European Commission

European Green Cars Initiative

Towards an electric future?

Research and Innovation

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Towards an electric future?

2012

Directorate-General for Research and Innovation
Transport

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Cataloguing data can be found at the end of this publication.

Luxembourg: Publications Office of the European Union, 2012

ISBN 978-92-79-26194-7
doi:10.2777/13660

Printed in Belgium

PRINTED ON ELEMENTAL CHLORINE-FREE BLEACHED PAPER (ECF)

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Table of Contents

Foreword

The European Green Cars Initiative is part of the EU's Economic Recovery Plan and of the Europe 2020 Strategy for a successful and sustainable social market economy. It is an example of action needed today in order to build towards a prosperous and sustainable future.

It combines short-term measures to overcome the economic crisis with a longer-term perspective aimed at providing a lasting economic boost, tackling climate change, meeting energy targets and producing important societal benefits.

I want to maximise the impact of the Green Cars initiative on creating new green jobs, on de-carbonising transport and on security of energy supply. One major contributor will be the development of transport electrification technologies, for which coordinated European research has high potential added value. By 2020, up to 20% of the European new cars market could be electric or hybrid, leading to significant CO_2 emissions reduction. The Initiative also supports shorter-term research developments in road haulage, responsible for 50% of road transport CO_2 emissions, and in logistics.

Stakeholders need to get behind the Initiative: car and truck manufacturers, equipment suppliers, logistics operators and research centres. Together with the Commission and the Member States they will have a key role in defining research objectives and establishing industrial targets. The Initiative will be based on a broad spectrum of generic research, including nanotechnologies, new materials, and digital electronic and transport technologies.

The European Green Cars Initiative is one of the first tangible illustrations of the changes the Europe 2020 vision will bring to the way research is carried out. I want to make it count and it will be a top personal priority for me.

Máire Geoghegan-Quinn
Commissioner for Research, Innovation and Science

The context

1

Europe's auto industry

A major player in the European economy

The European Union (EU) traditionally has a strong automotive sector, which contributes significantly to the economy and employs millions of people. However, it is currently facing three major challenges: environmental problems, rising oil prices and the economic crisis. Through the European Green Cars Initiative (EGCI), the EU is supporting the development of innovative, environmentally friendly vehicles that will hopefully see the industry emerge from the economic crisis as a world leader in the production of hybrid and electric vehicles.

The EU is a major force in the global automotive industry, manufacturing over a quarter of all vehicles (and almost a third of all passenger cars) produced worldwide. With an annual turnover of EUR 551 billion [(1)], this industry accounts for 6.5% of the EU's gross domestic product (GDP).

The EU's auto sector also provides jobs for millions of people across Europe. In 2007 [(2)], the industry employed over 2 million people directly. A further 10 million people were employed indirectly, including those working in companies that manufacture tyres, gears, bearings, computers, information processing equipment and electric equipment, as well as those involved in the sale, maintenance and repair of vehicles, fuel and accessories, to mention just a few. And these figures do not include the large numbers of people in sectors that are linked to the car industry, such as the steel, aluminium and glass sectors, car insurance, and vehicle licensing.

Vehicle manufacturers are also big spenders when it comes to research and development (R&D). They invest around EUR 20 billion annually in research, making them Europe's biggest private investors in R&D.

Europeans and their cars

Cars remain an important part of European life. The average European passenger travels over 13 000 km every year, over 70% of which is spent in passenger cars. Car ownership is also on the rise. In 1990, 345 people in 1 000 in the 27 current Member States of the EU owned a car; by 2007, this figure had risen to 464.

Increasing amounts of goods are also transported by road. Prior to the economic downturn, the road haulage sector saw dynamic growth, recording an average annual upsurge of 3.5%. This figure is higher than that of any other form of EU freight transport; indeed, rail freight only experienced annual growth of 1.1%.

A threefold challenge

However, in recent years, the vehicle industry has come up against major challenges on three sides. Climate change and air pollution are forcing the sector to literally clean up its act and reduce vehicle emissions of greenhouse gases and other pollutants. At the same time, rising oil prices and concerns about the security of oil supplies are placing the industry under pressure to design increasingly fuel-efficient vehicles. Finally, the economic crisis has caused sales of new cars to tumble, threatening the very survival of automakers (and their suppliers) worldwide.

The European Green Cars Initiative, launched at the end of 2008, represents the EU's response to these problems, which are explained in greater detail below.

[1] Figure from 2005.

[2] The latest year for which figures are available.

Environmental concerns

It is now widely acknowledged that climate change is happening, and that human activities are driving it. According to the Intergovernmental Panel on Climate Change (IPCC), developed countries need to slash their emissions by 25% to 40% by 2020 and 80% to 95% by 2050 to avoid the worst impacts of climate change.

The EU wants to keep average global temperatures within 2 ºC of pre-industrial levels. To this end, it has set itself the goal of reducing its greenhouse gas emissions by at least 20% (compared to 1990 levels) by 2020. Moreover, it has pledged to increase this commitment to a 30% cut if other industrialised nations do the same.

The transport sector has a major role to play in helping the EU achieve these goals, since it is responsible for around one-fifth of the EU's greenhouse gas emissions. Furthermore, over 70% of emissions from transport come from road transport.

The EU has set strict limits designed to dramatically cut greenhouse gas emissions from cars. In 2007, the average new car emitted around 160 grams of carbon dioxide per kilometre (g CO_2/km). By 2012, car manufacturers must bring this figure down to 120 g CO_2/km for at least 65% of their new cars. After 2012, the proportion of new cars that must comply with this limit will increase gradually until it reaches 100% in 2015. In 2020, the emissions limit is likely to fall further to 95 g CO_2/km.

Most of the emissions reductions will result from technological improvements, highlighting the fact that there has never been a better time to invest in research into greener cars.

A breath of fresh air?

However, CO_2 is far from being the only pollutant emitted by cars. According to the European Environment Agency (EEA), road transport is responsible for around two-thirds of nitrous oxides (NOx) emissions. On their own, these gases are one of the causes of acid rain and some of them are also powerful greenhouse gases. However, they can also react with volatile organic compounds (VOCs, another major transport pollutant) to produce ozone. The reaction is triggered by sunlight, making this a particular problem in the summer. Transport is also a major producer of particulate matter (PMs) — tiny particles that constitute another type of air pollution.

Thanks in part to EU legislation, the levels of many major pollutants have fallen significantly over the years; for example, the phasing out of leaded petrol has caused lead levels to fall dramatically, while the reduction of sulphur content in petrol and diesel led to significant reductions in the levels of sulphur oxide, another cause of acid rain.

Nevertheless, levels of ozone and particulate matter remain worryingly high, especially in towns and cities. These two pollutants are both harmful to human health; between them, they cause an estimated 370 000 premature deaths every year. In addition, ozone can cause severe damage to crops and other plants.

Under the EU's air quality legislation, Member States must reduce levels of fine particulate matter ($PM_{2.5}$) in urban areas by 20% between 2010 and 2020. Meanwhile, average ozone levels should not exceed 120 micrograms per cubic metre on more than 25 days per year.

Energy security worries

The pragmatic car manufacturer has another reason for investing in innovative, green technologies: the supply of fossil fuels that have powered our cars since the 1800s is becoming complicated. No one knows when the world's oil fields dry up, but when they do, transport will grind to a halt unless other, renewable sources of energy or technologies are fully functional.

In the meantime, as oil becomes an increasingly precious commodity, prices will soar. Add to that the EU's dependence on external countries for energy imports, and the need for alternative fuels and technologies becomes obvious.

Economic crisis

The economic crisis has hit the automotive sector hard. The sale of new cars fell by 7.8% in 2008, while commercial vehicle registrations fell by 9%. Meanwhile the production of new vehicles in the EU tumbled from 19.7 million in 2007 to 18.4 million in 2008, a fall of 6.6%. Europe's carmakers do not expect this situation to improve until 2010.

The crisis has had a major impact on employment in the auto industry, with companies taking a range of measures to adapt to the falling demand for their products. Many employees have seen their working hours cut, and numerous plants have simply halted production for a while. Temporary contracts are not being renewed, and workers who retire or leave the company are not being replaced.

Towards an electric future?

Electric vehicles (EVs) offer a viable solution to the problems faced by Europe's auto sector. On the environment front, EVs do not emit the cocktail of pollutants released by traditional, fossil fuel-powered cars. Used smartly, they can ease the use of renewable energy sources such as wind, solar and wave power, thereby reducing Europe's reliance on imported oil. Finally, they are very energy efficient, and so have lower running costs and CO_2 emissions. All this means that the demand for EVs is likely to grow in the future.

The race is on!

The immense potential offered by electric vehicles has not gone unnoticed around the world. Traditional competitors such as the US and Japan are investing heavily in the technology, as are many emerging economies; China has openly stated that it plans to become a world leader in EVs. Through the European Green Cars Initiative, the EU hopes to place its car industry at the forefront of the fledgling electric vehicle market.

The European Green Cars Initiative

2

The European Green Cars Initiative

Gearing up for a competitive future

Launched in November 2008, the European Green Cars Initiative forms part of the EU's wider Economic Recovery Plan. With a budget of at least EUR 5 billion, the initiative aims to help Europe's automotive industry become more competitive through the development of more environmentally friendly vehicles.

The Economic Recovery Plan is a wide-ranging package of measures designed to promote economic growth, save jobs, boost demand and restore confidence in the European economy. In addition to short-term measures, the plan includes an array of schemes that aim to promote economic growth in the longer term.

'The Recovery Plan can keep millions in work in the short term. It can turn the crisis into an opportunity to create clean growth and more and better jobs in the future,' commented European Commission President José Manuel Barroso at the launch of the plan in late 2008. 'Smart investments in tomorrow's skills and technologies will accelerate Europe's drive under the Lisbon Growth and Jobs Strategy to become a dynamic low-carbon economy for the 21st century.'

Specifically, the document sets out plans for three initiatives targeting sectors that have been hit particularly hard by the economic crisis: the automotive sector (European Green Cars Initiative), the manufacturing sector (Factories of the Future Initiative), and the construction sector (Energy-efficient Buildings Initiative).

