey, would be £12.16bn (around €17bn).<sup>9</sup>

<sup>4</sup> <http://www.ivl.se/english/startpage/about.4.4a08c3cb1291c3aa80e80001436.html>

<sup>5</sup> [http://www.eapa.org/usr\\_img/position\\_paper/fuel\\_efficiency\\_executive.pdf](http://www.eapa.org/usr_img/position_paper/fuel_efficiency_executive.pdf)

<sup>6</sup> [http://orbit.dtu.dk/en/publications/new-surface-layers-with-low-rolling-resistance-tested-in-denmark\(18404ed6-6890-4fdc-a452-5cbe10173504\).html](http://orbit.dtu.dk/en/publications/new-surface-layers-with-low-rolling-resistance-tested-in-denmark(18404ed6-6890-4fdc-a452-5cbe10173504).html)

<sup>7</sup> <http://www.highways.gov.uk/knowledge/publications/optimization-of-thin-asphalt-layers/>

<sup>8</sup> <http://www.iaia.org/conferences/iaia11/uploadedpapers/final%20drafts/Spanish%20Roads%20and%20Compensatory%20Measures.pdf>

<sup>9</sup> [http://www.asphaltindustryalliance.com/images/library/files/ALARM%202015/ALARM\\_survey\\_key\\_findings.pdf](http://www.asphaltindustryalliance.com/images/library/files/ALARM%202015/ALARM_survey_key_findings.pdf)

This is, according to the European Road Federation, because Europe has so far failed to build a preservation and adaptation culture based on preventive maintenance. A holistic, long-term view of infrastructure would look at roads as assets, whose value can decline if they are not correctly managed and maintained.

### Total potential of materials, maintenance and upgrade

The benefits of maintaining and upgrading surfaces can have a sizeable impact on CO<sub>2</sub> emissions. EPA calculates that at the recommended renewal speed (resurfacing roads every 20 years), all of Europe's roads could be resurfaced with lower-rolling resistance surfaces, resulting in CO<sub>2</sub> reductions of up to 5% by 2035. **Stakeholders project that by 2030, at normal resurfacing speed, new smoother road surfaces could cut annual road transport CO<sub>2</sub> emissions by up to 3.75% (compared to 2015).**

### 3.2.3 Design and planning

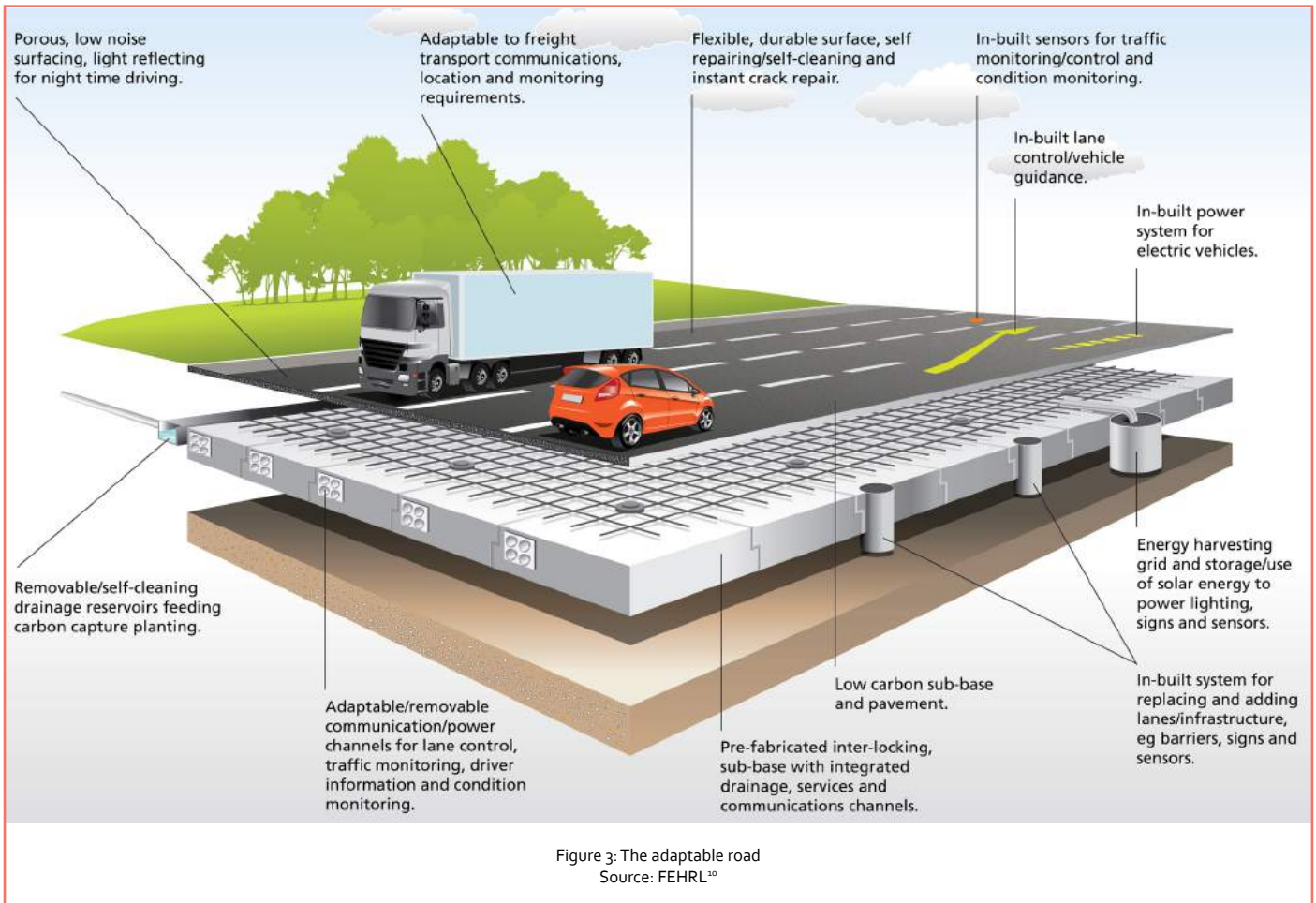
#### New technologies and better design for new roads

Many stakeholders, notably EUPAVE, underline the crucial importance of better road design. According to the Forum of European National Highway Research Laboratories (FEHRL), a well-designed road would not only feature a low-noise and low-friction surface – its surface would also be flexible, durable, self-repairing and self-cleaning. This means it would last longer and cost less in the long term to maintain. The long-term benefits are substantial in terms of less need for repair, as well as integration of new technologies that can capture CO<sub>2</sub> and harness lost energy. This must be part of a coherent spatial strategic vision when dealing with road infrastructure, according to the European Council of Spatial Planners (ECTP-EU).

