Fuelling the future

Reducing the emissions of passenger cars in the UK by 2020

Summary report

RSC | Advancing the Chemical Sciences

About this Publication

This publication is based on a series of workshops that were held at the RSC in April and May 2007. It reflects a number of expert views from academia, research and technology organisations, the motor industry, the chemicals industry and other key stakeholders. This is a summary of those views alongside the King Review aims to spark debate and contribute towards a realistic low carbon transport innovation strategy.

Reducing the CO_2 emissions from passenger cars is an important part of a wider strategy to reduce emissions from the power generation, industrial, transport and domestic energy sectors. The RSC has been actively campaigning since 2005 to demonstrate the vital role the chemical sciences will play in the provision of safe, clean, affordable and secure energy. The RSC position is laid out in the report "Chemical science priorities for sustainable energy solutions".

http://www.rsc.org/ScienceAndTechnology/Policy/Documents/SustainableEnergySolutions.asp

About the RSC

Since 1841, the RSC has been the leading society and professional body for chemical scientists and we are committed to ensuring that an enthusiastic, innovative and thriving scientific community is in place to face the future. The RSC has a global membership of over 44,000 and is actively involved in the spheres of education, qualifications and professional conduct. It runs conferences and meetings for chemical scientists, industrialists and policy makers at both national and local level. It is a major publisher of scientific books and journals, the majority of which are held in the RSC Library and Information Centre. In all its work, the RSC is objective and impartial, and is recognised throughout the world as an authoritative voice of the chemical sciences.

Summary of key messages

- Under the current policy framework it is unlikely that there will be a net reduction in carbon dioxide emissions from private vehicles in the UK by 2020. Therefore, CO_2 emission reductions demanded by the UK Climate Change Bill can only be achieved by reducing the CO_2 emissions of individual vehicles still further and/or by constraining the growth in travel.

- This report recommends that all EU countries should strive to reach the critical "100" target: to reduce new vehicle emissions to 100 grams of carbon dioxide for every kilometre driven as soon as possible. To meet this target advances in developments in key vehicle technologies will be required.

- Chemists, engineers and materials scientists will develop lightweight (and safe) vehicles; advanced tyres, engine oils and additives that save fuel; and ceramic engine technology that reduces engine wear and friction.

- To meet the EU Biofuels Directive and to reduce competition with food production, biofuels should ideally be produced efficiently from lignocellulosic biomass (2nd generation biofuels) and regulated by clear and appropriate international standards with an overall aim to minimise carbon dioxide emissions.

- Cars powered by a combination of fossil fuels and electric power (hybrids) can improve vehicle efficiency by 20-50+% dependent upon the degree of hybridisation and driving environment. Improved battery reliability and performance is a key research and development challenge. The goal should be to produce a light cheap battery vehicle with a 200 mile range.

- Hydrogen as an alternative fuel offers great potential but significant challenges in hydrogen storage and supply infrastructure remain. The ultimate aim is for a hydrogen vehicle with a 200+ mile range running on hydrogen produced from sustainable resources with minimal life-cycle carbon dioxide emissions.

Executive Summary

Since the invention of the motor car, advances in science and technology have continuously improved vehicle efficiency; however, growth in traffic volumes has negated these improvements. CO_2 emissions from passenger cars are now 12.5% (19.1 mega tonnes of carbon (MtC)) of total UK CO_2 emissions (2005 figure)[1]. Under the current policy framework it is unlikely that there will be a net reduction in carbon dioxide emissions from private vehicles in the UK by 2020. Therefore, CO_2 emission reductions demanded by the UK Climate Change Bill can only be achieved by a combination of improving the efficiency of individual vehicles still further through technological advances and by constraining the growth in travel.

This report focuses on how advances in fuels and technologies for passenger cars could contribute to a reduction in CO_2 by 2020. The likely scenario in the UK in 2020 is one where 99% of passenger cars will be running on a 10% biofuel 90% conventional fuel mix. There will not be one single, dominant technology by 2020 but many different combinations of fuel and engine technologies powering our vehicles.

Ambitious emissions standards for new vehicles are required to encourage technological advancements. Whilst the RSC supports the adoption of a mandatory EU vehicle emission standard of 120gCO_2/km for new vehicles we recommend that a further mandatory target of 100gCO_2/km be adopted at the earliest possible opportunity.

