BWG-P-06-12

Route Map – UK 2012 low carbon bus target

This document incorporates the recommendations of the Bus Working Group with regard to the Powering Future Vehicles strategy.

Executive summary

With the ever rising price of oil, concern about security of oil and gas supplies and the requirement for transport to improve local air quality and contribute to reductions in emissions of greenhouse gases, buses can and should form the catalyst for modal change. Public transport should be seen to lead the way in developing more sustainable forms of transport.

In the past 5 years a limited number of technologies have now been demonstrated in buses capable of delivering 30% or more reduction in carbon emissions in the UK. In addition, the small number of low carbon buses currently operating have all been purchased with EU or other support funding to reduce their initial capital cost, which is substantially higher than current buses in volume production.

In the absence of greater incentives and powers for local authorities to encourage low carbon buses, the current target for 600 low carbon buses to be sold annually by 2012 is unachievable.

The Bus Working Group (BWG) has been active in identifying the principal barriers to transforming the market for low carbon buses – these include:

- The bus industry in the UK has been in decline with falling bus patronage being widespread across the UK, with the exception of London and a few isolated areas where pro-bus policies have been introduced,
- majority of bus services outside London are not tendered and those that are tendered are generally subsidized because they are not commercially viable,
- carbon emissions are not regulated and local authorities do not have sufficient powers to encourage the use of low carbon buses,
- technology push by itself will not create market entry and overcome existing barriers,
- BSOG provides more grant support for buses with high fuel consumption than for low carbon buses which reduce carbon emissions but have a potentially higher capital cost,
- the UK bus market lacks sufficient volume to secure the robust development of low carbon buses in isolation,
- due to the difference in truck and bus duty cycles it is unlikely that buses will benefit from low carbon technology developed for the truck industry,
- ***the suspension and final withdrawal of the low carbon bus programme has caused a loss of confidence amongst bus***

manufacturers and suppliers and has undermined the business model for developing low carbon buses,

- there are too few low carbon buses being demonstrated in the UK to determine reliability and operating costs and little knowledge of demonstrations internationally,
- there is no incentive or requirement for operators to purchase low carbon buses particularly with the withdrawal of low carbon bus demonstration program.

The stakeholders in the bus market support the objectives of the Powering Future Vehicle strategy and are keen to work with DfT, DTI, DEFRA and HMT to overcome the barriers and allow these new technologies to be demonstrated and proved as part of creating a sustainable market in the UK.

To achieve the original target, the opinion of the BWG is that the following actions are required for which extra monies are *not* required but existing funds be *reallocated* to overcome the existing barriers. The actions required are:

- **increase bus patronage** by requiring councils to formulate and initiate integrated transport plans which includes a strategy for the use of low carbon buses,
- demonstrate proof of concept for a range of low carbon bus technologies, for which proof of concept has not yet been established; to form part of the next **DTI collaborative R & D call**,
- undertake a widespread demonstration of low carbon buses to prove reliability and maintainability: to be funded through the **EST R&D programme**,
- undertake a review of low carbon bus demonstrations worldwide, comprising study tour to be disseminated via seminar to bus market stakeholders,
- obtain a similar level of grant support for low carbon buses, independent of fuel type or drive-line technology, as provided by BSOG for diesel buses; to comprise an initial grant with lower running support that is revenue neutral to the Treasury,
- undertake a public procurement plan, working together with other interested European countries, to replace all buses currently used in park and ride schemes by low carbon buses: the additional cost to be funded by local revenues and DfT's Local Transport Plan settlements.
- establish a target for further development of low carbon bus technology for 2020. "All buses coming into operation will be low carbon by 2020 or sooner."

Such actions would;

- create an initial market for low carbon buses,
- reward existing bus manufacturers and component supply chain who have already invested and are prepared to continue to invest in low carbon driveline technology,
- offset the cost of oil which has risen threefold in the past three years and is likely to continue to rise as supply is unable to meet demand,

- initiate a market transformation process which should lead to a sustainable market for low carbon buses
- contribute towards the Government's present and future strategy of a low carbon economy,
- secure competitive advantage for UK manufacturers and supply chain in low carbon bus technology.

The attached report together with some annexes sets out the rationale for introducing such a strategy.

Introduction

The Powering Future Vehicles (PFV) Strategy was published in July 2002 with the objective that the UK should lead the world in the shift to clean, low carbon transport. The PFV strategy provides a framework for decision making and sets out targets to support this shift over the period to 2012 (although in relation to ultra low carbon cars it does look forward to 2020).

There is a specific target within the strategy relating to low carbon buses: by 2012, 600 or more buses coming into operation per year will be low carbon, defined as 30% below current average carbon emissions. This has been further refined by the Partnership's Bus Working Group to define a low carbon bus as:

> *Producing at least 30% fewer greenhouse gas emissions than a current Euro 3 equivalent diesel bus of the same total passenger capacity. The greenhouse gas emissions are expressed in grams of carbon dioxide equivalent measured over a standard test and covers Well-to-Wheel performance therefore taking into account both the production of the fuel and its consumption on board.*

The strategy also states that the Government will support the move to a low carbon transport system by ensuring the appropriate taxation of vehicles, fuels and infrastructure, and by encouraging the up-take of low carbon vehicles and fuels through appropriate financial measures and actions to overcome market barriers.