FEHRL underlines the importance of building roads that use innovation and new technology to reduce fuel consumption and CO<sub>2</sub> emissions – what it calls the 'forever open road', also known as a smart road. So-called because it rarely needs to be closed for serious maintenance work. Aside from integrating low-noise and low-friction surfacing that is also porous (meaning fast drainage during rain), it would include a flexible, durable surface that repairs and cleans itself, using technologies that detect cracks and repair them immediately, as well as self-healing materials. A porous surface and self-cleaning drainage system can feed into carbon capture vegetation alongside the roads. Energy-harvesting elements could use the energy generated by cars and trucks driving on the road to feed back into the grid or power lighting and signs, while solar panels could also be placed to power the electronic elements of the 'smart road'.

At the same time, a smart road or forever open road could be integrated with intelligent transport systems (ITS), as outlined in Chapter 7. ITS technologies that could be integrated into the road include sensors for traffic monitoring and control, condition monitoring, in-built lane control and vehicle guidance. Alongside this, there is even the potential for in-built power systems for ECVs: specifically, plug-less charging along roads that would charge ECVs as they drive.

While such innovations can be integrated into existing roads, it is more cost-effective to integrate them into new road constructions, as the marginal cost of building such technology into new roads is less than the cost of digging up and replacing existing roads.



## Holistic planning of road networks

When drawing up plans for road layout, as the European Road Federation (ERF) points out, building short, straight and sufficiently wide roads can help reduce CO<sub>2</sub> emissions. Better layout can cut overall travel time and distance and thus fuel consumption, notably through lowering congestion that can otherwise cause delays. This can be supplemented by building tunnels and bridges that would otherwise shorten journeys by cutting across valleys and mountains.

ERF highlights a study by the SINTEF Group<sup>21</sup>, which has observed the link between better road infrastructure and positive effects for the environment. Using a traffic-micro simulation, the researchers observed that upgrading a narrow and winding low traffic two-lane road to a wider two-lane one yielded a decrease of 11% in CO<sub>2</sub> emissions on an 80km stretch – showing that increasing the capacity of roads has a direct link to decreases in CO<sub>2</sub> emissions from motor vehicles.

The European Road Transport Research Advisory Council (ERTRAC) underlines that there must be a holistic approach to transportation, taking into account traffic control, congestion, intelligent traffic management, parking spaces and ITS technologies. This must look at the quality of signage (vertical/horizontal) and the interaction between vehicles and infrastructure, among other factors.

<sup>20</sup> <http://www.fehrl.org/>

<sup>21</sup> <http://www.sintef.no/en/about-us/#/>



## Total potential of design and planning

Design and planning are more difficult to quantify than improved road surfaces in terms of their CO<sub>2</sub> reduction potential, as it is difficult to scale up reductions made by very specific projects involving design either of specific roads or of road networks. What is clear is that straightening roads and building bridges and tunnels could substantially reduce CO<sub>2</sub> emissions. However, more research is needed to better understand the full potential of design and planning for reducing road transport CO<sub>2</sub> emissions.

### 3.3 Realising the potential

#### 3.3.1 Obstacles

There is a chronic lack of investment in road infrastructure, as ERF points out. Investment in maintenance and upgrading Europe's road infrastructure has been insufficient for years, but this underinvestment has been exacerbated by the current tough economic climate. Also, generating additional revenue streams, taxes or charges, is difficult given existing taxes on fuel and car ownership and use.

This lack of investment has been made even worse by the transfer of management and upkeep of roads to local authorities without giving them the necessary financial means and resources to fulfil their responsibilities. This is not because public authorities do not understand that there are issues with the quality of their roads. It is because at a time when budgetary decisions are often tough, local and national bodies prefer to tackle other issues that are seen as more immediately pressing, according to EAPA.

As the Forum of European National Highway Research (FEHRL) points out, there is also a more fundamental problem in the way infrastructure projects are planned – namely, that maintenance is rarely factored into budgets in public procurement. As a result, it is seen as an additional cost, when it should already be calculated at the time when a road is built. This is part of a greater problem, that management of roads and their contribution to reducing CO<sub>2</sub> emissions is undermined by a lack of long-term vision. Infrastructure is not seen as an asset but rather something that is 'there forever' and only requires serious attention when it 'fails'. Yet many solutions exist that could use roads to increase the contribution of our infrastructure to reducing the overall CO<sub>2</sub> emissions linked to road transport.

According to the Eindhoven University of Technology, rolling resistance is only one of three key factors taken into account when resurfacing roads – grip must be weighed against comfort and noise. Traditionally low rolling resistance surfaces sacrificed grip on the road. One key obstacle is therefore for the tyre and road surfacing industries to develop solutions that overcome this problem, by producing tyres and surfaces that lower fuel consumption without excessively sacrificing grip.

#### 3.3.2 Policies and other enablers

Road infrastructure has significant potential in terms of CO<sub>2</sub> emissions reduction, but investment is clearly needed. This investment must be in timely routine maintenance on that ensures roads remain smooth, but also resurfacing and improvement of surfaces. Many stakeholders also believe there is a need for new road projects that involve straighter, shorter routes and new technologies.

## Maintaining and boosting investment

While resurfacing Europe's roads would be costly, it could reduce fuel consumption by up to 5%. More needs to be done to stress to policymakers that road infrastructure maintenance and improvement can have a major impact on CO<sub>2</sub> emissions.

