Chapter 6: Reducing surface transport emissions through low-carbon cars and consumer behaviour change

Introduction and key messages

In our December 2008 report, we considered scope for transport emissions reduction through reductions in carbon intensity of vehicles and changes in consumer behaviour. Our analysis suggested that there is scope to cut surface transport emissions by up to 32 $MtCO_2$ in 2020, with most of the reduction potential coming from road transport.

We argued that there is significant scope for reducing the carbon intensity of vehicles (including cars, vans and Heavy Goods Vehicles (HGVs)) through improving efficiency of conventional combustion engines, non-powertrain measures such as low rolling resistance tyres and gear shift indicators, and increased use of sustainable biofuels. A major part of our transport story was the increasing importance of full electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs) in the second and third budget periods. We argued that it is important to develop the option for wide-scale deployment of electric vehicles in the 2020s, and projected that up to 20% of cars purchased in 2020 could be electric or plug-in hybrid. We also argued that there should be a major focus placed on developing a framework for van CO_2 at European and UK levels.

Our analysis of scope for emissions reductions through changed consumer behaviour focused on better journey planning and modal shift ('Smarter Choices'), eco-driving (e.g. gentle braking and acceleration and travelling without excess weight), and driving within the speed limit. The emissions reduction potential that we identified through consumer behaviour change was of the same order of magnitude as potential through reducing carbon intensity of vehicles.

In this chapter we consider transport emissions trends and progress in reducing emissions. We review developments in the EU framework and implications for the carbon intensity of new cars. We set out more detailed analysis for electric cars, focusing on market readiness, likely costs over time and the need for price support and charging infrastructure. We also review further the opportunity for changing consumer behaviour based on the latest evidence from the Sustainable Travel Town pilots. In addition, we consider the scope for emissions reduction through introduction of road pricing, and potential for emissions reductions through integrating land use and transport planning. We combine all of this analysis in a set of indicators for the surface transport sector against which we will assess future progress in reducing emissions (Box 6.1).

We do not consider the evolving EU framework for van emissions reductions. A draft framework has been developed by the EC, and we will comment on this in our June 2010 report to parliament.

The main messages in the chapter are:

- The UK should aim to converge on the EU trajectory for average new car emissions by 2015 and aim for a new car average of 95 gCO_2/km by 2020 in the wider context of meeting carbon budgets for the non-traded sector. Achieving this will require deployment of the full range of low-carbon options: improved fuel efficiency of combustion engines, non-powertrain measures, increased hybridisation and increasing numbers of electric cars/plug-in hybrids.

Box 6.1 Summary of transport indicators

Indicators include:

- Falling carbon intensity of new cars to 95 gCO_2/km in 2020 from the current 158 gCO_2/km.
- 240,000 electric cars and plug-in hybrids delivered through pilot projects by 2015, and 1.7 million by 2020.
- 3.9 million drivers trained and practicing eco-driving by 2020.
- Policy strengthening to include:
  - Support for electric cars and plug-in hybrids. A comprehensive strategy for rolling out electric cars and plug-in hybrids, including a funded plan for charging infrastructure, and large-scale pilots starting at the end of the first carbon budget period.
  - Smarter choices. Phased roll-out across the UK to encourage better journey planning and more use of public transport.
  - Integrated land-use and transport planning. A new strategy to ensure that land-use planning decisions fully reflect the implications for transport emissions.

- The Government should complement financial support committed for electric car purchase with charging infrastructure for up to 240,000 electric cars and plug in hybrids by 2015 on the way to 1.7 million cars in 2020.
- New evidence from the Sustainable Travel Towns suggests that Smarter Choices initiatives which aim to encourage people to travel on public transport and to better plan journeys can have a significant emissions reduction impact. The Government's recently announced Sustainable Travel City pilot is a positive step in rolling out Smarter Choices. This should be buttressed with a comprehensive plan for more widespread roll out to towns and cities.
- The large programme of home building over the next twenty years and possible increase in transport emissions through out of town developments poses a risk to meeting budgets. Significant land use change over the next decades offers an opportunity to change trip patterns and travel modes. In order to mitigate risks and take advantage of opportunities, the Government should develop an integrated planning and transport strategy, and ensure that planning decisions fully account for transport emissions.

We set out the analysis that underpins these conclusions in five parts:

1. Transport emissions trends
2. The EU framework and UK new car emissions
3. Demonstration and deployment of electric cars
4. Emissions reductions from changing transport consumer behaviour
5. Integrated land use and transport planning
6. Summary of transport indicators.

1. Transport emissions trends

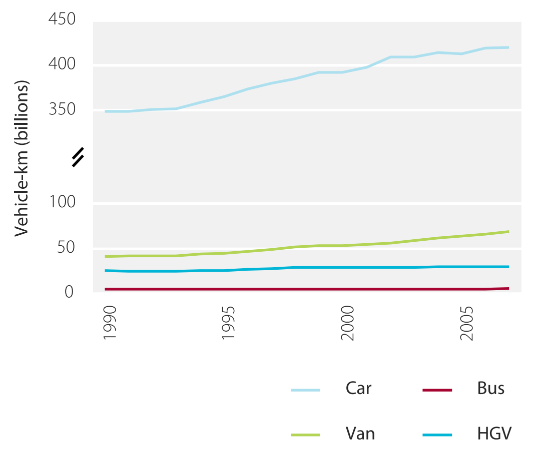
Total surface transport emissions

Transport demand in the UK has increased steadily between 1990 and 2007 (Figure 6.1), and domestic transport emissions have increased 11% over this period, and now account for over 131 $MtCO_2$. The overall trend in emissions is illustrated in Figure 6.2.

Emissions from cars

Demand for passenger car travel (measured in vehicle-km) increased by 20% between 1990 and 2007, on a trend growth path of 1% per annum, though growth was slightly lower (0.4%) in 2007 (Figure 6.3). The Department for Transport's (DfT) provisional estimates suggest that car travel fell by 0.6% in 2008 and by a further 0.8% (1.5% on an annualised basis) in the first two quarters of 2009. We would expect demand to decline as a result of the recession, and – absent new demand management policies – we would expect growth to return to trend as the recession ends.

Figure 6.1 Transport demand by mode 1990–2007



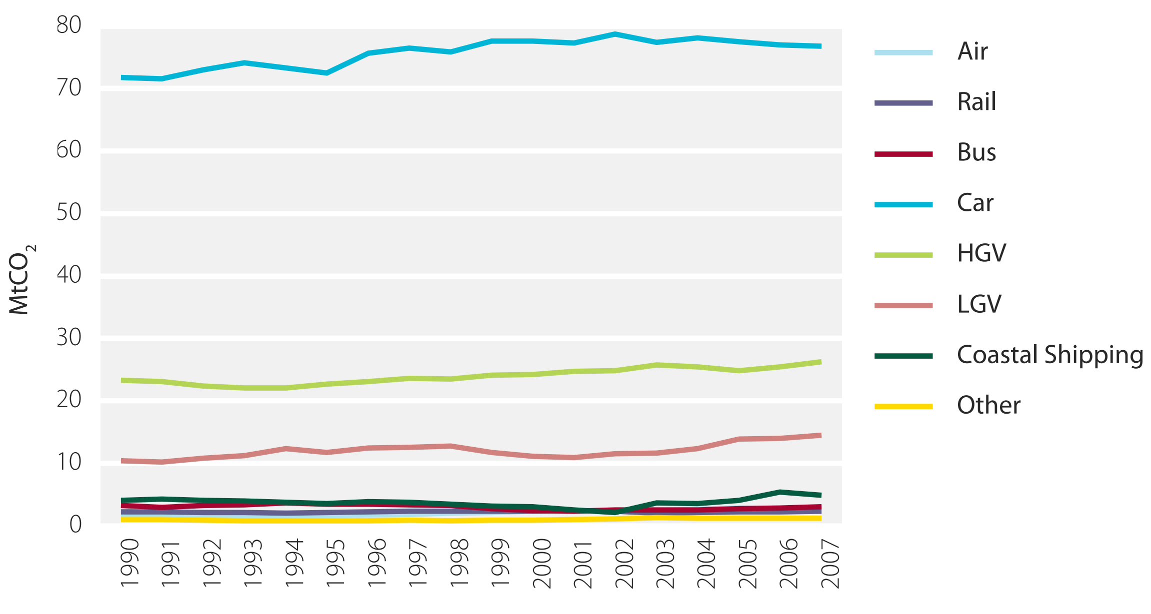
Source: Dft (2008), *Transport Statistics Great Britain*; Table 7.1; Dft (2009), *Road Traffic and Congestion in Great Britain Q1 2009*; Data is uplifted to include NI.
Note: Data for 2008 is provisional.

Demand growth has been offset by falling carbon intensity of cars, which declined by 11% between 1990 and 2007 (Figure 6.3), and was driven by lower carbon intensity of new cars (Figure 6.4). Carbon intensity reduction has been achieved through the EU Voluntary Agreements to reduce new car emissions, supported by measures aimed at raising customer awareness and differentiation of both company car taxation and Vehicle Excise Duty (VED) by carbon intensity. As a consequence of rising demand offset by increasing fuel efficiency, total car CO_2 emissions have increased by around 7% between 1990 and 2007, remaining relatively flat since 2000.

Emissions from vans and HGVs

Vehicle-km travelled by vans have grown very rapidly (a 71% increase 1990-2007), with growth of 4.6% in 2007 (Figure 6.5). DfT's provisional estimates suggest that van traffic fell by 0.4% in 2008 and again very slightly (0.1% on an annualised basis) in the first two quarters of 2009. However, unlike cars, there is no consistent long-term decline in the carbon intensity of vans. Carbon intensity decreased around 22% between 1990 and 2001 but in 2007 was slightly higher than 2001 levels, despite a decline of 1.3% in 2007 compared to 2006. As a consequence of rising demand with limited improvements in fuel efficiency, total van CO_2 emissions have increased by around 40% between 1990 and 2007.

Figure 6.2 Transport CO_2 by mode (by source) 1990 – 2007



Source: NAEI (2009).

Over the long term, HGV traffic has grown, with vehicle-km up 18% since 1990, but with a roughly flat trend more recently, and a slight increase (0.8%) in 2007 (Figure 6.6). Tonne-km have continued to increase, by 3.8% in 2007 (Figure 6.7), increasing total emissions from HGVs by 3.3% in that year. DfT's provisional estimates suggest that HGV traffic fell by 2.4% in 2008 and by a further 4.4% (8.7% on an annualised basis) in the first two quarters of 2009. Carbon intensity has decreased somewhat between 1990 and 2007 (by 4.3% measured in vehicle km and 11.2% measured in tonne-km). As a consequence of rising demand with limited improvements in fuel efficiency, total HGV CO2 emissions have increased by around 13% between 1990 and 2007.

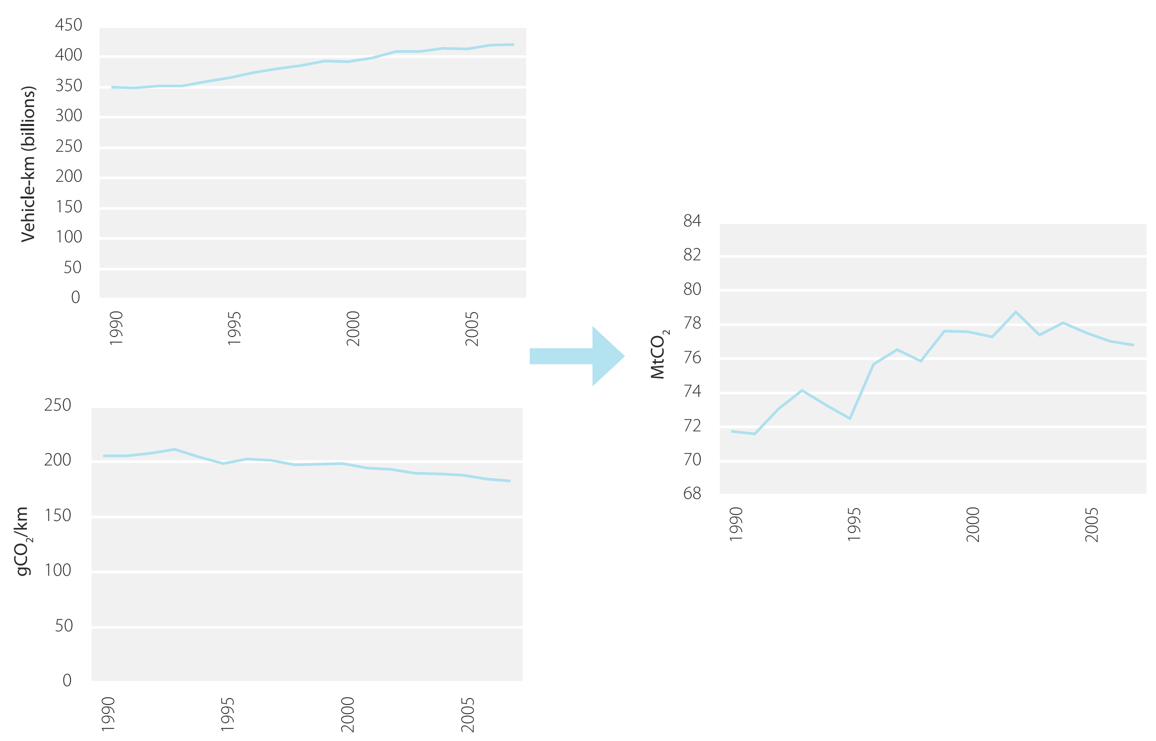
Emissions from bus and rail

Both bus and rail demand have increased in recent years:

- Bus vehicle-km, although relatively stable historically, increased by 4.2% in 2006 and 6.5% in 2007 (Figure 6.8). Total bus emissions have decreased by around 8% between 1990 and 2007.
- Rail passenger-km, after declining to the mid 1990s, are now on a strong upward path, increasing by 6.1% in 2006 and 6.4% in 2007 (Figure 6.9). Total rail emissions have increased by around 4% between 1990 and 2007.

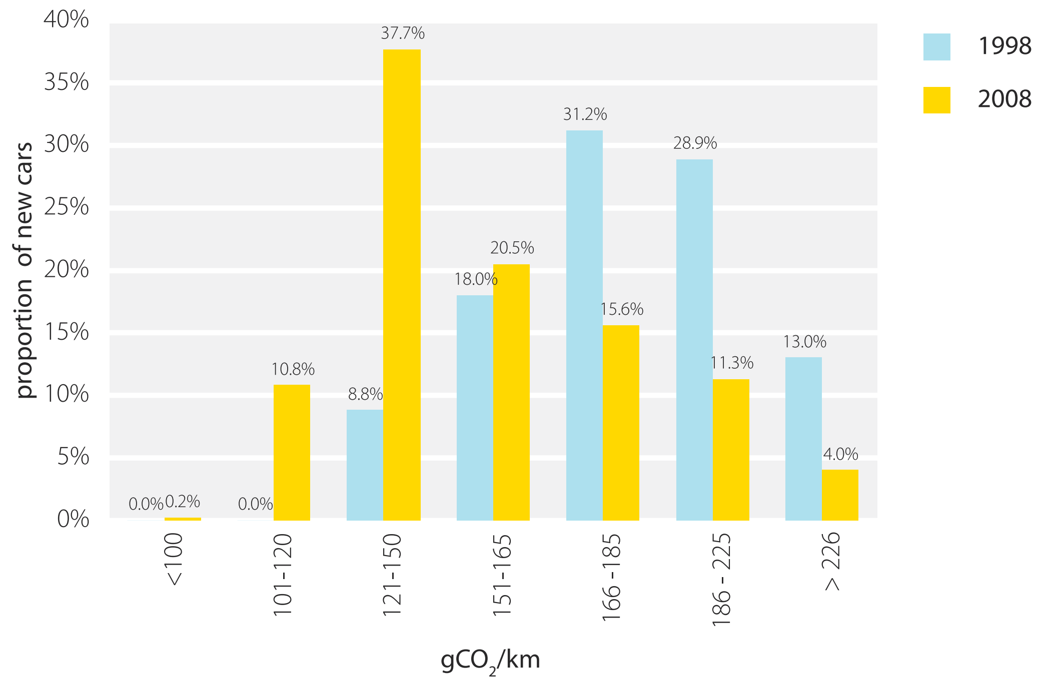
The demand for bus and rail travel is now increasing faster than the demand for car travel. Policies to encourage a shift from passenger car travel to public transport, discussed in Section 4, would be expected to support further increases in demand for bus and rail travel.

Figure 6.3 Historical trends in vehicle km, CO_2 and gCO_2/km for cars 1990 – 2007



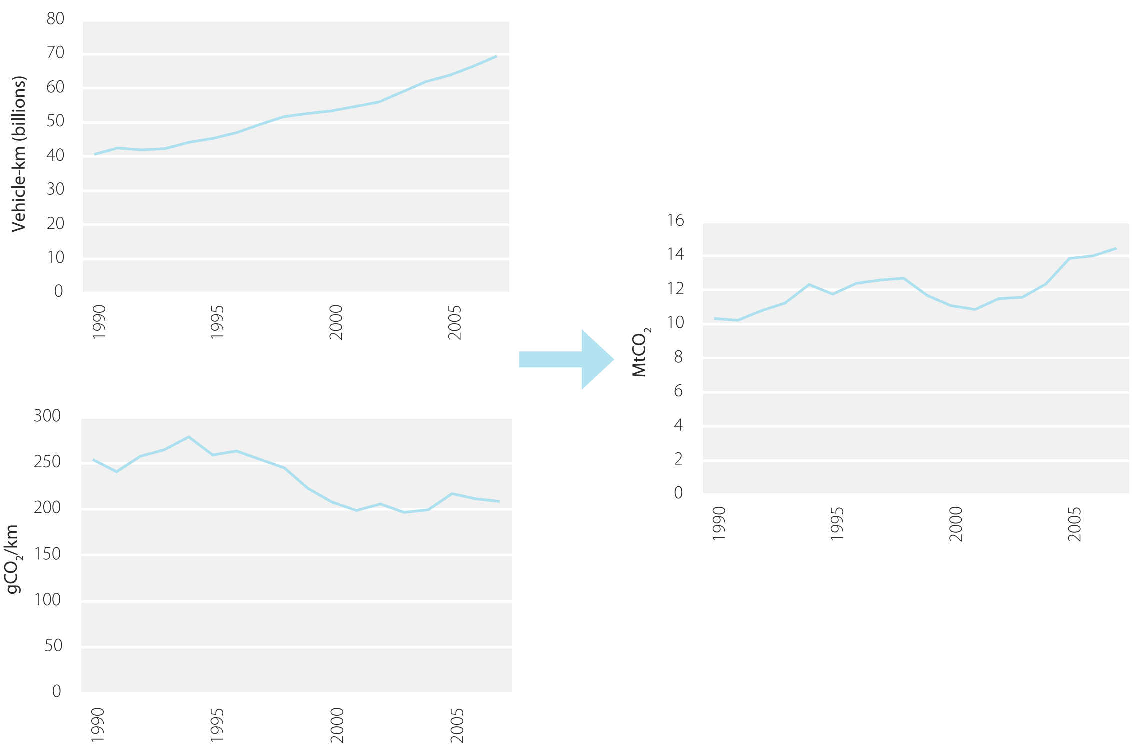
Source: DfT (2008), *Transport Statistics Great Britain*; Table 7.1; NAEI (2009).

Figure 6.4 New car sales by VED band, 1998 and 2008



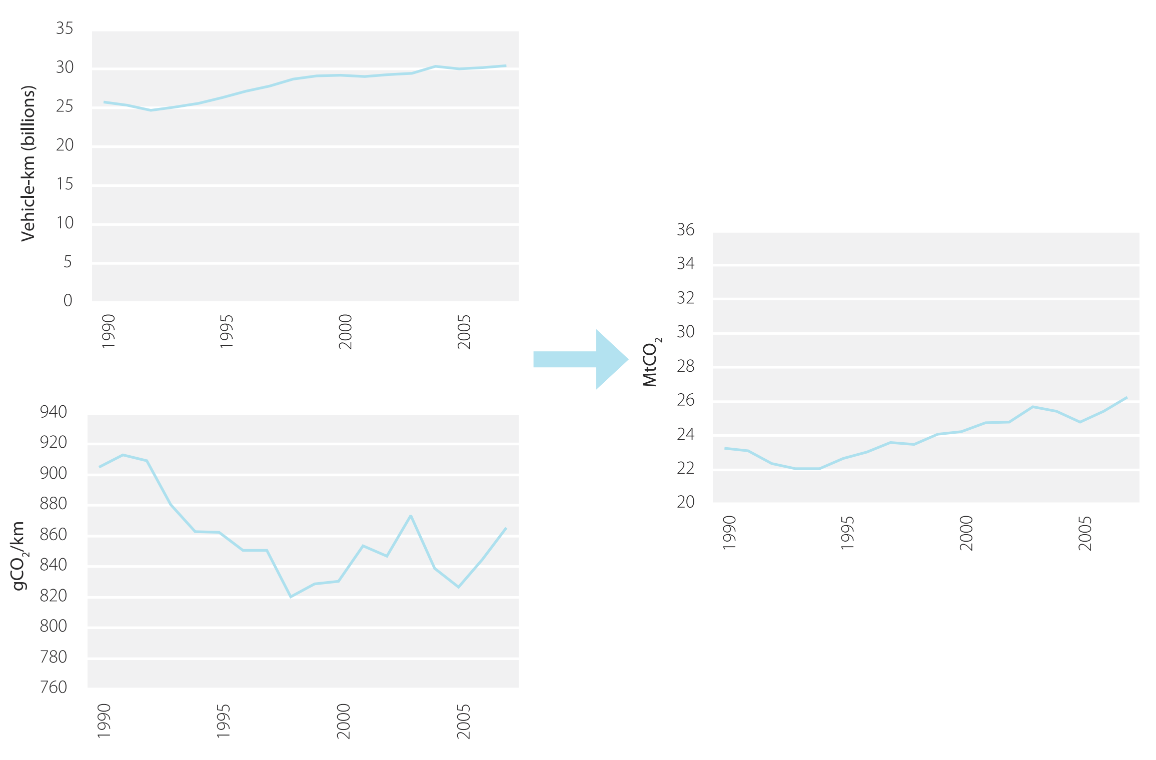
Source: Society of Motor Manufacturers and Traders (SMMT) (2009).