The strategy states that the targets will be kept up to date and will be reviewed in 2005. However, due to the timing of the Energy Review and the Climate Change Programme Review it was decided to defer the review of the PFV strategy until 2006.

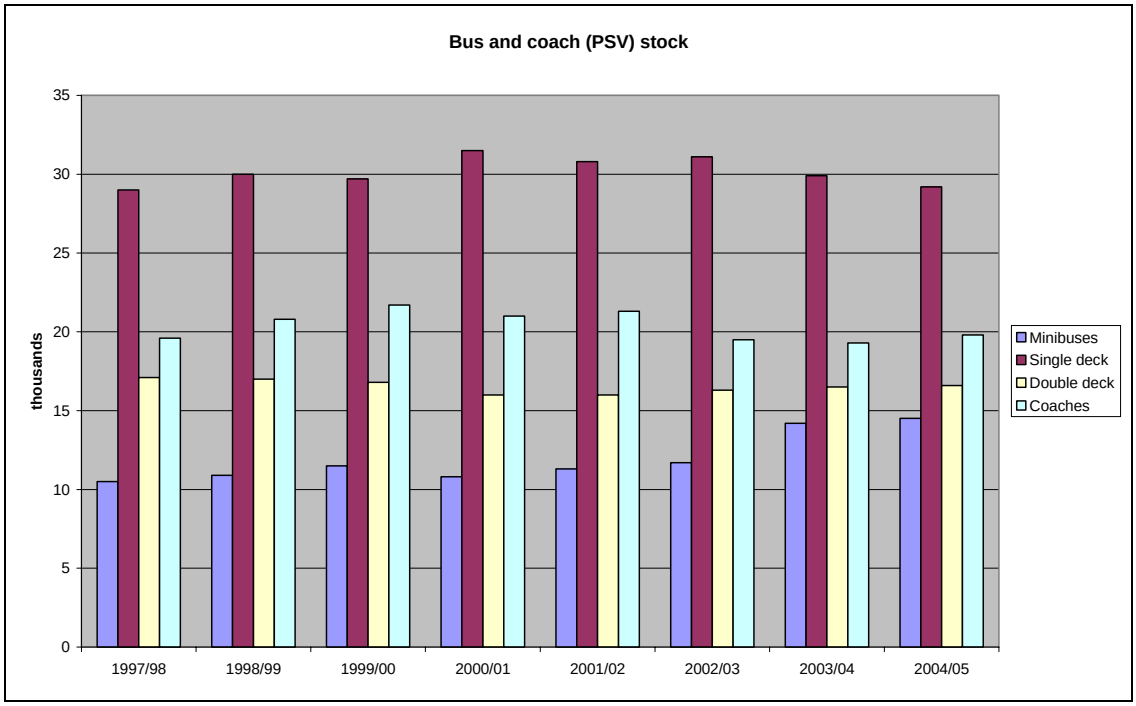
Officials have asked the LowCVP to provide recommendations on all targets, actual or aspired, in the PFV by the summer of 2006. This document outlines the issues foreseen in achieving the bus target and recommends actions and a potential alternative optional bus target developed by the Bus Working Group relating to the low carbon bus target.

Whilst low carbon buses will help limit climate change and fossil fuel usage, some of these technologies will also help to reduce local pollutants like SOX, NOX and PM10 so improving air quality. In addition some technologies will lead to quieter buses so helping local authorities to meet noise limits as prescribed by the EU environmental

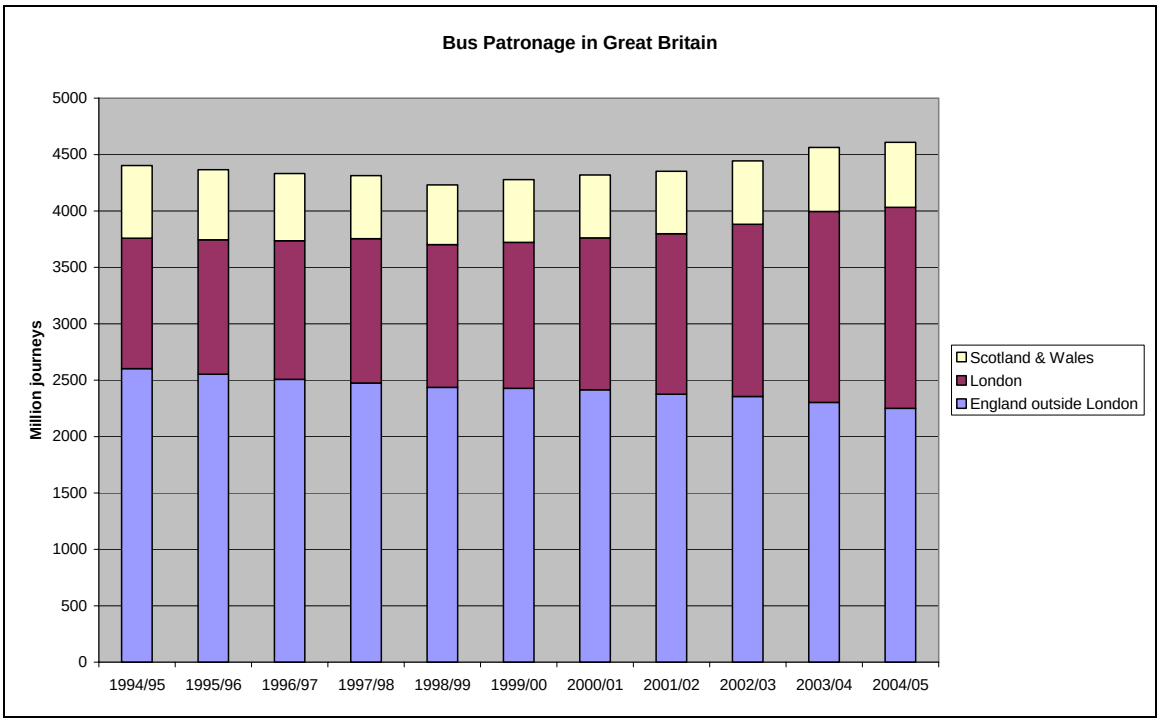
noise directive. Low carbon buses should form a central plank of a holistic policy to promote more sustainable public transport.