The "100 gram" target is necessary to provide a driver for the rapid development and deployment of alternative low-carbon fuels and vehicle technologies. To achieve this target will require the immediate implementation of nearer market technologies which can provide gradual, year on year reductions in emissions. In addition large scale investment is required in the discovery and development of technologies with longer term potential, such as radically improved batteries and hydrogen.

There will need to be significant developments and advancement in the materials and components of conventional vehicle design. Teams of chemists, engineers and materials scientists are vital to progress developments in lightweight (and safe) vehicles; advanced tyres, engine oils and additives that save fuel; and ceramic engine technology that reduces engine wear and friction.

The rapid development of, and a transition towards second generation biofuels must be a priority in the UK if carbons emissions from biofuels are to be minimised and competition with food crops avoided. Biofuel standards and obligations should be based on based on energy content and well-to-tank CO_2 volumes rather than volume. Further carbon emissions can be achieved by using smaller amounts of highly efficient and environmentally compatible agrochemicals.

Battery technology must be improved significantly if the large potential for the reduction of CO_2 emissions that hybrid and electric vehicles offer is to be realised. Additionally, alternatives to strategic materials such as cobalt oxide must be found. This will require increased investment in research and enhanced university – industry partnerships.

In the UK a decision must be taken on whether to invest in hydrogen powered transport and the supporting infrastructure, and if so, whether the capability should be developed for all vehicles or restricted to certain aspects of the transport sector, such as public transport.

[1] *Low Carbon Transport innovation Strategy,* Department of Transport (May 2007)

Background and context

The science of global warming has been accepted internationally and the need for urgent action on a massive scale has been outlined in the Stern Report. The UK Government has responded to the challenge by proposing statutory CO_2 emission reduction targets in the Draft Climate Change Bill and a policy framework for action in the Energy White Paper. Furthermore, transport has received special attention in the 2007 Department for Transport (DfT) Low Carbon Transport Innovation Strategy which claims that "[the road transport sector] is…the transport sector with probably the greatest potential to reduce carbon emissions in the coming decades".

The UK road transport sector, in addition to contributing to reduced air quality, is responsible for around 23% (32.5MtC – 2005 figures) of the UK CO_2 emissions. The dominant contribution to road transport emissions is passenger cars which account for 12.5% (19.1MtC) of UK CO_2 emissions. The DfT has conducted modelling and analysis on future road transport and predicts that by 2020 it is unlikely that there will be any net reduction in CO_2 emissions from the road transport sector[2]. This is because efficiency improvements in road vehicles are predicted to be negated by traffic growth.

The average fuel efficiency for the UK current passenger car fleet (i.e. all passenger vehicles presently on the road, new and old) was around 180g/km CO_2 in 2006. The average fuel efficiency for new cars in 2006 was 167.7g/km CO_2 despite a voluntary agreement between the EU automotive manufacturer associations aiming to reduce the average CO_2 emissions of new cars to 140g/km by 2008/9. The European Commission has recently issued a communication for a new legislative framework to deliver average new car fuel efficiency of 130 grams of CO_2 per kilometre (gCO_2/km) by 2012. The communication proposes a core target of 120 gCO_2/km by 2012 with the additional 10 gCO_2/km to be delivered through a range of other measures including biofuels, better fuel efficiency, better tyre pressure monitoring, more efficient air conditioning systems etc).

The conclusion of this analysis is that the transport sector will not contribute significantly to the Draft Climate Change Bill target of at least a 26% reduction in CO_2 levels by 2020 compared to 1990 levels. This means that emission cuts to meet this statutory target will have to come from the domestic, industrial and power generation sectors.

In response to this analysis of the road transport sector the RSC organised four workshops to examine how current and future fuel technologies could potentially contribute to CO_2 emission reduction. These workshops addressed conventional petroleum based fuels; biofuels; hydrogen; and hybrid and electric vehicles. Whilst the workshop scope focussed on technologies for 2020 these were placed in context of longer term technology and infrastructure development needs. This report represents a summary of the key conclusions and recommendations from these workshops Additional material was subsequently submitted by participants of the meetings and has been sourced from other areas such as the RSC's report on *Chemical Science Priorities in Sustainable Energy Solutions*.

The RSC is leading a sustained campaign to highlight the role of the chemical sciences in the provision of safe, clean, affordable and secure energy for the UK.