Figure 6.5 Historical trends in vehicle km, CO_2 and gCO_2/km for vans 1990 – 2007



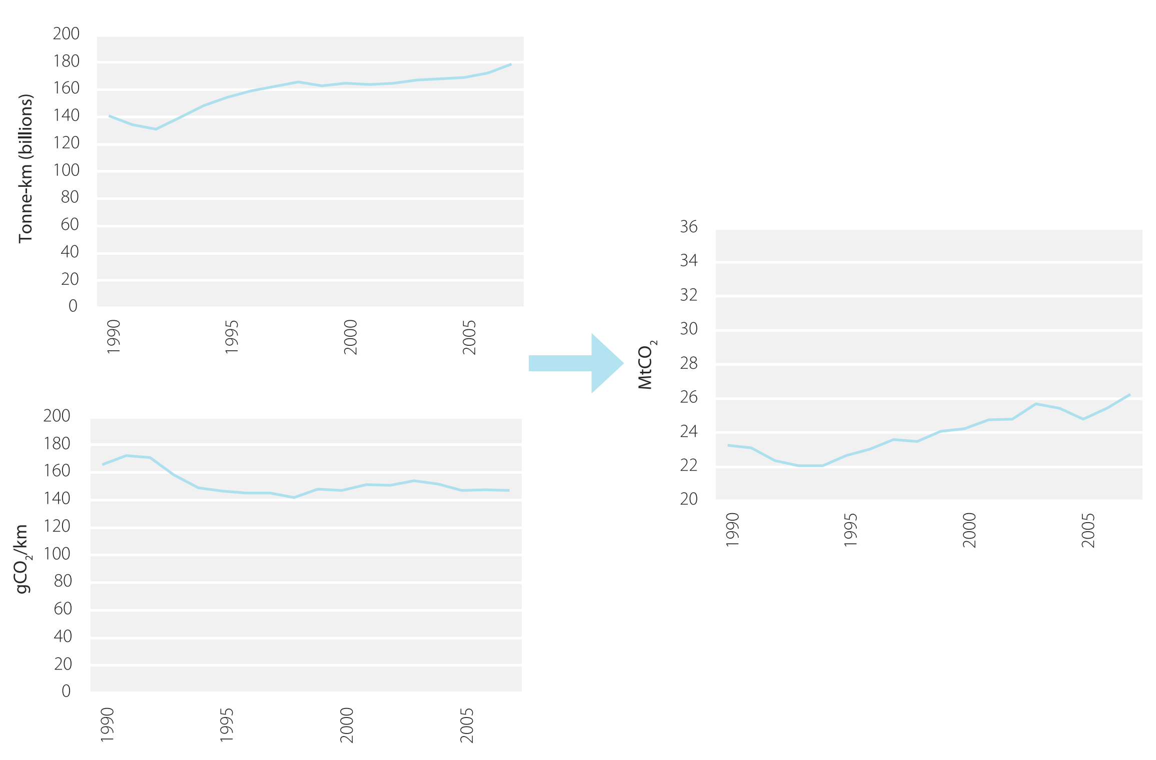
Source: DfT (2008), *Transport Statistics Great Britain*; Table 7.1; NAEI (2009).

Figure 6.6 Historical trends in vehicle km, CO_2 and gCO_2/km for HGVs 1990 – 2007



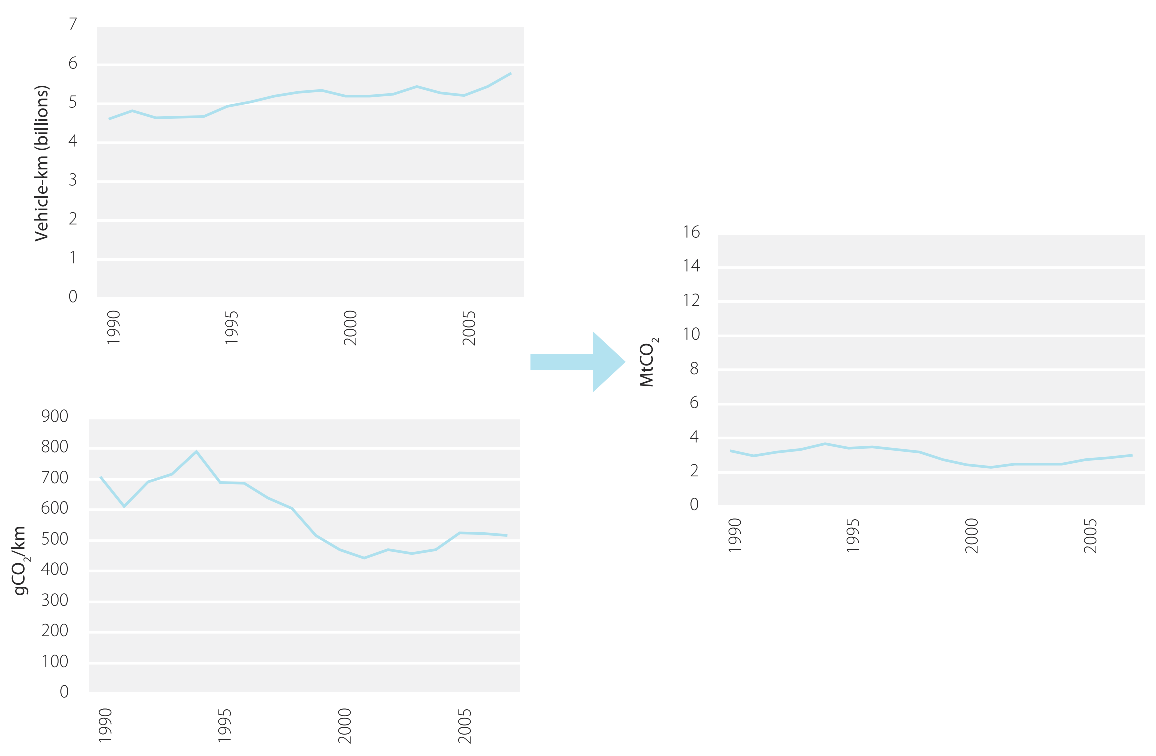
Source: DfT (2008), *Transport Statistics Great Britain*; Table 7.1; NAEI (2009).

Figure 6.7 Historical trends in tonne-km, CO_2 and gCO_2/tonne-km for HGVs 1990 – 2007



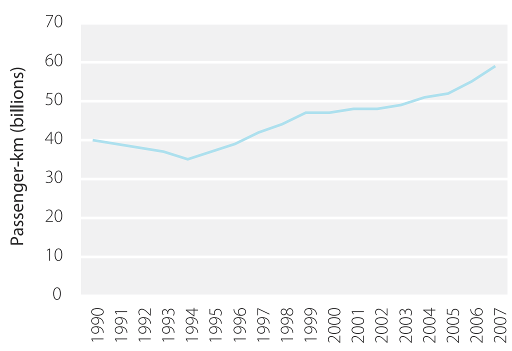
Source: DfT (2008), *Transport Statistics Great Britain*; Table 7.1; NAEI (2009).

Figure 6.8 Historical trends in vehicle km, CO_2 and gCO_2/km for buses 1990 – 2007



Source: DfT (2008), *Transport Statistics Great Britain*; Table 7.1; NAEI (2009).

Figure 6.9 Historical trends for rail passenger kilometres 1990 – 2007



Source: DfT (2008); Transport Statistics Great Britain; Table 1.1; uplifted to include NI.

2. The EU framework and UK new car emissions

The EU framework

In April 2009 a new EU framework for reducing car emissions was agreed (Box 6.2). This framework sets a legally binding target to reduce average new car emissions across Europe from the current level of 153.5 gCO_2/km to 130 gCO_2/km by 2015. In addition, there is a commitment that emissions will be further reduced to 95 gCO_2/km by 2020. The framework is weaker than originally envisaged in the sense that the 130 gCO_2/km target was originally proposed for 2012, but stronger in the sense that the ambitious target for 2020 has been introduced. It is envisaged that emissions reductions will be achieved through increasing fuel efficiency of cars, and the introduction of new technologies (e.g. electric cars). In parallel, the EU has set targets for increased use of renewable fuels and sustainable biofuels.

Delivering EU targets in the UK

In our December report, we set out an Extended Ambition scenario for UK car emissions that would achieve 95 gCO_2/km by 2020 (Figure 6.10).

Emissions reductions in the Extended Ambition scenario are driven by:

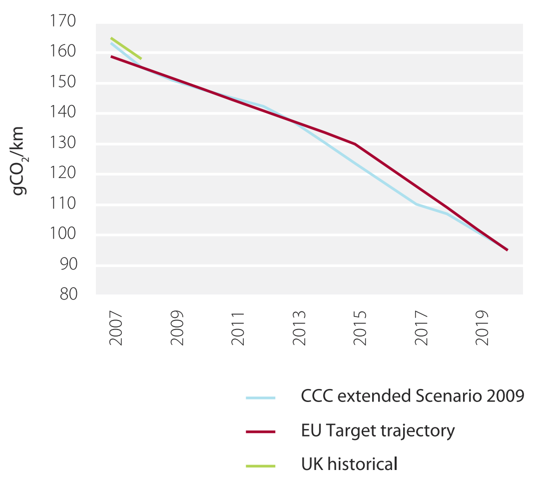
- Replacing old cars with new ones that have more efficient conventional combustion engines.
- Increasing uptake of hybrid cars from the first budget period.
- Increasing uptake of electric cars and plug-in hybrid vehicles in later budget periods.
- Incorporation of non-powertrain measures such as improved aerodynamic design, low rolling resistance tyres and gear shift indicators.
- Increased use of biofuels.

Box 6.2 EU New Car Framework

European legislation on the emissions from new passenger cars was officially adopted in April 2009. This legislation includes a 2015 emissions target for new cars, penalties for non-compliance with this target, and a 2020 target:

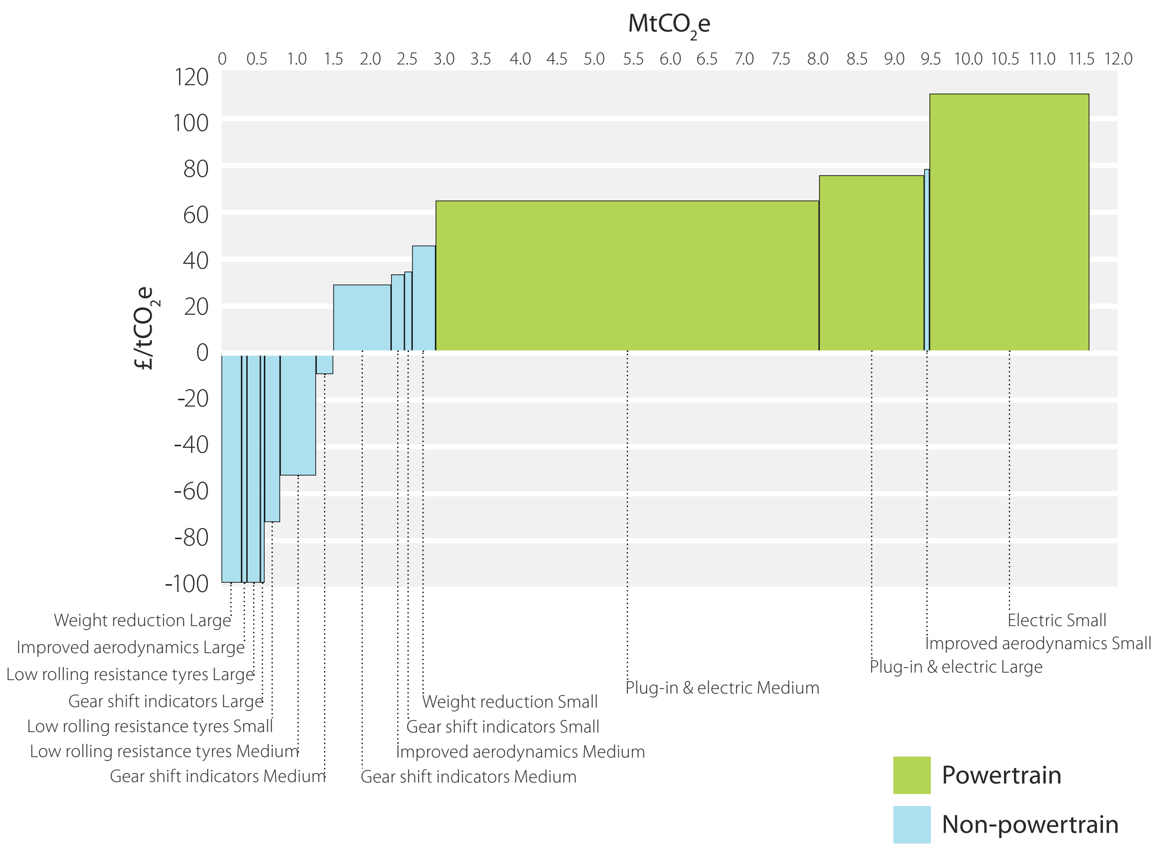
- The legislation stipulates that the average emissions of the new car fleet in the EU should be no more than 130 gCO_2/km in 2015. Measures which are or will be mandatory under other EU legislation such as gear shift indicators, tyre pressure monitoring systems and biofuels do not count towards meeting this target.
- Each manufacturer will be given an individual target and penalties if this is not achieved. Until 2018 the penalty will be €5 for each car sold for the first gCO_2/km over the target, €15 for the second gCO_2/km, €25 for the third gCO_2/km, and €95 for each subsequent gCO_2/km. From 2019, each gCO_2/km over the target will cost €95.
- A target of 95 gCO_2/km has been defined for 2020, with the target and modalities for reaching it to be confirmed before 2013.

Figure 6.10 Average new car emissions in the Extended Ambition scenario and trajectory under the revised EU framework



Source: SMMT (2009), *New Car CO_2 Report 2009*; CCC Modelling.

Figure 6.11 Extended Ambition scenario marginal abatement cost curve, 2020



Source: CCC Modelling.
Note: Does not include biofuels.

Our analysis suggested that several measures, particularly non-powertrain measures, are available at negative cost (i.e. ongoing operating cost reductions more than offset any upfront costs – see Figure 6.11. For measures that come at some cost (e.g. introduction of electric and plug-in hybrid cars), these can be justified in the context of economy-wide efforts to reduce emissions and achieve carbon budgets, and laying foundations for deep emissions cuts in transport through the 2020s.

Average emissions in the UK in 2008 were around 158 gCO_2/km compared to the EU average of 153.5 gCO_2/km. It is the view of the Committee that the UK should aim to converge on the EU average emissions trajectory by 2015 and meet the 95 gCO_2/km target in 2020, both through the technology measures in our Extended Ambition scenario and through change in customer choice (e.g. customers buying best-in-class or smaller cars), in order that transport makes an appropriate contribution to meeting the second and third carbon budgets.

It is also the view of the Committee that the UK should aim to meet EU average standards through delivering the full range of measures in the Extended Ambition scenario, including through critical mass penetration of electric cars / plug-in hybrids by 2020. Our rationale is that electric cars currently appear to be the most viable option for reducing transport emissions through the 2020s, and that demonstration in the years to 2020 will provide the option of full scale roll-out in the 2020s.

Policy levers for delivering EU targets

In our December report, we set out a range of policy levers to encourage purchase of lower carbon cars, each of which is likely to have an important role to play in delivering EU targets:

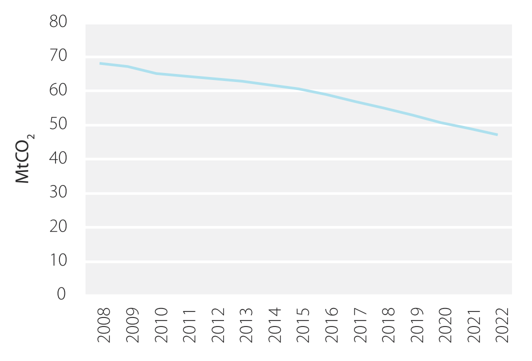
- **Price levers.** The EU framework includes penalties for manufacturers not meeting targets for new car efficiency. These penalties will encourage manufacturers to develop and market lower carbon vehicles. It is likely that penalties will be reflected in pricing policy, with relatively lower prices charged to encourage uptake of lower carbon cars.
- **Fiscal levers.** There is scope to influence car purchase behaviour through both Vehicle Excise Duty (VED) and fuel duty. Evidence from the UK and other countries such as France and the Netherlands suggests that measures to change relative purchase price according to carbon intensity (e.g. through higher first year VED for more carbon intense vehicles) can be effective in encouraging uptake of lower carbon vehicles, more so if higher VED is charged in every year (i.e. not just the first). Evidence also suggests that fuel duty is a potentially powerful lever in encouraging purchase of lower carbon cars (e.g. a 10% increase in petrol prices through a fuel duty increase could result in a 4% decrease in fuel used per kilometre, achieved in part via choice of more efficient cars).
- **Better information and awareness raising.** The EU framework recognises that car purchase decisions could be influenced by information at the point of sale, and requires that dealers display information on fuel efficiency and CO_2 emissions. We reviewed the evidence on the impact of better information and advertising campaigns aimed at promoting fuel efficiency in our December report, where we concluded that these alone are unlikely to result in significantly changed car purchase behaviour, but they are still likely to have an important role to play as part of a package of mutually supporting measures.

Indicators for car carbon intensity

We will consider four sets of indicators in future monitoring of progress towards reducing carbon intensity:

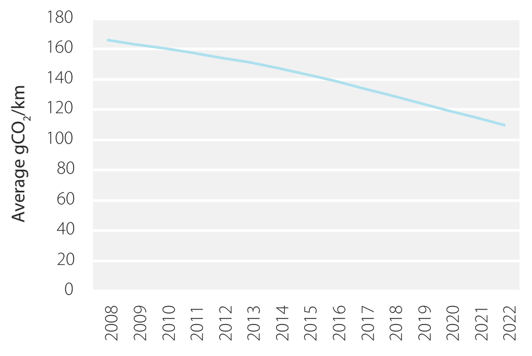
- **Car emissions.** Our benchmark for car emissions will be the emissions trajectory under our Extended Ambition scenario (Figure 6.12).
- **Carbon intensity of car travel.** Our Extended Ambition scenario requires the carbon intensity of car travel to fall over time; our benchmark will be the trajectory implied by our Extended Ambition scenario, where average emissions in 2020 are 116 gCO_2/km (Figure 6.13) across the car fleet.

Figure 6.12 Emissions trajectory for cars in the Extended Ambition scenario



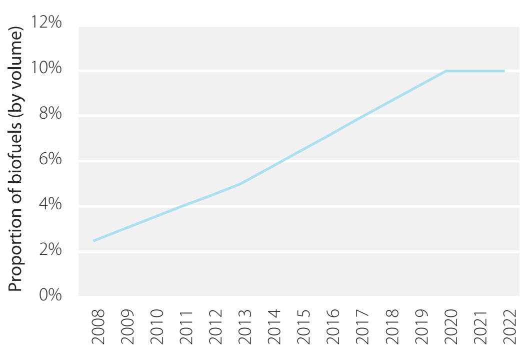
Source: CCC Modelling.

Figure 6.13 Carbon intensity of car travel in the Extended Ambition scenario



Source: CCC Modelling.

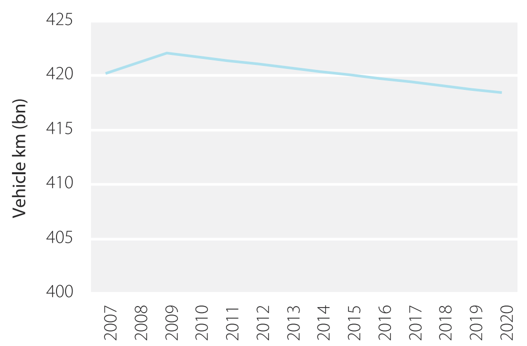
Figure 6.14 Proportion of fuel sold on forecourts that is biofuel



Source: RFA.

- **Average emissions of new cars.** Given that our Extended Ambition scenario is driven by reductions in carbon intensity of new cars, it will be important to monitor whether the full potential for carbon intensity reduction is being realised. We will therefore monitor new car emissions against the trajectory for new car emissions underpinning our Extended Ambition scenario, with average emissions falling to 95 gCO_2/km in 2020 (Figure 6.10).
- **Biofuels penetration.** Our Extended Ambition scenario includes penetration of sustainable biofuels to levels consistent with proposals in the Gallagher Review (Figure 6.14). We will monitor biofuels penetration against a trajectory starting at the current 2.5% (by volume) penetration and rising to 10% penetration in 2020, provided the review of the Renewable Transport Fuel Obligation (RTFO) in 2011-12 confirms that this target can be met through the use of sustainable biofuels exclusively.
- **Car kilometres travelled:** Emissions are determined both by carbon intensity and kilometres travelled. We will therefore monitor kilometres travelled relative to the trajectory underpinning our Extended Ambition emissions scenario.

Figure 6.15 Vehicle-km trajectory for cars in the Extended Ambition scenario



Source: CCC.
Note: Includes impact of demand side measures, see section 4(ii).

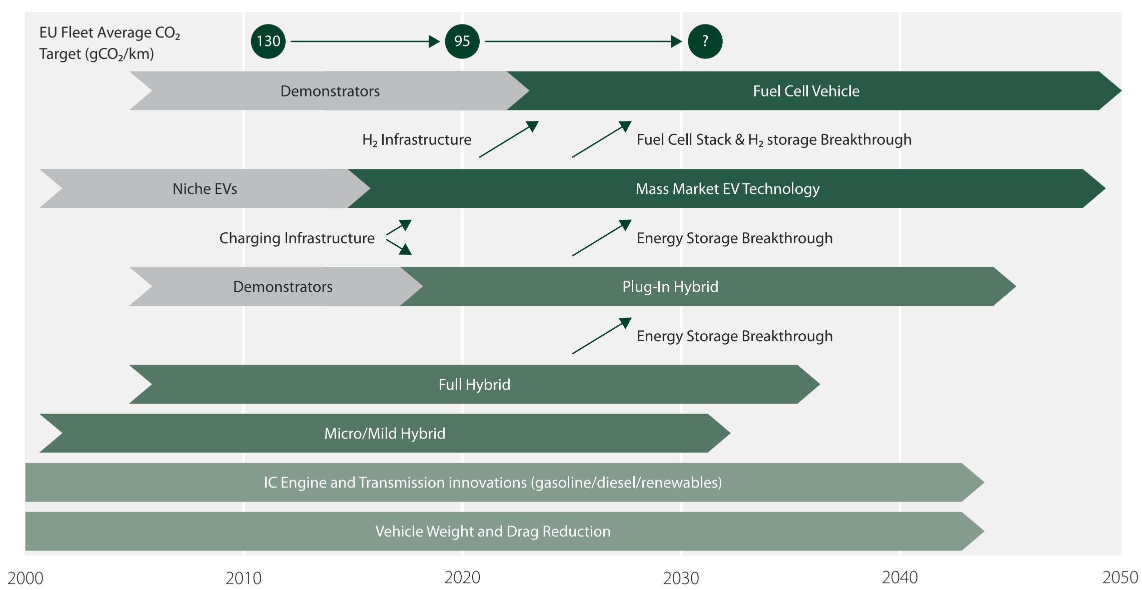
In addition to these indicators, there is a set of variables which may be important determinants of whether the Extended Ambition scenario is reached. These include:

- The proportion of new cars purchased that are the most efficient in class (i.e. proportion of small cars that are most efficient, proportion of medium cars that are most efficient, etc.).
- The size mix of new cars purchased (i.e. the balance of small/medium/large cars).
- The uptake of non-powertrain measures such as gear shift indicators and low rolling resistance tyres.
- The proportion of hybrids in the mix.

All available low-carbon car technologies (from improved vehicle efficiency, to non-powertrain measures to increasing hybridisation) are likely to play a role but there are myriad combinations of these variables which would deliver the Extended Ambition scenario for new car emissions. From the Committee's perspective, the key is to achieve this scenario, rather than to achieve it in a particular way (e.g. through increased hybrid penetration rather than a change in the car size mix). We therefore propose to track these variables as part of our monitoring framework rather than set out indicators in advance for how they should evolve.

We adopt a different approach, however, for electric and plug-in hybrid cars (for the rest of this chapter and where not otherwise specified we will often use the generic term electric car to indicate both battery electric cars and plug-in hybrids). These are potentially very important given limits to carbon intensity reduction based on conventional technology. It will be important, therefore, to achieve a critical mass of electric cars over the first three budget periods. This would contribute to meeting the second and third carbon budgets and would provide the option for possible roll-out in the 2020s. This approach has been endorsed by the Government in its Low-Carbon Transition Plan, where a high level timeline towards increasing levels of electric cars is set out (see Figure 6.16). We now turn to detailed analysis of electric cars, for which we will set out indicators against which we will monitor future progress.