Background

There are currently 103,000 buses and coaches registered in the UK, of which 80,000 are Public Service Vehicles (PSV). The target for low carbon buses was framed originally as buses over 8.5 tonnes incorporating full sized single and double deck buses of which there are circa. 46,000 in operation in the UK (see graph below).



Although total bus patronage is increasing across the UK this is being driven by of the growth in ridership in London where due to significant investment in the bus fleet and the introduction of the Congestion Charge bus patronage has increased. While Scotland and Wales has improved marginally in recent years, elsewhere in England patronage has been in decline.



Source: DfT

Public transport offers significant carbon reduction opportunities over private transport in the UK today. Based upon average occupancy rates for cars and buses, the average carbon dioxide emissions per passenger kilometre is 24% lower for a single deck bus than for a car for the UK as a whole, and 44% lower for single deck bus in London. A doubling of occupancy rates on buses would deliver a 62% and a 72% reduction in carbon dioxide emissions per passenger kilometre for the UK and London respectively. The adoption of low carbon bus technologies would have the potential to increase this to 73% and 81% respectively.

Vehicle	Carbon Emissions (g/km)	Average Occupancy	CO2 per passenger/km	Percentage change
Car	209*	1.6	131	0%
Single deck bus	1,088			
- UK		11	99	24%
- London		15	73	44%
Double occupancy bus				
- UK		22	49	62%
- London		30	36	72%
Low carbon high occupancy	761.6			
- UK		22	35	73%
- London		30	25	81%

*Based upon NAEI emission factor database @ 20km/h emission factor diesel / petrol mix (30% / 70%)

Prior to 1986 bus services were provided by local authority owned operators, subsidiaries of publicly owned corporations and smaller private companies. The Transport Act 1985 was introduced to promote competition and efficiency, limit use of public monies in funding bus operations, it also removed the requirement for road service licensing outside London.

The regime operates differently in London from the rest of the UK. In London a system of competitive tendering for bus routes operates, tendered by TfL as the executive agency of the GLA. In the rest of the UK bus operators are required to register services with the Traffic Commissioner giving 56 days notice of intention to set up or cease to operate a service and provide information on the proposed route. In the major conurbations public transport is then co-ordinated by the Passenger Transport Executives (PTE) who are responsible to the local authorities in their area, via the Passenger Transport authority, and act in partnership with private operators to provide public transport.

The UK has three domestic bus manufacturers which although they do not manufacture engines and gear boxes, do design the whole bus and retain much of the added value in the buses they produce. The major components are built on the basis of demand across Europe to achieve economies of scale and research and development is done in conjunction with that for commercial vehicles.

Role of Government and public authorities

Both central government and local authorities have a role to play in encouraging the up take of low carbon buses. In addition the PTEs have an important role in acting as an interface with local authorities to provide local public transport needs.

Central Government

Government provides significant funding support for the provision of bus services through a number of schemes, these are;

- Bus Service Operators Grant (BSOG) = £0.4 billion
- Local authority subsidy = £0.3 billion
- Re-imbursement of concessionary fares to operators = £1 billion
- Grant to TfL = £0.5 billion

Total support for bus operation in the UK currently runs at £2.2 billion per annum. The level of funding support to the bus industry is not a barrier to the introduction of low carbon buses but rather the fact that existing Government policies conflict with each other in what is a broadly competitive market. However, bus patronage outside London is in general decline despite the level of support from Government.

At the core of Government policy relating to public service vehicles is the need to encourage modal shift from private to public transport and to assist this public service vehicle services should be at a minimum cost. To this end the Government supports public service vehicles through the BSOG which rebates fuel duty paid by bus operators for the mileage which the buses are employed on public service routes. Currently the BSOG rebates 80% of fuel duty paid for diesel and 100% of fuel duty paid on natural gas, LPG or bio-fuels. Unfortunately, this has the effect of mitigating the incentives provided through fuel duty by the Government to encourage low carbon fuels and more fuel efficient vehicles.