This point is also stressed by the European Construction Industry Federation (FIEC), which highlights the need for greater investment. One potential revenue stream being the Investment Plan for Europe (also known as the 'Juncker Plan')<sup>12</sup>, which will unlock at least €315 billion of additional investments throughout the EU.

The total cost for the EU to resurface the entire European road network (roughly 5,000,000km) spread over a 20-year timeframe, according to calculations by EAPA and based on projected inflation is between €520-780bn (assuming inflation over 20 years, €450-675bn in today's prices). This is on average roughly €26-39bn per year for the next 20 years. While additional road expenditure does represent an extra cost at a time of budgetary constraints, the benefits more than outweigh the financial burden, several stakeholders underlined.

FIEC also supports a strong common funding framework and strategy for infrastructure. It campaigned for a robust budget for the Connecting Europe Facility (CEF), set up in October 2011 to fund European infrastructure, and which was threatened with cuts in the wake of the creation of the Juncker Investment Plan. FIEC believes that any additional resources made available for the Juncker Plan must not come at the expense of the CEF.<sup>13</sup>

Some stakeholders have suggested that tolls, 'vignettes' and urban congestion charges can help finance greater investment in maintenance and upkeep. FIEC underlines that charging for kilometre-use of roads can be an important revenue stream, and should be considered by other European countries.

## Infrastructure asset management

This lack of investment can be best combatted by changing the fundamental approach taken with regards to infrastructure. As an example, ERF highlights Germany, where the proportion of motorway bridges which require immediate investment or repair has increased from 36% to 46% during the last decade. In this case, one of the most used bridges (A1, nearby Leverkusen) had to be closed to heavy lorries from December 2012 to March 2013, with total costs – including the impact of increased travel times and CO<sub>2</sub> emissions – estimated to reach €80 million.<sup>14</sup> A proper asset management approach would have pre-empted this need by investing gradually in maintenance and upgrades, meaning lower overall cost, less disruption, and ultimately lower CO<sub>2</sub> emissions.

## Green design and planning

Several stakeholders have suggested policies to reduce road CO<sub>2</sub> emissions through design and planning. ECTP-EU believes that this must be part of a more fundamental strategy to move from car mobility to a diversity of mobility services through development of new network facilities, new concepts of individual transport and connecting networks. This should be part of a sustainable mobility paradigm, the group underlines.

For example, the ERF supports optimising road planning and design through optimising the use of Strategic Environmental Assessments (SEAs) to ensure environmental criteria are incorporated into road design, plans and programmes. Since the 2004 Strategic Environmental Assessment Directive, it is required that large scale development

<sup>12</sup> [http://ec.europa.eu/priorities/jobs-growth-investment/plan/docs/factsheet3-what-in\\_en.pdf](http://ec.europa.eu/priorities/jobs-growth-investment/plan/docs/factsheet3-what-in_en.pdf)

<sup>13</sup> <http://www.fiec.eu/en/themes-72/connecting-europe-facility-cef.aspx>

<sup>14</sup> [http://www.erf.be/images/Road-Asset-Management-for\\_web\\_site.pdf](http://www.erf.be/images/Road-Asset-Management-for_web_site.pdf)

projects in the EU look at potential environmental consequences of implementation and ways to mitigate these consequences.<sup>15</sup> A report by the Irish Environmental Protection Agency highlights that SEAs lead to clearer, more robust plans and more transparent plan-making.<sup>16</sup>

These SEAs can be supplemented by certifications. The French Institute of Science and Technology for Transport, Development and Networks (IFSTTAR) highlights the ECOLABEL certification as an example of how to incentivise the construction of more ecologically friendly roads.<sup>17</sup> ECOLABEL looks at technical, environmental, social and economic considerations in planning, design, construction, operation and maintenance. The attribution of such a certification can be of value both to public authorities and to private companies in securing more funding through environmental protection and CO<sub>2</sub> reduction spending streams, but will also contribute to improving overall uptake of such techniques and designs.

EAPA also believes that a more coordinated European approach to roads could be beneficial. It mentions the possibility of creating a European Road Agency that would oversee and contribute to thinking on the planning and development of Europe's future road infrastructure. This agency could be modelled on the European Railway Agency, which was set up to help create an integrated European railway area by reinforcing safety and interoperability, while also acting to create unique signalling standards. A European Road Agency could achieve similar harmonisation and 'norming'.

### 3.4 Conclusion

According to the stakeholders it is clear that road infrastructure can have a major impact on reducing CO<sub>2</sub> emissions of passenger cars and light commercial vehicles, through the use of materials with a lower rolling resistance, improved maintenance and operations of roads, and their design and planning. It is also clear that a wide range of technologies exist that have substantial potential and can be rolled out right now with the requisite investment.

These technologies include road surfacing where low rolling resistance, noise-reducing asphalt or concrete surfaces can all reduce friction, meaning less fuel is consumed. More generally, maintenance of road surfaces can have a substantial impact. However, there is currently a considerable backlog in road maintenance and resurfacing across Europe, contributing to more delays, longer journey times and greater fuel consumption.

According to EAPA, the total cost for the EU to resurface the European road network over a 20-year timeframe is between €520-780bn, which is roughly €26-39bn per year. Several stakeholders underlined that this cost, while significant, pales in comparison to the CO<sub>2</sub> emissions reduction potential. It is estimated that if all of the EU's roads are resurfaced with low rolling resistance materials over the next 20 years (meaning two-third by 2030), this could produce annual CO<sub>2</sub> reductions of up to 3.75% by 2030 (compared to 2015).

At the same time, new technologies including the integration of ITS technologies into roads, using renewable energy to power signs and lights, and combining drainage and carbon sinks planted alongside roads, can also contribute significantly. This must be integrated into a wider spatial strategy that looks at designing and building roads that are wider, straighter and shorter.

Several stakeholders stressed the importance of green design for future road projects, integrating smarter roads with ITS technology that can interact in real time and cut driving-related CO<sub>2</sub> emissions, while also ensuring planning and design reflect state-of-the-art science on materials, integrated technologies and alignment.