All three schemes are public-private partnerships (PPPs) that aim to boost research, innovation and investments in green technologies in their respective sectors. In this way, the schemes will help the EU to achieve its long-term goal of becoming a low-carbon, knowledge-based economy.

PPPs have a number of advantages. Firstly, they give industry a key role in setting strategic research priorities and carrying out R&D activities. Secondly, a long-term work programme with a predefined budget ensures continuity and allows industry to make long-term investment plans with confidence. PPPs also span the many stages of R&D activities, from basic research, through applied research and right up to large-scale demonstration projects.

Placing industry in the driving seat

The PPP approach has met with an enthusiastic response from industry — as reflected by a joint statement issued on 30 March 2009 by EU Science and Research Commissioner Janez Potočnik along with industrial representatives from the automotive industry (represented by ERTRAC (3), the European Road Transport Research Advisory Council and EPoSS (4), the European Technology Platform on Smart Systems Integration), as well as the manufacturing and construction sectors.

'We believe that it is important to combine the short-term economic and fiscal measures in the Recovery Plan with longer-term "smart investments" in R&D to lay down a strong base for the future competitiveness of European industry, once we have passed through the current crisis,' the statement reads. 'We need strong cooperation between stakeholders and a coordinated approach at European level to develop the sustainable technologies that will allow Europe to move forward towards a low-carbon, knowledge-based economy.'

[3] See http://www.ertrac.org
[4] See http://www.smart-systems-integration.org/public

On track for a cleaner, greener transport system

Although its name may suggest that it is only concerned with cars, the scope of the European Green Cars Initiative is actually extremely wide, covering all road vehicles (i.e. passenger cars, buses and lorries), infrastructures and the performance of the transport system as a whole.

If Europe is to dramatically slash its greenhouse gas emissions and meet its climate change goals, it is no longer enough to tinker around the edge of car technology in an attempt to make small reductions in pollutant emissions. A step change is required that will affect every aspect of the transport system. In addition to rethinking the way our cars are powered and how we move our goods around, we will need to overhaul transport infrastructure and create new business models to handle new ways of designing, powering, selling and using cars.

The long-term research goals of the European Green Cars Initiative are therefore extremely ambitious.

Electrification

The first and main goal concerns the electrification of road and urban transport. Studies have demonstrated that an electricity-based transport system is far more environmentally friendly than one based on oil, particularly when the electricity is generated using renewable sources. Priorities in this area include the development of high energy-density batteries as well as more energy efficient electrical components. And both must be cheaper.

Plug in electric hybrid vehicles (PHEV) and extended range EVs, which run on both electricity and petrol, represent an important step on the path towards full electrification, and projects under the European Green Cars Initiative will seek to develop specialised internal combustion engines to extend the range of these vehicles.

Like conventional cars, electric cars need to be refuelled, and so research is needed into innovative ways of linking vehicles up to the electricity grid. Of particular interest are studies in 'smart' electricity grids which could allow cars to both draw electricity from the grid and sell it back if needed.

Greener heavy goods vehicles

Road haulage is responsible for around half of the carbon dioxide (CO_2) emissions from transport. Batteries are simply not up to the task of powering heavy vehicles (such as lorries) over long distances, so the focus here is on improving the efficiency of the internal combustion engine, adding some hybridisation to capture energy when slowing down, recovering waste heat which today is released into the air and reducing tire rolling resistance. This could reduce fuel consumption by as much as 20% to 30%.

Better biofuels

Under EU climate change legislation, by 2020 at least 10% of energy used in transport must come from sustainable sources, including bioenergy. Research under this heading will concentrate on developing second generation biofuels (especially biomethane) for use in buses and bin lorries. Second-generation biofuels can be made from crop waste products, such as stems and leaves; they are more efficient than the biofuels of today and produce fewer unintended consequences.

Logical logistics

Congestion is a serious problem on many roads in Europe. As well as polluting the environment and harming health, traffic jams cost freight companies time and money. This strand of the initiative will investigate ways of moving freight from the road to other forms of transport such as railways and waterways. Logistics research, for example, could also cover ways of using lorries more efficiently so that they do not take to the road when empty of goods.

Three streams of help

Support for the European Green Cars Initiative comes from three main sources: research funding from the EU, Member States and industry, loans from the European Investment Bank (EIB), and measures to increase the demand for green cars at the Member State and European levels.

The initial budget set for the European Green Cars Initiative stands at EUR 5 million. EUR 1 billion of this total has been earmarked specifically for research activities. Half of this total will be provided by the European Commission, initially through the Seventh Framework Programme for Research (FP7), which has budgets dedicated to transport, energy, the environment, and information and communication technologies (ICT) research. The rest of the research budget will come from the industry, mostly through in-kind contributions, such as human resources.

The first series of European Green Cars Initiative projects funded under FP7 aim to build a critical mass of groups working on the electrification of road transport and hybrid technologies. Future projects are likely to focus on developing cleaner internal combustion engines for trucks, logistics, intelligent transport systems, eco-design, and the interface between vehicles, road infrastructure and 'smart' electricity grids.

Meanwhile, the EIB has committed to contributing a minimum of EUR 4 billion in loans for industrial research and innovation activities on green cars (EUR 2 billion in 2009 and EUR 2 billion in 2010). These funds come from the European Clean Transport Facility (ECTF), which was established in response to the impacts of the economic crisis on the transport sector. The ECTF supports research, development and innovation projects that aim to lower greenhouse gas emissions and improve energy efficiency across the transport arena.

The scheme has proven extremely popular, with ECTF loans to the automotive sector exceeding the EUR 4 billion mark in autumn 2009. Vehicle manufacturers have received loans for R&D on clean engine technologies, fuel efficiency, CO_2 emissions reductions, electric vehicles and the environmental performance of tyres, among other things.

What's more, these loans are in addition to the approximate figure of EUR 2 billion that the EIB already provides annually to the automotive sector via other operational objectives.

Small and medium-sized enterprises (SMEs) may also be able to apply for loans from an EIB facility specifically devoted to alleviating the difficulties often encountered by smaller companies and by new entrants to a market.

Finally, the PPP includes a series of demand-side measures to accelerate the development of a strong market for greener vehicles. Many EU nations, including France, Germany and Spain have introduced taxation-based measures or scrappage schemes encouraging car owners to replace older vehicles with greener models.

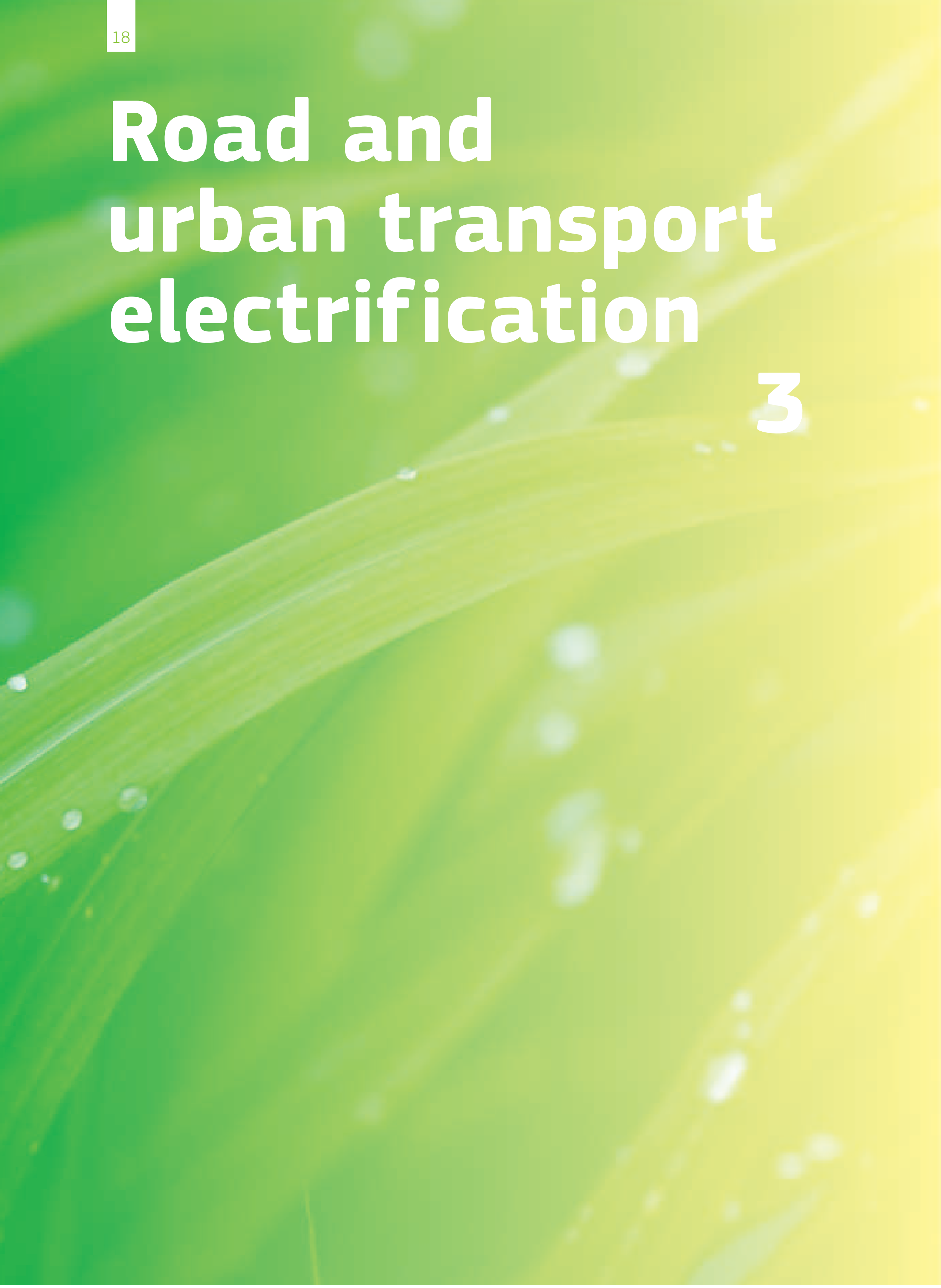
Reduced registration fees or road tolls and tax incentives for low-CO_2 cars are other examples, as are standardisation and public procurement measures. While these schemes appear to have been successful, the EU advocates closer coordination to optimise their effectiveness, avert internal market sideswipes, and avoid a race for subsidies.