Figure 6.16 Vehicle R&D roadmap



Source: New Automotive Innovation and Growth Team (2009), *An Independent Report on the Future of the Automotive Industry in the UK.*

Box 6.3: Carbon intensity of electric vehicles

An electric vehicle uses around 0.2 kWh/km. Given that the current carbon intensity of electricity production in the UK is around 515 gCO_2/kWh, an electric car is currently a low-carbon car, producing just over 100 gCO_2/km. Some conventional cars are capable of a better carbon performance than this even when accounting for emission from production of fuel; however, as the carbon intensity of electricity falls towards zero, electric cars will reach 0 gCO_2/km. Conventional internal combustion engines will never be able to achieve such a low level of emissions.

3. Demonstration and deployment of electric cars

At least two sets of barriers to electric and plug-in hybrid car development and uptake currently exist:

- Cost and performance characteristics of electric cars may make these unattractive relative to conventional alternatives.
  - Battery technology is at an early stage of development. Cost is therefore relatively high, range is constrained for electric cars (but not for plug in hybrids), and charging times are long.
  - Electric cars will be relatively expensive for an initial period, with a significant upfront price premium over conventional alternatives.
  - Range constraints may make electric cars unattractive relative to conventional vehicles.
- There are likely to be cheaper alternatives for meeting the EU targets in 2020 which do not rely on radical changes to the powertrain, such as advanced diesel engines combined with weight reductions, improved aerodynamics and other efficiency improvements. It would be cheaper for manufacturers to focus on these options which could deliver significant reductions in carbon intensity over the next decade, even though by themselves they do not offer opportunities for further, deeper decarbonisation in the 2020s.

These barriers need not, however, be prohibitive given appropriate policies. There is an important role, for example, in providing price support for purchase of electric cars, and charging infrastructure to address range constraints. This section considers barriers to uptake of electric cars in more detail and appropriate responses by Government to facilitate development of an electric car market. It is structured in four parts:

(i) Market readiness of electric cars

(ii) Electric car costs and price support

(iii) Electric car charging infrastructure

(iv) Scenarios and indicators.

(i) Market readiness of electric cars

Currently there are no electric cars and plug-in hybrids commercially available in the UK market that are substitutes for cars using conventional technology. Although some electric vehicles are available, these are limited to niche markets and are not type approved cars (e.g. the G-Wiz, which is a small vehicle, formally termed a 'quadricycle'). Going forward, however, a number of electric cars and plug-in hybrids that could potentially substitute for conventional cars are under development and likely to come to market in the next few years (Table 6.1).

In tandem with technology development, various business models to support purchase of electric cars and address some of the key barriers to the uptake of electric cars (particularly those relating to battery costs and reliability) are being developed. These include:

- **Battery leasing.** By retaining ownership and liability for the battery the manufacturer removes a significant element of the financial risk for consumers (both in terms of risk of failure and of uncertainty about depreciation and residual value of the battery) as well as helping consumers face the high upfront cost associated with electric cars. It has been reported that Nissan will offer battery leasing with purchase of their electric car, the Leaf.

- **Mobile phone-style transportation contracts.** This is the business model being pursued by Better Place, which plans to offer a range of EV models via packages that will provide access to a network of charging points and battery swap stations (owned, along with the batteries, by the company) (Box 6.10). The intention is that this would combine the benefit of battery leasing with infrastructure provision and greater flexibility for the consumer.
- **Vehicle leasing.** The natural extension to battery leasing is to use a vehicle leasing business model to further reduce risk and minimise upfront costs. Vehicle leasing is currently being pursued by Mitsubishi as the initial business model for the i-MiEV electric small car, which is due to become available in the UK by the end of 2009.
- **Car clubs.** The 'car club' business model could be a viable means of introducing the public to electric vehicle technology, thereby addressing what may be a key barrier in early years in terms of lack of familiarity and negative attitudes to the technology. Norwegian company Th!nk (which produces niche volume electric vehicles) is exploring scope for using this route to promote electric vehicles.

These business models will be useful in helping to support uptake and, in particular, addressing concerns about high up-front costs and range limitations of electric cars. They will require, however, complementary measures including price support and development of charging infrastructure if electric cars are to be attractive to consumers.

(ii) Electric car costs and price support

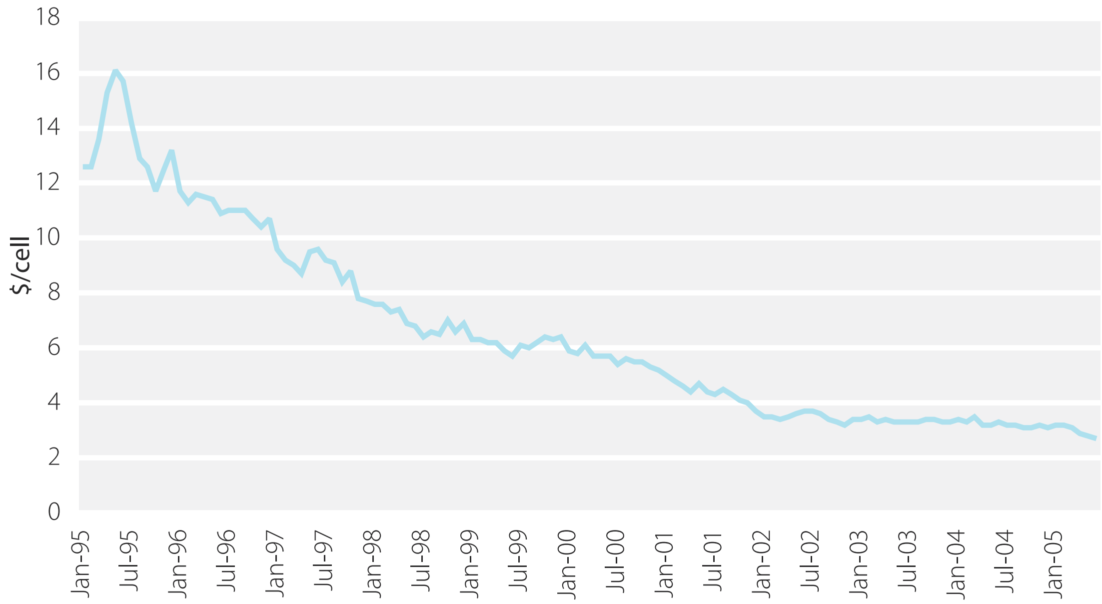
Electric car purchase cost premiums

The purchase cost premium for electric and plug-in hybrid cars derives almost wholly from battery costs. There is a trade off between battery cost and range, with disproportionately large and expensive batteries required to support increasing range. The cost premium for electric cars will therefore reflect this, with a bigger premium for cars with longer range. We estimate, for example, that battery costs for the Mitsubishi i-Miev will be around $13,000 to support a range of 80 miles, whereas the battery costs for a Tesla Roadster will be around $42,000 to support a range of 220 miles.

Although the cost of operating electric cars is significantly less than that for conventional cars – when fuel duty is accounted for in the operating cost of conventional cars – the operating cost saving for electric cars will not be sufficient in the early years to offset the higher purchase cost. At least for an interim period, electric cars will therefore be more expensive than conventional cars on a lifecycle basis, and specifically if the likelihood of a battery replacement during the lifetime of the car is factored into the calculations.

As for any new technology, however, there is scope for significant cost reductions as production levels increase, cumulative research and development commitments rise, and manufacturing scale is increased. The cost of lithium-ion laptop batteries, for example, fell 75% over the period from 1995-2005 (Figure 6.17). In the case of electric car batteries, research that we commissioned from AEA Technology suggested there is scope for cost reduction up to around 70% relative to the cheapest batteries currently available (Box 6.4).

Figure 6.17 Cost of Japanese manufactured lithium-ion laptop battery cells 1995-2005



Source: High Power Lithium; IIT (2009).

Table 6.1 Examples of EVs and PHEVs currently under development

Vehicle manufacturer/ model name	Planned date available on the market	Planned production volume	Retail price information
Mitsubishi i-MiEV (EV)	2009 (Japan, UK); rest of EU (2010).	2,000 vehicles globally in 2009, rising to 10,000 in 2010	Will only be available for lease, but Mitsubishi has quoted a current notional retail price of £35,000, dropping to below £20,000 by end of 2010.
Nissan Leaf (EV)	End 2010	Unknown	£10,000 to £15,000 for the car – batteries will be leased separately
Peugeot iOn (EV)	2011	10,000 in 2011 (estimate)	Unknown, but likely to be similar to Mitsubishi i-MiEV
Toyota Prius PHEV (PHEV)	2010 (initial release limited to selected fleet users), 2012 (series production)	Unknown	US$48,000 (£34,000)
Chevrolet Volt/ Vauxhall-Opel Ampera (General Motors) (PHEV)	2010 (US) 2011 (EU) 2012 (UK)	Initial production volumes range from 10,000 to 60,000 cars per year	US$40,000 (£28,000)
Tesla Roadster (EV)	2008 in USA Autumn 2009 in UK	Unknown, but by the beginning of April 2009, 320 cars had been sold and delivered to customers	£87,000 to £94,000

Source: AEA (2009b); Nissan press release, 2 August 2009;
AutoblogGreen (2009) http://green.autoblog.com/2009/07/05/toyota-will-launch-series-production-phev-prius-in-2012/

Regional availability	Other information
UK, Japan, EU, possibly USA.	SMMT category A (mini-car) UK will be one of the lead markets for the i-MiEV, with 200 vehicles available for lease here in 2009. Mitsubishi has also announced a joint venture with Peugeot whereby the i-MiEV will be rebadged as a Peugeot for EU markets. Vehicle range: 100 miles per charge
USA, Japan, EU, UK	SMMT category B (supermini) To be produced in conjunction with Nissan's parent company Renault. Vehicle range: 100 miles per charge
EU	SMMT category A (mini-car) Vehicle will be heavily based on Mitsubishi i-MiEV – Mitsubishi and Peugeot have signed a Memorandum of Understanding (MoU). Citröen (part of the same PSA group as Peugeot) are also offering electric conversions of the C1 in UK via its partner the Electric Car Corporation. Vehicle range: unknown
EU, USA, Japan	SMMT category C/D (lower/upper medium) Electric-only range will be limited to a maximum of 12 miles, reflecting the small battery capacity that will be fitted to this vehicle. Currently undergoing trials in the UK in a partnership between Toyota and EDF Energy.
EU, USA, Australia, Japan	SMMT category C/D (lower/upper medium) Vehicle range: Electric-only range will be 40 miles. Will be fitted with 16 kWh lithium-ion batteries. Petrol engine capable of 4.7 litres/100 km. Combination of petrol engine and electric motor anticipated by General Motors to return 40 gCO_2/km. General Motors' current financial problems might have an impact on whether or not this vehicle can be brought to market.
US, EU, UK	SMMT category G (specialist sports) Electric sports car designed around the chassis layout of the petrol-engine Lotus Elise sports car. Battery capacity: 53 kWh. Vehicle range: up to 244 miles per charge Recharging time: 3.5 hours (240 Volts)

Box 6.4 Potential battery cost reductions

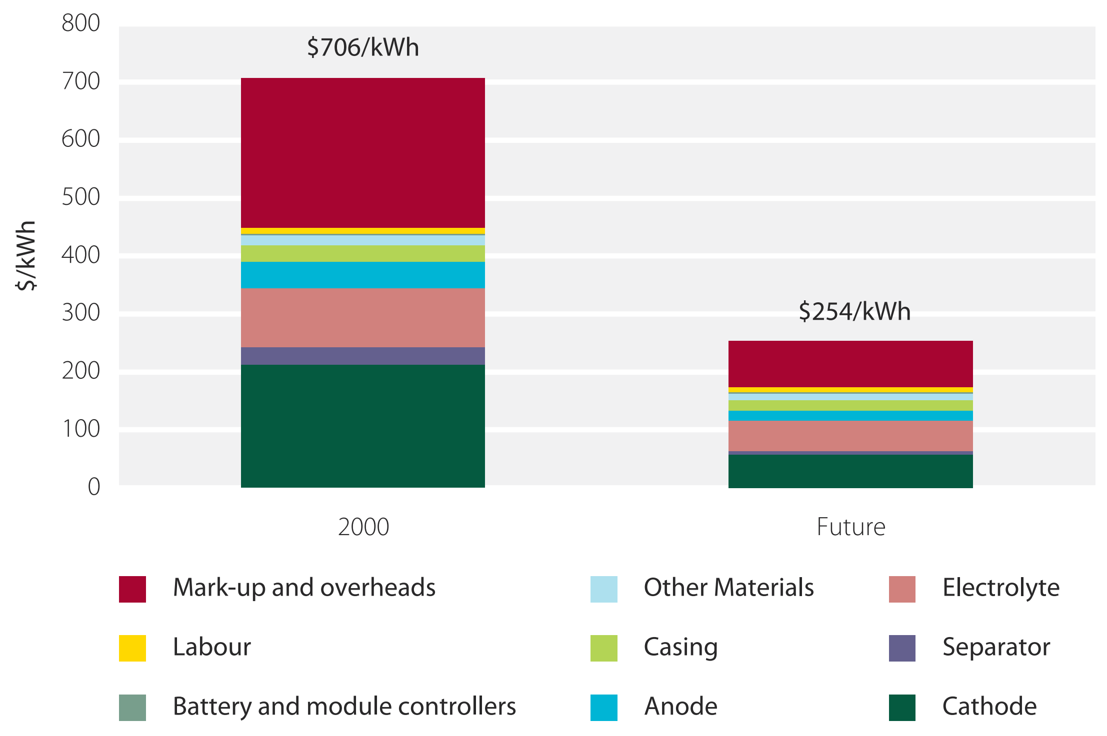
Lithium ion batteries are widely believed to be the most promising technology for electric powered vehicles. However, current battery costs of around \$800/kWh (\$28,000 for a 35kWh battery required by a medium car) will have to fall to make electric vehicles a viable mass market product.

Various analyses (e.g. Argonne National Laboratories (2000)[1], Electric Power Research Institute (2005)[2], and The California Air Resources Board Independent Expert Panel (2007)[3]) suggest that there is scope for significant battery cost reduction to \$200-300/kWh through a range of innovations including:

- Technological advances, particularly relating to innovation which would allow the cathode material to be switched from a cobalt compound to a manganese compound.
- Moving to mass production (100,000s/year) and exploiting economies of scale in the production of parts and of the whole battery.
- Learning effects, which increase efficiency in the manufacturing process.
- Recovery of research and development costs.

The figure below, taken from the Argonne analysis, is broadly indicative of where scope for battery cost reduction lies. This scope for reduction is reflected in the EUROBAT target to reduce battery costs to €300/kWh by 2020.[4]

Figure B6.4 The effect of the 'usable range ratio' on the contribution of electric cars



Sources: Argonne National Laboratories (2000), *Cost of Lithium-Ion Batteries for Vehicles.*

1 Argonne National Laboratories, Center for Transportation Research (2000). *Costs of Lithium-Ion Batteries for Vehicles.*
2 Electric Power Research Institute (2005). *Batteries for Electric Drive Vehicles – Status 2005: Performance, Durability, and Cost of Advanced Batteries for Electric, Hybrid Electric, and Plug-In Hybrid Electric Vehicles.*
3 Kalhammer et al (2007). *Status and prospects for Zero Emissions Vehicle Technology: Report of the Air Resources Board Independent Expert Panel.*
4 EUROBAT (2005). *Battery Systems for Electric Energy Storage Issues: Battery Industry RTD Position Paper.*

If these battery cost reductions can be achieved, the purchase cost premium declines to the point where this no longer outweighs the operating cost saving of electric cars. This analysis suggests, therefore, that price support for electric cars is likely to be required for an initial period, although cost reduction should allow for this to be phased out as penetration increases.

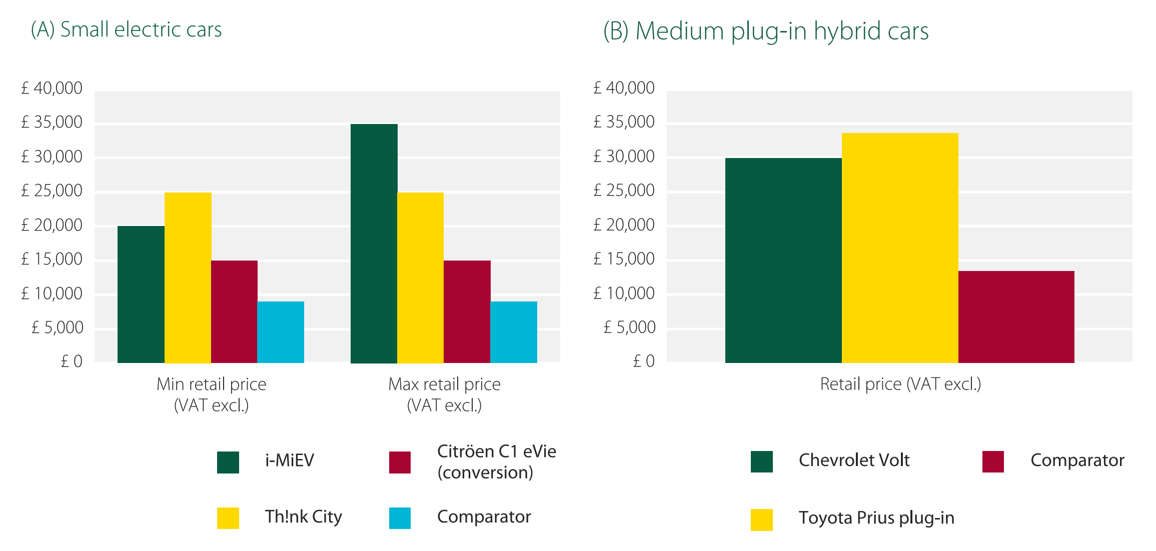
Price support required to offset purchase cost premium

One approach to determining required price support is simply to say that this should offset in full any purchase cost premium of electric cars. Required support would then initially range from £6,000 – £20,000 (Figure 6.18), falling to £1,000 – £7,000 by 2020. Total price support to reach cumulative penetration in the UK of 1.7 million in 2020 – consistent with our (revised) Extended Ambition scenario for electric cars set out below – would be up to £9 billion.

This approach does not, however, allow for the fact that operating costs of electric cars are significantly lower than operating costs for conventional cars. It may be thought of providing an upper bound for required support on the assumption that consumers are myopic (i.e. they fully discount electric car operating cost savings).

An alternative approach is to assess the purchase cost premium of electric cars net of any operating cost savings. Discounting under an assumption that consumers are rational economic agents (i.e. that they discount operating cost savings at their cost of capital) provides a lower bound on the level of price support.

Figure 6.18 Expected purchase price premium for representative early electric and plug-in hybrid cars compared to comparable cars



Source: AEA (2009a), *Review of cost assumptions and technology uptake scenarios in the CCC transparent MACC model.*

This is a lower bound because evidence suggests that consumers are somewhere between the extremes of myopic and rational economic agents in their car purchase behaviour, valuing but over-discounting cost savings. In addition, behavioural theories suggest individuals are likely to be resistant to purchasing electric cars rather than conventional cars given uncertainty and concerns over performance (Box 6.5).

Under an assumption that consumers are rational economic agents, required price support ranges from £1,500 – £7,000 per car initially (depending on the electric car model and the year of introduction), with declining support required over time and no support required beyond 2018. Total price support required to support roll out of electric cars in the UK in line with our Extended Ambition deployment scenario before costs fall to the break-even level would be around £800 million (Box 6.6).

What in practice is the appropriate level of price support will be determined by the way that consumers weight current versus future costs and by the way in which – price premium aside – they value performance characteristics of electric versus conventional cars.

Box 6.5 Influences on car purchasing behaviour: findings of a recent report by Ecolane

In 2008 Ecolane reviewed for DfT the evidence from a number of recent attitudinal research studies on car purchase behaviour. The evidence suggests that purchase decisions are essentially a two-stage process driven in the first instance by a choice of size/body type and available budget, after which secondary factors (which may include running costs and fuel economy) are accounted for. The weight attached to fuel economy, however, reflects heavy discounting due to:

- Consumers' lack of confidence in published miles per gallon (mpg) figures and/or belief that improved mpg compromised safety or performance.
- The complexity of fuel economy calculations, which involve multiplying fuel costs (in pence per litre) by fuel economy figures (in miles per gallon) to derive a fuel cost (in pence per mile).
- The low extent to which underlying pro-environmental attitudes affect vehicle choice.

This evidence (and evidence on the effects of incentive schemes introduced in the US and in the EU) bring Ecolane to conclude that an economic incentive equivalent to at least £1,100 per year would be required to significantly alter car-consumer choice (i.e. switching to an alternative fuel or a smaller engine) while a one-off incentive at the time of purchase (with a £10 per gCO_2/km gradient) would achieve the same effect more efficiently.

Ecolane's report does not focus specifically on attitudes towards electric vehicles, but their explanations for the attitude-behaviour gap (which include factors such as resistance to change) suggests that their conclusions may apply more strongly to the purchase of electric vehicles.

Source: Ecolane (2008). *Review of Attitudinal Influences on Car Purchasing Behaviour.*

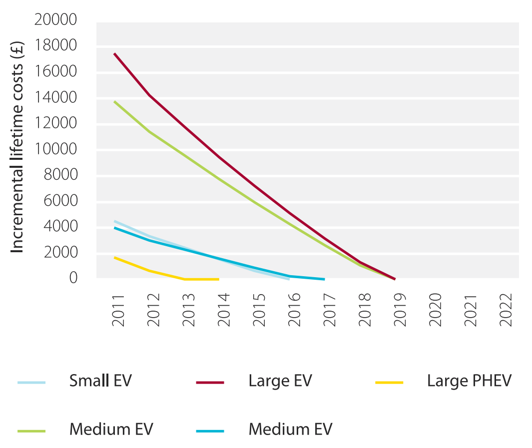
Box 6.6 CCC estimates of the required subsidy to cover lifetime cost differential of electric cars

We calculated required upfront price support by comparing lifetime costs (i.e. purchase and running) of conventional cars, plug in hybrids (PHEVs) and electric cars (EVs). We based our analysis on the following assumptions, which reflect our assessment of the available evidence (e.g. drawing on work for us by AEA and from other sources):

- A small EV has a 16kWh battery, a medium EV has a 35kWh battery and a large EV has a 53kWh battery. A medium PHEV has a 14kWh battery and a large PHEV has a 20kWh battery.
- The costs of a battery are assumed to fall over time, from $1,000/kWh[5] in 2009 to $285/kWh in 2020 in line with the goals set by EUROBAT (2005).
- Batteries are assumed to require replacement after eight years with a probability declining from 100% in 2009 to 10% in 2020.
- Capital costs for conventional car engines and electric motors are consistent with TNO (2006) and work done for the CCC by AEA[6]. An electric motor is less expensive than a conventional engine.
- The cost of petrol is consistent with pump prices based on DECC central projections for fossil fuel prices. The cost of electricity is also based on DECC projections. Per kilometre an electric car uses 1.6-2.7p worth of electricity (0.16-0.28 kWh/km), whilst a petrol car uses 6-14p worth of fuel.
- Small, medium and large cars travel 11,000, 14,000 and 18,000 km per year respectively for 12 years.

Future costs are discounted at 7% to reflect the real cost of borrowing. The figure below shows the upfront support required under these assumptions to negate lifecycle cost differences between conventional and electric/plug in hybrid vehicles; required price support ranges from £2,000-£18,000 initially, with no price support required from as early as 2014.