The RSC position on energy is that technology advances will not provide a short-term solution to meet Government carbon emission reduction targets; reducing energy demand and exploiting existing best in class technologies is the only way to achieve these targets. With sufficient support, chemical sciences will be critical in developing clean energy technologies in the medium and long-terms. Alongside the technologies outlined in this

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[2] http://www.dft.gov.uk/about/strategy/whitepapers/previous/coll_sustainabledevelopmentappra/thefutureoftransportmodellin5485

report for transportation, the development of carbon capture and storage technology to decarbonise fossil fuel power generation and smart technologies to reduce emissions from domestic living will be critical to achieving the UK 2020 target of at least a 26% reduction in CO_2 emissions compared to 1990 levels.

Key messages

The following are the key areas/challenges raised during the workshops.

1. Better vehicle design can improve fuel efficiency

Changes in vehicle design are being driven by the need to improve performance, efficiency and reduction of emissions. Chemists, engineers and material scientists must be encouraged to work together to develop the next generation of fuels and lightweight vehicles capable of two or threefold improvements in fuel economy. Contributing factors will include improvements in engine design, more efficient use of energy in electrical components such as air conditioning, lighter weight of chassis, engine and other components, more efficient fuel combustion engines, improved additives, better aerodynamics and improved tyre design.

These improvements do not take into account further limits from Government on speed restrictions and road charging schemes to reduce traffic.

2. Technology presents some barriers but consumer behaviour may prove to be a greater obstacle

The CO_2 emission reductions demanded by the UK Climate Change Bill can only be achieved by the road transport sector by reducing the CO_2 emissions from individual vehicles still further and/or by constraining the growth in travel. An appropriate and effective framework of legislation and incentives would be required to provide impetus for scientific and technological barriers to further reduce CO_2 emissions. An important consideration is that the ultimate success of any new vehicle technology relies on consumer acceptance and support.

There are geo-political issues to overcome; governments need to agree on CO_2 targets and demonstrate global leadership in implementing strategies to achieve these targets. A wide ranging approach is needed that takes into account the international nature of today's automotive and energy markets and ensures that changes in one region or continent do not result in increased emissions elsewhere.

3 Biofuels

3.1 Second generation of biofuels are needed as soon as possible

The Road Transport Fuel Obligation (RTFO) comes into effect from April 2008, and will require 5% of all UK fuel sold on UK forecourts to come from a renewable source by 2010 and is expected to rise to 10% in 2020. Current biofuel production (1st generation) is not optimised across the supply chain to minimise carbon emissions – this offers a significant opportunity for development. However, the RTFO is currently based on biofuel volume and not for CO_2 emission reduction (as discussed below).

Processes for the production of second generation biofuels from lignocellulosic biomass need to be realised in the near future. Second generation biofuels can potentially minimise the competition for food crops, from which first generation biofuels are derived and also have greater potential for CO_2 emission reductions. In order to progress there are several key technological hurdles that need to be overcome including enzyme development and separation technology. Additionally, the yield of biomass needs to increase so that more biofuel can be produced from less land.

The European Union's (EU's) energy policy target of a 5.75% biofuel contribution to transport by 2010 is unlikely to be achieved; but with significant changes in policy and investment in research the 2020 target of 10% may be reached. The EU is not the only region with a rapidly growing demand for biofuels and the consequences of this growth need to be examined.

Whilst organisations in the EU exist that deal with aspects of biofuels there is a need to coordinate the approach across the whole supply chain, including sources of supply outside the EU.

3.2 Smarter and greener agrochemicals are needed

Significant CO_2 savings as well as an increase in biomass and biofuel yield are possible by the development and deployment of smart agrochemicals such as fertilisers and pesticides. Ideally, agrochemicals would be used in minimal quantities, be highly effective and degrade quickly to benign products at end of life. In addition the application of green chemical technology will result in more energy efficient and lower cost manufacturing processes.

3.3 Defined biofuels standards

With an increasing focus on biofuels and the associated technologies, there is a need for a thorough and comprehensive definition of what constitutes a biofuel. For example, it is unclear whether biomass to liquid (BTL) derived fuels can be classified as biofuels. Clarification would have benefits when constructing regulatory frameworks. The RSC recommends that taxation and biofuel obligation volumes should be based on energy content and well-to-tank CO_2 rather than volume.

The UK should lead Europe in enforcing appropriate standards for biofuels. Basing biofuel obligations on CO_2 emission reductions rather than volume will ensure maximum effect. Quality control of biofuels should also be considered.

4. Hybrid and electric vehicles will increasingly play a part in the passenger vehicle fleet

Efficiency improvements from current hybrid technology can deliver up to 35% fuel savings, depending on where and how the car is driven[3].