Building bridges

The European Green Cars Initiative does not operate in isolation but maintains close links with other groups and initiatives working in the transport sphere. For example, the Fuel Cells and Hydrogen Joint Technology Initiative (JTI) is a PPP that supports R&D activities to speed up the commercial deployment of hydrogen and fuel cell technologies.

Another body with which the European Green Cars Initiative is expected to liaise is CARS 21 (Competitive Automotive Regulatory System for the 21st Century), a high-level group of experts that was set up by the European Commission in 2005. CARS 21 was tasked with making recommendations as to which policies and regulations could enhance the competitiveness of the European car sector while safeguarding jobs, keeping cars affordable, and making further progress on road safety and environmental performance.

Calls for proposals related to the European Green Cars Initiative are announced in the Official Journal of the European Union and on CORDIS, the Community Research and Development Information Service for Science, Research and Development.
More information:
http://eur-lex.europa.eu/JOIndex.do
http://cordis.europa.eu/fp7/dc/index.cfm



Road and urban transport electrification

3

Road and urban transport electrification

Towards the transport system of tomorrow

Electric cars are now widely viewed as a key part of the solution to our climate and energy security problems. Yet before they can take the world by storm, a great deal of research is necessary — as well as improving electric vehicle technology, the infrastructure needed to charge electric vehicles must be developed and put in place, and car designers and mechanics alike need training on how to put together and repair these cars of the future.

Electric cars have been around for a long time, and in the very early years of the 20th century, they dominated the auto market. Over the decades, however, their popularity dwindled and gas-guzzling cars bearing internal combustion engines (ICEs) came to dominate the roads.

Now, thanks to a combination of climate change concerns, air pollution, energy security issues, rising oil prices and the economic crisis, industry and consumer interest in more environmentally friendly and fuel efficient vehicles are on the rise.

In the short term, efforts to meet this demand are focusing largely on making improvements to existing cars with ICEs. Research into the production of biofuels for use in transport is also ongoing.

However, in the longer term, there is widespread agreement that vehicles and the wider transport system, especially in urban areas, need to go electric. As a result, the electric vehicle is enjoying something of a renaissance.

The advantages of electric cars over those with ICEs are manifold, as Dr Pietro Menga of CIVES (Commissione Italiana Veicoli Elettrici a Batteria, Ibridi, a Celle a Combustibile) explains. 'All these aspects have an economic impact on the community,' he comments. 'Green electric vehicles, for example, would allow savings in oil imports, reductions in CO_2, reductions in acid rain, and a reduction in health expenses due to local air pollution.'

On the climate change front, an electric vehicle powered by electricity from nuclear power or renewable sources like wind, hydroelectric or solar power would release no greenhouse gases while on the move.

And even in regions and countries where much of the electricity comes from fossil-fuel burning power plants, electric vehicles are still less harmful to the environment than cars that burn fossil fuels directly in their engines. This is because power plants use energy more efficiently than ICEs (although some adjustment needs to be made for electricity lost during transmission along the wires from the power station to urban areas). This all means that electric vehicles can help to reduce Europe's greenhouse gas emissions and dependence on imported fossil fuels.

Furthermore, electric vehicles do not emit other pollutants such as nitrous oxide and particulate matter that can be so harmful to human health and the environment. Electric vehicles are silent, meaning that noise pollution will fall once they represent the bulk of traffic on the road.

In addition, even where electric cars are powered indirectly by fossil fuels, power stations (and their emissions) tend to be located far from towns and cities, so introducing electric cars should reduce smog levels within urban areas. It is also easier to limit emissions from a few large power plants than from millions of individual cars.

According to Dr Menga, these factors could save a few cents per kilometre; over the lifetime of the vehicle, this would add up to thousands of euro.

Electric vehicles are particularly well suited to the urban environment, where few people travel more than 100 km a day, and most drive even less than 50 km. This is important because half the world's population already lives in urban areas, and the UN expects this figure to rise to 70% by the middle of the century. Over short distances, ICEs do not have the time to warm up; while cold, they work less efficiently and emit more pollution. Electric vehicles do not have this problem.

And economically, as electric vehicles have fewer moving parts than petrol- and diesel-powered cars, they are expected to have lower manufacturing and running costs.

Brake on progress?

So why are there so few electric cars on the road today? One major problem is cost: current electric vehicles are not mass-produced and are known to be vastly more expensive than cars running on an ICE. A recent survey by Frost and Sullivan of 2 000 people in France, Germany, Italy and the UK revealed that the high initial price of electric vehicles is indeed a major barrier to their adoption.

This suggests that proving to consumers that an electric vehicle is cheaper to run than a conventional vehicle with a small engine, while reducing costs through mass production, will be extremely important in winning drivers over to the electric cause.

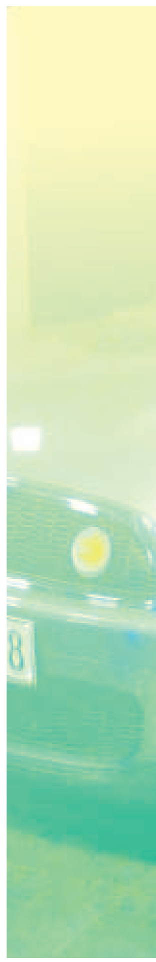
A second problem is range; despite improvements in battery performance, few of the electric vehicles available today can travel more than 200 km before the battery needs recharging. While this may be adequate for small trips around town and short weekend trips, it quickly becomes a problem on longer journeys, especially when the long recharging time of the batteries is taken into account.

The problem lies in the low energy density of batteries. The most modern lithium-ion batteries, which are designed for use in electric and plug-in hybrid vehicles, have an energy density of around 150 Wh/kg, which is up to 5 times higher than that of the older lead acid ones. For comparison, the energy density of petrol and diesel is much higher, at around 12 kWh/kg, although the weight of the engine and the related components such as the gearbox and the exhaust system eat away most of the difference in density at system level, particularly in smaller vehicles. And many electric car batteries take up to between 5 and 8 hours (depending on the size of the battery) to charge from a normal plug in the home. Even a 'fast' recharging option of around one hour would pose problems, especially if there were queues at the charging station.

Although there is some talk of getting round the battery lifetime problem by swapping batteries, this could be complicated engineering-wise and the environmental, cost, logistic and life-cycle impacts of this 'quick-change' concept need to be analysed carefully.

This leads on neatly to the fourth problem — the lack of an infrastructure to support electric cars. Not everyone has a garage equipped with the right power supply for an electric car, and obviously car owners will sometimes need to recharge their batteries while away from home. Recharging stations and points need to become as common as petrol stations are today,

In addition, the overwhelming majority of mechanics are unfamiliar with electric vehicles, so finding someone who could service and repair an electric car would initially be problematic and restricted to the costlier service network of the seller.



A 'step change' is needed!

As ERTRAC (European Road Transport Research Advisory Council) and EPoSS (European Technology Platform on Smart Systems Integration) point out in their joint strategy paper [5] on the electrification of urban mobility and transport, getting round these problems will require 'a "step change" of technologies, business models and user practice that requires strong efforts in terms of research and development'.

The scale of the electrification task should not be understated. 'The migration towards electricity is a massive change in vehicle technologies and systems that will not only substantially alter R&D priorities but even influence the decisions of OEMs (original equipment manufacturers, i.e. the car producers) and suppliers on investments, product portfolio and vehicle concepts,' ERTRAC and EPoSS write.

Beneath the bonnet — unpicking the innards of the electric vehicle

From the outside, electric cars look almost identical to their ICE-powered counterparts. However, a glance under the bonnet reveals a very different picture. Many commentators explain it simply by comparing an ICE to a 'plumbing job' and the electric vehicle to a 'wiring job'.

In the electric vehicle, the engine is replaced with one or more electric motors, which get their power from an array of rechargeable batteries. In reality there are many different kinds of electric vehicle, some of which are powered entirely by electrical energy and some of which are powered in part by other fuels such as petrol or hydrogen.

Hybrid electric vehicles (HEVs) have both an electric motor and an ICE (or a fuel cell). These vehicles are extremely fuel efficient because they can draw heavily on the electric motor when conditions mean that the ICE is not operating at its maximum efficiency, for example when it is cold or while accelerating at low speeds. Because of the ICE, HEVs do not have the driving range problems associated with electric cars. Hybrid technology is fairly well developed, and hybrid vehicles have been commercially available for a number of years.

A relatively recent variation on the hybrid theme is the plug-in hybrid electric vehicle (PHEV). These have a larger battery pack than conventional HEVs, and, as their name suggests, they can be charged directly from a wall socket. In addition, the PHEV's control system allows it to be driven solely in electric mode for shorter distances. At the same time, its ICE allows it to drive much further than full electric vehicles.

As the automotive industry is well aware, even though most car journeys fall well within the range of electric vehicles (and would therefore be perfectly adequately covered by an urban vehicle), consumers who want a single car for the family are likely to buy a car that has a

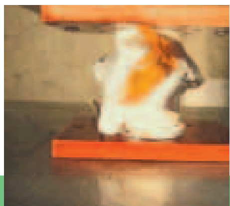
[5] See www.green-cars-initiative.eu/documents/ERTRAC-EPoSS%20Strategy%20Paper.pdf/at_download/file

less limited mileage. PHEVs are therefore widely viewed as an important stepping stone on the path to full electrification of the transport system.

Vittorio Ravello of the Fiat Research Centre and coordinator of HI-CEPS project comments: 'People say they want to protect the environment, but they also want power and style. For many people, hybrid vehicles could be the answer.'