<sup>15</sup> [http://www.dlrco.ie/files/devplan2016\\_2022/media/pdf/Chapter10\\_Strategic\\_Environmental\\_Assessment\\_Appropriate\\_Assessment.pdf](http://www.dlrco.ie/files/devplan2016_2022/media/pdf/Chapter10_Strategic_Environmental_Assessment_Appropriate_Assessment.pdf)

<sup>16</sup> <http://www.epa.ie/pubs/advice/ea/SEA%20EFFECTIVENESS%20REVIEW%20MAIN%20REPORT%202012.pdf>

<sup>17</sup> <http://ecolabelproject.eu/home/overview/>

Yet funding remains a major challenge. All stakeholders taking part in the writing of the chapter agree with the general need to invest more in road maintenance and upgrade. While justifying expenses at a time of budgetary austerity is never easy, some solutions do exist. According to the stakeholders, these include European funding streams such as the Juncker Plan and the Connecting Europe Facility (CEF), but also targeted charges such as selected tolls and congestion charges.

Ultimately, European policymakers need to understand the role roads can play in reducing fuel consumption – which will, in turn, help Europe meet its CO<sub>2</sub> reduction goals. The EU and national governments must be made aware of the substantial positive impact that proper maintenance and upgrade of Europe's road infrastructure can have in cutting emissions according to various stakeholders. This should lead to a more asset management-based approach, looking at roads as an asset and not a burden, and building a culture of stewardship over shared road networks.



# ECO-DRIVING





## 4. Eco-driving

### 4.1 Introduction

Changing driver behaviour can contribute to reducing CO<sub>2</sub> emissions from passenger cars and light commercial vehicles. These techniques and choices are grouped under the umbrella of 'eco-driving'. Eco-driving brings together steps, techniques and behaviours that drivers can employ before a journey, during the journey and after the journey. It can lead to savings in terms of fuel usage and CO<sub>2</sub> emissions. This can also lead to savings for drivers in terms of fuel spend – although it is easier to realise such savings on a fleet level in freight than in individual passenger transport.

Although eco-driving has not, to date, received the same level of recognition from the public and policymakers as for example intelligent transport systems (ITS) or alternative fuel options, there are a wide number of initiatives that exist across Europe. These include training schemes, public information campaigns and online training, as well as in-car and hand-held technologies.

Generally, eco-driving measures can be divided into two categories:

- Pre- and post-trip techniques; including car maintenance, reducing vehicle weight, planning trips to avoid congestion and analysing trip data to plan future trips;
- Driving techniques; including reducing engine idling and adopting smooth and reasonable speeds.

This chapter brings together input from a wide range of stakeholders (including driving schools, universities, research institutes and technology providers), focussing on the two categories outlined above, while also including a section on ways to concretely encourage more ecologically friendly driving behaviour, including training and in-car applications.

The chapter only includes ITS measures that improve eco-driving in particular, leaving out other technologies (as much as possible). It is widely recognised though that several ITS measures have the potential to enhance and support eco-driving, include Gear Shift Indicator, Adaptive Cruise Control, Green Navigation Systems etc.

## 4.2 CO<sub>2</sub> reduction potential

According to the stakeholders, the potential of eco-driving techniques in terms of reducing CO<sub>2</sub> emissions from passenger cars and light commercial vehicles is substantial. This applies to both categories as outlined above (pre- and post-trip techniques, as well as driving techniques), which will be further explored in this sub-chapter.

### 4.2.1 Eco-driving techniques: before and during the drive

#### Pre-trip techniques to cut CO<sub>2</sub> emissions

There are several pre-trip measures that can contribute significantly to cutting CO<sub>2</sub> emissions from passenger and light commercial vehicles.

These start with very basic steps. Maintaining and servicing one's car plays a crucial role, improving fuel efficiency and thereby reducing CO<sub>2</sub> emissions by up to 10%. This is according to the RAC Foundation, whose report 'Easy on the Gas: The effectiveness of eco-driving' was quoted as a key reference document by several stakeholders.<sup>1</sup> This includes getting the vehicle serviced, checking the oil, and also checking tyres every month to ensure that rolling resistance (the friction with the road) is optimal. In particular, underinflated tyres increase rolling resistance, which is why drivers should check tyres regularly to ensure they are at the optimum pressure. The Energy Saving Trust estimates that tyres underinflated by a quarter can cause a 2% increase in fuel consumption<sup>2</sup>, and in addition, up to 71% of drivers in Europe seem to have underinflated tyres.<sup>3</sup> These findings have led to the compulsory introduction of the Tire Pressure Monitoring Systems (TPMS) for new cars in the EU (in 2012).

Stakeholders underline that planning routes in advance is a simple and cost-effective step that can cut CO<sub>2</sub> emissions. By taking routes optimised for emission reduction for specific times of the day, drivers can avoid zones of known congestion. This can be more efficiently assisted by so-called automated green navigation systems that are currently being developed by several technology developers and OEMs.

Avoiding congested areas prevents the reinforcement of congestion and creates beneficial network benefits, which can be combined with additional pre-trip steps that can lower fuel consumption. More aerodynamic vehicles have lower fuel use and CO<sub>2</sub> emissions; removing unused roof racks and roof boxes can cut wind resistance and thus lower fuel consumption. As well as air resistance, unnecessary weight also has an impact on emissions. Every additional 45kg carried reduces a car's fuel economy by 2%, which is why emptying the boot and removing excess weight is so important.<sup>4</sup>

#### Driving techniques that cut fuel consumption

As well as steps that can be taken before leaving the house that contribute to reduce CO<sub>2</sub> emissions, there are many things that can be done during the drive.

Driving at appropriate and constant speeds can help reduce fuel consumption and, therefore, CO<sub>2</sub> emissions. Poor driving choices – driving too slowly or too fast, braking and accelerating too quickly – can increase fuel use by 37% over a journey.<sup>5</sup> This is because cars are least efficient at low or high speeds, and consume even more fuel when accelerating sharply or braking abruptly. Driving more calmly also means anticipating and making gear changes in a fuel efficient manner (ideally changing as soon as necessary).

