LowCVP
Low Carbon Vehicle Partnership

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Barriers and opportunities to expand the low carbon bus market in the UK

Task 1: Identification of barriers to uptake of low carbon buses

Prepared for the LowCVP by Transport & Travel Research Ltd, in partnership with TRL.

June 2014

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1 INTRODUCTION

1.1 Background

The overall aim of this study is to assist LowCVP, its key members (including central Government) and bus industry stakeholders to identify the most promising low carbon emission bus (LCEB) technologies from a market perspective, taking into account not only environmental outcomes but a range of barriers and potential related solutions. This will inform recommendations on market support mechanisms, both financial and non-financial.

The purpose of this reported activity (Task 1) is to identify barriers to advancing the LCEB market in the UK informed by a broad consultation with a range of stakeholders in the bus industry, focusing particularly on those who have a significant role in specifying and purchasing vehicles or vehicle upgrades.

Task 1 has collected information to inform a subsequent task on potential support mechanisms. It has also begun a shift in focus from the wide range of technologies considered in the LowCVP low carbon bus technology roadmap, to a more refined list based on the priorities identified in the consultation and the feedback from the customer base for buses and retrofit technologies.

1.2 Report contents

The aim of Task 1 - Identification of barriers and levels of interest to LCEB technology (options and packages) - is to gain input from a range of types of organisation that collectively impact upon vehicle purchasing and retrofitting choices within the bus industry. This has influenced our approach to the consultation sample as outlined in Section 2 on the method employed. The results from the consultation are presented for each stakeholder group in turn in Section 3. The interview guide and invitation letter are contained in the Annex to this report.

2 METHOD

2.1 Approach

Structured telephone interviews were used to gather data from key stakeholders on a number of topics related to the key research questions. The key research questions fell into the following categories:

- Experience and awareness of LCEB
- Decision making processes for purchasing (including barriers and opportunities)
- Financing additional technology costs
- Incentive mechanisms (financial and non-financial)
- Future considerations

The interview data were analysed using qualitative techniques designed to extract central themes and messages, so that conclusions could be drawn.

2.2 Participant recruitment procedure

A contact list was generated by collating contacts from successful Green Bus Fund (GBF) applications, supplemented by contacts known to LowCVP, the study Steering Group and TTR. The list consisted of 120 contacts across a range of organisation types including local bus and coach operators, the Confederation of Passenger Transport, Local Transport Authorities (City Councils, Country Councils, Passenger Transport Executives (PTE), and Transport for London (TfL)), bus manufacturers, technology suppliers and vehicle leasing companies.

Participants were recruited through a multiphase approach. Firstly, every contact on the list was invited to take part in the research by LowCVP (see Appendix A). Following the initial email invitation, each person on the list was contacted by telephone and email to arrange a time and date to participate in a 45 minute telephone interview. Two further attempts were made to contact those where no response was received. Following successful contact, and once the interview was agreed, a meeting request was emailed containing the key topics that would be discussed so that participants could prepare for the interview if they wanted to do so. In total 23 interviews were conducted with representatives from a range of organisation types. The breakdown of respondents can be seen in Table 2 1:

Table 2-1: Breakdown of interviews by organisation type

Organisation type	Number interviews
Bus operator	12
Local Transport / Integrated Transport Authority / PTE	4
Transport for London	1
Manufacturer	3
Technology supplier	1
Leasing company	1
Passenger Transport Executive Group	1
Total	23

In addition, the study team received 1 written response from an additional Passenger Transport Executives (PTE). A description of the types of organisations that participated is provided in the relevant sub-section of Results.

2.3 Interview topic guide

All interviews followed an interview topic guide, an example of which can be seen in Appendix B. Two versions of the topic guide were used, one for the bus operators and one for the local transport authorities. A subsequent variation of this was used for interviews with bus manufacturers, and other stakeholders. The interviews contained the same core topics, but had slight differences in the wording of questions. This standardised approach ensured consistency and that all participants were asked the same basic questions.

2.4 Interview analysis

Interviews were conducted by researchers with expertise in using qualitative techniques from TRL and TTR using the same interview guides to ensure consistency of approach. The interviews were recorded using a Digital Voice Recorders and notes were made after each interview so that thematic content analysis could be conducted by researchers afterwards.