Another type of electrified vehicles is the fuel cell electric vehicle (FCEV), which obtains its electricity from a hydrogen fuel cell. Finally, there are of course growing numbers of pure electric vehicles, which run entirely on electricity supplied by a large array of rechargeable batteries.

According to ERTRAC and EPoSS, further research is needed to explore the best combinations of fuel type and vehicle concept for different situations, locations and user profiles.



POMEROL

Power oriented low cost and safe materials for Li-ion batteries

The POMEROL project developed prototype Li-ion cells for use in hybrid vehicles based both on conventional engines and fuel cells. They increased the battery's power density to almost 3 000 W/kg at cell level and brought the estimated price down to around EUR 20/kW (for mass production). Because they are based on lithium iron phosphate technology, the batteries are also safer, as demonstrated in several types of tests. Thisproject follows up other EU funded projects which developed a previous generation of cells which are currently in production for the first European hybrid car.

Coordinator: SAFT SA (France)
EU funding: EUR 2.47 million
Start/end: 01/12/2005 - 30/11/2008
Project information on CORDIS: http://cordis.europa.eu/search/index.cfm?fuseaction=proj.document&PJ_LANG=EN&PJ_RCN=8326686

Building better batteries

At the heart of the electric vehicle is the battery. Early electric cars were powered by ordinary lead-acid car batteries, while hybrids currently on the market mostly use nickel-metal hydride (NiMH) batteries. However, more advanced batteries are needed if electric vehicles are to become a reality.

As EUCAR (the European Council for Automotive R&D) [6] points out in its recommendations on the electrification of the urban transport system, 'Even if a lot of progress has occurred in terms of energy content related to volume and weight of a modern battery, these characteristics remain about a hundred times lower than that of fuels for combustion engines. This fact is one of the main challenges for electric mobility, as it influences both costs and usability.'

Currently, lithium-ion (Li-ion) batteries appear to be the best option for the vehicle industry as they offer the highest energy and power density levels. The problem is that the Li-ion batteries of today were not designed for the car industry, but for the portable electronics sector, for use in products like laptops, mobile phones and MP3 players. Progress is urgently needed on the safety, lifetime and cost fronts to make these batteries more suitable for use in vehicles.

For example, the vast majority (98%) of Li-ion batteries in use today use lithium cobalt oxide for the positive electrode. However, cobalt is rather expensive, so much of the research focuses on investigating the potential of cheaper metals such as iron, nickel and manganese.

Batteries containing cobalt can also have a serious safety problem known as 'Thermal runaway'. When the batteries get too hot, they can become self-heating, eventually bursting into flames or even exploding, as has happened with a few laptop and mobile phone batteries.

[6] EUCAR is part of ACEA, the European Automobile Manufacturers' Association.

Cobalt-containing batteries become prone to runaway at lower temperatures than batteries based on more stable compounds, such as lithium iron phosphate or lithium manganese spinel oxide.

As well as investigating safer electrochemistry, the mechanical design of the system can be set so that the circuit breaks if the pressure exceeds a certain level. Electrical sensors monitoring the temperature and voltage of the cells are also used to ensure the safety of the batteries.

Another challenge facing those adapting Li-ion batteries to cars is extending the lifetime of the product. The consumer electronics industry only demands a lifetime of a few years. In contrast, the car industry needs its batteries to last at least 10, and ideally around 15 years.

The lifetime of a battery is determined in large part by the materials used in the electrodes and in the electrolyte (battery fluid). The EU-funded HELIOS project is investigating four highly promising materials to see how they perform in the long term. 'Within HELIOS, common European test procedures for the assessment of novel battery technologies for electric and plug-in hybrid applications will be established,' says HELIOS project coordinator Dr Anna Teyssot of Renault.

Regarding performance, current commercially available NiMH technologies have an energy density of less than 100 Wh/kg, and current lithium batteries can reach energy densities of 150 Wh/kg, but carmakers believe that this needs to be improved to at least 200 Wh/kg, if not higher. Increasing the energy density of electric vehicles' batteries is essential because it largely determines the car's range.

According to Dr Cécile Tessier of French battery manufacturer SAFT, a great deal of recent battery research has focused on developing batteries for plug-in hybrid electric vehicles. 'The batteries are rather different from pure hybrids,' she explains. 'For this kind of vehicle the challenge is to find the right trade-off between power, energy, safety and life.' Solutions to each of these problems exist; the difficulty is finding a battery electrochemistry that addresses all four at once.

At the moment, many new and promising materials address some but not all of these problems. For example, manganese spinel does well on power and safety but lags behind on lifetime, while lithium iron phosphate excels in power and safety, but has only an average lifetime and does not have very high energy levels. Research focuses on investigating different materials and studying the way the different components of the battery interact with one another.

In the longer term, investigations are needed into technologies that could result in even better batteries (with an energy density in excess of 500 Wh/kg). Among other things, these studies could experiment with using entirely different materials, such as silicon, tin or other metals for the different parts of the battery, and look into ways of replacing rare or toxic materials like nickel and cobalt.

An even more radical approach (the so-called metal-air batteries) completely does away with one of the components by replacing it with oxygen from the air, thus massively reducing the battery's weight and cost, and increasing safety. The air electrode is separated from the electrolyte by a semi-permeable membrane.

However, these technologies are still in the very early stages of development and are unlikely to be available before 2020 in car applications (although they may be available sooner in portable devices).

The European Commission now plans to fund research projects that will give Europe a head start in the development of both the next generation of Li-ion batteries and of even more advanced batteries based on entirely different materials.

In addition to the batteries themselves, research is needed to develop systems that allow drivers and mechanics to determine the state of the battery and diagnose any problems. Furthermore, thought should be given to how the various materials that make up car batteries could be recycled.

HELIOS
High energy lithium-ion storage solutions

The materials used for the various components of a battery strongly influence its overall performance. The recently-started HELIOS project is working on four materials Lithium Nickel Oxyde (NCA), Lithium Nickel Manganese Cobalt Oxide (NMC), Lithium Iron Phosphate, and Lithium Manganese Spinel Oxide (blended) that are emerging as strong candidates for use in energy batteries (i.e. for pure electric and plug-in hybrid electric vehicles) in the near future. The team is testing how these materials affect the characteristics, especially the lifetime and safety, of the battery. They are also carrying out 'post-mortems' on aged batteries to provide battery makers with the detailed information they need to design better, longer-lasting batteries and their control systems.

Coordinator: Renault S.A. (France)
EU funding: EUR 2.9 million
Start/end: 01/12/2009 - 30/11/2012

Supercapacitors — buffering the battery

Along with the battery, some hybrid and electric vehicle prototypes are equipped with supercapacitors. These high-power storage devices are able to store and release large amounts of energy extremely rapidly, something that batteries simply cannot do. As such, supercapacitors are important at times of high power intake and release. Because of this, supercapacitors are particularly suitable for capturing the energy released during braking, for example, and then using it during the next acceleration. If the battery tried to take up a lot of energy very fast, it could become damaged and have its lifetime reduced.

Supercapacitors can therefore maximise energy efficiency and increase the battery's life expectancy by reducing the stresses of hard charging-discharging cycles.

Over the years, EU-funded research has resulted in steady improvements in the performance of current supercapacitors. At the same time, other projects are working on the next generation of supercapacitors.

One problem with today's supercapacitors is the fact that they contain organic solvents. These toxic chemicals are harmful to the environment and need to be handled and disposed of carefully. Such compounds can also become volatile at the high temperatures often found in fuel cell and hybrid cars.

The EU-funded ILHYPOS project has developed a prototype supercapacitor which replaces the organic solvents with ionic liquid. The ionic liquid offers a number of advantages over organic solvents: it is extremely stable, non-flammable and non-toxic. It does not damage the environment and can be recycled.

The prototype ILHYPOS supercapacitors also work better than the supercapacitors that are commercially available today. The project partners are on track to meet their targets of achieving specific energy levels of 15 Wh/kg and specific power levels of 7 kW/kg. The corresponding figures in today's best commercial supercapacitors are less than 10 Wh/kg and around 6 kW/kg respectively. The next step is to scale up production of the supercapacitors.

'Their impact in the future would be substantial if the increase of specific power and energy were confirmed at industrial scale, as well as the cost and the durability. These targets can be achieved by optimising materials, design and process, and by working on the integration at module and system level as well as thermal and electronic management,' comments ILHYPOS project coordinator Mario Conte of the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA).

Meanwhile there is some debate as to what battery-supercapacitor combination will work best in the cars of the future. If more robust batteries are developed that can take up and release large amounts of electricity without their overall performance suffering, supercapacitors could become redundant. On the other hand, some cars, such as hybrids, may function well with a supercapacitor alone and no battery. Some researchers are even working on 'hybrid' devices which combine the properties of a supercapacitor and a battery.

ILHYPOS

Ionic liquid-based hybrid power supercapacitors

The ILHYPOS project worked on the next generation of supercapacitors, radically improving their performance and making them safer and more environmentally friendly in the process. The fluid in the prototype supercapacitors developed by the ILHYPOS researchers is much more stable at high temperatures than the toxic fluids used in today's supercapacitors. The ionic liquid can also be used in other devices, such as fuel cells, solar cells and batteries. The project partners also worked on cell designs and an advanced concept for a pilot production line for the assembly of their novel supercapacitors.

Coordinator: ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development (Italy)
EU funding: EUR 1.64 million
Start/end: 01/12/2005 - 31/5/2009
Project information on CORDIS: http://cordis.europa.eu/search/index.cfm?fuseaction=proj.document&PJ_LANG=EN&PJ_RCN=8330870

HYHEELS

Hybrid high energy electrical storage

The HyHEELS project succeeded in improving the performance of supercapacitors, particularly at very high and very low temperatures, and increased the amount of energy that a single capacitor can store by increasing voltage to 2.7 volts via a smart package that increases the power density. In addition, the researchers developed an advanced system that ensures all of the cells in the supercapacitor always have a balanced voltage when being charged and discharged. This significantly improves the reliability and lifetime of the module.