Figure B6.6 Estimated incremental cost of different types of EV and PHEV compared to a conventional car



Source: CCC Modelling.
Note: Modelling shows estimated incremental costs for years where cars of a particular type may not be available.

The total price support required before EVs and PHEVs break even depends on the pace at which these are rolled out. In our Extended Ambition scenario (see section 3(iv) below) 450,000 vehicles would be sold before EVs and PHEVs break even, and would therefore require price support of around £800 million (the number of vehicles sold each year multiplied by the price support required in that year). A Monte Carlo analysis of required support which allows for uncertainty in battery costs, discount rates, distance travelled and the size of the battery suggests a median value for required price support of £500 million, with a first and third quartile value of £150 million and £1.5 billion respectively. Analysis based on linking battery cost reduction to volume of EVs and PHEVs sold rather than time suggests required price support of around £1 billion.

5 Arup (2008). *Investigation into the Scope for the Transport sector to Switch to Electric and Plug-in Hybrid Vehicles.*
6 AEA (2009a). *Review of cost assumptions and technology uptake scenarios in the CCC transport MACC model.*

It should be noted that all these calculations assume that conventional fuels continue to be taxed at current levels, thus providing an additional implicit subsidy for use of electricity as a transport fuel; the Committee's view is that these implicit and explicit subsidies for electric cars are justified to develop what is likely to be a key technology for decarbonising transport in the 2020s.

Measures to address over-discounting of electric car operating cost savings

There are at least three levers which can be used to encourage purchasers to attach appropriate weight to operating cost savings of electric cars:

- Consumers can be encouraged to consider both purchase costs and operating costs more fully through provision of information about operating cost savings and lifecycle costs of electric versus conventional cars.
- Business models such as battery leasing turn some purchase costs into operating costs, thus eroding the purchase cost premium for electric cars.
- To the extent that heavy discounting may reflect concerns about electric car performance, these can be addressed through ensuring that appropriate infrastructure is in place and demonstrating that this addresses concerns over range limitations.

We concluded in our December report that better information alone is unlikely to result in changed purchase behaviour, but is still likely to have an important role to play as part of a package of mutually supporting interventions. Together with new business models, it is reasonable to assume that better information could mitigate over-discounting of operating cost savings by consumers. These measures would only be effective, however, if consumer confidence in electric cars can be increased, which crucially depends on the introduction of a charging infrastructure; we consider the design of charging infrastructure in Section 2(iii) below.

The UK Government's price support package

In April 2009 the Government announced a support package for developing an electric car market. From 2011 this will provide up to £2,000 to £5,000 per car up to a total amount of £230 million. Whilst this is a useful contribution to developing the electric car market, but that some flexibility is likely to be required over the time for disbursing support, and further support over and above this initial amount is likely to be required:

- The price support per car is of the order of magnitude that our analysis suggests is likely to be required if purchasers fully value operating cost savings of electric cars. It is comparable to the level of price support being offered in other countries (Table 6.2).
- This level of price support combined with measures that spread some purchase costs over time may be sufficient to encourage uptake of electric cars.
- It is possible that stronger incentives may be needed in early years (e.g. higher price support – e.g. £10,000 per vehicle for the first 25,000 vehicles sold – might be required to encourage early stage take up); this type of tapered structure should be considered further.
- Overall our analysis suggests that cumulative support significantly above the initial £230 million already committed will be required (Box 6.6).

It is not imperative that new funding is committed now given uncertainty over how costs will fall in coming years. The Committee's view, however, is that the likely need for extra funding should be acknowledged, and that this issue should be revisited at the appropriate time to determine exactly what level of funding for purchase incentives in combination with other levers such as fuel duty is required.

Table 6.2 Upfront price support offered for low-carbon vehicles in a number of countries

Country/Vehicle Details	Price Support		
	Value of support in currency of origin	Value of support in £ (approximate)	Value of support as % of total vehicle price
Canada: (Federal rebates for vehicles 5.5l/km, e.g. Toyota Prius 1.5 l, Honda Civic Hybrid, 1.3l and additional provincial rebates for plug in electric and hybrid vehicles)	C$2,000 / C$3,000	£1,115/£1,675	
Belgium: (vehicles with emissions up to 105 g CO_2/km)	€4,350	£4,000	20% to 40%
Ireland: (Hybrid and Flexi-Fuel – first registration)	€2,500	£2,300	Up to 15%
Sweden: (Hybrids with emissions less than 120g CO_2/km, electric cars – less than 37 kWh)	10,000 SEK	£850	Up to 5%
France: (Class A, vehicles under 100g CO_2/km)	€2,000	£1,850	Up to 15%
France: (Class A+, vehicles under 60g CO_2/km)	€5,000	£4,700	Up to 25%
USA: (Plug-in electric, batteries of at least 4kWh)	$2,500	£1,700	Up to 8%
USA: (Plug-in electric, gross vehicle weight up to 10,000 lbs)	$7,500	£5,250	Up to 20%
USA: (Plug-in electric, gross vehicle weight up to 14,000 lbs)	$10,000	£6,800	
USA: (Plug-in electric, gross vehicle weight between 14,000 lbs and 26,000 lbs)	$12,500	£8,500	
USA: (Plug-in electric, gross vehicle weight over 26,000 lbs)	$15,000	£10,160	
Japan: (Nissan Hypermini – electric car)	¥940,000	£5,040	27%
Japan: (Mitsuoka CONVOY88 – electric car)	¥210,000	£1,125	24%
Japan: (Zero Sports Elexceed RS – Hybrid)	¥380,000	£2,040	19%
Japan: (Toyota Prius – hybrid)	¥210,000	£1,125	10%
Japan: (Honda Civic Hybrid)	¥230,000	£1,240	11%

Source: AEA (2009b), *Market outlook to 2022 for battery electric vehicles and plug-in hybrid electric vehicles.*

(iii) Electric car charging infrastructure

If people are to purchase electric cars, they will have to feel confident that these will be able to meet their needs. It is likely that initial range for electric vehicles would be 60-100 miles, possibly increasing to 250 miles over time. Even the limited range for initial models would be sufficient to cover the majority of trips currently made in the UK, suggesting that range constraints need not be a prohibitive factor in electric car uptake (Box 6.7).

In purchasing cars, however, it is likely that consumers would look for a range beyond their daily driving distance given concerns about batteries running out mid-journey ('range anxiety') and given the need to make infrequent longer journeys. This suggests that there may be a market for plug-in hybrid vehicles as primary/only cars, and electric vehicles as primary or second cars:

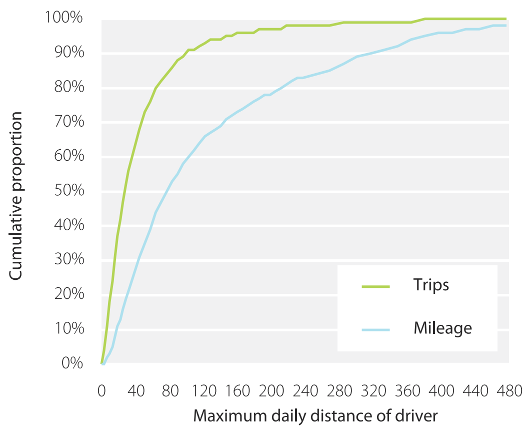
- Plug-in hybrids are subject to the same range constraints as conventional cars. A household purchasing a primary conventional car with the capability for occasional long journeys might equally choose a plug-in hybrid.
- Electric vehicles are potentially subject to the same range constraints as conventional cars depending on the charging infrastructure. In particular, where there is fast charging public infrastructure or battery exchanges (see below), range should not be an issue even for longer journeys (Box 6.8).

Box 6.7 Typical driving distances

The typical daily driving distance of many car users is well within the indicative range of 160 km (100 miles) for a new electric car.

The figure below presents analysis derived from work commissioned from Element Energy.[7] It uses data from 13,390 individuals who had recorded trips as a car driver in the 2006 National Travel Survey. The data records the typical maximum daily distance of each driver[8] and the figure below shows this plotted against the cumulative proportion of total trips taken by all drivers and the cumulative proportion of total distance driven. This tells us that 96% of trips are made by drivers who normally travel no more than 160 km a day, whilst 73% of kilometres driven are undertaken by drivers who normally travel no more than 160 km a day.

Figure B6.7 Cumulative contribution to total number of trips and total mileage as a function of car drivers' maximum daily driving distance



Source: Element Energy analysis based on the National Travel Survey (2006).

This analysis suggests that an electric vehicle with a range of 160 km would, in principle, be sufficient for drivers who undertake 95% of total car trips and 73% of aggregate car-kms. It also suggests that a plug-in hybrid car with an electric range of 64 km (40 miles) would be able to cover 80% of all trips in electric mode, although this only amounts to 44% of total distance driven, due to the large proportion of short trips. Such a vehicle would, however, additionally be able to drive the first 64 km of longer trips in electric mode.

7 Element Energy (2009), *Strategies for the uptake of electric vehicles and associated infrastructure implications.*
8 This does not mean that the driver *never* exceeds this distance, but that their usual driving pattern does not exceed this.

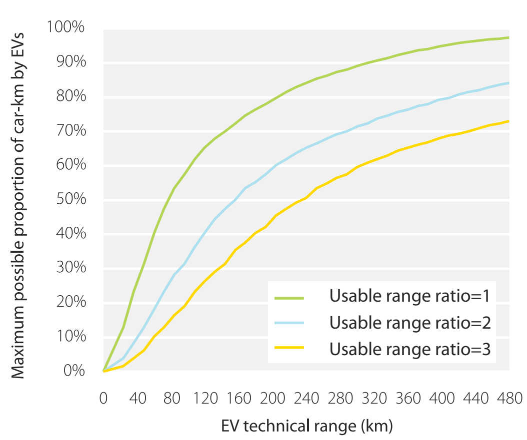
Box 6.8 Technical and utilised range of electric vehicles

Based on an indicative range for an electric vehicle of around 160 km (100 miles), the technical range of an electric vehicle would be sufficient for the normal driving patterns of many drivers as discussed in Box 6.7.

However, survey evidence[9] shows that, at least to date, users of electric vehicles are generally unwilling to utilise more than a third to a half of the vehicle's technical range. Possible explanations for this behaviour include a cautious approach to new technology and a lack of publicly available charging infrastructure that meets their needs.

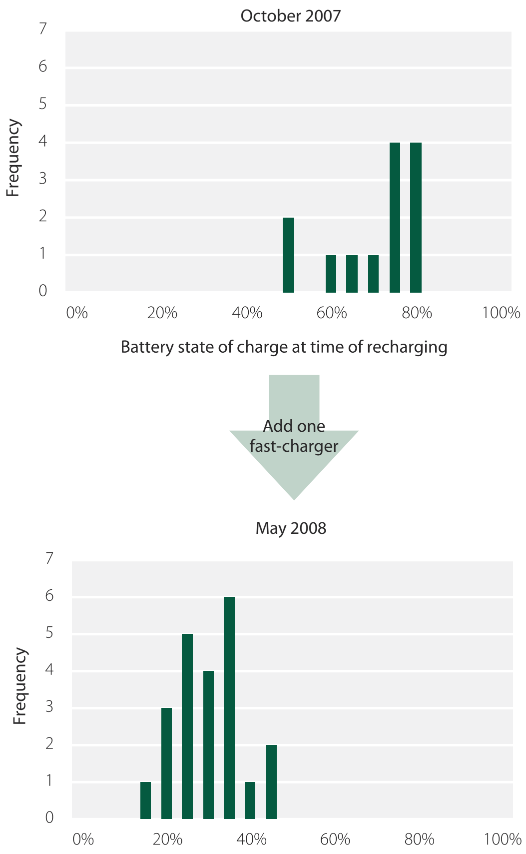
The effect of this unwillingness to use the full technical range of a vehicle is that the 'usable range ratio' – the ratio of the vehicle's technical range to the range utilised by the user – is relatively high, at 2-3, bringing down the potential contribution of an EV with 160 km technical range to 36-51%.

Figure B6.8a The effect of the 'usable range ratio' on the contribution of electric cars



Source: Element Energy analysis, based on data from the National Travel Survey.
Note: The 'usable range ratio' is the ratio of the technical range of a vehicle to the range that a user is actually willing to use. A ratio of 2 implies that a user is only willing to utilise 50% of the vehicle's technical range.

Figure B6.8b The impact on utilised range from the installation of a fast charging point, evidence from Japan



Source: Tokyo Electric Power Company (Tepco), relating to the operation of Tepco's own fleet of EVs. Fast-charger is rated at 45 kW.

There is a potentially important role for public charging/battery swap infrastructure to reduce this ratio, so enabling electric vehicles of a given technical range to be suitable for a much greater proportion of car drivers.

The figure above shows such an effect within the electric vehicle fleet of the Japanese utility Tepco. The addition of a fast-charging station reduced the amount of energy left in the battery at the point of recharging from 50-80% to 20-50% of its capacity, implying a substantial increase in the utilisation of the vehicles between charges.

9 Element Energy (2009), *Strategies for the uptake of electric vehicles and associated infrastructure implications.*

- Second cars are typically used for shorter journeys within the range for electric cars without fast charging public infrastructure or battery exchanges. The many households currently using second cars might equally choose electric cars. Currently 42% of car-owning households have more than one car.

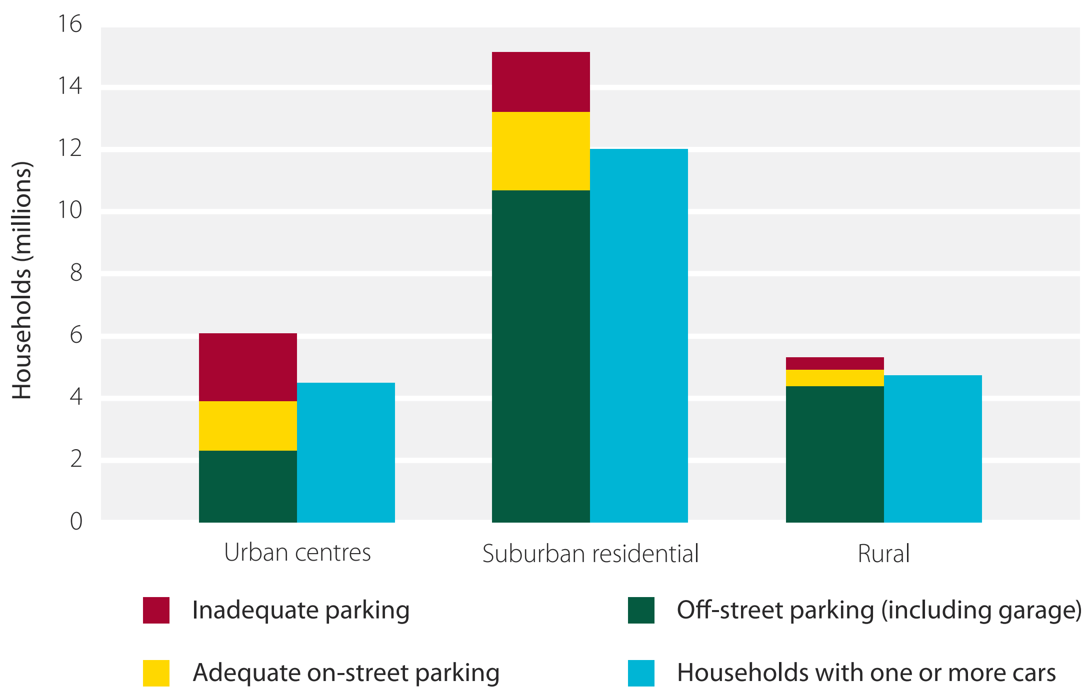
There is therefore a potentially large market for both plug-in hybrids and electric cars. Unlocking this potential will require introduction of charging infrastructure that facilitates required charging consistent with range constraints and trip patterns.

Options for charging infrastructure

We commissioned Element Energy to assess technical and economic aspects of electric car charging infrastructure. Element considered five options for charging infrastructure:

- **Off-street charging.** Over 60% of households in the UK have off-street parking (less than 40% in urban areas and around 75% in suburban and rural areas). The cost of associated charging infrastructure is very low, at around £50 per car, and significantly lower than the other options listed below (Box 6.9). This makes off-street charging a very cost-effective option for a large proportion of potential drivers.
- **On-street charging outside homes.** Targeting those urban households without off-street parking is likely to be important as part of encouraging electric car uptake, especially as urban users tend to make shorter trips well-suited to electric vehicles, and dedicated on-street charging points are therefore likely to be required. One low cost option would be to run cables from houses to the street. Installation of more sophisticated charging points – probably a more enduring solution – would cost several thousand pounds.
- **Charging in public places (e.g. car parks, supermarkets, etc).** This could be necessary in order to allow substitution of longer non-commuting journeys (Figure 6.21) to electric cars (e.g. business journeys, visiting friends, day trips)

Figure 6.19 Parking availability and car ownership by area type

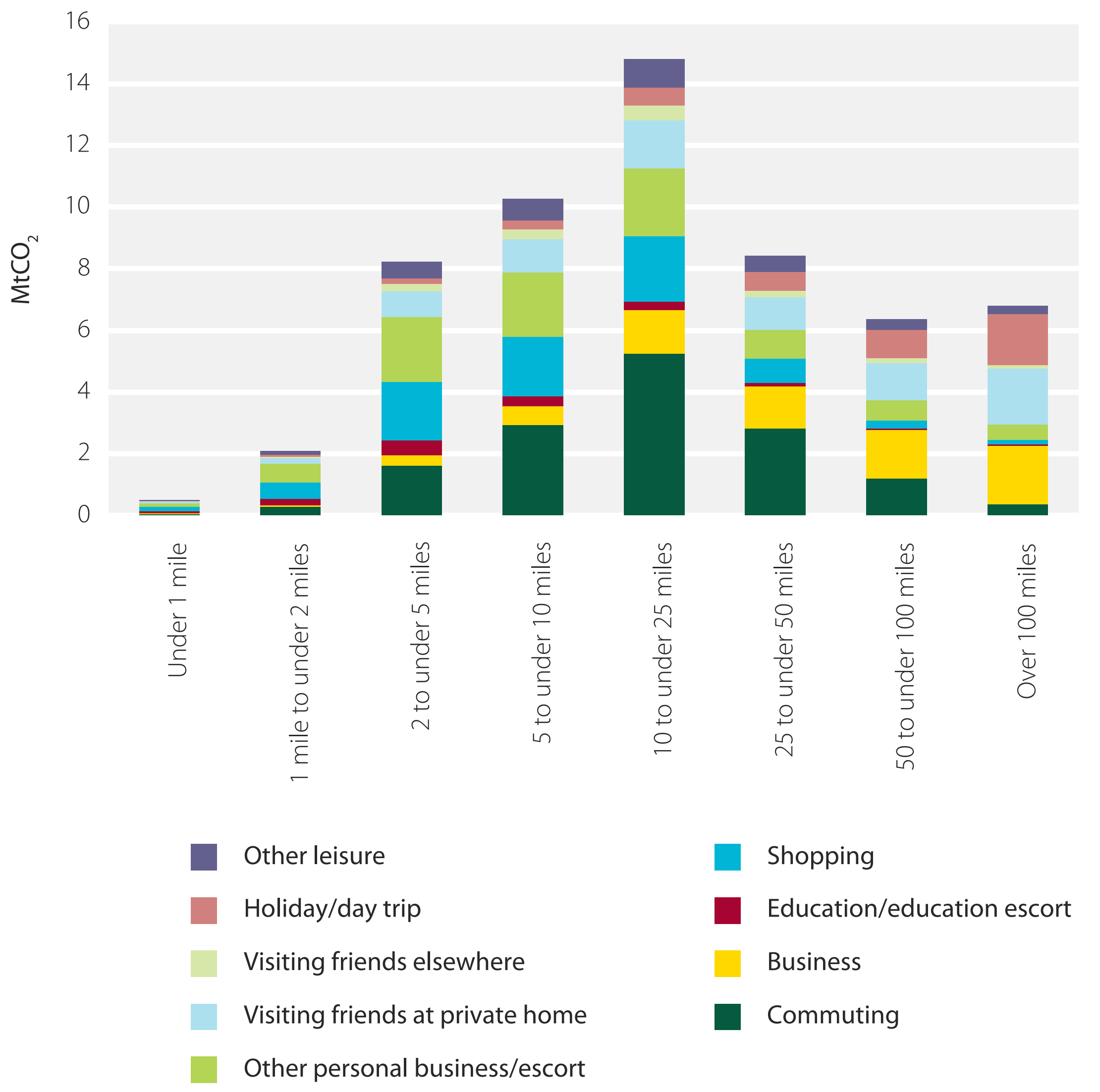


Sources: Parking data from the English Housing Condition Survey; car ownership data from the National Travel Survey.
Note: Despite the apparent correlation, it is not possible to state definitively that households without cars are also those that do not have adequate parking availability, as the data on car ownership and parking availability are from different sources.

which together account for 17 $MtCO_2$ annually (Figure 6.20) and in doing this increase the potential size of the electric car market. Fast-charging technology is likely to be needed given that people tend to stay at such public places for one or two hours rather than the eight hours required for a full slow charge (Figure 6.22). Fast charging points are likely to cost around £40,000 on average, although their installation may in some places also necessitate an upgrade of the distribution grid, costing a further £50,000 on average.

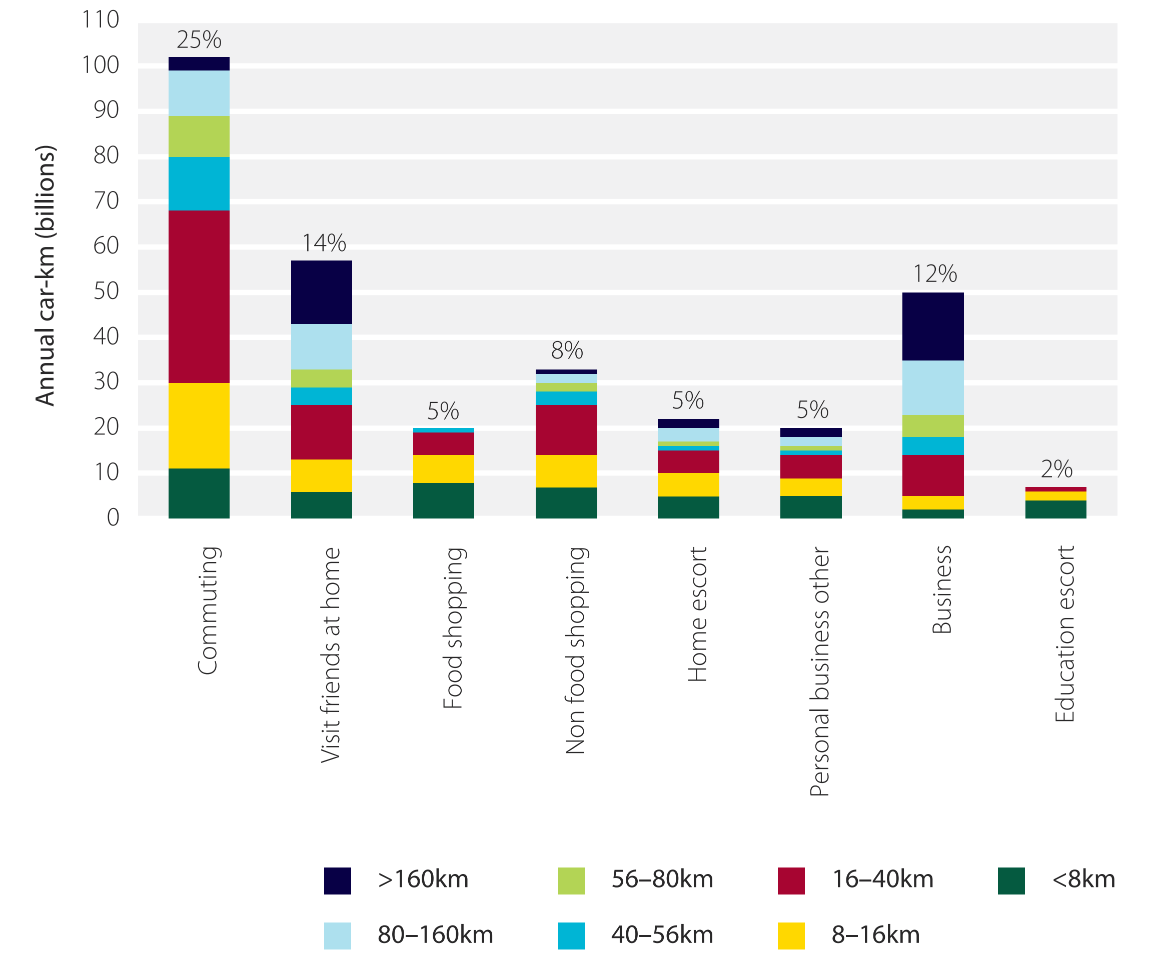
- **Workplace charging.** Commuting journeys between 25-100 miles account for around 4 $MtCO_2$ annually and substitution of these journeys to electric cars therefore offers an important emissions reduction opportunity. Substitution would, however, require access to recharging points before returning home given the range constraint of electric cars. For workplaces with car parks, installing charging infrastructure is relatively straightforward, either through adding points to existing circuits or installing more sophisticated charging points.