Qualitative analysis is an approach which relies on developing themes during data collection to inform the analysis. The interview notes were analysed using Thematic Content Analysis (e.g. Neuendorf, 2002). This involves condensing raw data into categories and themes based on inference and interpretation. The data were explored by the two researchers who coded the data, and compared the themes and sub-themes to ensure that any new themes emerging from the data were captured.

All results were reviewed in consideration of the five topic areas set out in Section 2.1.

3 RESULTS

3.1 Introduction

The results for each major stakeholder group are presented together, based on the major themes that emerged during the structured discussions. The qualitative nature of the research method and the sample size means that the results cannot be assumed to be representative of the views of the wider member population of each stakeholder group. These results should therefore be used to provide insight and inform understanding, but not taken as the definitive result on a particular topic.

3.2 Bus operators

3.2.1 Overview

- Representatives from 13 bus operators took part in the research.
- Six respondents were from three of the largest national operating groups.
- One community transport operator and one local authority fleet operator (of buses) were included in the sample.
- Fleet sizes reported for the larger operators tended to be between 4,000 and 6,500 vehicles.
- Smaller operators reported fleet sizes of up to 120 vehicles.
- All fleets contained single deck vehicles, and most also contained double deck and some midi or minibus vehicles.
- Average age of fleet (where provided) ranged from 4 years to 11 years. One smaller operator reported a fleet average age of 23 years.

Representatives from thirteen bus operators took part in the survey. The majority took part in telephone interviews, and two provided written responses to the discussion guide topics. A range of services were represented including urban local bus services, dedicated business park operations and school buses. Some operators also conducted long distance services.

3.2.2 Current status of LCEB technologies among operators

- The most commonly used LCEB technology is diesel-electric hybrid.
- Some respondents reported the use of vehicles using compressed natural gas.
- One operator was using UCO (Used Cooking Oil) in a biodiesel blend.
- Some participants had experience of, or were shortly due to introduce, battery electric vehicles (induction charging and plug-in technology).

Respondents were asked to describe their experiences of LCEB within their organisation. If low carbon buses were not currently used operationally, they were asked whether the use of LCEB was being trialled or investigated for potential future use.

All of the respondents had some experience of LCEB. Diesel-electric hybrid buses were the most commonly cited LCEB technology reported to be in service, and this was true for both the larger and smaller operators. Some of the operators (again, both larger and smaller) also reported the use of battery electric vehicles (BEVs) either currently in service or due to be so shortly. Two operators reported using vehicles fuelled by Compressed Natural Gas (CNG), and a further operator had vehicles converted to use Used Cooking Oil (UCO) as bio-fuel.

For the two smaller operators that currently had no LCEB, one (a charitable trust that leases vehicles) is exploring the potential for obtaining gas vehicles using a grant. This operator had previously trialled electric vehicles but had found this type of vehicle was unable to cope with the topography of the service routes. Another respondent, a public authority that operates a small fleet of buses, had previously part-funded two electric vehicles, the operation of which has now been passed on to the operator.

Operators were asked whether they would be most interested in new-vehicle-based technologies or technologies that could be retrofitted to current vehicles. Some of the larger operators were open to both. There appeared to be less knowledge among the smaller operators about the technologies suitable for retrofitting and in the main respondents stated that they would prefer to purchase new vehicles. One respondent explained that this was because new vehicles are 'more reliable and designed for purpose'. Another reported that he would consider retrofitted technologies but was constrained by the conditions of the leasing company they used. There was also a suggestion that when vehicles are required for a specific contract, the route owners specify only new vehicles.

With regards to exploring alternative technologies, one large operator reported that they were investigating the use of liquid air as a fuel, and a further large operator had received funding to explore the use of electromechanical flywheels as a retrofitted feature. The user of UCO stated in their view this gave the best carbon saving of any liquid fuel, and a reduction in tail-pipe emissions.

It was clear that fuel cost was of prime concern to the operators and therefore cost savings were a key motivator for the uptake of LCEB. Some respondents emphasised that while it was desirable to reduce carbon emissions, their primary concern is to achieve greater fuel economies, as fuel costs form a large part of their expenses. One of the larger operators described their fleet strategy as working towards smaller, lighter vehicles, with the main factor driving this being to achieve greater fuel economies. Further emphasis on fuel costs was highlighted by several operators explaining that new standard diesel vehicles will be purchased with the highest Euro-rated engine, which have greater fuel efficiency.