Coordinator: Continental AG (Germany)
EU funding: EUR 2.64 million
Start/end: 01/11/2005 - 31/12/2008
Website: http://wwwa.vito.be/hyheels/

Fuel cells

Even though their development has been somewhat delayed, fuel cells are widely considered to have an important role to play in the vehicles of the future, and the technology could be complementary to electric vehicle development by helping to significantly extend their range. Fuel cells convert chemical energy to electrical energy very efficiently, the only by-product of the reaction being water vapour. Furthermore, if the hydrogen is produced using renewable energy sources, hydrogen fuel cells are extremely environmentally friendly.

However, as with much of the technology associated with hybrid and electric vehicles, further research and development is needed before fuel cells are ready to be deployed on a wide scale.

Most EU-funded research on hydrogen and fuel cells is not channelled through the European Green Cars Initiative, but through the Fuel Cells and Hydrogen Joint Technology Initiative (JTI), a seven-year, EUR 1 billion public-private partnership (PPP) which also covers other applications (for instance stationary or emergency power generation).

Around a third of the JTI's budget is devoted to developing hydrogen-fuelled road vehicles and a corresponding hydrogen refuelling infrastructure, as well as other supporting elements needed for a wider uptake of hydrogen-powered vehicles. Among other endeavours, the JTI supports demonstration projects involving large fleets of fuel cell hybrid vehicles. The JTI is also financing research to improve hydrogen quality, design better storage tanks and ensure the safety of hydrogen powered vehicles in crashes.

Another important priority for the JTI is hydrogen production and distribution; it aims to increase the proportion of hydrogen from carbon-free sources to between 10% and 20% by 2015.

The JTI also places a strong focus on stimulating the creation of early markets for hydrogen and fuel cell technologies, as a stepping stone towards their wider distribution and deployment.

HyTRAN
Hydrogen and fuel cell technologies for road transport

The HYTRAN project developed a completely European 80 kW hydrogen fuel cell system and successfully installed it in an urban car. The fuel cell demonstrated relevant improvements in important areas such as power density, low temperature behaviour and durability, while the new vehicle's fuel efficiency is 15% better than the previous generation of the Fiat Panda Hydrogen Concept Car. The novel passenger vehicle has competed successfully in a number of 'green car' rallies. In May 2009 the HYTRAN car completed the 750 km EVS Viking Rally in 6 hours and 5 minutes, winning second place in the hydrogen vehicle category. However, on fuel efficiency it came first, consuming just 6.08 kg of fuel for the entire journey.

Coordinator: Volvo Technology Corporation (Sweden)
EU funding: EUR 8.81 million
Start/end: 01/01/2004 - 30/05/2010
Website: http://www.hytran.org

The motor

While electrical motors exist for many applications, there is currently no facility in Europe that is geared up to produce the large numbers of electric vehicle motors eventually needed by the auto sector to switch over to electric cars.

As ERTRAC and EPoSS note, the research needs for the motor are somewhat contradictory. 'Strong demands for small package volume and low weight and cost efficiency are opposed by the needed increase of power and torque,' they write. 'Additionally the motors need to have the ability to withstand the harsh temperature and mechanical vibration conditions in a vehicle application.'

Keeping costs down while improving performance and ensuring reliability and safety will require new materials and possibly even entirely new electrical motor concepts. Hybrid vehicles pose a particular problem as they require electrical and ICE systems to work together.

HOPE

High density power electronics for fuel cell hybrid electric vehicle powertrains and internal combustion engine hybrid electric vehicle powertrains

The HOPE project came up with a prototype power electronics system that is able to operate within a temperature range of -40ºC to 40ºC. Normally the power electronics need to be cooled in order to work effectively, and this means that they have to be located in parts of the car where coolant is available. The HOPE project employs a heat pipe system, which means that it does not need to be linked up to the cooling loop and so can be placed anywhere in the engine compartment wherever there is space available. In addition, the project also developed a system for low-cost mass market production of inverters for electric drives and pursued the development of Silicon Carbide chips, which are intrinsically capable of working at higher temperatures and therefore with no cooling.

Coordinator: Siemens AG (Germany)
EU funding: EUR 2.4 million
Start/end: 01/01/2006 - 31/12/2008
Website: http://www.fp6-hope.ecpe.org/f6hope/public/home.php

At the same time, a good deal of research is needed to develop compact ICEs that are perfectly adapted for use in PHEVs. Using the ICE and battery as efficiently as possible will require 'smart' solutions that allow the car to take into account the battery's state of charge, the driver's habits, road attributes and the traffic situation.

In fact, the perfect solution might not be a derivative of current piston engines, but may involve some other concepts (such as rotary, two-stroke engines or even microturbines) that have been discarded in the past for automotive applications but might be better suited to the role of providing a continuous flow of electric energy.

Power electronics

Electric vehicles' limited range is a major challenge, so the industry is keen to exploit every available opportunity to save energy in the vehicle, and the power electronics have a key role to play in ensuring that the vehicle is as energy efficient as possible. As well as controlling how the energy is used in the car, the power electronics are responsible for converting the battery's direct current into an alternating current for the motor.

The power electronics are also needed during a process called 'regenerative braking'. Normally, when a car brakes, the energy generated by braking is lost as heat through the brake pads. A car with regenerative braking slows the vehicle by capturing this energy and transferring it, with the help of the power electronics, back to the battery or supercapacitor.

As with many other components of the electric car, research is needed to find ways of bringing down the costs of the power electronics; in an electric car, only the battery is more expensive. In addition, engineers need a better understanding of how electric cars are used and the stresses and strains they experience as they go through countless charging-recharging cycles. It is also vital that the power electronics be able to withstand high temperatures and voltages. Finally, in terms of size, power electronics tend to be rather bulky, and much of this space is taken up with cooling equipment to stop the unit from overheating.

Auxiliaries

Over the years, car manufacturers have added large numbers of components to cars to make them both safer and more comfortable. Examples include air conditioning, lights, heating, power steering, the pumps for fuel, brakes, oil and cooling fluids, not to mention the ever-expanding range of communication and entertainment devices (MP3 player, radio, navigator, mobile phone, etc.). However, these 'auxiliaries', as they are known, were designed for use in conventional, fossil-fuel burning cars and need adapting for use in electric vehicles, in order to minimise the impact of their use on the vehicle's range.

A case in point is the air conditioning system. In a car with an ICE, the engine powers the compressor of the air conditioning system. Similarly, the heating system traditionally uses waste heat from the combustion of fuel in the engine. In an electric vehicle, these systems are powered directly by the battery, and so their use can dramatically reduce the vehicle's already limited range even further.

Research in this area focuses on ensuring that all auxiliaries use as little energy as possible, and on ways of using them that minimise their energy requirements (by switching them on and off, or storing heat in special devices for later use, for instance). There is also a lot of work on developing innovative ways of capturing energy, for example through regenerative braking, the integration of photovoltaic (PV) cells into the vehicle and the development of 'smart' systems to optimise heat flows through the vehicle.

EE-VERT
Energy efficient vehicles for road transport

EE-VERT is investigating ways of reducing fuel consumption by coordinating the production and consumption of energy within the vehicle, for example through systems such as electric power steering and air conditioning, and by developing a more efficient generator. Ultimately, the project aims to reduce CO_2 emissions from conventional cars by 10% using smart, low-cost electrification. Although EE-VERT is focusing its efforts on cars with an ICE, many of its findings are likely to be relevant to hybrid and electric vehicles.

Coordinator: MIRA Ltd (United Kingdom)
EU funding: EUR 3.62 million
Start/end: 1/1/2009 - 31/12/2011
Website: http://www.ee-vert.net

The control software

The car battery in an electric or hybrid vehicle experiences significant strain in its lifetime; energy is constantly flowing in and out, not only during charging and driving, but also during regenerative braking, for example. At the same time, as we have seen, there are many other devices which draw precious energy out of the battery for auxiliary purposes. The car's software has a vital role to play in managing these energy flows and ensuring that the various components of the car use energy as efficiently as possible. In this way, the software significantly influences the car's energy use and, by extension, its range.

In electric and hybrid vehicles, the car's software is responsible for managing the traction drives, regulating the speed of the motor or the levels of electric power, for example. High levels of control are also needed to implement the driver's requests (such as those coming from the accelerator and brake pedals), while still respecting the limitations imposed by different subsystems (such as the battery system). In hybrid electric vehicles, the software also controls the interactions between the electric motor and the ICE.

'Obviously the more sophisticated the system is, the more complex is the high level of control needed to satisfy as much as possible the driver's requests while trying to maximise at the same time overall efficiency and assuring the desired comfort and proper safety levels,' explains Dr Ravello.

According to Dr Ravello, vehicle manufacturers are increasingly taking a new approach to tackling these problems, by working on the interactions between the vehicle and the powertrain right from the design phase.

HI-CEPS

Highly integrated combustion electric powertrain system

The aim of the HI-CEPS project is to come up with hybrid car concepts that have lower CO_2 emissions but maintain high standards in terms of driveability and comfort. The project is developing three early prototype hybrid vehicles (one small passenger car, one medium-sized car, plus a light delivery vehicle). The project partners took a modular approach to powertrain design. This has allowed engineers to arrange a set of basic building blocks (battery, power electronics and motor modules) in different ways to suit different kinds of vehicles. The researchers are also investigating how to reduce the amount of energy needed by auxiliaries such as the air conditioning, and how to recover energy from waste heat.

Coordinator: Centro Ricerche Fiat SCpA (Italy)
EU funding: EUR 9.83 million
Start/end: 01/09/2006 - 31/12/2010
Website: http://www.hi-ceps.eu

Infrastructure/charging

Obviously electric vehicles need to be recharged fairly regularly. While some drivers may have private garages that could be equipped with a charging station (or even a standard plug, although it takes longer to charge a car from a normal plug than from a proper charging station), many do not. This means that a network of charging points is needed close to residential areas, workplaces or shopping centres, while kerb-side solutions must be found for charging 'on the go'.