<sup>1</sup> [http://www.racfoundation.org/assets/rac\\_foundation/content/downloadables/easy\\_on\\_the\\_gas-wengraf-aug2012.pdf](http://www.racfoundation.org/assets/rac_foundation/content/downloadables/easy_on_the_gas-wengraf-aug2012.pdf)

<sup>2</sup> <http://www.energysavingtrust.org.uk/businesses/sites/default/files/Ecodriving%2BGuide%2Bfinal%2Bfor%2Bweb%2BJune%2B2013.pdf>

<sup>3</sup> <http://www.recytyre.be/media/43835/tyre%20safety%20check%20results.pdf>

<sup>4</sup> <http://deepblue.lib.umich.edu/bitstream/handle/2027.42/96632/102926.pdf>

<sup>5</sup> [http://www.unep.org/transport/PCFV/PDF/EcodrivingJesseBaltutis\\_UNEP.pdf](http://www.unep.org/transport/PCFV/PDF/EcodrivingJesseBaltutis_UNEP.pdf)



Braking can also be done in a more fuel efficient way, stakeholders stressed. Drivers should stay in gear when slowing down, but remove pressure on the accelerator early. This cuts fuel flow to the engine to almost zero. By knowing about reduced speed limits in advance, through signage or digital map systems, drivers can release the accelerator, to reach the desired speed without braking entirely. Modern cars have fuel cut-off switches and are able to recognise when momentum is enough to move the vehicle and cut the flow of fuel to the engine temporarily. This should not be confused with 'coasting in neutral' which is unsafe and illegal.

Using engines more efficiently is also important, as 5-8% of fuel consumed comes from 'idling'.<sup>6</sup> Modern engines do not need to 'warm up' and can be used 'from cold'. Warming up an engine before a drive is an unnecessary waste of fuel and can also contribute to engine wear. Idling with the motor on is particularly wasteful at lengthy stops. For waits of one minute, experts advise turning off the engine, which can be turned on again with little fuel use. This can be done manually or automated through the use of stop-start systems.<sup>7</sup> It should be noted that the vast majority of modern cars are equipped with efficient stop-start systems.

One additional factor that can contribute significantly is air conditioning. Air conditioning – as well as other ancillary loads on the engine – consumes power and thus fuel. It may not always be necessary to lower the temperature in the car, which is why air conditioning should be turned off when possible. However, if the car is too warm, it is more environmentally-friendly to open the window at speeds under 64km/h. When driving faster than this speed, the drag created by open windows in terms of air resistance is a bigger drain on fuel than air conditioning, meaning closing windows is advised.<sup>8</sup>

## 4.2.2 Drivers of ecologically friendly behaviour

### Eco-driving training and information

Many training schemes exist across Europe that aim to teach drivers to use their cars in a more fuel efficient, and thus environmentally-friendly, way. These come alongside public information campaigns that encourage wider adoption of eco-driving habits. The UK government is just one of many public authorities that has launched eco-driving campaigns, involving online information, including YouTube training videos and online simulators.<sup>9</sup> These initiatives are a first step in reaching and raising awareness of the importance of eco-driving with a wider audience.

Many public and private bodies have also introduced training schemes, either on a trial basis or more permanently. PostEurop (the European postal body) highlights the French 'Mobigreen' initiative rolled out by La Poste.<sup>10</sup> Using specialised trainers, and subsequently tracking fuel consumption with a measurement device, the programme has trained 80,000 postmen since 2009. 'Mobigreen' has reduced the carbon footprint of postal deliveries by around 15%, delivering additional benefits such as a 20% reduction in the number of accidents, a 10% drop in maintenance costs, and lower stress levels.

The ECOeffect project, supported by the International Road Transport Union (IRU), provides a stand-alone one-day eco-driving course that incorporates best practice from project partners such as GoGreen and HSF Logistics, as well as other European projects and industry leaders in eco-driving.<sup>11</sup> Focussing on heavy commercial vehicles, the course is a mixture of theoretical training on eco-driving and road safety, and practical driving exercises on public roads. Training 2,200 drivers since 2011, it has prevented 7,700 tonnes of CO<sub>2</sub> emissions and saved €3.5 million in fuel costs. As an example of the potential, training sessions in Central Europe from April to June 2012 produced average fuel consumption savings of 12.6% (averaged out over drivers).

<sup>6</sup> [https://www.iru.org/cms-filessystem-action?file=mix-publications/Ecodriving\\_bus.E.pdf](https://www.iru.org/cms-filessystem-action?file=mix-publications/Ecodriving_bus.E.pdf)

<sup>7</sup> [https://www.iru.org/cms-filessystem-action?file=mix-publications/Ecodriving\\_bus.E.pdf](https://www.iru.org/cms-filessystem-action?file=mix-publications/Ecodriving_bus.E.pdf)

<sup>8</sup> <https://www.tc.gc.ca/eng/programs/environment-etv-menu-eng-2939.html>

<sup>9</sup> [http://www.measures-odyssee-mure.eu/public/mure\\_pdf/transport/UK25.PDF](http://www.measures-odyssee-mure.eu/public/mure_pdf/transport/UK25.PDF)

<sup>10</sup> [http://www.mobigreen.fr/ecoconduite\\_laposte.htm](http://www.mobigreen.fr/ecoconduite_laposte.htm)

<sup>11</sup> [https://www.iru.org/en\\_ecoeffect](https://www.iru.org/en_ecoeffect)

The Dutch programme 'Het Nieuwe Rijden' (HNR) aimed to teach eco-driving with the goal not only to reduce fuel consumption but also to improve comfort, increase road safety and improve the driving experience. The results showed fuel consumption down by 2.1% on average among the group that received training (compared to the control group), and maintenance costs cut by 3.5%.<sup>12</sup>