The DfT undertook a review of the operation of BSOG in 2004/05 and whilst understanding concerns regarding of the conflict in objectives in BSOG and Fuel Duty policy, it was decided that BSOG should remain in its current state. Given this

state of affairs other fiscal incentives need to be considered if low carbon buses are to be viable.

Other fiscal incentives which might be deployed by central Government are:

- Enhanced capital allowances for the purchase of low carbon buses,
- Grant support of research and development of low carbon bus technology,
- Grant support for field trials and demonstration projects of low carbon bus fleets,
- Renewable transport fuel obligation, and
- Emission trading scheme for transport.

As an overriding recommendation Government should take action to increase bus passenger patronage as this in itself would help to reduce carbon dioxide emissions from road transport. It would also provide a more conducive environment in which to assess low carbon bus investment decisions by bus operators.

Local Authorities

Local authorities can have a significant impact in co-ordinating action and marshalling resources in their area. However there is no direct and simple power which allows a local authority to directly influence the market for low carbon buses. The powers that local authorities have are spread across a number of Acts, the most important of which are described below.

The 1985 Transport Act generally precludes local authorities from operating regular bus services. Although Section 7 of the Act does give the local authority the power to ask the Traffic Commissioner to place conditions on an operator's licence, local authorities do not have any powers to declare low carbon zones unlike air quality or noise abatement zones . Recent amendments have added environmental factors to the grounds that can be used to request Traffic Regulation Conditions but this does not include CO2 emissions and so could be subject to judicial review.

The Transport Act 2000 introduced the concept of Quality Partnerships, which is a partnership approach to improve services by in kind action between bus operators, local authorities and users. Whilst a number of voluntary Quality Partnerships are in place, only one statutory Partnership has so far been established. The objective of such partnerships is to improve local bus services rather than to tackle climate change issues, although in theory a Statutory Quality Partnership could be used to bar all but low carbon buses from enhanced facilities provided by an authority.

The Local Government Act 2000 gives local authorities the power to do anything which they consider is likely to achieve the promotion or improvement in one or more of the following;

- The economic well being of their area,
- The social well being of their area, and
- The environmental well being of their area.

This, in theory, should allow local authorities to incur expenditure on low carbon buses provided it is consistent with other primary legislation and benefits all residents and conforms with state aid regulations.

Section 106 under the Town and Country Planning Act allows local authorities to enter into legal agreements with developers by which a local authority can require a developer to undertake specific actions or make contributions to the provision of services. This could be used in principle to support the introduction of low carbon buses, but is more likely to be used to develop communal facilities for new developments and ensure that public transport is available.

The powers given to local authorities are primarily focused on air quality, social deprivation, economic development and integrated transport planning. These powers need to be enhanced to require local authorities to develop local transport plans which include provision of low carbon public transport.

Projects

The most influential area in which local authorities have played a role in introducing clean low carbon vehicle technology has been through project initiatives. These are funded through Government programmes such as the Energy Saving Trust's grant programmes and the DTI grant programmes, and the European Commission through the Framework Programmes and other initiatives. Virtually, all clean low carbon buses demonstrated in the UK to date have been funded through this manner.

Public procurement

Local authorities have played a role in procurement through the formation of joint procurement consortiums in order to gain economies of scale of less polluting vehicles in the past. The DfT has established a local authority work stream aimed at increasing efficiency of local authority tendered bus services which might be extended to include specifically low carbon buses.

This has been used to secure clean low carbon vehicle technologies in the past, most notably through the ZEUS and is currently being explored by the Cenex through the use of Forward Commitment agreements to overcome the risk of introducing low carbon vehicle technologies.

The new EU directive on energy services and public procurement will require local authorities to allocate a proportion of any tender to energy efficient products. Since the deregulation of the bus industry in the UK, the vast majority of buses are operated by the private sector and so likely to fall outside the scope of this directive. However almost all bus services in Europe are publicly owned and so future procurement will require the availability of energy efficient buses that is low carbon. So the market for low carbon buses will be driven by countries other than the UK and the UK supply industry will not benefit by any home market.

We therefore propose that the UK initiate a public procurement process to replace all park and ride buses by low carbon buses in order to initiate a transformation of the market. This additional cost could be part financed by local park and ride revenues and funding allocated Local Transport Plans. This could be undertaken together with other interested European partners through a pan European procurement process and could attract European funding.

Technology Pathways

There are a number of potential technology pathways which hold out the potential for significant carbon dioxide emission reductions. The most promising technologies investigated by the Group are shown in appendix I along with estimated costs, fuel consumption and carbon dioxide emissions.

There are three core technology types which are capable of achieving the low carbon target of a 30% reduction in carbon dioxide compared to Euro 3 buses are:

1. Internal combustion engines using renewable fuels (bio-diesel, bio-gas or renewable hydrogen)
2. Hybrid vehicles (using internal combustion or fuel cell as the prime mover)
3. Battery electric

There are also a number of enabling technologies (appendix II) which by themselves could deliver a significant reduction in carbon dioxide and combined with other technologies could deliver up to 50% reduction. These include; stop-start, continuously variable transmissions, regenerative braking, energy storage devices and some forms of SCR.