Figure 6.20 Car CO_2 emissions by journey length and purpose



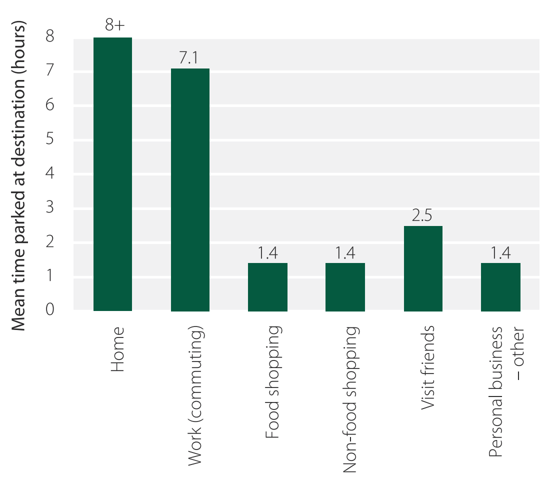
Source: Carbon Pathways Analysis (2008), *Informing Development of Carbon Reduction Strategy for the transport sector.*

Figure 6.21 Estimated contribution of trip types to total car driving distance



Source: Element Energy analysis, based on the National Travel Survey (2009).

Figure 6.22 Mean time spent parked at destination for various journey purposes



Source: DfT (2009).

- **Battery exchanges.** These could operate in a similar way to today's filling stations, restoring the vehicle to a full state of charge in a matter of seconds by swapping the discharged battery for a pre-charged module. With sufficient coverage, a battery exchange infrastructure would potentially enable EVs to be used for all car journeys. A major challenge would be the requirement for standardisation of both battery design and car battery mounting system.

A national charging infrastructure would probably need to include most of the above in order to maximise the potential size of the electric car market and emissions reduction ensuing from substitution to electric cars. There would be scope over time for electric car drivers to contribute to infrastructure costs as battery costs fall and electric cars become profitable to drive.

A charging infrastructure consistent with our Extended Ambition scenario for electric car deployment in 2020 may not, however, require a widespread public charging infrastructure, and could be supported by primarily off-street, on-street home and workplace slow-charging. We estimate that the cost of introducing such charging infrastructure would be in the range £150m to £1.5bn, depending on the options chosen for on-street home and workplace charging (Box 6.9).

Box 6.9 Cost estimates for electric vehicle charging infrastructure

The costs of electric charging facilities can vary from around £50 for off-street home-charging, to several thousand pounds for a public slow-charging point, to £40,000 – or more if electricity grid upgrades are required – for a fast-charging point.

The cost of the battery, electricity and charging infrastructure have the potential to become lower than the cost of driving a petrol or diesel car, which are current around 7p per km.

Depending on the type of infrastructure used, the total infrastructure costs to support the roll out of 1.7m EVs and PHEVs to 2020 could be very low, at around £150m. This cost estimate would require all charging to be undertaken via off-street home charging, or simple solutions in workplaces that use the existing power supply and don't require major works to be undertaken.

A more extensive infrastructure for the same number of users might cost around £1.4bn, comprising:

- dedicated slow-charging posts for the 25% of drivers who do not have off-street parking, at a cost of around £1bn.
- charging posts in work-places for 5% of drivers, at £210m.
- a total of 3,200 fast-charging points (i.e. two for every 1,000 electric cars) in public places, e.g. supermarkets, at a cost of £130m.
- provision of four fast-charging points every 35 km in each direction on motorways and every 50 km on trunk roads, at £70m.

Table B6.9 Estimates for electric cars costs including infrastructure

Costs of EV operation		£ per vehicle	pence per km
Battery ($200-800 per kWh)		2,900 – 11,500	4 – 15
Electricity (12p/kWh)			1.7
Home-charging infrastructure			
– off-street charging		50	0.05
– on-street charging		100 – 2,600	0.1 – 2.8
plus	**Workplace charging**	50 – 2,600	0.05 – 2.8
and/or	**Fast-charging** (2-10 per 1,000 cars)	130 – 650	0.15 – 0.75

Source: CCC analysis, based on data from Element Energy on infrastructure costs.
Notes: This analysis makes numerous assumptions, including 7% real discount rate; Ford Focus with 160 km range; battery lifetime 8 years; charging infrastructure lifetime 10 years; 13,000 vehicle-km/year.

It will be important to understand how the presence of public charging infrastructure might affect uptake and use of electric vehicles to give a better idea of how a charging infrastructure to support wider roll-out might best be designed.

Next steps in rolling out charging infrastructure

There are likely to be economies of scale in concentrating roll-out of electric cars in certain areas. The Committee therefore recommends that the appropriate next step is to develop a number of pilot projects that should:

- cover different types of areas (e.g. a city, a town, a pair of neighbouring towns with significant traffic between them, etc.).
- cover the range of charging options (off-street charging; on-street charging outside homes on-demand; public place charging built to anticipate demand based on an assessment of likely car uptake, trip patterns of people driving cars, battery range constraints and cost; workplace charging on-demand; and possibly battery exchanges) (Box 6.10).
- be designed to produce clear evidence on the effect of public charging points on vehicle purchase and utilisation, by having pilot areas with similar demographics but differing levels of publicly available infrastructure.
- include participation of national and local government, energy companies, providers of charging infrastructure and the electric car industry and local businesses.
- be supported by any necessary planning and regulatory changes (e.g. to facilitate installation of on street charging points).
- be funded to cover costs of on-street charging, public place charging, work place charging and possibly battery exchanges, either by central or local government; this would provide a bridge to alternative funding mechanisms upon wider roll-out (e.g. full commercial financing).

Box 6.10 An alternative approach to pilot project design: the Better Place proposal for London

Better Place has proposed a London pilot project that would aim to install to service 50,000 electric cars by 2015 at a cost of £200 million:

- Better Place envisage an infrastructure with battery exchanges and 90,000 charging points.
- The bulk of the cost relates to public charging infrastructure.
- The focus on battery exchanges and public charging infrastructure fits with the Better Place business model which is targeted at the high mileage driver market (i.e. drivers who cannot just recharge at home).

The Better Place proposal raises questions over the target market for pilot projects and implied requirements for charging infrastructure. Appropriate pilot design will depend on the proportion of high mileage drivers, and the cost of public charging infrastructure.

Source: Discussion with Better Place.

- use a range of levers to promote electric cars, from price support to network measures (e.g. allowing use of bus lanes, prioritising parking, exempting from road pricing, etc.) and innovative marketing campaigns (e.g. aimed at making electric cars fashionable).

Implementation of pilot projects forms part of our scenarios for electric car deployment and our indicators. We envisage pilot projects covering up to 240,000 electric cars in the period to 2015. In addition to the cost of purchasing the vehicles, we estimate that this would cost:

- Up to £230 million to pay for installation of on-street charging points outside homes and public fast-charging (depending on the balance of off- versus on-street charging in the pilots, and the choice of technology for on-street charging – costs could be negligible for pilots focused on households with off-street parking or on running cables from houses to the street).

- Additional funding for public charging infrastructure, workplace charging and battery exchanges.

Implications for the power system

In our December report we set out scenarios to 2050 where there is increasing demand for electricity from the 2020s partly due to electric cars and partly due to electric heating. Our working assumption, at least for electric cars, was that the bulk of this demand would be overnight. Electric cars would therefore support power sector decarbonisation by creating demand for low-carbon baseload capacity.

We did not consider possible investments in power generation or networks that could be needed as a result of demand from electric cars. In order to fill in this gap in our analysis, we commissioned Element Energy to assess implications of increasing electric car penetration for power sector investment (Box 6.11).

The Element Energy analysis suggests that near term implications should be very limited, both because demand for electricity from electric cars is expected to be relatively small, and the bulk of this is expected to be overnight. These factors together suggest that increased electricity demand could be accommodated within existing system capacity constraints. To the extent that distribution grid upgrades may be required, accommodating increased demand is a standard part of ongoing investment programmes.

Going further out in time, the analysis suggests that investments in power generation, transmission and distribution could be required to meet increasing demand, particularly if there is significant charging in peak periods.

Box 6.11 Power system implications of electric vehicle introduction

Peak electricity demand occurs in the early evening, when people arrive home from work. Charging an electric vehicle at this time would add to system peak demand, implying significant investment in generating plant and distribution networks to provide the necessary peak capacity.

These investments can largely be avoided using a simple solution such as a delay timer, which would facilitate charging in the off-peak overnight periods, (i.e. 11pm-7am). In addition to this simple technical solution – which could incorporate an 'override' button to ensure that users can charge immediately if necessary – electricity tariffs with a lower overnight rate will be required to incentivise charging during this period. The resultant increase in off-peak demand is also conducive to an increase in the proportion of baseload generating plant on the system, i.e. favouring nuclear, wind and CCS rather than gas.

The electrical loads for a fast-charging point are much greater than those of a slow-charging point or home charging, and fast-charging will also tend to occur during the daytime period rather than off-peak. As a result, the installation of fast-charging points could increase the peak load on distribution networks, potentially requiring an upgrade to transformers and/or lines and cables. This can be minimised with placement of fast-charging points where the local network is strong, e.g. near to the substation.

Existing processes for the upgrade of distribution networks to accommodate growing electricity household demands are also appropriate for any reinforcements required to support electric vehicle charging.

Power system implications should therefore not be a barrier to moving forward with electric car roll-out to 2020. It will, however, be important to better understand implications of larger scale roll-out in the 2020s and how impacts in terms of power sector investment can be minimised. The Committee will undertake further work on this and, in particular, will look in more detail at how smarter operation of the grid and new electricity pricing schemes could encourage the timing of electricity consumption to reflect system capacity constraints at different times of the day; we will publish this in our report on the fourth carbon budget which we will present to Government in 2010.

Based on a high level assessment of electricity sector investment costs, when these are spread over asset lifetimes and compared against very significant emissions cuts, then electric cars should remain the least cost option for transport decarbonisation in the 2020s.

(iv) Electric car scenarios and indicators

In our December report we set out scenarios for carbon intensity improvement of cars over the first three budget periods in which electric car and plug-in hybrid penetration reached around 20% of new cars and 7% of the fleet in 2020. We developed these scenarios based on analysis that we commissioned from a consortium of transport consultancies.

We now update these scenarios to incorporate evidence from three new pieces of analysis:

- In May 2009 the RAC Foundation published survey data that suggested around 20% of people would consider purchasing an electric car; this is higher than the Committee would expect given uncertainty over performance characteristics of electric cars, and is consistent with the level of deployment required to 2020.
- We commissioned AEA technology to review our scenarios given their analysis of electric car costs. AEA's revised analysis suggests a central case electric and plug-in hybrid car penetration of 7% to 10% of new car sales in 2020.
- The consultancy Arup, in partnership with Cenex (the Government's delivery agency for low-carbon and fuel technology) developed scenarios for DfT showing uptake in the range of 8% to 16% of new cars in 2020 by building on information of planned vehicle releases by manufacturers under a medium and high scenario respectively, with 20% of new car sales being reached shortly after 2020[10] (Figure 6.23).

In addition, there is evidence that manufacturers are now moving faster towards developing and introducing electric car models than anticipated a year ago, with a major manufacturer (Nissan) having announced the launch in late 2010 of an electric car with potential to reach mass production.

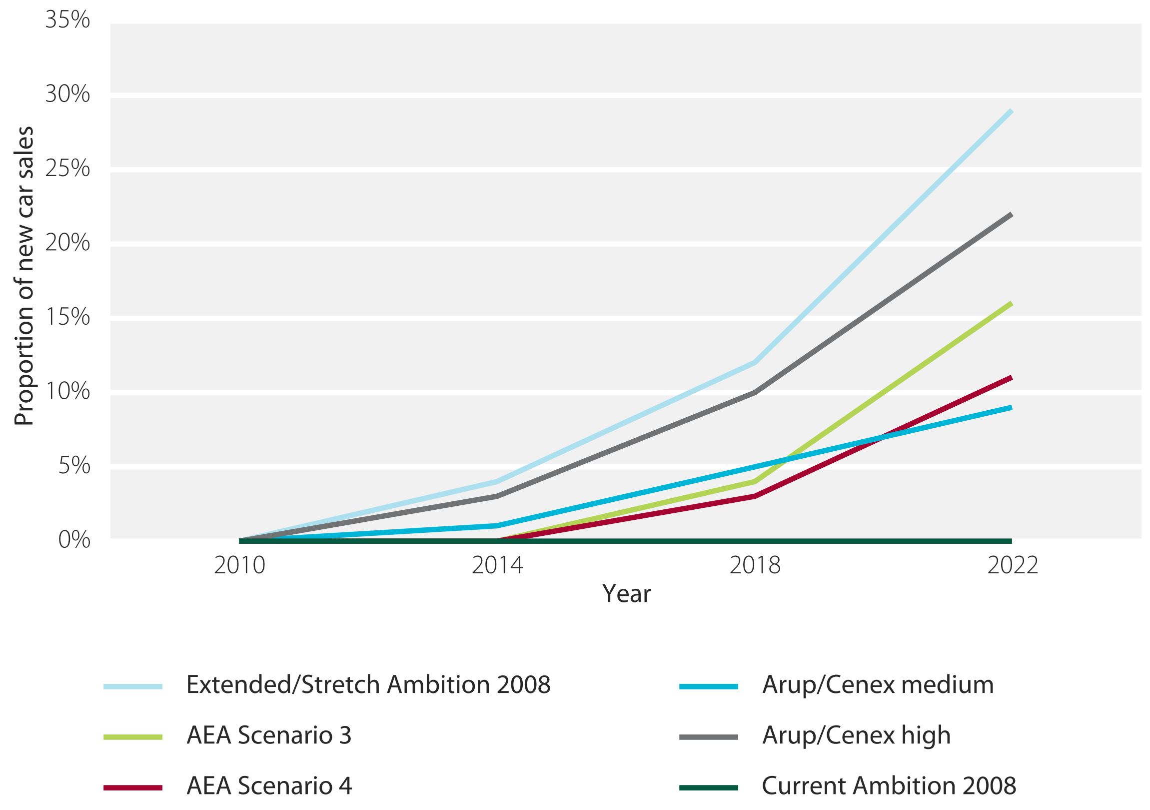
Based on this evidence, it is the view of the Committee that an Extended Ambition scenario under which electric and plug-in hybrid cars achieve significant penetration (tens of thousands of combined vehicles sold annually) from 2013 and account for 5% of all new cars in 2015, 16% in 2020 and 20% shortly thereafter (i.e. a scenario consistent with Arup/Cenex above) is ambitious but feasible; this would result in cumulative penetration of 240,000 cars by 2015, and 1.7 million cars by 2020.

This level of penetration would provide critical mass for more widespread roll-out through the 2020s, if evidence continues to show that electric cars are the most economically attractive option for sector decarbonisation. The scenario also embodies an assumption (consistent with the aspirations set out by the Government) that the UK will be a leader in the adoption of ultra-low-carbon vehicles.

We will therefore use our Extended Ambition scenario as a benchmark for assessing progress in rolling out electric cars. To the extent that electric car roll-out were not to be consistent with this scenario, this would raise a question whether sufficient progress were being made developing the electric car option, whether remedial action were required, or whether there is an alternative strategy for reducing transport emissions through the 2020s.

10 Arup (2008), *Investigation into the Scope for the Transport sector to Switch to Electric and Plug-in Hybrid Vehicles*.

Figure 6.23 Combined annual sales of electric and plug-in hybrid cars as a proportion of new car sales under different scenarios



Source: CCC 2008; Arup/Cenex (2008), *Investigation into the scope for transport sector to switch to electric and plug-in hybrid vehicles.* AEA (2009), *Market outlook to 2022 for battery electric vehicles and plug-in hybrid electric vehicles.*

Our general approach to indicators is to look at high level indicators and drivers of these indicators. This approach is relevant in the case of electric car penetration. Our analysis has suggested that electric car roll-out will be driven both by pilot projects and cost reductions.

- **Pilot projects**: the focus of our monitoring in the near term will be on development of the pilot projects which will be key to unlocking the Extended Ambition scenario.
- **Cost reductions:** further out in time as electric car penetration increases, we will consider whether costs have fallen in line with the AEA learning scenarios upon which the roll-out scenario is predicated. To the extent that cost reductions diverge from the AEA learning scenarios, this would require a reconsideration of the appropriate path for roll-out.

4. Emissions reduction from changing transport consumer behaviour

In our December report we considered high level evidence on scope for emissions reductions through a range of options for changing transport consumer behaviour including using price levers, providing better information on transport choices, encouraging eco-driving and limiting speed. We now return to these options. We discuss the use of price levers in the specific context of road pricing. We revisit our estimates of what may be achievable through implementation of Smarter Choices based on the Sustainable Travel Town data. We recap our recommendations on eco-driving and assess the role of technology in supporting enforcement of the speed limit.

We consider in turn:

(i) Using prices to manage transport demand

(ii) Smarter Choices and Sustainable Travel Towns

(iii) Eco-driving indicators

(iv) Enforcing the speed limit.

(i) Using prices to manage transport demand

The December report reviewed the evidence on transport demand responsiveness to changes in price and concluded that this provides scope for emissions reductions in two ways:

- The demand for car travel is responsive to fuel prices, with lower demand at higher prices as consumers adjust trips made, trip distances and mode of travel.
- Demand for more fuel efficient cars is also responsive to the fuel price, with consumers purchasing more efficient cars as the fuel price is higher.

Given that fuel duty is a key component of fuel prices, we concluded that fuel duty is a potentially important lever in reducing emissions. This is borne out in the recent fuel duty increase announced in Budget 2009, which Government projections suggest should result in an annual emissions reduction of 2 $MtCO_2$ (Box 6.12).

Box 6.12 Budget 2009 fuel duty increase and expected impact

Fuel duty in the UK at Budget 2009 was £0.54 per litre of petrol and diesel and accounted for around 50% of petrol and diesel prices. On 22 April the Chancellor of the Exchequer announced that fuel duty would increase by 2 pence per litre on 1 September 2009, and by 1 penny per litre in real terms each year from 2010 to 2013. This represents a 6p increase by 2013, bringing total fuel duty to £0.60 per litre. The Treasury estimated that this would save 2 $MtCO_2$ per year by 2013-14.

Whilst debates about possibly increasing fuel duty further remain very controversial, this should not be ruled out as an option for triggering a short term response to meet carbon budgets should emissions reductions fall short in other sectors or should there be a significant drop in the oil price. From a purely economic perspective, however, there is a stronger case now for introducing road pricing rather than increasing fuel duty given the large market failures associated with current and projected levels of road congestion.

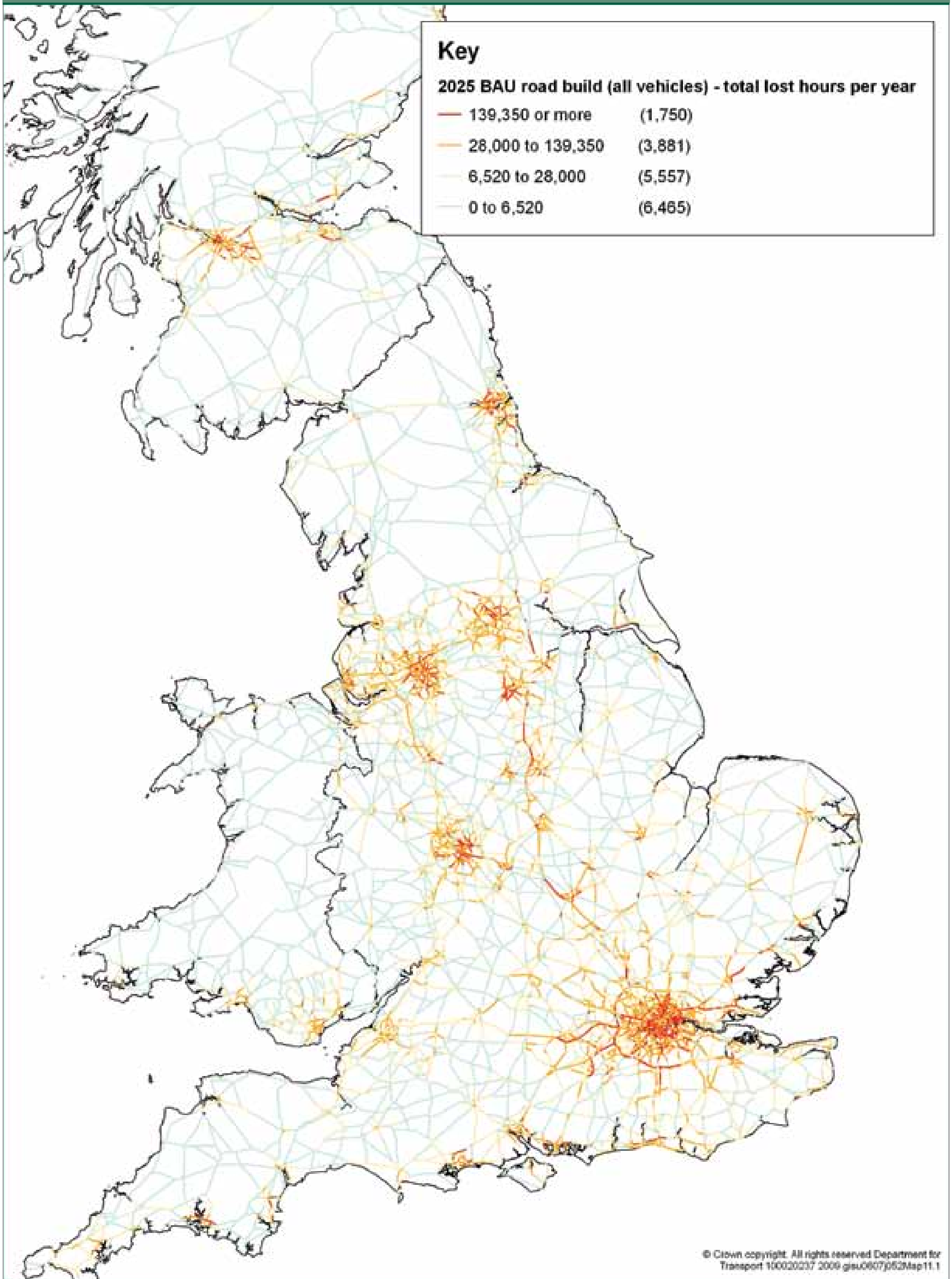
Road pricing impacts on emissions

In the absence of road pricing across almost all the UK road network, high levels of transport demand have resulted in congestion, which is forecast to worsen significantly in future (Figure 6.24). Road users consider only the private cost of travel, and not the impact that they will have on other road users in terms of exacerbating congestion. In not accounting for the costs that they impose on others, road users therefore overuse roads. This is a market failure which standard microeconomic theory would suggest should be addressed through introduction of prices that reflect congestion costs.