Hybridising any vehicle increases fuel economy, regardless of the energy carrier: hybrids will remain a key vehicle concept in tackling transport emissions in the long term. As such, the benefits and the lasting role of hybrids must be made clear to the public. However, technological barriers of battery limitations may delay electric vehicles (EV)/hybrid electric vehicles (HEV) uptake for personal automobiles.

Public transport has predetermined routes and known travel distances. As such, buses can benefit from HEVs/EVs in the short term.

Plug-in Hybrid Electric Vehicles (PHEVs) will become a key technology in the mid- to long-term, potentially providing significant CO_2 savings, dependent upon the availability of clean power. The demand that the PHEVs will place on the electricity supply infrastructure should be recognised.

5. Hydrogen– should the investment be made?

[3] The King Review of low-carbon cars - http://www.hm-treasury.gov.uk/media/9/5/pbr_csr07_king840.pdf

Many barriers to hydrogen-powered transport remain including hydrogen storage and supply infrastructure. A consensus needs to be reached on whether hydrogen is a viable option; this will partly depend on technological progress and partly on the political appetite to combat climate change. The hydrogen economy is unlikely to develop without political support in terms of carbon taxes, tax incentives or subsidies, as well as support for large scale fundamental research and demonstration programmes. Without major breakthroughs hydrogen technologies may only be taken up in niche markets (for example forklift trucks), although this could nevertheless have a positive impact on CO_2 emission. In the UK, deregulation of the public buses and considerable diesel incentives currently make it difficult to deploy alternative technologies: this requires careful examination.

6. Government and political barriers

The lack of specific CO_2 emissions regulations is a barrier to research and development and the adoption of new technologies. Governments should stimulate development of better environmental design and fuels for vehicles and should encourage consumers to select these options. This can be achieved by implementing a supportive regulatory and fiscal framework and manipulation through taxation.

7. Society and consumer acceptance of new technologies in vehicles

Some estimates suggest that oil prices will continue to rise as we progress towards 2020 (although there are many factors to take into account). The real price of gasoline is estimated to increase by 1-3% per annum. While consumers tend to grudgingly accept such increases, it has been postulated that an increase of 4.2% or above would prompt consumers to look at alternative technologies. Cost of vehicles is a prohibitive issue for consumers, as is the preoccupation with status. Cars must be aesthetically pleasing, driveable and luxurious if possible. Reducing vehicle weight or removing luxury facilities (such as air-conditioning) may receive a negative response and result in lower uptake.

The public will not deliberately buy inefficient vehicles and simple indicators such as star ratings (as are now used on refrigerators for example) will enable people to compare vehicle efficiency. The mile-per-gallon rating of vehicles indicates a degree of fuel efficiency but a more comprehensive rating system would take into account other environmental and life-cycle energy factors. Governments could also do more to encourage consumers to buy smaller cars with smaller, more efficient engines.

The RSC considers that all the above measures will contribute to achieving the goal of the 100gCO_2/km car and that legislation that provides a target date for this standard will provide a spur for innovation.

Chemical science challenges

There is a clear need for more research and development to be done to ensure that better low carbon vehicle technologies are developed.

Vehicle design

Develop:

- new structural materials and designs to radically reduce vehicle weight without compromising safety
- better tyre designs to maximise fuel efficiency of the vehicle
- more efficient low emission engines
- better fuel and lubricant additive packages which increase fuel economy of the vehicle
- ceramic materials for engines to reduce wear and friction on moving parts and increasing fuel efficiency

Biofuels

- Research, develop and demonstrate 2nd generation biofuels technology
- Life-cycle assessments on all biofuels must be carried out to optimise biofuel production and minimise CO_2 emissions as well as minimise deforestation
- Research into ecosystem studies and diversity will provide important information on how to minimise the impacts of biofuels

Batteries for hybrid and electric vehicles

- Launch a major research programme to develop a battery vehicle with a 200 mile range which is light, inexpensive to produce and not dependent on strategic materials
- Reduce or replace the use of the strategic material cobalt oxide in battery electrodes
- Develop 'fast charge' technology which can recharge within minutes

Hydrogen

Storage

- Create a system which costs no more than 10% of the value of the car, in which hydrogen accounts for 10% of the total storage system weight

Production

- Generate hydrogen at an appropriate scale which produces low CO_2 per MJ of hydrogen on a well to wheel basis

Fuel cells vs. internal combustion engines

- Develop a cost and performance competitive hydrogen-powered vehicle with a 200+ mile range