Demonstrations of Low Carbon Buses in the UK

To date there has been very limited demonstration of some low carbon technologies in buses in the UK, and there is limited knowledge of demonstrations elsewhere in the world. Consequently service operation is limited and it has not been possible to resolve issues such as availability, reliability and maintainability of even prototype, not necessarily pre-production components, which are the key to successful commercial bus operation. Current demonstrations include:

- London – 3 hydrogen fuel cell buses developed by Ballard
- Manchester, Bristol & London – 6 hybrid buses developed by Eneco
- London – 6 hybrid buses developed by Wrightbus
- Mersey Travel – battery electric, CNG, LPG developed by various companies
- Newcastle – 6 hybrid buses powered by gas turbine developed by Designline

Previous trials of alternative technology have shown poor reliability and high costs and as a consequence bus operators are cautious about the prospects for any new technology.

Some technology options have yet to be demonstrated as funding for such proof of concept was stopped in April 2003. **It is recommended that the next technology call of the DTI collaborative R & D programme include a special call for demonstrating low carbon technology.**

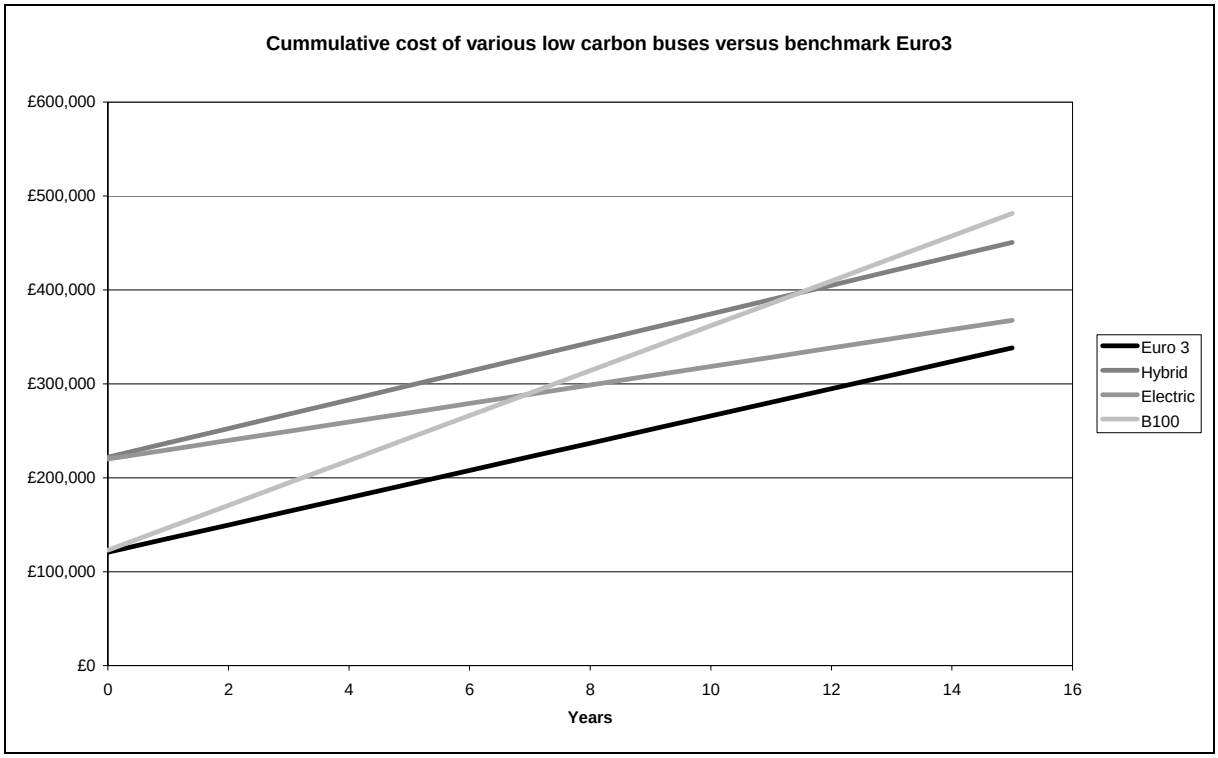
To tackle this and provide strong evidence of how different technologies will perform a large demonstration of low carbon bus technology should be conducted in the UK. This should be combined with a campaign to disseminate the results to all interested parties. In addition a study tour of key bus demonstrations in the rest of the world would assist UK bus operators and government officials in assess the potential for market transformation. **It is recommended that the EST R&D programme issue a special call for low carbon bus demonstration of 100 buses.**

Bus economics

Due to the current fiscal regime in the UK and the competitive nature of the bus market, low carbon buses in the UK will have to be price competitive with their high carbon counter parts. This implies that a price premium is likely only to be acceptable if a higher purchase cost it is offset by lower operating cost giving a payback period, to be no more than 5 years due to the fact that the majority of buses are leased for a 5 year time period.

The graph below shows the cumulative cost, without discounting, of a variety of low carbon buses compared to a Euro3 benchmark. This shows there is currently no financial incentive for bus operators to invest in low carbon buses or for bus manufacturers to develop them.