These charging points will need a standardised plug, so that any electric vehicle can use them. They will also need to be resistant to extreme weather conditions and vandalism. Charging points could in theory be integrated into existing 'street furniture' such as lamp posts as well as into pay and display units. Research must determine the best business models for the installation and maintenance of these charging points, as well as for their density.

In the meantime, research is urgently needed to bring down the charging time required to 'fill up' an electric vehicle. Charging time varies depending on the type of vehicle, how empty the battery is, and how much driving range is needed. However, slow charging options can take several hours, while even fast charging options can last half an hour much longer than the few minutes it takes to fill an ordinary car with petrol or diesel.

There is no reason, however, to require that the vehicle be stationary while charging. Several solutions are being investigated in which alternating plates at the centre of the road would allow vehicles passing over them to pick up energy with a conducting wheel under the car (more or less equivalent to the pantograph of a train) and there are even studies exploring contactless ways of recharging electric cars.

One example of the latter system, which has apparently worked well in model tests, exploits certain electromagnetic laws. When electricity flows through a conductor, it generates a magnetic field. If the current is an alternating one, it can induce a voltage in a second conductor, even if the two conductors are not touching. If the system is set up correctly, it is possible to transfer energy from one electrical circuit to another, although the efficiency of such a system still needs to be optimised. Obviously, the system could also work in an even easier way while the car is parked.

Although it sounds like science fiction, car production plants and large warehouses already use robotic vehicles that are supplied with power in this way.

A control system would ensure that in both types of systems the conductors in the road are only activated when a car is over them. The companies are also working on technology that would allow the system to identify the car being charged for billing purposes.

The impact of electric cars on the energy system

Obviously large numbers of electric vehicles hooking themselves up to electric plugs on a regular basis will have an impact on the electricity grid. According to calculations by ERTRAC and EPoSS, a million electric passenger cars travelling around 10 000 km every year will require about one terawatt hour (TWh) of energy. This represents just a tiny proportion of the total energy generated in most European countries.

However, in the short term, if all the electric car owners in an area decide to charge their cars at the same time, the result could be power outages as the grid breaks down under the strain. As Dr Frans Nieuwenhout of the Energy research Centre of the Netherlands (ECN) warns: 'The electricity system and network infrastructure can handle large numbers of electric cars only if controlled charging is applied.'

In fact, electric vehicles could actually speed up the deployment of renewable energies by acting as temporary storage devices when supply exceeds demand, and temporary energy sources when demand outstrips supply.

One problem with renewable energy sources, such as wind, solar power and wave energy, is their often unpredictable nature. We cannot always tell when the wind will be strong or how clear the skies will be — information that would be needed to predict the level of energy that could be produced. And even predictable sources such as tides have their drawbacks if the tidal currents are at their strongest when electricity demand is lowest, for example.

What is needed is a system which can take up excess electricity whenever it becomes available, and release it back to the grid when it is needed. This is where electric cars come in. Imagine a situation where the wind is strong but the demand for electricity is low. A smart electricity grid could channel some of the excess energy into cars connected to the grid. Conversely, if demand for electricity is high and the wind is still, the grid could draw on the energy stored in electric vehicles' batteries and transport it around the grid to where it is needed.

Clearly this system has a number of requirements. Firstly, the car charging systems need to be bi-directional, so that energy can flow from the grid to the car and from the car back to the grid. Smart meters would also be required so that consumers pay for electricity they take from the grid, but are paid in turn for energy they provide back to the grid (and in principle, if this transfer took place at peak time, the price would be higher). Of course, such a system would also avoid situations where a consumer goes to use his or her car only to find that the grid has 'purchased' the electricity stored in its battery, leaving the car's owner stranded, if a few euro richer. This would be achieved, for instance, by allowing users to dial in the minimum range for which they would need to be covered when they come back to pick up the car. Of course consideration should be given to the need not to damage the battery in the process.

New business models must be created to cope with the constant flows of energy back and forth between the consumer and the grid. More research is also needed into public acceptance of these schemes, privacy protection issues and smart grids in general.

Education — training up the engineers of the future

As the vehicle industry starts to move down the electrification path, engineers, car designers and mechanics need to do the same. There is currently a dearth of people who have the skills, know-how and simple hands-on experience to design and repair hybrid and electric cars (and also to intervene in an emergency involving them). In a world where unemployment is rising, the electrification of the vehicle industry offers exciting job prospects for young people with the right skill set.

Until recently, almost all university courses for auto engineers were tailored entirely to those who would spend the bulk of their careers working with the ICE. However, the car industry's growing interest in hybrid and electric vehicles means that the demand for people with a combination of mechanical- and electrical engineering skills is growing fast. At the same time, ongoing efforts to improve battery performance are making those involved in battery chemistry, design and integration highly employable. Software experts are also much sought after.

Within the car industry, engineers with decades of experience working with ICEs are finding themselves on a steep learning curve as they get to grips with the novel technologies found in hybrid and electric vehicles. Some have likened it to learning a new language.

All of this has not gone unnoticed by the higher education sector, and universities on both sides of the Atlantic are starting to offer courses that combine mechanical engineering with electrical engineering, electronics, systems integration, software programming and chemistry. Many universities are forging partnerships with industry to ensure that their students get the chance to put their studies into practice in the real world.

'For this reason, the European Commission is planning to fund projects and ideas that raise the awareness of young people concerning the opportunities offered by the electric vehicle sector,' says Maurizio Maggiore of the Surface Transport Unit at the European Commission's Directorate-General for Research.

Meanwhile automakers are setting up courses for their staff to help them adapt to the ongoing electrification of their sector. They are also building multi-disciplinary teams in which different types of engineers work together and learn from each other.

Car mechanics also need training in fixing hybrid and electric cars. The battery system in these vehicles is unlike anything in a conventional car with an ICE, and mechanics need to be taught how to handle and repair these safely and effectively.

As the number of hybrid and electric vehicles on the roads rises, mechanics are becoming increasingly aware of the need to develop these new skills and courses, and qualifications are being developed to meet their needs. In the UK, the Institute of Motor Industry (IMI), together with three leading car manufacturers, has developed awards in hybrid system components, operation, repair and replacement.

Car mechanics are not the only ones who need to know how to deal with hybrid and electric cars. People working for the emergency services, such as the police and fire brigade, have to be familiar with the risks posed by these vehicles when rescuing victims of a road traffic accident or investigating it, for example.

The wider consequences

Electric vehicles clearly offer many advantages over ICE-powered cars. Nevertheless, switching to such a radically different technology could have unintended consequences. 'Increasing demand for raw materials and commodities for electric and electronic vehicle components and modules will expose industry to skyrocketing basic costs, in particular in cases when these materials are rare and the providers are limited,' ERTRAC and EPoSS note.

Today's cars are built mostly with steel, aluminium and a small amount of copper. In contrast, electric vehicles will require materials which may not be available in the quantities needed.

For example, most lithium comes from just a small number of South American countries. Currently lithium is not recycled as there is no shortage of supply in the short and medium term and recycling is not economically profitable. 'Nevertheless, we should be prepared to recover lithium from electric vehicle batteries,' comments Jan Tytgat of Umicore Recycling Solutions in Belgium. 'This is technically feasible but needs some support.' Again, the European Commission has recognised this problem and battery recycling is a subject of the 2010 call for proposals of the sustainable surface transport work programme.

Dr Tytgat also points out that recycling materials is beneficial for the environment. 'Metals from recycled materials have a CO_2 footprint which is 70% below the footprint of metals from primary sources,' he explains. 'Illegal export of used batteries can create an environmental time bomb in countries with lower environmental standards.'

As researchers continue to come up with new electric vehicle technologies involving different materials, recycling processes will need regular review.

A major issue facing electric vehicle makers now is the supply of certain rare earth (e.g. neodymium, samarium, etc.) that are widely used in a range of green and other technologies. They are the vital ingredients in the extremely powerful magnets found in some types of electric motors used in hybrid and electric cars. These powerful magnets keep the motor extremely compact and also keep its weight down.

One country, China, currently controls over 95% of the world's supply of rare earth, and in autumn 2009 the Chinese government announced plans to restrict exports of these important materials. Finding more readily available alternatives for these important materials will be a research priority.

Putting it all together

Electrifying urban transport systems represents an immense, long-term challenge that will require many diverse groups to work together. In their strategy paper, ERTRAC and EPoSS conclude that 'automakers, suppliers, independent research and development capacities, standardisation bodies, utilities, national and local authorities, public transport operators and user organisations, European Technology Platforms and the European Commission' should all cooperate on setting research priorities and ensuring that electric vehicles, their infrastructure, the wider industry and associated rules and regulations all collaborate together coherently.

It is also imperative that work be undertaken to facilitate intense cooperation between schemes related to electric vehicles and initiatives at both global and EU Member State levels.

The car industry and utilities also need to collaborate on setting standards for the interface between the vehicle and the charging infrastructure. Put simply, a standardised smart plug for electric cars in Europe is required, to allow any electric vehicle to recharge (and pay the bill) in any EU country and beyond. The interfaces between the different components of the car must also be clearly defined and standardised.

The Green Cars Initiative putting green cars on Europe's roads

Through the European Green Cars Initiative, the European Commission is supporting a large scale demonstration project, scheduled to start in 2010, that will complement the many existing national initiatives by testing how fleets of electric vehicles perform in real-life conditions in towns and cities across Europe. The vehicles involved in the project will range from two-wheelers to cars and buses, and have different types of powertrains, including plug-in hybrid and full electric technologies.

With respect to infrastructure, the initiative should try out different systems for vehicle-grid interaction, including bidirectional vehicle-grid charging stations, as well as maintenance facilities. During the project, data on the impact of the electric vehicles on electricity grids will be gathered. This will then be used to make reliable computer models of the impacts of the large-scale use of electric vehicles on grids.

The impact of the vehicles on the environment will be investigated, as will the economic aspects of running the vehicles. A survey of customer acceptance of the vehicles also forms an important part of the project.