The economic benefit of road pricing would mainly ensue through lower levels of congestion resulting in travel time savings. In addition, however, road pricing could result in emissions reductions both through reducing demand for car travel and through increasing car speed to levels where fuel consumption is more efficient.

In political debates, it is sometimes argued that if road pricing were to be introduced this would have to be offset by a reduction in fuel duty. From a carbon perspective, however, this would result in increased emissions (i.e. fuel consumption and emissions are potentially more responsive to fuel duty than to road pricing). From an emissions perspective, therefore, road pricing should be introduced as a complement to fuel duty rather than a substitute. This conclusion is buttressed by the fact that fuel duty plays a crucial role in providing incentives for purchase of electric cars, increasing electric car cost savings relative to conventional cars and offsetting upfront cost premiums.

Figure 6.24 Map of projected congestion on roads in Great Britain in 2025



Source: DfT (2006), *The Eddington Transport Study*.
Note: Business As Usual (BAU) road build refers to road-building equivalent to an additional 3,500 Highways Agency lane kilometres by 2025, representing a continuation of current spending levels.

Where road pricing is additional to fuel duty, evidence suggests that this could result in significant emissions reductions:

- Modelling by the Department for Transport for the Committee on Climate Change suggests that a national road pricing system could reduce annual CO_2 emissions by around 5% in 2020.
- Analysis by the RAC Foundation on the effects of road pricing on carbon emissions in 2040 suggests that an efficient national road pricing system would reduce annual CO_2 emissions by around 15% in that year.

It is beyond the scope of the Committee to recommend that road pricing should be introduced given the political judgements involved. The analysis suggests, however, that road pricing could be a useful component of a strategy for transport emissions reduction, and the Committee recommends that this should be seriously considered by the Government. Recognising this, we include an additional 5.6 $MtCO_2$ reduction in 2020 corresponding to roll-out of a national road pricing scheme in our Stretch Ambition scenario.

(ii) Smarter Choices and Sustainable Travel Town data

Smarter Choices refers to a range of measures promoting voluntary reductions in levels of car use, achieved either through the elimination of unnecessary trips, or through modal shift to public transport, walking and cycling.

Such measures were first implemented in the UK in the 1990s, and include:

- Travel plans (workplace and school travel plans)
- Travel awareness promotion (personalised travel planning, public transport information and marketing and travel awareness campaigns)
- Information Technology (teleworking, teleconferencing and home shopping)
- Car clubs and car sharing schemes.

In our December report we accepted estimates of emissions reductions through Smarter Choices from work commissioned by DfT, including an emissions reduction around 2.9 $MtCO_2$ in 2020 in our Extended Ambition scenario (Box 6.13).

Box 6.13 Alternative estimates of emissions reduction potential of Smarter Choices

Estimates of the emissions reduction potential of Smarter Choices vary considerably. In addition to the 2.9 $MtCO_2$ estimate presented in the December report, the Commission for Integrated Transport (CfIT) estimate a reduction of around 3.7Mt while the Department for Transport have significantly revised their estimate downward to 0.94Mt.

CfIT define a scenario in which implementation of Smarter Choices measures results in a total nationwide reduction in car traffic (vehicle km) of 11% in urban areas and 5% in rural areas and on motorways. Using forecast emissions disaggregated by road type (urban, rural and motorway) from the DfT's National Transport Model (NTM), CfIT calculate the reduction in emissions that corresponds to the reduction in car traffic.

DfT define a scenario with a total nationwide reduction in car trips of 7%, and model the implications of this reduction using the NTM. This is accomplished by raising the modelled cost of car travel to produce a 7% decrease in modelled car trips. This results in an overall reduction in car traffic that is lower than the overall reduction in car trips, as the NTM estimates that most of the reduction in car trips is accounted for by trips of shorter than average distance, for each road type (urban, rural and motorway). DfT assume that Smarter Choices policy is likely to be targeted towards urban areas and that the reduction in car traffic occurs only in urban areas. Using the forecast emissions from urban roads only, DfT calculate the reduction in emissions that corresponds to the 3.7% reduction in car traffic that the NTM estimates for urban roads.

We highlighted uncertainty over both what is achievable through Smarter Choices and the extent to which changed travel behaviour and emissions reductions will persist over time.

New evidence on Smarter Choices

We have subsequently undertaken a deeper review of the evidence on Smarter Choices. Data from the Sustainable Travel Towns and from a literature review carried out by the UK Energy Research Centre (UKERC) suggests that Smarter Choices may offer significant emissions reduction potential (Box 6.14):

The consistency of the conclusions in this evidence suggests that we can be more confident that there is a significant potential emissions reduction from Smarter Choices, if not necessarily in its exact magnitude.

Box 6.14 Evidence on Smarter Choices

Evidence from the Sustainable Travel Towns

The DfT has funded three Sustainable Travel Towns in Peterborough, Darlington and Worcester to assess the results of the intensive implementation of packages of Smarter Choices measures in one locality. The three towns are sharing £10 million of DfT funding over the five years of the project 2004/05 – 2008/09.

The implementation packages comprised the following measures:

- Travel plans (workplace and school travel plans)
- Travel awareness promotion (personalised travel planning, public transport information and marketing and travel awareness campaigns)
- Car clubs.

Car sharing outside the context of workplace travel plans and Information Technology measures were not included. Uptake of complementary traffic restraint measures to 'lock in' the reduction in traffic was relatively limited.

The project was conducted in the context of a national increase in traffic of 1.1% on all urban roads between 2004 and 2007 (a 1.8% decrease in traffic on major urban roads more than offset by a 3.2% increase in traffic on minor urban roads).

Emerging evidence on the effects of implementation comes from two sources:

- The results of household travel surveys conducted between 2004 and 2008
- National Road Traffic Estimates manual and automatic counts.

The results of the household travel surveys suggest that over the study period the number of car driver trips per person declined by 9% in Darlington and Peterborough, and by 7% in Worcester. Data on car mileage was not collected so it is not clear to what extent the reduction in car driver trips translates into a reduction in car mileage.

Other evidence on Smarter Choices measures

A UKERC literature review outlines further evidence of the effectiveness of Smarter Choices measures:

- An evaluation of UK case studies on the effectiveness of personalised travel planning suggests that this can reduce car driver trips by 11% and distance travelled by car by 12%.
- A trial of individualised marketing in South Perth, Western Australia in 1997 suggests that car driver trips were reduced by 10% and mileage by 14%.

Data from case studies in the UK (including from British Telecom), the US and the Netherlands on individual workplace travel plans suggest that this can reduce car driver trips for commuting purposes by between 10% and 30%.

Source: Sloman, Cairns, Newson, Anable, Pridmore and Goodwin (2009 forthcoming), *Draft results from Smarter Choices Follow-On Study.* May be revised before publication.
UK Energy Research Centre (2009), *What Policies are Effective at Reducing Carbon Emissions from Surface Passenger Transport?*

Network management and locking in benefits

We noted in our December report that there is a question as to whether changed travel behaviour through Smarter Choices will persist over time. This question remains as the Sustainable Travel Town data do not cover a long enough period to make inferences about locking in of benefits.

We argued in our December report that network management measures (e.g. bus lanes, parking controls) could be important in 'locking in' emission reductions, through encouraging persistence of changed behaviour and preventing additional traffic in response to improved travel conditions for cars as more people use public transport.

New evidence considered by the Committee relating to the effects of road space reallocation and road infrastructure provision suggests that network management measures are potentially very strong levers which could both lock in and leverage benefits from implementation of Smarter Choices (Box 6.15):

Box 6.15 Evidence on effects of network management

There is considerable evidence that network management measures that reallocate road space away from private car use can result in lower traffic levels without exacerbating congestion or loss of economic vitality.

For example, the Cambridge Core Traffic Scheme was implemented between 1997 and 1999 to reduce the negative impacts of traffic. The Scheme involved the removal of through traffic via closure of the main through routes to the City centre. A reduction in overall traffic levels of 8.4% has been observed over the period 1996-2000.

Similarly, the Oxford Integrated Transport Strategy was implemented to reduce problems of traffic congestion and pollution and improve conditions for pedestrians and cyclists. This involved the full pedestrianisation in 1999 of the most important shopping streets, and exclusion of traffic from other important streets during the day. In addition, bus priority routes and central area parking restrictions were introduced. A reduction in traffic levels of 17% was observed in the city centre over the period 1998-2000.

It should be noted that these results refer to traffic within the city centre and not to total traffic within the city as a whole.

The notion that road capacity influences traffic volumes is widely accepted, and has been recognised by the UK Government since publication in 1994 of the report Trunk Roads and the Generation of Traffic (SACTRA, 1994), which discussed the phenomenon of 'induced traffic' (i.e. additional traffic generated by an increase in road capacity). Evidence on the size and significance of this effect is limited at present but a recent study highlights some features. The effects on traffic of completion of the M60 Manchester Motorway Box, a major highway scheme that generated significant induced traffic, were studied through traffic observations and before and after surveys (roadside interviews, public transport intercept surveys and a household interview survey).

The research evidence collected allowed the effects of the scheme on choices of travel frequency, travel time, mode and destination to be estimated. The results suggested that the greatest proportion of the induced traffic (70% for commuter traffic and 76% for other traffic) was generated through selection of new journey destinations facilitated by the scheme, with the remaining proportion generated through modal shift. Given that such effects arise when highway capacity is increased, it seems plausible that similar effects lie behind the reduction in car traffic observed following implementation of network management measures such as those described above.

Source: Cairns, Atkins and Goodwin (2002), *Disappearing Traffic*; RAND Europe (2009).

Areas for increased focus in Smarter Choices

Data from the Sustainable Travel Towns includes some emissions reductions through changing behaviour around commuting journeys. New evidence from DfT, however, suggests that longer commuting journeys (journeys over 8km) account for around 22% of total car emissions (see Figure 6.20 in Section 3 above). In light of this evidence, there may be more emissions reduction potential from more specific targeting of long commuting journeys than was envisaged at the time that the Sustainable Travel Town pilots were designed. Increased focus on work journey planning, for example through local authorities working with employers and commuters to encourage car pooling, could therefore offer emissions reductions over and above what has been achieved in the Sustainable Travel Towns.

The estimates also exclude potential emissions impacts through teleworking, teleconferencing and home shopping which could in principle be incorporated into a Smarter Choices programme:

- These measures can reduce travel demand and therefore reduce emissions.
- Emissions reductions may be offset, however, as telecommuting employees choose to live further from work, or where time saved through home shopping or reduced commuting is used for other travel.

The available evidence on these measures suggests that there may be considerable opportunities to replace car travel with teleworking, teleconferencing and home shopping. The evidence is, however, incomplete, and scope for emissions reductions is currently highly uncertain. These measures might therefore usefully be trialled in further roll-out of Smarter Choices, with a working assumption that these may reduce emissions, but without banking this as a firm contribution towards meeting carbon budgets in advance.

Recommendations, revised scenarios and indicators

In summary, new evidence supports our earlier assumption that there is a significant potential emissions reduction available from Smarter Choices. Given this evidence, it is the view of the Committee that Smarter Choices should now be scaled up.

The UK and Scottish Governments have recently announced positive steps in rolling out Smarter Choices:

- In May 2009 the UK Government announced funding of £29 million over a three year period to support a Sustainable Travel City project.
- In March 2008, the Scottish Government announced the Smarter Choices, Smarter Places initiative. This provides funding for a number of Local Authorities to implement Smarter Choices measures over a two year period, with funding agreed for seven projects to date.

The Committee welcomes these initiatives, but believes that these should be complemented through scaling up implementation of Smarter Choices through:

- Phased roll-out of Smarter Choices to other towns that are comparable to the Sustainable Travel Towns, and a plan to roll out to other cities following the city pilot.
- A demonstration project in rural areas.
- Incorporation of measures to encourage emissions reduction from longer commuting journeys.
- Introduction of complementary network measures alongside Smarter Choices measures.
- Ongoing evaluation of Smarter Choices implementation to inform design for roll-out.

Given the significant potential but also significant uncertainties, we continue to include a 2.9 $MtCO_2$ emissions reduction for Smarter Choices in our Extended ambition scenario (Box 6.16).

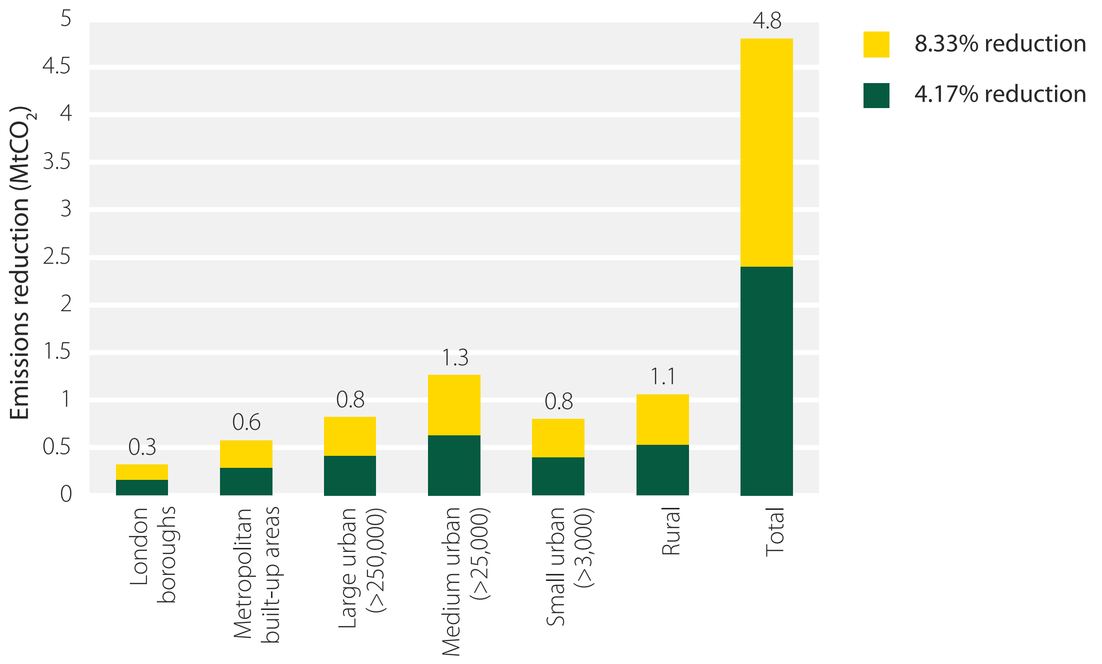
Box 6.16 Emissions reduction potential from Smarter Choices

The Sustainable Travel Towns evidence suggests that implementation of Smarter Choices reduced the number of car driver trips per person by 9% in Darlington and Peterborough, and by 7% in Worcester, or an average of 8.33% overall (Box 6.14). Evidence on the reduction in car mileage is not yet available, and in any case the Sustainable Travel Towns project does not include measures to target a reduction in longer distance trips.

In the absence of conclusive evidence on these effects we have examined the implications of both a reduction in car mileage that is equal to the reduction in car trips (i.e. 8.33%) and a reduction in mileage that is half as great as the reduction in car trips (i.e. 4.17%); the latter assumption is consistent with the DfT approach outlined in Box 6.13.

The figure below shows possible CO_2 emissions reductions for roll out of Smarter Choices in different types of settlements, totalling up to 2.4-4.8 $MtCO_2$.

Figure B6.16 Implications of reduction in total mileage from trips originating in different sizes of settlement



Source: CCC analysis.

In monitoring implementation of Smarter Choices, we note that emissions reductions ensue through reduced car emissions which in turn require reduced car miles. We will therefore track car miles to assess the extent to which these fall from trend as a result of demand-side measures (Figure 6.25).

(iii) Eco-driving indicators

In our December report we set out analysis showing that fuel efficiency can be significantly improved by adopting a smoother style of driving, with less aggressive use of accelerator and brake, even without reducing average or maximum speeds. We reviewed the evidence which suggests that adoption of these eco-driving techniques can improve average fuel efficiency by 5-10%.

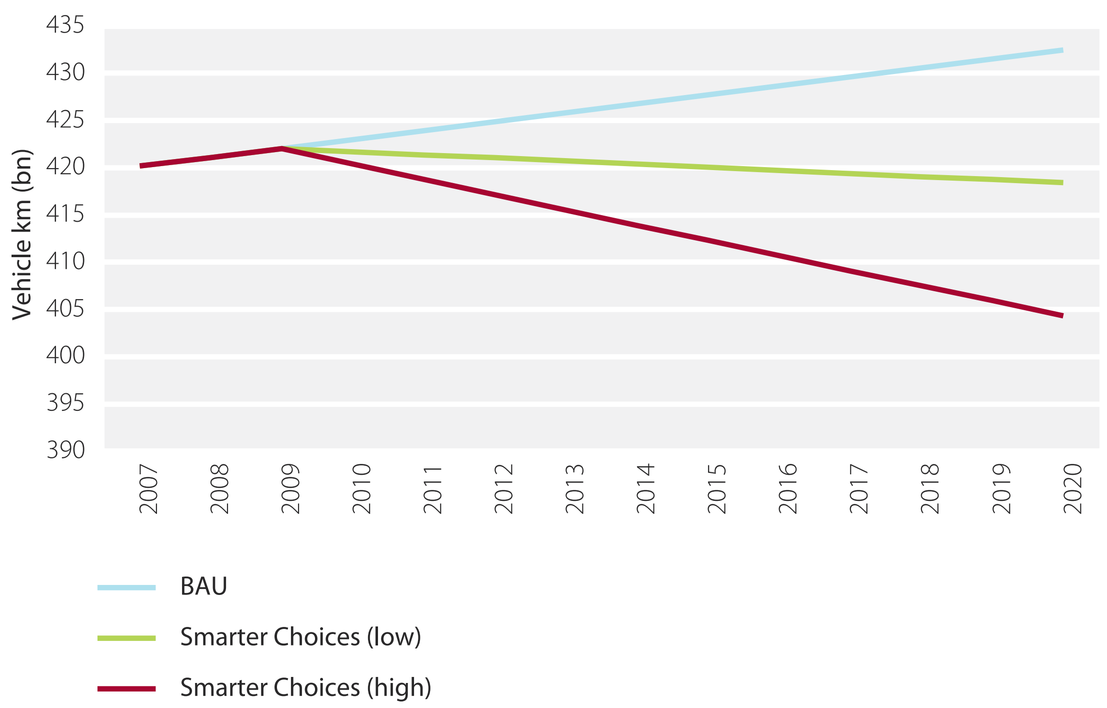
We reviewed survey evidence suggesting that a significant proportion of the population are willing to adopt eco-driving techniques in order to reduce fuel bills, and that there are various means in place for eco-driver training (e.g. through driving tests, measures aimed at the freight sector, etc.).

Under an assumption that up to 1% of all drivers are trained to eco-drive annually (which would require the roll-out of an ambitious, government-funded training programme), and that this results in a 3% reduction in fuel consumption, we estimated that emissions reduction of 0.3 $MtCO_2$ would be achievable in 2020. We also estimated that 1.0 $MtCO_2$ would be achievable given wider uptake (with 40% of car drivers adopting eco-driving behaviour by 2020).

DfT is currently funding the Smarter Driving programme, in which eco-driving training is delivered by the Energy Saving Trust (EST). The EST forecasts, however, that only 21,000 drivers will be trained in 2009-10. This is significantly less than the 350,000 drivers implied by our assumption that 1% of all drivers are trained annually, and it is not clear how the EST delivery mechanism could be sufficiently scaled up.

An alternative would be to target new drivers. From 10 September 2008, the UK driving test has included questions about eco-driving in the

Figure 6.25 Trend car mileage and potential reductions through demand-side measures



Source: DfT Projections; CCC.

theory part of the driving test. Whilst useful, the Committee believes that better training could be achieved through including eco-driving in the practical test, and proposes that this should be seriously considered. Effective testing of eco-driving as part of the driving test could have a significant impact given that 900,000 new driving licenses are awarded annually.

Given that driver training will be key in supporting uptake of eco-driving, however, we include this as the relevant variable in our wider set of transport indicators. In particular, we will monitor the number of drivers trained through (i) specific programmes (ii) driving tests.

At a higher level, we will also track emissions to assess whether there is any evidence of eco-driving (e.g. through emissions reductions over and above what would be expected due to reductions in the carbon intensity of cars – see Figure 6.26).

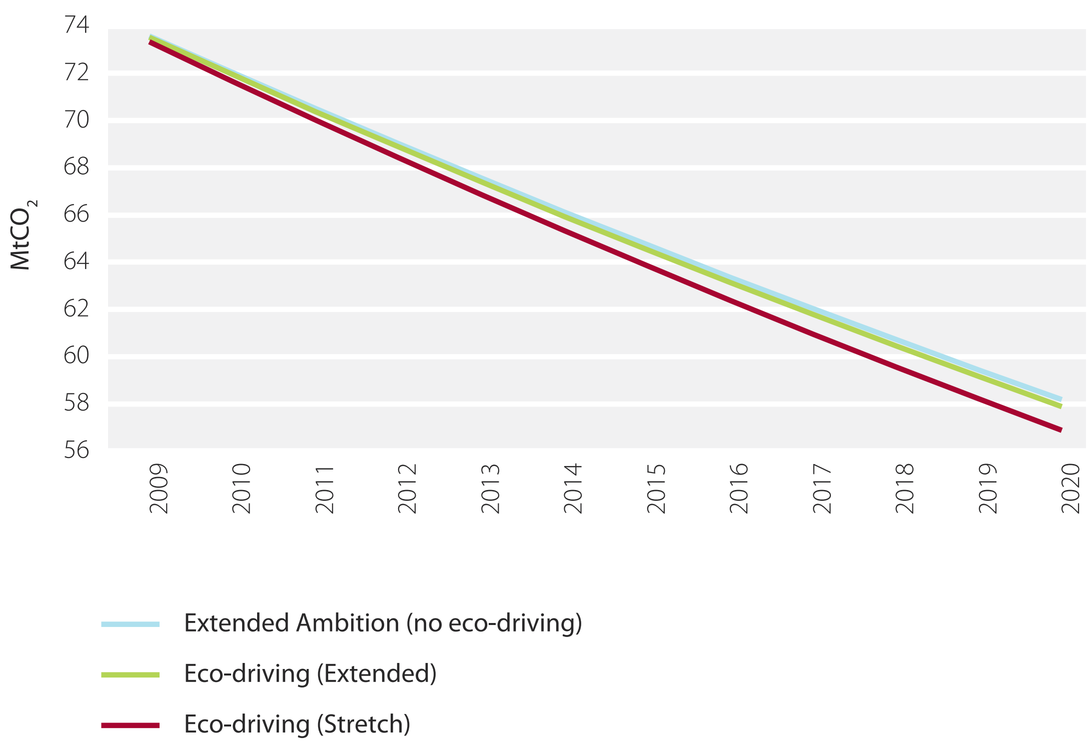
(iv) Enforcing the speed limit

We previously set out analysis showing that fuel efficiency falls significantly as vehicle speeds are pushed above optimal levels. A petrol car driven at 70 mph, for example, emits around 20% more CO_2 per km than when driven at 50 mph. A significant proportion of drivers currently exceed the speed limit on motorways and dual carriageways (Figure 6.27). This provides an opportunity for reducing emissions through limiting speed.