This view is supported by a study of market transformation for the bus market in the UK undertaken by Element Energy and Ricardo, funded by the EST and which the Bus Working Group contributed to and peer reviewed, assessed the market take up of a variety of carbon reducing technologies. The conclusion was that the bus market would not take up low carbon bus technologies given the current fiscal framework.



To achieve this would require public subsidy to reduce the capital cost of low carbon buses, an increase in the differential in operating costs between diesel and low carbon buses or local authorities being empowered to encourage the up take of low carbon buses through existing legislation and regulation.

Oil price and BSOG

Buses perform a public service and their occupancy is dependent upon the ticket price and hence their running cost. Oil prices have risen by a more than a factor of 3 over the past 3 years from $22 to in excess of $70/barrel. Oil prices are expected to

continue to rise steadily as a trend due to the rapid depletion of large, easily accessible oil fields (like the North Sea) and the time and cost to develop much smaller and deeper and less accessible fields like west of Shetlands.

This has resulted in a significant rise in costs for bus operators. For diesel buses, eligible for 80% fuel duty rebate the BSOG is worth 37.96p/litre (increased from 36.68p/litre on 1st October 2003), the *average net cost of fuel to the operator is estimated to have risen between 2003 and 2006 from 25.5 p/litre to 43.0 p/litre.* With an economy of 50 litres/100 km this equates a consumption of 21.5p/km.

Low carbon buses and BSOG

Clearly a low carbon bus, offering fuel consumption savings of 30% would offer significant savings on fuel costs if run on diesel or natural gas. A low carbon bus, using 30% less fuel, would have its fuel cost reduced from 21.5p to 15.3 p/km equal to an annual saving of *£3228/year (for a distance of 50,000 kms).* However, initially the additional capital cost of a low carbon bus is likely to exceed the cost saving over the expected life of the bus, although with volume production a five year payback may be achievable.

Due to the basis on which BSOG is calculated the purchase of every low carbon bus would represent a saving in BSOG to the Treasury. By replacing a conventional diesel bus with a 30% more efficient drive-line, Treasury would reduce the grant paid to bus operators by 0.3 X 37.68 p/litre or 11.3 p/litre that is BSOG savings of £2847/year which equates to £43,000 over the life of the bus or £14,000 over a five year time period.

The BSOG in its present form provides no incentive for operators of diesel buses to switch to low carbon buses; however as shown above the Treasury will benefit by having to pay a substantially smaller grant. Moreover the societal and environmental benefits associated with low carbon buses such as lower SOX, NOX, CO, particulates and CO2 carry no monetary credit for the operator.

We therefore recommend that for low carbon buses an initial grant equal to the BSOG savings over between five to ten years be made available to help offset some of the higher capital cost of a low carbon bus. The BWG members do not believe such a change would require state aid approval because the amount paid out over the five/ten year time period is the same and over a 15 year time period would be no more than would have been paid out under BSOG for a diesel bus.

UK Automotive Supply Chain Impacts

The UK automotive sector has a number of strengths, of which the most notable are:

- Automotive component supplier diversity
- Powertrain manufacturer
- Design engineering

<u>Automotive Component Supplier Diversity</u>

The UK automotive component sector is well developed and covers all aspects of automotive supply. It is dominated by major tier 1 suppliers who operate at a global level, with a large number of small to medium sized companies. There are a number of innovative first tier suppliers developing low carbon powertrains in the UK currently.

Powertrain Manufacturer

The UK has developed a specialism in powertrain manufacturer as a result of major recent investments in addition to its existing facilities. The UK now has 12 major Powertrain manufacturing facilities. As a consequence the UK is in a good position to benefit from developments in low carbon vehicle technology which relate to Powertrain.

Design engineering

The UK has a long-established, independent, design engineering sector whose services cover the full range of capabilities from concept design through to limited-series vehicle production. The sector's assets include major testing facilities for vehicles, systems and sub-systems. The sector employs over 10,000 and has a turnover in excess of £0.75 bn with a continued rise of the export proportion to a current value of around 70%. Its more successful companies are those that have best responded to the market's demand for world-class expertise, integrated into appropriate packages and delivered locally to the customer.

Impact on UK Production

The UK remains a location for bus manufacturer through Alexander Dennis, Optare and Wrightbus, in addition to assemblers and bodybuilders. Although these companies source major components including engines, gear boxes and other components worldwide they undertake to design the whole bus, including chassis, and consequently secure a high proportion of the added value in the manufacturing process. Clearly some of the IP involved in developing low carbon technologies could be secured by UK manufacturers although equally the powertrain suppliers are likely to be well placed to benefit also.

Impact on UK Supply Chain

- UK design engineering sector is likely to benefit from the development and integration of low carbon vehicle technologies.
- UK bus manufacturers may develop competitive advantage from development of low carbon bus manufacturer through integration of technologies.
- UK first tier suppliers may benefit from demand for low carbon vehicles to the extent that they are innovative and are able to develop a competitive or first mover advantage.
- UK second tier suppliers may benefit given that innovative first tier suppliers are successful.