3.2.3 Perceptions of LCEB technologies

Respondents were asked to consider which LCEB technologies were particularly relevant to the bus sector, and what the main benefits and costs were. Respondents did not have direct experience of all technologies and therefore the responses that follow are based on their perceptions of those technologies for which they do not have direct experience as well as their experience of the technologies they use. The results are shown in Table 3-1.

It should be noted that this information is not presented as a summary or assessment of LCEB technology (options or packages), rather it provides the context and experience that the participants had of these technologies at the time of interview. It may be factually incorrect in some cases.

Table 3-1: Perceived advantages and disadvantages of the main LCEB technologies by interview participants

Technology type	Interviewee Perceptions	Views expressed during interviews
Diesel – Electric Hybrid	Perceived Opportunities	• Uses same technology and fuel infrastructure as diesel vehicles • Smoother and cleaner than diesel vehicles • Fuel savings over standard diesel vehicles[1] • Large numbers currently operating that increase confidence in the technology
	Perceived Barriers	• High capital cost • Uncertainty regarding battery life and replacement costs • Reputation of unreliability • Unintended consequence is that driving in a 'defensive driving' manner undermines fuel economy via regenerative braking
Battery Electric Vehicle (BEV)	Perceived Opportunities	• Smoother ride, more comfortable for passengers • Quieter than diesel • Low running costs • Makes sense if on a suitable route
	Perceived Barriers	• High capital cost • Limited range • Smaller vehicles • Needs to be on a suitable route topographically and speed-wise • Uncertainty regarding battery life and replacement costs • Significant refuelling infrastructure costs
Compressed Natural Gas	Perceived Opportunities	• Running costs are favourable once the refuelling infrastructure is in place • Smoother and quieter than diesel • No mid-life costs • Reports that experience from Europe has been favourable
	Perceived Barriers	• High capital costs • Require specialist maintenance[2] • Problems with operational reliability • Significant infrastructure costs • Concerns about potential shortening of engine life • Gas canisters are commonly stored on the roof and this is currently only possible for single deck, so limiting the types of gas vehicles • Lengthy refuelling times

It is emphasised again that there are perceptions based on those with operational experience and those without direct experience. Therefore it is **not** a summary on the actual performance of any given technology option at this current time, but rather the position taken by the respondents at the time of the interview, including some gaps in knowledge.

The three main technology types represented in the table were readily described by all respondents. The general feeling was that while all LCEB produce fuel savings, key considerations for operators was the high purchase cost of all

[1] It was acknowledged by some that this is dependent on average speed and driving style.
[2] One respondent stated there was additional safety training required for staff using CNG

technologies, and the requirement for additional refuelling infrastructure for battery electric hybrids and compressed natural gas vehicles, which adds to the challenges for implementation.

Several respondents mentioned that they had found diesel-electric hybrids to be reliable over several years of operation, resulting in greater confidence about purchasing them. Conversely one respondent without direct experience of diesel-electric hybrids expressed concern with reports of unreliability. As a smaller operator with specific vehicle requirements there would be greater risk if any of the fleet went out of service, and this led to reluctance to consider this technology type. However this operator is currently exploring the potential to add two CNG vehicles into the fleet.

Fuel savings were mentioned by several respondents as one of the reasons for operating diesel-electric hybrids, but it was noted that there is variation in the fuel savings possible as this is dependent on route and driving style. One operator expressed disappointment with the diesel-electric hybrids as the efficiencies obtained had not met expectations. However, another indicated that the improvement in fuel is duty-cycle dependent, and a higher average speed (such as those found outside of urban centres) would provide a greater impact on fuel economy with diesel-electric hybrids.

Two respondents (from the same larger operating group) made reference to an unexpected negative effect on fuel savings of training drivers to drive in a safe and considerate fashion. One respondent reported that the group had observed underwhelming fuel returns. It was suggested that in order to take full advantage of the regenerative braking system in diesel-electric hybrids it is necessary for drivers to use more a more aggressive braking style. However, the organisation operates a scheme for drivers which encourages them to be gentle with the brake and accelerator (for example to 'coast' up to traffic lights) in order to ensure a safe and smooth ride for passengers and to boost fuel economy in standard diesel vehicles. The unintended consequence is that driving in a defensive manner undermines the fuel economy that would otherwise be obtained through regenerative braking in diesel-electric hybrids.