EcoWill, another major European project, ran from 2010 to 2013 and rolled out short-duration eco-driving training programmes for licensed drivers in 13 European countries. The project focused on five main aspects: anticipating flow by training drivers to better predict slow and fast moving traffic flows; maintaining steady speeds while putting the car in the highest gear possible; shifting up early; checking tyre pressures frequently; and cutting extra energy drains by using air conditioning and electrical equipment more sparingly, while also reducing weight and aerodynamic drag.<sup>13</sup>

### On-board eco-driving technologies

Training of this type can be supplemented by on-board tools, eco-innovation in eco-driving. One of these is being developed by the ecoDriver project, which includes partners such as TomTom, RWTH Aachen University and IFSTTAR. The ecoDriver project provides drivers with eco-driving recommendations and feedback adapted to them and to their vehicle characteristics, based on a range of driving styles, fuel/power options (conventional, hybrid and electric) and vehicles (passenger cars, vans, trucks and buses). The ultimate goal is to better develop tailored eco-driving advice and feedback in real time for any given situation.<sup>14</sup>

TomTom, a technology provider and a frequent participant in European eco-driving research projects, has developed tools including the 'optiDrive 360' programme. This tool provides data to help drivers adopt more eco-friendly behaviours based on real-time feedback to drivers (and also freight fleet managers). The programme looks at aspects including idling, speed fluctuations, the optimal 'green speed', gear shifts and coasting. Initial testing shows it can provide reductions in fuel consumption of up to 25%.<sup>15</sup>

Overall, according to ERTICO, in-vehicle technology has a CO<sub>2</sub> emissions reduction potential of between 5-20% depending on conditions including topography, road type, vehicle type, transmission system and traffic fluidity.<sup>16</sup>

### 4.2.3 Total CO<sub>2</sub> reductions potential

Given the wide range of methodologies and variables associated with eco-driving – which, as a behaviour-based approach, is more difficult to study scientifically – the range of predicted CO<sub>2</sub> emissions reduction is large, from conservative estimates as low as 2% to highs of 35% depending on the programmes, sample size and other factors.<sup>17</sup> Assuming that eco-driving is learnt and maintained as a key factor in driving techniques over the long term – which is a key argument for regular training 'top-ups' as well as in-car tools to encourage eco-driving – the overall RAC Foundation estimate for CO<sub>2</sub> emission reduction is up to 10% based on current techniques.<sup>18</sup> **Combined with growth in technologies built into cars that help drivers lower their CO<sub>2</sub> emissions, the European Driving Schools Association (EFA) believes that an annual eco-driving-based reduction in CO<sub>2</sub> emissions of 10% (compared to 2015) is realistically achievable by 2030.**

<sup>12</sup> [http://www.dvr.de/download/broschuere\\_auf-den-punkt-3.pdf](http://www.dvr.de/download/broschuere_auf-den-punkt-3.pdf)

<sup>13</sup> [http://www.ecodrive.org/en/home/ecowill\\_the\\_project/](http://www.ecodrive.org/en/home/ecowill_the_project/)

<sup>14</sup> <http://www.ecodriver-project.eu/about/overview/>

<sup>15</sup> [http://business.tomtom.com/en\\_gb/products/webfleet/optidrive360/](http://business.tomtom.com/en_gb/products/webfleet/optidrive360/)

<sup>16</sup> <http://erticonetwork.com/wp-content/uploads/2015/09/ITS4rCO2-Report-Final-2015-09-10-submitted.pdf>

<sup>17</sup> The RAC Foundation report lists studies by the UK Driving Standards Agency, the Dutch Consumer Organisation, Ford, Quality Alliance Eco-Drive, Fiat eco-Drive, TNO and others

<sup>18</sup> [http://www.racfoundation.org/assets/rac\\_foundation/content/downloadables/easy\\_on\\_the\\_gas-wengraf-aug2012.pdf](http://www.racfoundation.org/assets/rac_foundation/content/downloadables/easy_on_the_gas-wengraf-aug2012.pdf)

## 4.3 Realising the potential

### 4.3.1 Obstacles

#### Behavioural barriers to promoting eco-driving

While people understand the CO<sub>2</sub> impact of driving in general, TomTom argues that not enough drivers are interested in playing a part in cutting their CO<sub>2</sub> emissions by making certain environmentally-friendly choices. Changing human behaviour requires not only greater understanding of CO<sub>2</sub> emissions-reducing driving techniques, but also incentives to ensure that people do not fall back into bad habits. This is hard to achieve, as IFSTTAR points out, which is why the European Conference of Transport Research Institutes (ECTRI) believes that alongside voluntary eco-driving initiatives, stronger mandates for training programmes are necessary. This is confirmed by the EFA, which points out that there is no easy way to create a model that will push people to take training courses and refresh their knowledge of eco-driving techniques on a regular basis.

Drivers quickly revert to previous behaviour, which is why more continuous training needs to be encouraged. The European Automobile Clubs Association (EAC) suggests that as cars become more fuel efficient, the financial incentive for drivers to change their behaviour lessens, which means even more must be done to bring training to the forefront of drivers' minds. The need to regularly re-train and refresh makes this a challenge in terms of time, effort and expense.

#### Divergent national and local approaches

National regulatory landscapes for eco-driving are very diverse, according to the EFA – which means that approaches to encouraging eco-driving must strike a balance between harmonisation and adaptation to national circumstances, legal, environmental and cultural specifics. To develop a truly effective approach to eco-driving, rules must be tailored to national regulations, but a baseline common (EU) standard is needed. ECTRI underlines that in National Energy Efficiency Action Plans (NEEAP), which Member States are obliged to develop under the Energy Efficiency Directive, eco-driving is often not counted as an indicator.

#### Assessing and measuring CO<sub>2</sub> reduction potential

Calculations of potential CO<sub>2</sub> reductions provided by eco-driving can differ. This is because eco-driving is varied and personalised, looking at individual car types, driving behaviours and other factors. While local and short-term trials provide useful insights, they are more difficult to extrapolate, meaning that only wider trials and deployment can fully measure the impact of eco-driving initiatives. Additionally, there is a need to improve consistency in measurements and calculations of the penetration, both of eco-driving training and technologies that help people drive in a more efficient way.