Ultimately the European Commission hopes that the project will speed up the market roll-out of electric vehicles. 'This project should contribute to clarify the safety, economic and technical viability of the different types of electrical vehicles for broad market introduction, as well as identify needed standards and requirements for fixed electrical infrastructure at European level,' explains Hugues Van Honacker of the Clean Transport and Urban Transport Unit at the European Commission's Directorate-General for Energy and Transport.
In addition, the results will provide researchers and the auto industry with valuable information that will aid them in developing the next generation of electric vehicles.

The European Commission is not alone in having spotted the need to fund research into electric vehicles. Many national research-funding bodies are also financing research and development activities in this area. If there is no coordination between these national schemes, there is a strong likelihood that some research will be duplicated while other research questions will remain unaddressed.

To tackle this problem, the European Commission is supporting the creation of a Public-Private-Partnership (PPP) which would link up the road transport industries with the relevant public authorities in the implementation of both European and national research programmes.

In addition, the PPP would coordinate the efforts of different European Technology Platforms (such as ERTRAC and EPoSS) working on issues related to green cars.

Other areas of the Green Cars Initiative

4

More than just electric cars

Freight transport cleaning up its act

Despite its name, the European Green Cars Initiative aims to reduce CO_2 emissions from all forms of road transport and therefore its scope extends beyond passenger cars to incorporate heavy goods vehicles and logistics. Almost half of the EU's freight now travels by road, and this has a huge impact on the environment. Improving the fuel efficiency of Europe's freight vehicles, encouraging a switch to other modes of transport where possible and improving logistics will result in a greener, more competitive freight transport system.

Beyond passenger vehicles, there are other important transport issues to be addressed in the pursuit of a greener Europe. Improvements in the performance of heavy duty goods vehicles and reductions in polluting emissions from freight transport, for example, are important steps in the EU's mission to develop a cleaner, more efficient transport system.

Roads have become the dominant mode of freight transport in the past half century: 45.6% of the EU's freight [7] is conveyed by road and there are some 33 million commercial freight vehicles [8] plying the EU's roads. Freight transport is one of the main drivers of the EU economy. The road freight sector alone employs 2.8 million people [9] and has a turnover of EUR 280 billion [10].

However, while growth is good for the economy, the rise in road freight transport is also leading to congestion and bottlenecks, which means wasted time and consequent loss of GDP.

The sheer volume of freight transport in the EU is also placing a huge strain on the environment. Road transport is responsible for almost 30% of all carbon dioxide (CO_2) emissions in the EU, and while emissions from most sectors are in decline, emissions from freight transport rose by 62% between 1990 and 1995. If the EU is to meet its ambitious climate change goals, radical changes are needed in this sector too.

Freight transport also contributes significantly to levels of other pollutants, such as nitrous oxide and particulate matter, both of which harm health and damage the environment. In addition, heavy lorries rumbling through towns and cities are a source of noise pollution.

Furthermore, freight transport is almost entirely dependent on precious supplies of fossil fuels. New ways must be found of generating power and scaling down the use of the planet's remaining oil. And this means finding more sustainable ways of powering Europe's freight vehicles.

When it comes to smaller vehicles like cars, the European Green Cars Initiative's ultimate goal is nothing less than electrification. However, electrification is not feasible for most of the freight sector, as it is simply not possible to power a heavy goods vehicle over long distances with a battery alone. Therefore efforts for these larger vehicles focus on developing cleaner fuels, making vehicles more fuel efficient and improving logistics to ensure that vehicles do not take to the roads while entirely or partially empty.

More efficient vehicles

Through the European Green Cars Initiative, the European Commission is promoting research that will lead to the development of more energy-efficient trucks and lorries. Diesel engines for lorries are already very efficient. Nevertheless, further improvements can be made to improve the efficiency of internal combustion engines (ICEs), while the overall efficiency of the vehicle can also be enhanced, for example by recovering energy from the heat of the exhaust gases.

[7] 2007 figures.
[8] 2007 figures.
[9] 2006 figures.
[10] 2006 figures.

Another avenue of investigation concerns 'mild' hybridisation. A mild hybrid lorry is still powered largely by an ICE, while a small electric motor acts as a kind of power booster. The electric motor helps to reduce fuel consumption by shutting down the ICE when the vehicle is stationary or braking. It also helps the ICE to restart more efficiently.

The presence of the electric motor also allows the vehicle to take advantage of regenerative braking, during which the energy which is normally lost during braking is captured and stored in the battery. This energy can be used to power auxiliaries such as the lights and air conditioning, for example.

Although they do not offer the same fuel savings as full hybrids, mild hybrids nevertheless improve fuel efficiency by between 10% and 15%. In addition, mild hybrids are much less expensive than full hybrids. The HCV FP7 funded project, which began recently, is looking into the benefits of hybrid systems in buses and light trucks, and more work might be carried out in the future to look into the application of hybrid technology to long-range lorries.

Another important factor for future powertrain development concerns the impacts of blending biofuels with diesel on fuel quality, particularly its effect on combustion and the after-treatment system. A rise in the use of other fuels such as natural gas or bio-gas will make it necessary to improve dual fuel capabilities.

Tyres also have a major impact on a vehicle's fuel efficiency. Friction between the tyre surface and the ground accounts for up to 10% of a fully loaded vehicle's fuel consumption. Reducing friction could therefore significantly improve a vehicle's fuel efficiency. Simply switching from the least efficient to the most efficient tyres available on the market today would allow drivers to cut their fuel consumption by 10%.

The EU recently approved rules that will see all tyres sold in the EU labelled with an energy efficiency rating. The eco-label will see tyres rated from A (the most efficient) to G (the least efficient), allowing consumers to see at a glance which tyres are likely to result in the best fuel savings.

The A to G energy efficiency rating scheme has been applied to household appliances for a number of years, and has proven successful in promoting more energy-efficient products in that sector.

The new tyre eco-label will also provide drivers with information on a tyre's wet grip and noise levels.

Given the high mileage of heavy goods vehicles, using more fuel efficient tyres could result in massive reductions in the sector's total greenhouse gas emissions, as well as savings for haulage companies.

SECURCRANE

Design of an innovative system for the drive and control of port cranes for safe remote operation

The SECURCRANE project set out to improve the productivity (as measured by lifts per hour) of cranes in ports by reducing the high stress levels experienced by crane operators. The partners designed a remote control station that allows crane operators to work in safer, more comfortable positions on the ground. Controlling swaying cargo is a big problem for crane operators; SECURCRANE developed an intelligent anti-sway system that predicts and prevents loads from swaying. Finally, a cargo monitoring system applies existing scanning technologies to check containers for ID codes, possible damage and other characteristics.

Coordinator: SCIROIDEA (Italy)
EU funding: EUR 2.2 million
Start/end: 01/05/2006 - 30/09/2009
Website: http://nuke.securcrane.info/

Smart and simple logistics

At the moment, road freight transport is the quickest and most efficient freight option as it can deliver door-to-door, something no other mode of transport can do. However, poor organisation and resistance to sharing information in the sector mean that only around 60% of the loading capacity of road transport is currently being used, meaning that many lorries are travelling around while only partially laden with goods. Freight transport logistics has a significant effect on the economy frequent delays and damage push up product prices so Member States working together to improve EU freight transport logistics makes economic sense.

While the current economic situation has had an impact on investments in sustainability, interest in this area remains strong. In fact the financial crisis may have focused more attention on measures which can cut costs with only limited investments. It is in global retailers' interests to exert pressure on their supply chains to improve sustainability. Considered from this angle, green logistics becomes a business solution. Technologies that enhance supply chain visibility are being used to drive sustainable improvements in lead times, delivery reliability and inventory reductions. At the same time, improvements in efficiency must be matched by improvements in security.

With this in mind, a major priority of the European Green Cars Initiative is improving logistics in the freight sector so that faster and more efficient deliveries can be made with fewer lorries on the roads.

SMART-CM

Smart container chain management

The SMART-CM project, funded under the Seventh Framework Programme (FP7), brings together major global container companies, including small and medium-sized enterprises (SMEs), and port authorities to investigate ways to streamline customs procedures and container management processes. It will result in a simple, transparent and neutral way for customs officials and companies involved in container transport to interact with one another. This will make information exchange faster and more accurate.

Coordinator: Centre for Research and Technology Hellas/ Hellenic Institute of Transport (Greece)
EU funding: EUR 6.5 million
Start/end: 01/08/2008 - 31/07/2011
Website: http://www.smart-cm.eu

INTEGRITY

Intermodal global door-to-door container supply chain visibility

The INTEGRITY project is looking at how to improve the reliability and predictability of current door-to-door freight transport chains. It is developing a system called the Shared Intermodal Container Information System (SICIS), which will allow companies and authorities access to information on all aspects of particular freight cargos. Enhancing security measures and sharing data on vehicles, cargo and inspections will speed up customs clearance.

Coordinator: Institute of Shipping Economics and Logistics (Germany)
EU funding: EUR 6.5 million
Start/end: 01/06/2008 - 31/05/2011
Website: http://www.integrity-supplychain.eu

The EU needs to put in place a working, co-modal transport infrastructure that can improve the efficiency of freight transport networks by making use of all modes of transport: land, air, sea and perhaps even a return to the use of Europe's extensive network of canals. The increasing containerisation of freight transport is a positive step towards co-modality development.

A transport system that seamlessly links water, road and rail would reduce road congestion, be better for the environment, and take some of the pressure off EU roads. Plus co-modality would be more cost-effective and efficient than lorries travelling thousands of miles across congested European motorways to deliver goods.

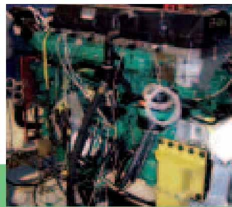
The European Commission's 2007 Communication 'Freight Transport Logistics Action Plan' discusses the vital need for a freight transport logistics policy across the EU. One of its visions for the future is the concept of 'Green Transport Corridors' for freight. Representing a set of defined traffic routes, these corridors would see short sea shipping, rail, inland waterways and roads complement one another, allowing users to pick the most environmentally friendly form of transport for each stage of the journey: this is also what co-modality is all about.