Strategic Options (Targets & Carbon Saving)

To assess the achievability of the original low carbon bus target as stated in the PFV strategy, the market transformation model developed by Element Energy and Ricardo, and funded by EST was used to estimate the business as usual case given current policy framework. This was then compared with two alternative cases, the

first based upon market up-take of the intermediary technologies, the second based upon an enhanced set of policy tools to encourage the up take of low carbon buses.

Scenario 1: Original target with business as usual
The base case considered is that under which the original target is retained:

> *By 2012, 600 buses or more coming into operation per year will be low carbon, defined as 30% below current average carbon emissions.*

This scenario assumes that BSOG remains in its current form, no further incentives are provided to bus operators nor are local authorities provided with further powers to encourage the uptake of low carbon buses.

The outcome of this policy option will be;

- Majority of buses being diesel powered
- SCR being widely taken up due to the switch to Euro 4 engines
- Extremely limited uptake of low carbon buses
- Isolated demonstrations and trials of a variety of potential low carbon bus technologies
- Limited reduction in carbon emissions from bus transport
- No competitive advantage secured for UK manufacturers or supply chain
- B20 only technology which is likely to be taken up in limited volume

Scenario 2: Alternative target based upon intermediary technologies
An alternative policy option would be to revise target as stated below and focus on achieving at least as great a carbon saving from a wider number of buses utilising lower carbon technologies, but which are unable to achieve the 30% reduction originally required.

> *By 2012, all buses coming into operation per year will be lower carbon, defined as 10% below current average carbon emissions.*

This scenario is based upon the same business as usual policy framework that is used in scenario 1 but assumes that a revised target is adopted for low carbon buses, based around intermediary technologies.

This scenario assumes that BSOG remains in its current form, and no further incentives are provided to bus operators. However, it is proposed that local authorities are provided with further powers to encourage the uptake of low carbon buses either through requirements on bus operators or through financial support for specific routes.

The outcome of this policy option will be;

- Majority of buses continue to be diesel powered,
- Limited number of lower carbon technologies will be taken up,
- Initially a number of demonstrations will be required to determine which technologies are reliable and cost effective,
- Significant reduction in carbon emissions from bus transport,
- Little competitive advantage secured for UK manufacturers or supply chain,

- Initial investment in low carbon drive-lines by bus manufacturers and component supply chain is diffused and industry will be unlikely to reinvest at some later stage,
- Will not offset sufficiently the ever rising cost of fuel,
- Will be over taken by public procurement of energy efficient buses in continental Europe.

Scenario 3: Original target with enhanced policy framework

The final policy option retains the original low carbon bus target combined with a range of policy tools aimed at demonstrating low carbon bus technology, attracting low carbon technology development to the UK, widespread dissemination of results of technology, engagement of local authorities in tackling carbon emissions from road transport and securing mass market demand.

This policy option is based upon sufficient incentives being provided directly by Government initially during demonstration phase, and then through additional powers to local authorities and mass procurement to make low carbon buses as originally defined by the PFV strategy, cost effective compared to current diesel buses.

To achieve the original target, the opinion of the BWG is that the following actions are required for which extra monies are *not* required but existing funds be *reallocated* to overcome the existing barriers, which are;

- **increase bus patronage** by requiring councils to formulate and initiate integrated transport plans which includes a strategy for the use of low carbon buses,
- demonstrate proof of concept for a range of low carbon bus technologies, for which proof of concept has not yet been established; to form part of the next **DTI collaborative R & D call**,
- undertake a widespread demonstration of low carbon buses to prove reliability and maintainability: to be funded through the **EST R&D programme**,
- undertake a review of low carbon bus demonstrations worldwide, comprising study tour to be disseminated via seminar to bus market stakeholders,
- obtain a similar level of grant support for low carbon buses, independent of fuel type or drive-line technology, as provided by BSOG for diesel buses; to comprise an initial grant with lower running support that is revenue neutral to the Treasury,
- undertake a public procurement plan, working together with other interested European countries, to replace all buses currently used in park and ride schemes by low carbon buses: the additional cost to be funded by local revenues and DfT's Local Transport Plan settlements.
- establish a target for further development of low carbon bus technology for 2020. "All buses coming into operation will be low carbon by 2020 or sooner."

The outcome of this policy option will be;

- create an initial market for low carbon buses,

- reward existing bus manufacturers and component supply chain who have already invested and are prepared to continue to invest in low carbon driveline technology,
- offset the cost of oil which has risen threefold in the past three years and is likely to continue to rise as supply is unable to meet demand,
- initiate a market transformation process which should lead to a sustainable market for low carbon buses
- contribute towards the Government's present and future strategy of a low carbon economy,
- secure competitive advantage for UK manufacturers and supply chain in low carbon bus technology.

Recommendations and conclusions

There is an urgent need to increase the carbon efficiency of road transport in light of ever tightening scarce resources including road space and fossil fuels. This needs to be achieved through two routes, firstly encouraging modal shift from cars to public transport and secondly, by improving the carbon efficiency of individual vehicles. The benefits include using less fuel, reducing environmental emissions, preventing climate change and less pressure on increasingly scarce resources.

As the bus market is coherent and substantial, it is able to serve as a technology demonstrator for other markets which are much more diffuse and are not generally within the domain of influence of public authorities.