The effect of eco-driving also depends on traffic conditions. The ICT-Emissions project shows that eco-driving offers significant benefits in normal and free flow conditions but seems to worsen congestion under heavy traffic. This may even lead to a slight increase in CO<sub>2</sub> emissions at fleet level.

As eco-driving may lead to an early saturation of the road, as the fraction of eco-drivers increases, it can have a negative effect in high-traffic conditions because it seems to worsen congestion, possibly including emissions increase. This indicates that possibly the wider deployment of eco-driving should be combined and supported by traffic related ITS measures and technologies to optimise its effects, while avoiding negative side effects.

### Technological barriers

Improving human-machine interfaces is crucial according to ERTICO. Interfaces help drivers control their cars' overall CO<sub>2</sub> emissions better by allowing them to enable and disable applications and systems. Yet eco-driving interfaces are quite different from one another and are quite visual, meaning that they are often distracting. This means that drivers need to 'relearn' systems when changing cars. In addition, there are certain aspects of eco-driving that are yet to be captured by existing systems, such as overall energy consumption.

It is much more effective and practical to realise these advances through integrated systems – which are built into cars and react with a vehicle – than with nomadic systems (systems using smartphones and other stand-alone tools) because of a lack of direct interaction with many of the car's measurements. There is no standardised method to read the emissions of a vehicle, and even reading current fuel consumption suffers from indirect measurements that lead to inaccurate estimations. However, nomadic systems may be a solution for older cars, as they can be installed easily. ERTICO underlines that with time, systems will improve gradually, though a lack of public investment in research and development and support means this progress is slower than it should be.

### 4.3.2 Policies and other enablers

#### Wider and more comprehensive driver training

Several stakeholders underlined that while driver training was crucial to encouraging more people to adopt eco-driving techniques, it was not widely-spread or frequent enough. While some of this could be tackled by gamification – essentially, making eco-driving more fun and engaging by turning it into a challenge – there also needs to be a more concrete effort by public and private bodies to spread training more widely. That is why the European Transport Safety Council (ETSC) encourages the inclusion of eco-driving in EU driver training and testing.

The easiest way to achieve this is by teaching eco-driving from the outset. In the United Kingdom, eco-driving both as an overall topic and in its constituent parts (smooth acceleration, using gear shifts appropriately) is covered both in training and in the test – which ingrains best practice in drivers before they begin driving on open roads. The UK Driving Standards Agency's Driving Standard requires an understanding of 'the environmental and economic implications' of travel. This goes alongside understanding the basics of vehicle maintenance and checks, as well as effective and environmentally-responsible control of the vehicle.

#### Information campaigns

Information campaigns can play a significant role in encouraging more people to eco-drive – but if they are to have a substantial impact, there need to be more of them and they need to be better adapted for specific audiences. Many stakeholders agree with this need for more visible campaigns, underlining that these campaigns should focus on the key messages that matter to drivers. They can also be linked with an element of competition or 'gamification' where online interactive challenges can help add a playful aspect to eco-driving learning.

The UK's 'Act on CO<sub>2</sub>' initiative involved multimedia communication and marketing to raise awareness of the role citizens can play in reducing CO<sub>2</sub> emissions. This type of online initiative can also be supplemented by advertising in public places and in the media. TomTom underlines that negative campaigns like those against smoking or to reduce excess energy consumption have a role to play. Helping people visualise the impact of their driving behaviour can be a powerful tool in encouraging more people to eco-drive.

### Incentivising in-vehicle eco-driving technologies

In-vehicle technologies can have a significant impact on CO<sub>2</sub> emissions reduction, as they provide drivers with real-time information on their fuel consumption and how it is affected by driving choices. Multiple incentives would encourage take-up of such technologies by drivers, stakeholders suggested: including subsidies, tax breaks, or investment in research and development to make them more cost-effective and high-performing. ERTICO in particular underlined that eco-driving technologies were in their early stages, and that boosting innovation in the field could mean high-performance systems are released onto the market earlier.

### Encouraging companies to promote eco-driving

Large public and private companies can have a significant impact on CO<sub>2</sub> emissions because of the size of their fleets. Encouraging eco-driving among employees can therefore be a useful strategy both from an environmental point of view and also in terms of brand image, and also reduce fuel bills (for companies or employees). One example is the BPost Eco-driving Challenge, highlighted by PostEurop, where participants competed in teams of two in postal vans around a closed circuit. It helped raise awareness of responsible driving among staff, while also demonstrating innovative alternative mobility solutions.<sup>19</sup>

### Incentivising insurance companies to factor eco-driving into premiums

Eco-driving is not only good for CO<sub>2</sub> emissions; it also saves fuel and reduces the risk of accidents, according to ERTICO. This should interest insurers. Several stakeholders underlined that if insurers encouraged drivers to drive in a better way (optimum driving including eco-driving techniques) through preferential premiums, this could improve take-up of training courses and eco-driving technologies as well as encourage better driver behaviour more generally.

### Common standards and regulatory framework

A harmonised EU impact assessment on the full potential of eco-driving, feeding into a recommendation on ecologically friendly driving behaviour, would be very useful in encouraging the practice, ECTRI underlines. Some elements of that recommendation could include a common set of key performance indicators and common calculation methodologies so that eco-driving based energy savings can be taken into account in NEEAPs. This also requires a demanding and harmonised European eco-drive standard for training and tools.

<sup>19</sup> <http://landmarkglobal.com/the-new-challenges-for-e-logistics-moving-towards-eco-logistics/>

## 4.4 Conclusion

Eco-driving can be a major tool in Europe's response to CO<sub>2</sub> emissions from passenger car and light commercial vehicle transportation. The behaviours and choices that together make up eco-driving can be learnt or encouraged in a variety of ways. The conventional approach – and one which can bring significant results if applied correctly and regularly – is by training drivers to prepare their car and route to minimise CO<sub>2</sub> emissions before leaving the house, and drive in a more ecologically-friendly way. This can be done by driving schools, but also companies and non-profit organisations.