We estimate that there is a potential emissions reduction of 1.4 $MtCO_2$ through enforcing the existing 70 mph limit on motorways and dual carriageways, with an additional 1.5 $MtCO_2$ saving through reduction of the speed limit to 60mph (a total saving of 2.9 $MtCO_2$).

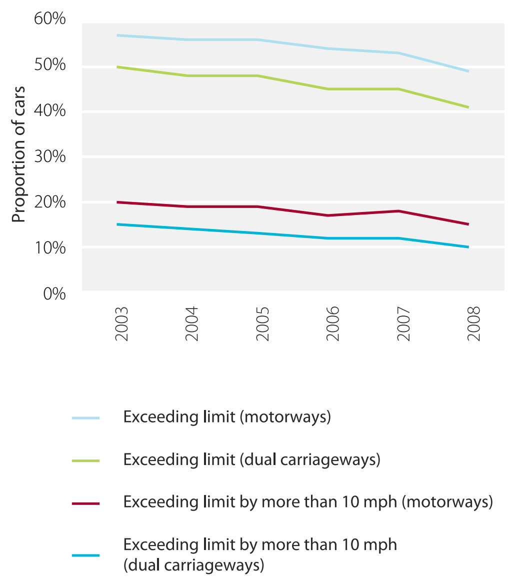
There are at least two means for enforcing the existing speed limit:

Figure 6.26 Emissions from cars in the Extended Ambition scenario with and without eco-driving



Source: DfT Projections; CCC.

Figure 6.27 Proportion of cars exceeding the speed limit on motorways and dual carriageways



Source: DfT (2009), *Road Statistics 2008: Traffic, Speeds and Congestion*; Table 4.2.

- Greater use of speed cameras or average speed controls
- Use of intelligent Speed Adaptation (ISA) technology.

Intelligent Speed Adaptation (ISA) is a system that provides a vehicle driver with information on the speed limit for the road on which the vehicle is being driven. The technology involved is similar to that for satellite navigation systems and is available in three forms:

- Advisory ISA, which displays the speed limit and warns the driver if the vehicle is being driven above the speed limit.
- Voluntary (overridable) ISA, which is as advisory ISA but is linked to the vehicle's engine management system to limit vehicle speed to the speed limit; can be overridden by the driver.
- Mandatory (non-overridable) ISA, which is as voluntary ISA but cannot be overridden by the driver.

Given that the 70 mph speed limit is an existing policy, the Committee believes that the Government should seriously consider enforcing this, either through the current enforcement mechanism, or through rolling out ISA technology to both new and existing cars.

We reflect enforcement of the 70 mph limit by including emissions reductions of 1.4 $MtCO_2$ in 2020 in our Extended Ambition scenario. We continue to include an additional emissions reduction from reducing the 70 mph speed limit to 60 mph in our Stretch Ambition scenario. We estimate an additional saving of 1.5 $MtCO_2$, which could be considered as an option if there were a shortfall in meeting budgets.

The Committee will therefore assess the extent of enforcement using DfT data to understand whether and how much current levels of speeding are reduced.

5. Integrated land use and transport planning

Evidence on land use and transport demand

In our December report we referred to the literature on the relationship between land use and emissions, and committed to consider this area in more detail. We noted that energy consumption for passenger transport varies according to the proportion of journeys made by different transport modes. We argued that new construction presents an opportunity to build from the start a pattern of transport activity associated with shorter journeys and less emitting modes.

We have now reviewed the evidence on land use and transport demand in more detail. There are various complexities and uncertainties which make it extremely difficult to quantify the potential scale of impacts, but the evidence bears out our hypothesis that land use planning will have potentially significant implications for transport emissions (Box 6.17):

Box 6.17: Effects of land use factors on the demand for car travel

A study using multiple regression to determine effects on car ownership and mode choice on land use characteristics based on data from the UK National Travel Survey collected in 1989/91 and 1999/2001 identified the following factors:

- Density: municipalities of population density greater than 40 persons/ha are associated with a 10% decrease in the share of distance travelled by car compared with municipalities of population density of 1-15 persons/ha.
- Size: London is associated with an 11% decrease in the share of distance travelled by car compared with municipalities with a population of 3,000-100,000. While this study does not identify a similar effect of settlement size for other municipalities of population greater than 100,000, it is likely that where towns are well connected to each other, larger towns are associated with lower levels of car travel.
- Bus frequency: areas with buses serving every quarter of an hour are associated with a 4% decrease in the share of distance travelled by car compared with areas with buses serving half hourly, and a 13% decrease compared with areas with less than one bus per hour.
- Walking distance to bus stop: areas over 13 minutes' walking distance to the nearest bus stop area are associated with a 9% increase in the share of distance travelled by car compared with areas 7-13 minutes to nearest bus stop.
- Walking distance to amenities: areas a 'short walk' to amenities are associated with a 6% decrease in the share of distance travelled by car compared with areas a 'medium walk' to amenities, and an 11% decrease compared with areas a 'long walk' to amenities.

Source: Dargay (2009). *Land Use and Mobility in Britain.*

Application to new residential development

This evidence has potentially important implications in the UK context given the ambitious programme of new housing development in the period to 2030:

- CLG projects that the number of UK households will increase from the current level of 21.5 million to around 27.8 million in 2030 (i.e. there will be an increase of 6.3 million households).
- The accommodate this growth, the Government has set a target to add two million new dwellings by 2016 and three million new dwellings by 2020.

It is difficult to provide precise estimates of the impact of new development on transport emissions, but we can be clear that – depending on how new developments are planned – these could be significant.

- In the absence of land use designations and other planning policy restrictions, a 'market' approach to the provision of new housing could result in patterns of development associated with very high levels of car travel and associated emissions.
- Planning and transport policy focusing new development within existing cities and large towns could therefore result in significant emissions reductions.
- We estimate that such a land use framework could deliver an emissions reduction of at least 2 $MtCO_2$ in 2020 and 3.6$MtCO_2$ in 2030 (Box 6.18).

This can be compared to the additional 0.7 $MtCO_2$[11] saving Government estimates the Zero Carbon Homes initiative would deliver on top of other policy measures in the residential sector in 2020. This suggests that transport emissions should be given at least as much consideration as residential emissions in the design of new development.

11 10.4Mt non-traded and 0.3Mt traded.

Box 6.18 Estimate of emissions reduction potential from land use policy

If three million new homes were to be located far from workplaces, this could result in significantly increased transport emissions. We have constructed an example to illustrate the possible order of magnitude of this impact. The table below shows emissions from commuting trips where different proportions of the population living in new houses commute between 10 and 25 miles to work. If one person from each of three million households were to commute this distance on a daily basis, the table shows that this could increase transport emissions by around 4.7 $MtCO_2$.

More detailed analysis of possible impacts from new housing development on transport emissions has been undertaken as part of the Sustainability Of Land Use and Transport In Outer Neighbourhoods (SOLUTIONS) project funded by the Engineering and Physical Research Council (EPSRC) (www.suburbansolutions.ac.uk), formed to examine factors relating to economic, social and environmental performance in planning towns and cities.

The SOLUTIONS project involved modelling the effects of concentrating future development in both the Wider South East (WSE), 50 miles around London, and the Tyne and Wear City Region (TWCR) in each of three spatial configurations:

- Compaction (concentrating development within existing settlements; public transport investment)
- Planned expansion (concentrating development at edge of settlements, within transport corridors, or in new settlements; highway and public transport investment)
- Market dispersal (allowing development with no land use zoning restrictions; highway investment).

The modelling suggests that the three spatial configurations would have the following effects on total car km in 2031, compared to 'trend' (development according to existing land use policy).

- Compaction: 3% reduction in the Wider South East and a 2% reduction in the Tyne and Wear City Region
- Planned expansion: neutral
- Market dispersal: 4% increase in the Wider South East and a 1.5% increase in the Tyne and Wear City Region.

These results reflect the change in car travel demand arising from all development (i.e. both existing and new development). The table below sets out the implications of these results for the effects of spatial configuration on car travel demand in new development only.

Table B6.18a the potential effect of longer car commuter trips from new dwellings by 2020

Proportion commuting 10-25 miles	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Total car commuter CO_2 (Mt)	1.3	1.7	2.1	2.4	2.8	3.2	3.6	3.9	4.3	4.7

Table B6.18b Effects of spatial configuration on car travel demand

	Increase in dwellings	Total car km change over trend		Effect of compaction over	
		Compaction	Market	Trend	Market
WSE	25%	-3%	4%	-12%	28%
TWCR	15%	-2%	2%	-15%	26%

Source: EPSRC (2009).

Box 6.18 continued

The total increase in dwellings over the period 2000-2031 is 25.4% in the Wider South East and 15% in the Tyne and Wear City Region. The modelled effects of the compaction and market configurations on total car travel (arising from both existing and new development) imply that in new development, compaction is associated with a 12-15% reduction in car travel compared with 'trend' and a 26-28% reduction compared with market dispersal.

The Government target of 3 million new dwellings in England by 2020 represents a 13.5% increase in the housing stock, implying that planning policy for new development has the potential to address an equal proportion of car km. Under the assumption that compaction could reduce total car travel by 26-28% of this 13.5% (around 3.6%), our projected car emissions of around 60MtCO_2 could be reduced by around 2MtCO_2.

Redesigning existing cities

Whilst significant, emissions reduction potential from location of new homes in cities and towns is limited by the fact that these only account for a small proportion of the population; 99% of existing homes will still exist in 2020 and these will form around 90% of the housing stock. Even by 2030, existing homes are likely to account for around 80% of the total.

The evidence reported above about settlement size, population density, proximity of homes to shops and work places and public transport suggests that there may be an opportunity to reduce transport emissions by changing land use and public transport infrastructure in existing cities. This is borne out by both national and international city specific evidence, which shows a wide range of car use for cities with different characteristics (Box 6.19).

This raises questions over whether there is scope for changing design of existing urban areas to reduce car use and emissions. Clearly it is not feasible to knock down existing cities and rebuild these to encourage shorter journeys and increased public transport use. There are, however, a number of land use and transport planning levers available in principle that would result in reduced car emissions:

- Planning measures to encourage significant urban regeneration over the next two decades in a manner to support less carbon intense transport choices.
- Planning measures to support shopping developments in towns or cities rather than in out of town locations (Box 6.20).
- Network and pricing measures to improve the cost and convenience of public transport relative to private transport.
- Smarter Choices measures to leverage planning and network measures, providing better information and encouraging travel by public transport.
- Public transport infrastructure investment (e.g. in modern tram systems) to change the relative costs of public versus private transport.
- Transport investment appraisal that fully account for carbon impacts of investment in new transport infrastructure (e.g. roads, high speed rail lines).
- Planning measures addressing any barriers to delivery of infrastructure to support roll-out of electric cars.

As far as the Committee is aware, there is not comprehensive evidence on the emissions impacts and economics of these measures in the UK context. Changing the building stock and enhancing public transport infrastructure, for example, would require significant investment which may or may not be justified given increasing penetration of low-carbon vehicles.

Greater clarity would be desirable given the potentially significant emissions reduction that may be available, and could be provided as part of developing the integrated approach to land use planning and transport.

Box 6.19 International and national city specific evidence

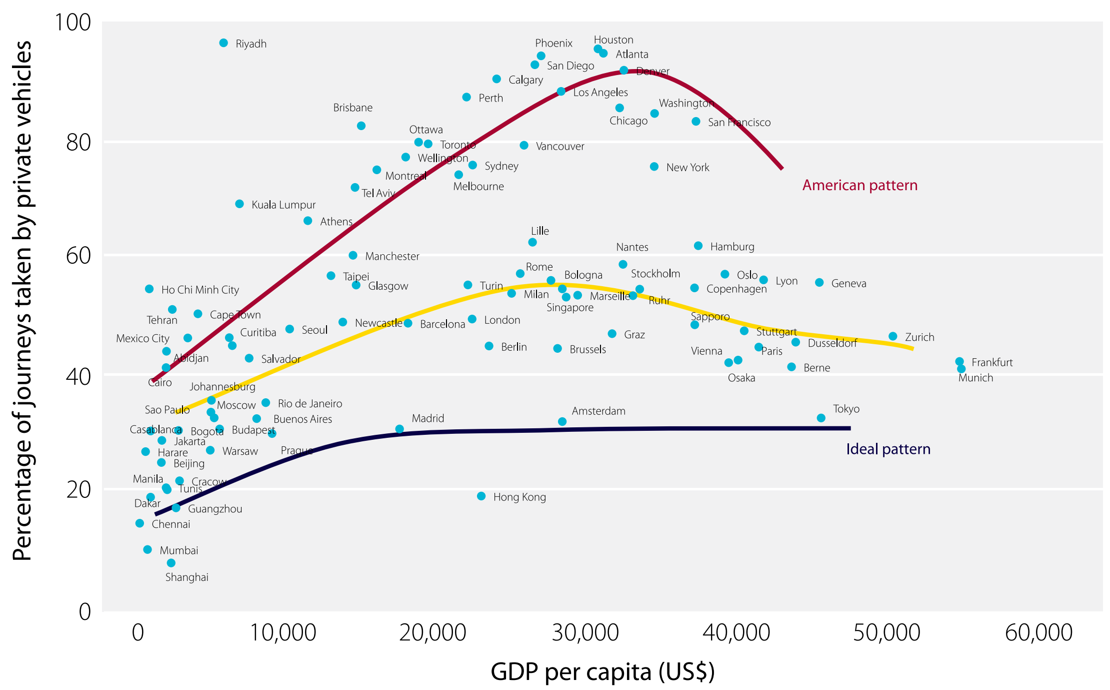
The figure below demonstrates the great variation in levels of private car use in cities across the world. For any given level of prosperity several patterns of car use can be identified.

For example, while the New York tri-state and Tokyo areas possess many similar characteristics, they have significantly different levels of car use, as shown in the table below.

Outside Manhattan, the majority of the urbanised New York tri-state area consists of relatively low-density neighbourhoods in the other New York City boroughs and the surrounding states of New York, Connecticut and New Jersey, and overall levels of car use are far higher than in major European and Asian cities (Figure).

In contrast, Tokyo has one of the lowest levels of car use of the major world cities. While levels of road infrastructure and public transport provision are similar to those in the New York tri-state area, there are also some major differences. First, Tokyo has much higher population density. Second, it has lower levels of parking provision. Third, traffic speeds are lower in Tokyo, so that the average speed of public (rail and metro) transport exceeds that of general road traffic.

Figure B6.19 Use of private and public transport in cities of varying prosperity levels



Source: IEA (2008); International Association of Public Transport (2006).

Box 6.19 continued

Table B6.19 Spatial and transport characteristics of New York tri-state and Tokyo areas

	New York tri-state area	Tokyo
GDP per capita (2008$)	34,000	45,000
Population of urbanised area	19 million	33 million
Proportion of jobs in the Central Business District	21%	14%
Average trip length	12km	11km
Total urbanised area	11,000	4,000
Population density of urbanised area	1,804	8,768
Length of road network per 1,000 residents	4,900	4,000
Average traffic speed	39kph	26kph
Formal parking spaces per 1,000 CBD jobs	66	40
Length of metro system per million residents	93km	92km
Percentage of journeys taken by private vehicles	75%	32%

Source: IEA (2008); IAPT (2006); CfIT (2005); CLG.

While UK cities do not generally demonstrate the same variability in levels of car use as can be observed in the international evidence, there is nevertheless a significant difference between cities with the lowest and highest levels of car use:

- Cambridge (population 109,000) has the lowest level of car use of any UK city outside London, with 41.2% of residents travelling to work by car. It is likely that the Cambridge Core Traffic Scheme (Box 6.13) has contributed to this.
- Other cities with similar populations to Cambridge – Brighton (population 307,000), York (181,000), Hull (244,000), Newcastle (795,000) and Ipswich (117,000) – have higher car use, with 50-60% of residents travelling to work by car.
- At the other extreme, Milton Keynes (population 207,000) has among the highest at 71%. Milton Keynes was developed as a New Town in the 1960s, and designed specifically to accommodate high levels of car use. Population density is very low at around 5.3 people per hectare, and the city road system is laid out in a grid pattern, with roads at the national speed limit.

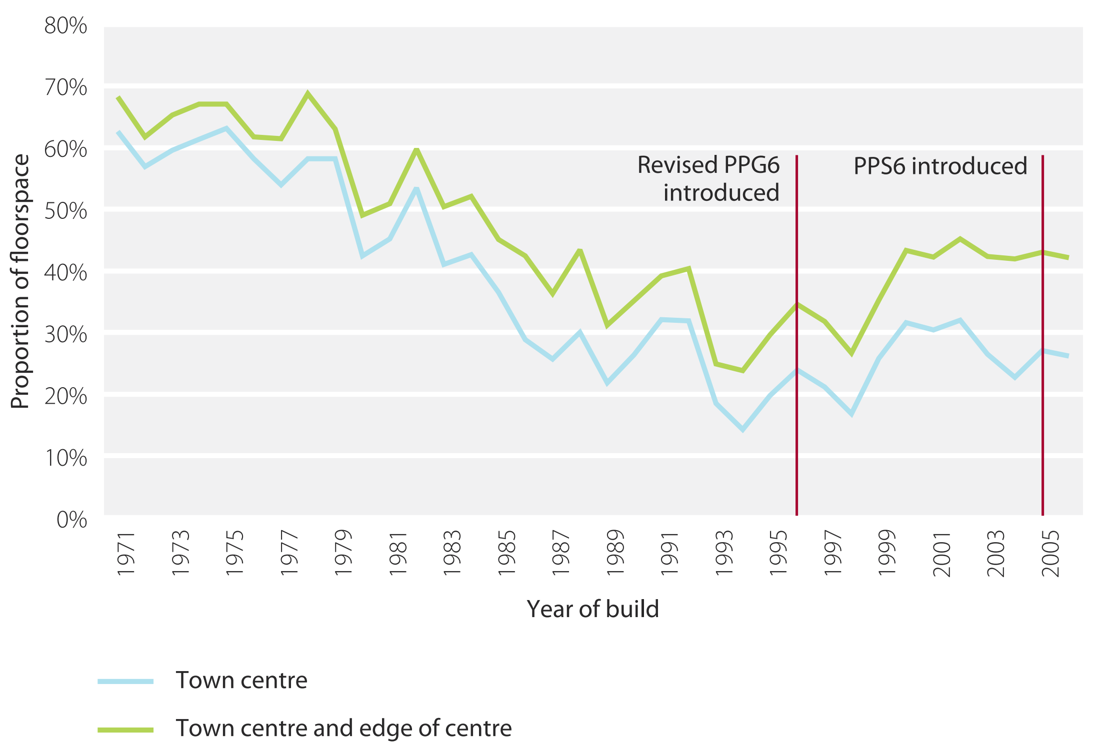
Box 6.20 Government planning policy on out of town retail development

Planning policy since the mid 1980s resulted in the rapid growth of out of town retail development, such that by 1994 only 14% of new retail floorspace was located in town centre locations, and a total of less than 25 per cent in both town centre and edge of centre locations (figure).

This trend has been partially reversed since the introduction of new planning guidance setting out a policy objective of promoting vital and viable town centres through a 'town centre-first' policy (Planning Policy Guidance Note 6: Town Centres and Retail Developments introduced in 1996, replaced by Planning Policy Statement 6 in March 2005). By 2006 the proportion of new retail development located in town centre and edge of centre locations had risen to 42%, with 78% of new of shopping centres located within the town centre, and 85% at edge of centre.

However, significant new retail development continues to be located out of town and in edge-of-centre locations, in particular supermarkets (23% within the town centre, 50% at edge of centre), and retail warehouses (7% within the town centre, 50% at edge of centre).

Figure B6.20 Proportion of new build retail floorspace in town centres 1971-2006



Source: CLG; Valuation Office Agency.

An integrated approach to land use planning and transport

It is not clear that incentives under current land use and transport planning systems attach sufficient weight to transport emissions. At a high level, much planning guidance acknowledges that it may be desirable to constrain transport emissions. In practice, however, there is sufficient flexibility such that other factors may take priority over transport emissions. There is a risk, therefore, that development of both existing and new areas does not unlock emissions reductions, and that the design of new transport schemes pays insufficient attention to their implications for emissions and land use (Box 6.21).

The Committee's view is that a new approach to planning that fully accounts for transport emissions should be developed:

- Barriers to urban development should be addressed.
- Planning decisions should incorporate consideration of all transport emissions (e.g. commuting, leisure and shopping trips within developments and between developments and other areas).
- Transport policies should be designed to reinforce this planning approach (e.g. through network measures, Smarter Choices to address commuting journeys, etc.).
- Possible investment in public transport infrastructure should be further considered.

The first step in developing this approach is to develop an integrated planning and transport strategy. The Committee believes that such a strategy should be developed as a priority in order to inform planning decisions around the ambitious home building programme over the coming years and to allow unlocking of emissions reduction potential in a timely manner.

Box 6.21 Campaign for Better Transport assessment of regional priorities under Regional Funding Advice

It is widely accepted that the influence of pure land use policy on decreasing the demand for car travel depends strongly on the degree to which broader transport measures are aligned with this objective. Investment in public transport services and walking and cycling provision, which increase the relative attractiveness of these modes, would strengthen the effectiveness of land use policy in reducing car travel. Equally, highway investment to increase capacity for private vehicles, which increases the relative attractiveness of car travel, would weaken the effectiveness of land use policy in reducing car travel.

A review of transport scheme funding priorities of the English regions undertaken by the Campaign for Better Transport suggests that highway schemes tend to be prioritised over public transport schemes, even when the latter are shown to be both more compatible with national and regional policy objectives, and more cost-effective.

The Campaign for Better Transport's review of the Regional Funding Advice (a process through which regions advise the Government on their long-term investment priorities in transport, housing and other areas) highlights the following concerns:

- Schemes are prioritised which conflict with national and regional environmental and transport policy objectives.
- Schemes are prioritised despite having no assessment, or inadequate assessment, of their carbon impacts despite the instruction to do so in the Regional Funding Advice guidance. While most regions failed to compare the greenhouse gas emissions of individual options, some incorrectly treated schemes where carbon impacts were not assessed as carbon neutral, thus penalising those schemes where such information was provided.
- Schemes which are considered to carry risks to deliverability on time and to budget are prioritised over alternative public transport options which are considered to be more readily deliverable.
- In many cases there did not appear to be a systematic consideration of the full range of possible alternatives that could be taken forward as the solution to the transport problem, such that public transport options that might have delivered better solutions were not considered. Independent analysis frequently confirmed that alternative options performed better and were more cost effective than the proposed scheme.

The dominance of highway schemes in transport investment suggests that planning policy and practice for transport and land use may not be sufficiently integrated to deliver real reductions in the demand for car travel.

Source: Campaign for Better Transport (2009).