Technology is now available which will produce carbon savings or 30% or more, although some driveline options remain to be demonstrated. The bus market is an ideal market in which to demonstrate to the wider public the benefits of low carbon technology allowing large numbers of people to experience low carbon technologies.

Whilst the target for low carbon buses is appropriate, the UK needs to involve other European countries and the Commission to agree a common target which will be sufficiently large that the European bus manufacturers will be willing to commit to produce low carbon buses. This should be undertaken within the scope of the new EU energy efficiency action plan.

Like all other energy efficient technologies, the low carbon buses have a higher initial cost and will have a lower running cost once the new technology has matured. Extra funding is not required, but existing sources of financing need to be re-examined to understand how these can be used to finance the additional capital cost

The major beneficiaries in terms of competitiveness and employment would be to the UK component supply chain and bus manufacturers. In order to maintain development and investment in the UK supply chain it is recommended that a long term target for low carbon buses should be established.

Annex 1 Technology pathways

This data was collated by Ricardo and Element Energy in conjunction with the LowCVP and the members of the Bus Working Group. It is based upon a range of sources including and is indicative only.

Technology	Year available	Initial cost (2005)	Service and maintenance in first year	Infrastructure cost in first year	Fuel consumption	Source-to-wheel CO2g/km	CO2g/km % of benchmark
Euro 3 (Benchmark)	2001	£120,815	£5,500	£0	0.40 l/km	1,062	100%
SCR	2006	£121,093	£6,000	£2,000	0.36 l/km	1,030	97%
Stop-start	2011	£148,115	£6,092	£0	0.30 l/km	897	84%
Natural gas	2007	£144,000	£6,900	£8,000	17 MJ/km	905	85%
Bio-gas	2008	£140,000	£6,900	£8,000	17 MJ/km	0	~0%
Biodiesel B20 blend	2007	£122,815	£6,050	£4,000	0.41 l/km	955	90%
Biodiesel B100	2008	£122,815	£6,895	£5,000	0.42 l/km	606	57%
Diesel-electric (hybrid)	2005	£222,000	£8,500	£5,000	0.30 l/km	690	65%
Hydrogen fuel-cell (hybrid)	2005	£1,000,000	£45,000	£5,000	0.2 kgH2/km	1,710	161%
Electric (renewable / fossil mix)	2005	£220,000	£12,000	£5,000	5.5 MJ/km	657	62%

Source: Ricardo & peer reviewed by Bus Working Group

These technologies were compared to a based line Euro 3 diesel engine. The attributes for the technologies are based upon what the technologies are actually able to achieve today or will become available in the near future. It should be noted that in the case of electricity and hydrogen fuel-cells that the carbon dioxide emissions of the fuel life-cycle could greatly reduced by the generation of electricity from renewable sources.

Annex II

Status of low carbon technology

The three fundamental drive line options for attaining 30% low carbon involve a step change in the technology –

- Internal combustion engine using renewable fuels
- Hybrid (using diesel of fuel cell as the prime mover, with either lectric or mechanical energy storage)
- Battery electric

Internal combustion engine using renewable fuels. To achieve 30% reduction in carbon emissions requires the use of high levels of renewable fuels including bio-diesel, bio-gas and renewable hydrogen.

Hybrid vehicles – three options:

1. ***Diesel/electric*** involves a diesel/electric energy conversion through a diesel engine driving an electric generator; battery storage can be included to provide zero emission operation – suppliers in UK are Wright and formerly Eneco – 10 buses in operation.

2. ***Fuel cell bus***: 3 prototypes operating in London through EY funded program – high initial cost.

3. ***Diesel/mechanical*** involves an infinite variable transmission and flywheel storage; grant request lodged with EST/DfT 4 years ago - no demonstration yet available.

Note that diesel could be replaced by natural gas, biogas or bio-diesel as the prime fuel source.

All electric – two options

1. ***battery buses***: 12 mini size buses operating in Liverpool (?) – limited range.

2. ***battery/flywheel***: grant request lodged with EST/DfT 3 years ago - no demonstration yet available.

Of the 5 major types of drive-line, 3 are operating in small numbers to provide proof of concept and to obtain limited operating experience.

Current data is insufficient to understand the true operating costs because there are so few low carbon buses operating and these are effectively prototypes.

Annex III

Likely improvements in driveline efficiency

(from report to DFT by R Mayer and T Davies (2003)

Table 4.2 Possible efficiency improvements in diesel drive lines

Component	possible efficiency improvement	comment
Euro 3 engine	base line	
Euro 4 engine	?	by 1 October 2006
Continuously variable transmissions (CVT)	10 - 15%	like Torotrak
CVT + regenerative braking system	25 -30%	requires on board storage like flywheel

Table 4.3 Possible efficiency improvements in electric drive lines

Component	possible efficiency improvement	comment
Traction drives	base line	
Industrial drives	2 - 3 %	
Traction motors	base line	
High efficiency motors	1 - 2 %	
Battery lower depth of discharge	5 - 10%	dc link voltage kept within close limits
Small diesel generator	2 – 5%	helps maintain dc link voltage so increasing battery efficiency
Regenerative braking system	25 - 30 %	requires on board storage like flywheel