The Communication also highlights the need to implement 'e-freight' solutions. 'The concept of e-freight denotes the vision of a paper-free, electronic flow of information associating the physical flow of goods with a paperless trail built by ICT (information and communication technologies),' the Communication explains.

As the Communication notes, freight should be identifiable and locatable regardless of the mode of transport conveying it at any given time. An e-freight system would allow users to track and trace freight throughout its journey and to automate the exchange of information for regulatory or commercial purposes.

Education

A driver's behaviour heavily influences his or her vehicle's fuel consumption. Accelerating smoothly, limiting speed, reducing the use of air conditioning and switching off the engine if the vehicle is likely to be stationary for long all help to save fuel.



GREEN

Green heavy duty engine

The GREEN project brought together leading European heavy-duty engine manufacturers, suppliers, researchers and top engineering institutes. Their goal was to design advanced future engine technologies with a view to lowering both emissions and fuel consumption. The researchers focused their efforts on developing engines for use in lorries and on the railways as well as in urban vehicles. Among the achieved results, several simulation codes to design advanced turbocompressors and heat recuperation cycles, as well as advanced fuel injectors and control systems.

Coordinator: Volvo (Sweden)
EU funding: EUR 12 million
Start/end: 01/03/2005 - 31/05/2008
Website: http://green.uic.asso.fr/

TRAIN-ALL

Integrated system for driver training and assessment using interactive education tools and new training curricula for all modes of road transport

The FP6 project TRAIN-ALL is developing an integrated training system aimed at all drivers, including lorry drivers. One of the aims of the project is to promote economical/ecological driving through its many training tools. The objectives include:

- a review of the state-of-art in Computer Based Training curricula and trainee performance criteria;
- a common framework definition for the training of different driver types from the training needs;
- a set of Uses Cases (UCs) to implement the scenarios, and;
- a common training curricula for the different drivers groups.

Coordinator: Centre for Research and Technology Hellas / Hellenic Institute of Transport (Greece)
EU funding: EUR 2.3 million
Start/end: 01/11/2006 - 31/12/2009
Website: http://www.trainall-eu.org/

ITARI

Integrated tyre and road interaction

Both the tyre and the road surface have a huge impact on a vehicle's fuel consumption. The aim of the ITARI project was to develop computer models and design tools to help road designers and engineers investigate the interaction between tyres and the road surface. These models allow users to predict the properties (in terms of noise reduction, fuel consumption and safety) of a given road surface early on in the design stage, thereby reducing costs later on.

Coordinator: Chalmers University of Technology (Sweden)
EU funding: EUR 1.7 million
Start/end: 01/02/2004 - 31/01/2007
Project information on CORDIS: http://cordis.europa.eu/search/index.cfm?fuseaction=proj.document&PJ_LANG=EN&PJ_RCN=7520216

Conclusions

5

The future

En route to a greener transport system

Hybrid and electric vehicles have come a long way in recent years, but a lot of research is still needed before they are likely to become a common sight on Europe's roads. Nevertheless, public and political interest in the vehicles is at an all time high, and the European Green Cars Initiative should give Europe's automotive sector the boost it needs to develop the vehicles of the future and remain competitive.

Europe's vehicle manufacturers are facing immense challenges. They urgently need to reduce emissions of greenhouse gases and other pollutants that are harmful to human health and the environment. At the same time, the economic crisis has placed the future of many car companies in peril; if these collapse, millions of jobs will be lost and the impacts on the economy will be disastrous.

By setting up the European Green Cars Initiative, the EU hopes to give its ailing car industry the boost it needs to take the lead in the race to develop the next generation of cleaner, greener vehicles.

As the previous pages show, European researchers have already come up with innovative ways of improving the performance of hybrid and electric vehicles and greening the overall transport system. Today, scientists and engineers across the EU are working on prototypes of exciting new technologies that hold the promise of much greater improvements in performance in the future.

The strength of the electric vehicle research community was evident at the 24th Electrical Vehicle Symposium (EVS), held in May 2009 in Stavanger, Norway. The event attracted almost 3 000 visitors and featured presentations of around 400 research papers by representatives of academia, industry and governments on all aspects of electric vehicle technologies, policies and markets. Meanwhile the EVS Viking Rally, which saw 26 battery electric, hybrid, plug-in hybrid and hydrogen vehicles drive around the southern coast of Norway from Oslo to Stavanger, amply demonstrated the capabilities of the participating vehicles.

Popular and political support

Meanwhile, electric vehicles are becoming a regular feature at public motor shows around the world; dozens of new prototypes and concept cars were on display at the International Motor Show in Frankfurt in September 2009, an event which drew some 850 000 visitors from Germany and beyond.

Politicians too are steering the auto sector along the path to sustainability. The Communication of the Future on transport, adopted by the Commission in June 2009, takes stock of where we are today and sets out a vision for the future. The next White Paper, due in 2010, will define more concrete proposals, but it will undoubtedly point in the direction of decarbonisation, as indicated by the Commission's President, José Manuel Barroso, in a document presenting his political guidelines to the next Commission and sent to the President of the European Parliament in September 2009.

'The next Commission needs to maintain the momentum towards a low emission economy, and in particular towards decarbonising our electricity supply and the transport sector – all transport, including maritime transport and aviation, as well as the development of clean and electric cars,' the document reads.

The European Commission's 2007 Communication 'Freight Transport Logistics Action Plan' sets out a series of measures that will ultimately lead to freight transport moving from A to B as fast as possible, while minimising damage to the environment.

An action plan on intelligent transport systems adopted by the Commission in December 2008 is accelerating the deployment of new technologies that make cars safer, more efficient and greener. It is intended to overcome the current fragmentation in intelligent transport systems that is obstructing their roll-out across the EU. Transnational deployment of continuous cross-border services for travel information and traffic management cannot be achieved if the Member States continue to act individually.

Challenges ahead

Yet, despite the latest research and the excitement that electric vehicles are generating among the public and politicians alike, the scale of the challenges facing the electric vehicle sector should not be underestimated. Today, electric vehicles are still too expensive, their driving range is just about able to cover the needs of urban dwellers but is still too short to cover everybody's needs, their charging time is too long, and their supporting infrastructure for wider use is still lacking.

Investment in research has therefore never been so important and the EU knows this. The budget for transport research under the Seventh Framework Programme (FP7) has grown to a substantial EUR 4.16 billion, and a significant part of this sum (around 1 billion euro) is devoted to research into sustainable surface transport.

Through the Green Cars Initiative, the EU aims to drive research and innovation and raise the international bar for green transport technologies.

What next?

The first calls for proposals, which have a combined budget of EUR 100 million, were launched in July 2009 by the European Commission's Directorates-General for Research, Transport and Energy, and Information Society. They address the need for better electrical motors and generators, more efficient internal combustion engines (ICEs) for use in hybrid and plug-in hybrid vehicles, as well as better batteries and the impacts of electrification on the shape and design of cars.

The first projects funded under this initial round of calls for proposals should get off the ground in 2010. Their results are expected to bring about a step change in their respective areas.

In the 2009 call for proposals, the European Commission also sets out its plans to support the creation of a public-private partnership (PPP) that will coordinate research in this area. The scheme, which intends to bring together representatives of the road transport sector with public authorities, is expected to closely involve relevant stakeholders (at national and European level and in the public and private sectors) to draw up a European roadmap for research and development into green cars.

Subsequent calls in 2011 will broaden the focus of projects to include research into lorries and their internal combustion engines and logistics. Future calls will also address smart grids and vehicle recharging systems.

In addition, each project will begin laying the foundations for further collaborations in the future by bringing together some of the continent's best research teams with private sector companies who possess a solid grasp of consumer demand and legislative requirements. For the first time too, the projects will bring together utilities and grid operators with automobile manufacturers and drivers — evidence once again of the European Commission's integrated approach to making Europe's surface transport sustainable.

The race is on

So the political will is there and researchers are ready for the challenge of greening Europe's road transport. But are the users on board as well? While there has been some reluctance in the past to embrace green vehicles due to the issues of power and price, the reality is that consumer and industry habits have to change. Fossil fuels are becoming scarcer and more expensive, while environment regulations mean that the race is on among vehicle manufacturers to find the most efficient, reliable and clean technologies.

Meanwhile, other governments around the world have spotted the immense potential of electric vehicles and are injecting vast sums of money into their national auto industries. Through the Green Cars Initiative, the EU hopes to ensure that Europe's car industry will emerge from the crisis as a major competitor in the exciting new market for hybrid and electric vehicles.

Find out more

More information about the Green Cars Initiative can be found at the following websites:
http://ec.europa.eu/research/transport/info/green_cars_initiative_en.html
http://www.green-cars-initiative.eu/

Details of the latest calls for proposals in the transport area under the EU's Seventh Framework Programme (FP7) can be found by clicking on 'Find a call' at:
http://cordis.europa.eu/fp7/transport/home_en.html

European Clean Transport Facility at the European Investment Bank:
http://www.eib.org/products/loans/special/ectf/index.htm?lang=en

European Commission

European Green Cars Initiative — Towards an electric future?

Luxembourg: Publications Office of the European Union
2012 — 48 pp. — 17.6 cm x 25 cm
ISBN 978-92-79-26194-7
doi:10.2777/13660

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KI-31-12-974-EN-C

In a response to the severity of the current economic crisis, the European Commission has adopted a European Economy Recovery Plan to stimulate economic activity and employment.

In this brochure you will find information on the European Green Cars Initiative, one of the measures of this plan, which supports the industries involved in the road transport sector.

The initiative encompasses more than just technological research, and includes other types of measures, such as innovation and new incentives to support cleaner road transportation. The topics covered in the brochure deal exclusively with the research and development aspects, focussing on the three major research areas that are critical for success: the electrification of road and urban transport systems, road haulage and logistics.

The aim of the brochure is to give you an appreciation of the current state of art and to explain how the European Green Cars Initiative will support further economic activity, preparing the future for a sustainable and clean transport system, ensuring European Leadership of automotive industry worldwide.

Research and Innovation

Publications Office

ISBN 978-92-79-26194-7

doi:10.2777/13660