6. Summary of transport indicators

Our indicators of progress in reducing transport emissions (Table 6.3) include the following categories:

- Transport sector emissions and emissions intensities;
- Indicators relating to the measures that have to be implemented (e.g. penetration of biofuels, penetration of electric cars, etc.);
- Policy milestones required to be met for appropriate enabling frameworks to be in place (e.g. development of large scale EV pilots, roll-out of Smarter Choices, etc.).

Table 3.4 Transport indicators

Road Transport		Budget 1	Budget 2	Budget 3
Headline indicators				
Direct emissions (% change on 2007)	Total	-11%	-19%	-29%
	Car	-17%	-24%	-37%
	Van	11%	16%	14%
	HGV	-13%	-16%	-19%
gCO_2/km (carbon intensity of a vehicle kilometre)	Car	152	132	104
	Van	247	226	196
	HGV	743	687	639
Vehicle-km billions	Car	421	419	420
Supporting indicators				
Vehicle technology				
New vehicle gCO_2/km	Car	142	110	95 (by 2020)
New electric cars registered each year (value at end of Budget period)		11,000	230,000	550,000
Stock of electric cars in vehicle fleet		22,000	640,000 (240,000 delivered through pilot projects in 2015)	2.6 million (1.7 million by 2020)
Biofuels				
Penetration of biofuels (by volume)		4.5%	7.9%	10.0%
Decision on whether future biofuels target can be met sustainably		2011/12		

Table 3.4 continued

Road Transport	Budget 1	Budget 2	Budget 3
Demand side measures			
Proportion of drivers exceeding 70mph		0%*	0%
Car drivers who have undergone eco driving training	1,050,000	2,800,000	4,550,000
Smarter Choices – demonstration in a city and development plan for roll out if successful, demonstration in rural areas and demonstration targeting longer journeys	2010		
Smarter Choices – phased roll out to towns	2010		Complete
Development of integrated planning and transport strategy	2011		
Other drivers			
*Fuel pump prices, Fuel duty, Proportion of new car sales that are 'best in class', Proportion of small/medium/large cars, Van and HGV km (vehicle/tonne)**, Petrol/diesel consumption, Surface transport modal split, Average speed of drivers exceeding 70mph*			
*Agreement of modalities for reaching an EU target of 95 gCO_2/km target and strong enough penalties to deliver the target, New Car CO_2 in EU, New Van and HGV gCO_2/km***, Number of EV car models on market, Developments in battery and hydrogen fuel cell technology, Battery costs*			
Successful conclusion of EU work on Indirect Land Use Change/development of accounting system for ILUC and sustainability			
Number of households and Car ownership by household, Cost of car travel vs. cost of public transport, Funding allocated to and percentage of population covered by Smarter Choices initiatives[†], Proportion of new retail floorspace in town centre/edge of centre locations, Ratio of parking spaces to new dwellings on annual basis			

Note: Numbers indicate amount in last year of budget period i.e. 2012, 2017, 2022.
* These are the values implied by the estimated savings from speed limiting. CCC recognise that in practice it is impossible to achieve zero speeding. However, as close to zero as practicable is required to achieve the greatest carbon savings.
** We will include van and HGV km travelled in our headline indicators following new work on freight for our 2010 report.
*** We aim to include new van and HGV gCO_2/km in our indicator set as the available monitoring data improves
[†] Our initial recommendation is for phased roll-out of Smarter Choices to further establish emissions reduction potential. If initial roll-out proves successful, our subsequent recommendation would be for national roll-out. We would then need to monitor population covered and also total expenditure to verify sufficient coverage and intensity. Once national roll-out is underway and suitable data sources are identified, population covered and total expenditure will be included in our set of supporting indicators.

Key: Headline indicators Implementation Indicators Milestones Other drivers

Future work of the Committee

The Committee is required either under the Climate Change Act 2008 or at the request of Government to produce a number of reports over the next year including:

UK aviation emissions review: the Committee was requested by the UK Government to review UK aviation emissions and recommend how these can be reduced to meet the target that emissions in 2050 will be no more than 2005 levels. The Committee will report back in December 2009.

Advice to the Scottish Government on emissions reduction targets. The Committee has agreed to a request by the Scottish Government to advise on appropriate Scottish emissions reduction targets, and will report back in February 2010.

Annual report to Parliament: the Committee's second annual report to Parliament is required in June 2010. This will include an assessment of progress reducing emissions to meet budgets. It will also report any new analysis, particularly as regards scope for reducing agriculture emissions.

Advice on the second phase Carbon Reduction Commitment (CRC) cap: The Low Carbon Transition Plan noted the Government's request that the Committee advise on the CRC cap in 2010. The Committee will report back on this at a date to be determined in 2010, possibly in conjunction with the annual progress report.

A review of UK low carbon R&D: this has been requested by the Government's Chief Scientist. It will cover technologies to be supported, support mechanisms and the institutional framework. The Committee will report back in summer 2010.

Advice on the fourth budget (2023-27): the Committee is required under the Climate Change Act to advise on the appropriate level of the fourth carbon budget by the end of 2010. In undertaking this work, the Committee will consider any new scientific evidence, appropriate global trajectories, UK contributions, and emissions reduction opportunities. This work will include consideration of outcomes from Copenhagen including implications for moving from the Interim to Intended budgets.

Glossary

Achievable Emissions Intensity
The minimum average annual emissions intensity that could be achieved in a given year, given the installed capacity, projected demand and the projected profile of that demand

Anaerobic Digestion (AD)
A treatment process breaking down biodegradable, particularly waste, material in the absence of oxygen. Produces a methane-rich biogas that can substitute for fossil fuels.

Best Available Technology
The latest stage of development of a particular technology (or e.g. a process or operating method) that is practically suitable for deployment.

Biofuel
A fuel derived from recently dead biological material and used to power vehicles (can be liquid or gas). Biofuels are commonly derived from cereal crops but can also be derived from dead animals, trees and even algae. Blended with petrol and diesel biofuels it can be used in conventional vehicles.

Biogas
A fuel derived from recently dead biological material which can be burned in a generator or a CHP plant, or upgraded to biomethane for injection into the gas grid.

Biomass
Biological material that can be used as fuel or for industrial production. Includes solid biomass such as wood and plant and animal products, gases and liquids derived from biomass, industrial waste and municipal waste.

Carbon Capture and Storage (CCS)
Technology which involves capturing the carbon dioxide emitted from burning fossil fuels, transporting it and storing it in secure spaces such as geological formations, including old oil and gas fields and aquifers under the seabed.

Carbon dioxide equivalent (CO_2e) concentration
The concentration of carbon dioxide that would give rise to the same level of radiative forcing as a given mixture of greenhouse gases.

Carbon dioxide equivalent (CO_2e) emission
The amount of carbon dioxide emission that would give rise to the same level of radiative forcing, integrated over a given time period, as a given amount of well-mixed greenhouse gas emission. For an individual greenhouse gas species, carbon dioxide equivalent emission is calculated by multiplying the mass emitted by the Global Warming Potential over the given time period for that species. Standard international reporting processes use a time period of 100 years.

Carbon Emissions Reduction Target (CERT)
CERT is an obligation on energy supply companies to implement measures in homes that will reduce emissions (such as insulation, efficient lightbulbs or appliances).

Carbon Reduction Commitment (CRC)
A mandatory carbon reduction and energy efficiency scheme for large non-energy intensive public and private sector organisations. CRC will capture CO_2 emissions not already covered by Climate Change Agreements and the EU Emissions Trading System and will start in April 2010.

Clean Development Mechanism (CDM)
UN-regulated scheme which allows credits to be issued from projects reducing GHG gases in Kyoto non-Annex 1 countries (developing countries).

Climate Change Levy (CCL)
A levy charged on the industrial and commercial supply of electricity, natural gas, coal and coke for lighting, heating and power.

Combined Cycle Gas Turbine (CCGT)
A gas turbine generator that generates electricity. Waste heat is used to make steam to generate

additional electricity via a steam turbine, thereby increasing the efficiency of the plant.

Combined Heat and Power (CHP)
The simultaneous generation of heat and power, putting to use heat that would normally be wasted. This results in a highly efficient way to use both fossil and renewable fuels. Technologies range from small units similar to domestic gas boilers to large scale CCGT or biomass plants which supply heat for major industrial processes.

Company car tax
A tax applied where because of their employment, a car is made available to and is available for private use by a director or an employee earning £8,500 a year or more, or to a member of their family or household. This tax is based on the CO_2 performance of the car.

Contracts for Difference
A contract between a buyer and a seller, stipulating that the seller will pay to the buyer the difference between the current value of an asset and its value at contract time.

Derated capacity
Electricity plant capacities expressed in terms of their average plant availability during peak demand (rather than in terms of their maximum potential output).

Discount rate
The rate at which the valuation of future costs and benefits decline. It reflects a number of factors including a person's preference for consumption now over having to wait, the value of an extra £1 at different income levels (given future incomes are likely to be higher) and the risk of catastrophe which means that future benefits are never enjoyed. For example the Social Discount Rate (3.5%) suggests future consumption of £1.035 next year is equivalent in value to £1 today. Discount rates in the private sector generally reflect the real cost of raising capital, or the real interest rate at which consumers can borrow.

Display Energy Certificate (DEC)
The certificate shows the actual energy usage of a building and must be produced every year for public buildings larger than 1,000 square metres.

Eco-driving
Eco-driving involves driving in a more efficient way in order to improve fuel economy. Examples of eco-driving techniques include driving at an appropriate speed, not over-revving, ensuring tyres are correctly inflated, removing roof racks and reducing unnecessary weight.

Electric vehicle
Vehicle capable of full electric operation (i.e. without an internal combustion engine) fuelled by battery power.

Emissions Performance Standard
A CO_2 emissions performance standard would entail regulation to set a limit on emissions per unit of energy output. This limit could be applied at plant level, or to the average emissions intensity of a power company's output.

Energy Efficiency Commitment (EEC)
The predecessor of the CERT, and a type of Supplier Obligation.

Energy intensity
A measure of total primary energy use per unit of gross domestic product.

Energy Performance Certificate (EPC) The certificate provides a rating for residential and commercial buildings, showing their energy efficiency based on the performance of the building itself and its services (such as heating and lighting). EPCs are required whenever a building is built, sold or rented out.

Energy Unserved
The amount of demand within each year that cannot be met due to insufficient supply.

European Union Allowance (EUA)
Units corresponding to one tonne of CO_2 which can be traded in the EU ETS.

European Union Emissions Trading Scheme (EU ETS)
Cap and trade system covering the power sector and energy intensive industry in the EU.

Fast-charging
A process of charging a battery quickly by delivering high voltages to the battery.

Feed-in-tariffs
A type of support scheme for electricity generators, whereby generators obtain a long term guaranteed price for the output they deliver to the grid.

Fuel Duty
A tax on petrol and diesel. In May 2008, the UK tax was £0.55 per litre for diesel and £0.52 for unleaded petrol.

Fuel Poverty
A fuel poor household is one that needs to spend in excess of 10% of household income on all fuel use in order to maintain a satisfactory heating regime.

Full hybrid
A vehicle powered by an internal combustion engine and electric motor that can provide drive train power individually or together.

Funded Decommissioning Programme (FDP)
A plan developed by operators to tackle back-end waste and decommissioning costs of nuclear power stations.

Generic Design Assessment (GDA)
Generic Design Assessment (GDA), also known as pre-licensing, is intended to ensure that the technical aspects of designs for nuclear power plants are considered ahead of site-specific license applications.

Global Warming Potential (GWP)
A metric for comparing the climate effect of different greenhouse gases, all of which have differing lifetimes in the atmosphere and differing abilities to absorb radiation. The GWP is calculated as the integrated radiative forcing of a given gas over a given time period, relative to that of carbon dioxide. Standard international reporting processes use a time period of 100 years.

GLOCAF
The Global Carbon Finance model was developed by the Office of Climate Change to looks at the costs to different countries of moving to a low carbon global economy, and the kind of international financial flows this might generate.

Greenhouse Gas (GHG)
Any atmospheric gas (either natural or anthropogenic in origin) which absorbs thermal radiation emitted by the Earth's surface. This traps heat in the atmosphere and keeps the surface at a warmer temperature than would otherwise be possible, hence it is commonly called the Greenhouse Effect.

Gross Domestic Product (GDP)
A measure of the total economic activity occurring in the UK.

Gross Value Added (GVA)
The difference between output and intermediate consumption for any given sector/industry.

Gt
A gigatonne or 1000 million tonnes.

GWh (Gigawatt hour)
A measure of energy equal to 1000 MWh.

Heat pumps
Can be an air source or ground source heat pump to provide heating for buildings. Working like a 'fridge in reverse', heat pumps use compression and expansion of gases or liquid to draw heat from the natural energy stored in the ground or air.

Heavy Good Vehicle (HGV)
A truck over 3.5 tonnes (articulated or rigid).

Infrastructure Planning Commission
A new body established by the Planning Act (2008) to take decisions on planning applications for major infrastructure projects.

Integrated gasification combined-cycle (IGCC)
A technology in which a solid or liquid fuel (coal, heavy oil or biomass) is gasified, followed by use for electricity generation in a combined-cycle power plant. It is widely considered a promising electricity generation technology, due to its potential to achieve high efficiencies and low emissions.

Intergovernmental Panel on Climate Change (IPCC)
The IPCC was formed in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP).

It is designed to assess the latest scientific, technical and socio-economic literature on climate change in an open and transparent way which is neutral with respect to policy. This is done through publishing a range of special reports and assessment reports, the most recent of which (the Fourth Assessment Report, or AR4) was produced in 2007.

Justification
The concept of Regulatory Justification is based on the internationally accepted principle of radiological protection that no practice involving exposure to ionising radiation should be adopted unless it produces sufficient net benefits to the exposed individuals, or society, to offset any radiation detriment it may cause. This principle is derived from the recommendations of the International Commission on Radiological Protection (ICRP) and included in the European Council Directive 96/29/Euratom 13 May 1996 which sets the basic safety standards for protecting the health of workers and the general public against dangers arising from ionising radiation.

kWh (Kilowatt hour)
A measure of energy equal to 1000 Watt hours. A convenient unit for consumption at the household level.

Kyoto gas
A greenhouse gas covered by the Kyoto Protocol.

Kyoto Protocol/Agreement
Adopted in 1997 as a protocol to the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol makes a legally binding commitment on participating countries to reduce their greenhouse gas emissions by 5% relative to 1990 levels, during the period 2008-2012. Gases covered by the Kyoto Protocol are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

Levelised cost
Lifetime costs and output of electricity generation technologies are discounted back to their present values to produce estimates of cost per unit of output (e.g. p/kWh).

Life-cycle
Life-cycle assessment tracks emissions generated and materials consumed for a product system over its entire life-cycle, from cradle to grave, including material production, product manufacture, product use, product maintenance and disposal at end of life. This includes biomass, where the CO_2 released on combustion was absorbed by the plant matter during its growing lifetime.

Light Goods Vehicle (LGV)
A van (weight up to 3.5 tonnes; classification N1 vehicle).

Lithium-ion batteries
Modern batteries with relatively high energy storage density. Presently used widely in mobile phones and laptops and likely to be the dominant battery technology in the new generation of plug-in hybrid and battery electric vehicles.

Marginal Abatement Cost Curve
Graph showing costs and potential for emissions reduction from different measures or technologies, ranking these from the cheapest to most expensive to represent the costs of achieving incremental levels of emissions reduction.

MARKAL
Optimisation model that can provide insights into the least-cost path to meeting national emissions targets over the long-term.

Micro hybrid
Vehicle engine with stop start and capable of regenerative braking.

Mild Hybrid
An internal combustion engine which can be assisted by an electric motor when extra power is needed, but where the electric motor cannot power the vehicle independently.

Mitigation
Action to reduce the sources (or enhance the sinks) of factors causing climate change, such as greenhouse gases.

$MtCO_2$
Million tonnes of Carbon Dioxide (CO_2).

MWh (Megawatt hour)
A measure of energy equal to 1000 KWh.

National Atmospheric Emissions Inventory (NAEI)
Data source compiling estimates of the UK's emissions to the atmosphere of various (particularly greenhouse) gases.

National Balancing Point (NBP)
A measure of the wholesale price of gas in the UK (measured in p/therm or p/kWh).

National Policy Statement (NPS)
The Government would produce National Policy Statements (NPS) that would establish the national case for infrastructure development and set the policy framework for the Infrastructure Planning Commission (IPC) to take decisions.

Non-powertrain
Relating to parts of a vehicle that are not components of the engine or transmission

Offset credits
Credits corresponding to units of abatement from projects, such as those generated under the Kyoto treaty's project based flexibility mechanisms, Joint Implementation (JI) and Clean Development Mechanism (CDM).

Ofgem (Office of Gas and Electricity Markets)
The regulator for electricity and downstream gas markets.

Plug-in Hybrid
A full hybrid vehicle with additional electrical storage capacity which can be charged from an external electrical source such as mains supply.

Powertrain
Relating to the engine and transmission of a vehicle.

Pre-Industrial
The period before rapid industrial growth led to increasing use of fossil fuels around the world. For the purposes of measuring radiative forcing and global mean temperature increases, 'pre-industrial' is often defined as before 1750.

Pumped storage
A technology which stores energy in the form of water, pumped from a lower elevation reservoir to a higher elevation. Lower cost off-peak electric power is generally used to run the pumps. During periods of high electrical demand, the stored water is released through turbines.

Renewable Energy Strategy (RES)
Strategy to promote renewable energy to meet its 2020 target. Published in 2009 by DECC.

Renewable Heat Incentive (RHI)
Will provide financial assistance to producers (householders and businesses) of renewable heat when implemented in April 2011.

Renewables
Energy resources, where energy is derived from natural processes that are replenished constantly. They include geothermal, solar, wind, tide, wave, hydropower, biomass and biofuels.

Renewables Obligation Certificate (ROC)
A certificate issued to an accredited electricity generator for eligible renewable electricity generated within the UK. One ROC is issued for each megawatt hour (MWh) of eligible renewable output generated.

Reserved powers
Policy areas governed by the UK Government. Also refers to 'excepted' matters in the case of Northern Ireland.

Rising Block Tariff (RBT)
Energy is priced at a low initial rate up to a specified volume of consumption, and then the unit price increases as consumption increases.

Security of supply
The certainty with which energy supplies (typically electricity, but also gas and oil) are available when demanded.

Standard Assessment Procedure (SAP)
UK Government's recommended method for measuring the energy rating of residential dwellings. The rating is on a scale of 1 to 120.

Strategic Siting Assessment (SSA)
The Government is undertaking a process called Strategic Siting Assessment (SSA), to identify sites that are suitable or potentially suitable for the deployment of new nuclear power stations by the end of 2025, which includes assessing the sites against set criteria. These sites will be included in a National Policy Statement.

Smart meters
Advanced metering technology that allows suppliers to remotely record customers' gas and electricity use. Customers can be provided with real-time information that could encourage them use less energy, (e.g. through display units).

Smarter Choices
Smarter Choices are techniques to influence people's travel behaviour towards less carbon intensive alternatives to the car such as public transport, cycling and walking by providing targeted information and opportunities to consider alternative modes.

Social Tariff
An energy tariff where vulnerable or poorer customers pay a lower rate.

Solar photovoltaics (PV)
Solar technology which uses the sun's energy to produce electricity.

Solar thermal
Solar technology which uses the warmth of the sun to heat water to supply hot water in buildings.

Stop start
Vehicle engine with automated starter motor.

Technical potential
The theoretical maximum amount of emissions reduction that is possible from a particular technology (e.g. What would be achieved if every cavity wall were filled). This measure ignores constraints on delivery and barriers to firms and consumers that may prevent up take.

Tidal range
A form of renewable electricity generation which uses the difference in water height between low and high tide by impounding water at high tide in barrages or lagoons, and then releasing it through turbines at lower tide levels.

Tidal stream
A form of renewable electricity generation which harnesses the energy contained in fast-flowing tidal currents.

TWh (Terawatt hour)
A measure of energy equal to 1000 GWh or 1 billion kWh. Suitable for measuring very large quantities of energy - e.g. annual UK electricity generation.

United Nations Framework Convention on Climate Change (UNFCCC)
Signed at the Earth Summit in Rio de Janeiro in 1992 by over 150 countries and the European Community, the UNFCCC has an ultimate aim of 'stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.'

Vehicle Excise Duty (VED)
Commonly known as road tax, an annual duty which has to be paid to acquire a vehicle licence for most types of motor vehicle. VED rates for private cars have been linked to emissions since 2001, with a zero charge for the least emitting vehicles (under 100 gCO_2/km).

Abbreviations

AD	Anaerobic Digestion
ASHP	Air Source Heat Pump
BETTA	British Electricity Trading and Transmission Arrangements
BIS	Department for Business, Innovation and Skills
BWEA	British Wind Energy Association
CCA	Climate Change Agreement
CCC	Committee on Climate Change
CCGT	Combined-Cycle Gas Turbine
CCL	Climate Change Levy
CCP	Climate Change Programme
CCS	Carbon Capture and Storage
CDM	Clean Development Mechanism
CERT	Carbon Emissions Reduction Target
CHP	Combined Heat and Power
CLG	Department for Communities and Local Government
CRC	Carbon Reduction Commitment
DEC	Display Energy Certificate
DECC	Department for Energy and Climate Change
Defra	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
DUKES	Digest of UK Energy Statistics
EC	European Commission
EEC	Energy Efficiency Commitment
ENSG	Electricity Network Strategy Group
EPC	Energy Performance Certificate
EST	Energy Saving Trust
EU ETS	European Union Emissions Trading Scheme
EUA	European Union Allowance
EV	Electric Vehicle
EWP	Energy White Paper
FDP	Funded Decommissioning Programme
FEED	Front-End Engineering Design
FIT	Feed-in Tariff
G8	Group of 8 main industrialised countries
GDA	Generic Design Assessment
GHG	Greenhouse Gas
GLOCAF	Global Carbon Finance Model
GSHP	Ground Source Heat Pump
GVA	Gross value added
GWP	Global Warming Potential
HESS	Heat and Energy Saving Strategy
HGV	Heavy duty vehicle
ICAO	International Civil Aviation Organisation
ICT	Information and Communication Technologies
IEA	International Energy Agency
IMO	International Maritime Organisation
IPC	Infrastructure Planning Commission
IPCC	Intergovernmental Panel on Climate Change
ISA	Intelligent Speed Adaptation

LDV	Light duty vehicle
LULUCF	Land Use, Land Use Change and Forestry
MACC	Marginal Abatement Cost Curve
MPP	Major Power Producer
MS	Member State
MTOE	Million Tonnes of Oil Equivalent
NAEI	National Atmospheric Emissions Inventory
NAIGT	New Automotive Innovation and Growth Team
NETA	New Electricity Trading Arrangements
NG	National Grid
NPS	National Policy Statement
NTM	National Transport Model (DfT)
NTS	Non-Traded Sector
OFTO	Offshore Transmission Owner
OLEV	Office for Low Emission Vehicles
PHEV	Plug-In Hybrid Electric Vehicle
PV	Photovoltaic
RBT	Rising Block Tariff
RHI	Renewable Heat Incentive
RO	Renewable Obligation
ROC	Renewable Obligations Certificate
RP	Redpoint
RTFO	Renewable Transport Fuel Obligation
SAP	Standard Assessment Procedure
SMEs	Small & Medium Enterprises
SMMT	Society of Motor Manufacturers and Traders
	Supplier Obligation
SSA	Strategic Siting Assessment
UEP	Updated Energy Projections
UKERC	UK Energy Research Centre
UNFCCC	United Nations Framework Convention on Climate Change
VED	Vehicle Excise Duty

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