Yet training is not enough on its own, it also needs incentives. As many stakeholders have underlined, drivers quickly fall back into 'bad habits' and either forget or choose to ignore techniques that cut fuel consumption and CO<sub>2</sub> emissions. This is why driver training must be more widespread, more comprehensive and more regular. National governments can play a major role in making eco-driving training commonplace, according to many stakeholders, who believe that the training framework does not currently exist for eco-driving to truly succeed. Some EU countries have already made eco-driving obligatory in driver training and licences – others could follow suit.

Alongside training, public information can also have an impact on encouraging positive eco-driving behaviour. The goal of such campaigns is to spread understanding of the role that individuals can play in cutting their CO<sub>2</sub> emissions – and also their fuel bills. Existing technologies that provide data and advice to drivers are increasingly sophisticated, but need more research and development, according to some stakeholders, in order to deliver significant benefits in a shorter time span. Encouraging greater roll-out of these technologies is very important. Financial, and indeed insurance, incentives can underpin the development and growth of eco-driving practices, training and technologies. Engaging with insurance companies can encourage them to integrate eco-driving into their premium calculations. At the same time, stakeholders should work with governments to achieve fiscal advantages for eco-driving technologies and teaching.

Stakeholders underlined that it is important to balance adapted local approaches with integration on a European level with a harmonised EU recommendation. This would focus on common key performance indicators (KPIs), common calculation methodologies and a European eco-drive standard for training and taxation.

Although most of the measures highlighted in this chapter have been analysed and evaluated in isolation and therefore are not additive, estimates by the EFA suggest that annual CO<sub>2</sub> emissions reductions of 10% from eco-driving by 2030 are feasible. Stimulating eco-driving can thus have a very significant impact on CO<sub>2</sub> emissions of passenger cars and light commercial vehicles – but training, information, technology and financial factors are essential to ensure that this potential is fully unlocked.



# ANNEX







## ANNEX: the moderators

External moderators have been involved in the initiative, moderating two workshops per workstream and reviewing the output of these workshops. In addition, they have moderated break-out sessions and presented the chapters during the wrap-up event, ensuring that the inputs of the stakeholders are reflected in the report in a balanced way.



### **GRAHAM FLOATER (LONDON SCHOOL OF ECONOMICS)** **FUEL OPTIONS**

Graham Floater is EGC Director at LSE Cities, London School of Economics, Managing Director of SENECA market analysis, was appointed Cities Director for the Global Commission on the Economy and Climate and was lead author on cities and transport for the Commission's report - Better Growth, Better Climate - launched with the UN Secretary General Ban Ki Moon in 2014. Graham was previously a senior official in the UK Treasury and Cabinet Office where his positions included Deputy Director in the Prime Minister's office of energy and climate change and Head of European Economic Negotiations. He also oversaw the Stern Review Team on the Economics of Climate Change and represented Lord Stern as advisor to President Barroso of the European Commission.



### **ANNIKA HEDBERG (EUROPEAN POLICY CENTRE)** **INTELLIGENT TRANSPORT SYSTEMS AND THE CONNECTED CAR**

Annika Hedberg is a Senior Policy Analyst in the 'Europe's Political Economy' Programme. She specialises in the EU's health, energy, climate and environmental policies, and regularly writes and speaks on these topics. She coordinates EPC activities on energy, climate change, resource efficiency and eco-innovation. She is currently responsible for EPCTask Force on Blue Gold, which looks at the EU's role in managing the water challenge in Europe and beyond, and previously worked on projects on Climate Change Adaptation and Eco-Efficiency. She worked previously at the Finnish Business and Policy Forum EVA, a policy think tank based in Helsinki, and at the Finnish Foreign Ministry.



### **CHRISTIAN EGENHOFER (CENTRE FOR EUROPEAN POLICY STUDIES)** **ROAD INFRASTRUCTURE**

Christian Egenhofer has more than 20 years' experience working with EU institutions on numerous policy areas. Over the last decade he has been specialising in EU energy and climate change policy, with a particular focus on the EU energy, climate and transport policies. He is currently Senior Fellow and Head of the Energy, Climate and Environment Programme at the Centre for European Policy Studies (CEPS), a Brussels-based think tank. He is also Visiting Professor at the College of Europe in Bruges (Belgium) and Natolin (Poland), SciencesPo (Paris/France) and LUISS University in Rome/Italy. From 1997 to 2010 he was Senior Research Fellow and Jean-Monnet Lecturer at the Centre for Energy, Petroleum and Mineral Law and Policy at the University of Dundee in Scotland/UK (part-time).



**FABIO GENOESE (CENTRE FOR EUROPEAN POLICY STUDIES)  
ECO-DRIVING**

Dr Fabio Genoese is a specialist in energy policy with over seven years of work experience in the sector. He is currently Research Fellow at the Centre for European Policy Studies (CEPS) in Brussels and Visiting Professor at Sciences Po in Paris. Before joining CEPS in September 2013, Fabio worked in Germany at Fraunhofer ISI from 2008 to 2013, where he managed policy-related research and consulting projects both for public bodies and for private clients in the energy sector. In 2012 he was a visiting researcher in Italy at Fondazione Eni Enrico Mattei (FEEM).



**ARNO BEHRENS (CENTRE FOR EUROPEAN POLICY STUDIES)  
ECO-DRIVING (REPLACING FABIO GENOESE DURING THE WRAP-UP EVENT)**

Arno Behrens is Head of Energy and Research Fellow in the Energy and Climate Change research unit of the Centre for European Policy Studies (CEPS). Prior to joining CEPS, he worked as Second Secretary at the German Federal Foreign Office in the context of the 2007 German Presidency of the Council of the European Union. Other postings in his career include the European Commission, the Sustainable Europe Research Institute (SERI), the United Nations Industrial Development Organisation (UNIDO) and the United Nations Development Programme (UNDP). He specialises in EU energy policy and more broadly in sustainable development issues. He is also lecturer on EU energy and climate policy, inter alia at the College of Europe (Bruges).

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