Whilst battery electric vehicles were mentioned by several respondents as the technology they would choose to operate if the service routes were suitable, the high purchase cost combined with the necessary infrastructure requirements meant that currently a business case could not be made for their purchase. One of the larger operators currently running both diesel-electric hybrids and battery electric vehicles reported that he saw the use of hybrids as a stepping stone on the way to a fully electric fleet.

Respondents were asked if they were currently investigating any further LCEB technologies. The following were mentioned:

- Retrofitting technologies such as stop/start or flywheel technologies.
- Increasing fuel economy by reducing vehicle weight.
- Exploring ways to allow the battery to power more of the ancillary controls.
- One operator is investigating the use of liquid air.

One respondent from a large operator suggested that smart alternators, smart or clutch compressors and stop-start technologies would offer best value in terms of costs and benefits as they can be retrofitted and provide incremental savings in carbon emissions.

It was also highlighted that reducing fuel use impacts positively on carbon emissions, and this could be achieved by reducing vehicle weight, or by finding ways to allow the battery in diesel-electric hybrids to power more of the ancillary controls. One respondent suggested that a desirable development would be an extension in battery of hybrid buses, to allow more urban driving to be achieved using the electric element.

It was suggested that carbon savings could also be achieved by exploring how to make standard diesel buses more fuel efficient, for example by re-engineering earlier Euro bus models with the Euro 5 engine, or removing excess weight from standard diesel busses.

3.2.4 Key drivers for uptake of LCEB (in decision making)

The main considerations that would feed into the decision making process for purchasing LCEB were:

- Availability of funding such as the GBF to assist with purchase price.
- Fuel savings and efficiencies.
- Ease of adopting the new technology (refuelling / maintenance).
- Confidence in the technology (particularly reliability being key).
- Meeting environmental targets (both organisational and external).
- Opportunity to upgrade vehicle fleet (taking advantage of funding).
- The perceived competitive edge from using 'Green technology'.
- Public Image / Reputation.

Respondents reported a range of motivations which informed the business case for the purchase of LCEB. Achieving savings in fuel costs was one of the primary considerations for operators, particularly as rising diesel costs form a large part of annual expenditure. Another key motivator was the availability of grants to assist with the purchase price of the various technologies. Several respondents reported that they would not consider LCEB if funding was not available. Even with assisted purchase to offset some of the financial risks, the perceived confidence in the operational reliability of particular power-trains played an important role in the decision-making process. One respondent from a smaller operator suggested that the more technologies are used operationally, the more confident smaller operators will be in using it themselves. A respondent from the larger operating groups suggested that 'in difficult economic times it can be the easier option to stick to what you know.'

Other considerations were similarity with the current fleet regarding maintenance or refuelling requirements. It was suggested that diesel-electric hybrids are more likely to be selected by operators when purchasing LCEB as they are similar to diesel vehicles and maintenance differences are minor, therefore the risks appear to be lower.

Some operators have organisational carbon reduction targets to meet, or a need to assist Local Authorities to achieve theirs. In addition, respondents suggested that operating LCEB would assist their public image and be an advantage in marketing the service.

A respondent from one of the larger operating groups suggested that there was a responsibility by the larger operators to be aware of the available technologies.

3.2.5 Barriers to uptake

The main barriers to the uptake of LCEB were quoted by survey participants as being:

- High capital cost.
- Indication that a reduction in financial support will lead to some operators being less likely to consider the new technologies.
- Infrastructure for CNG and battery electric vehicles requires significant investment.
- Application process for funding is complicated and the response time is too short.
- No steer/guidance on future of the LCEB technologies.
- Concern over battery life and replacement costs of new technologies.

A repeated theme from the interviews was the significant capital costs of LCEB, and this was seen as a key barrier to their uptake. The availability of grants to assist with the purchase price was seen by some respondents as the only way they would consider purchasing LCEB, and there was concern that if the amount or size of available subsidies was reduced, there would be an unwillingness to consider incorporating LCEB into fleets. Some operators mentioned that level of subsidy provided in the latest round of the GBF did not provide a business case for taking an application forward.

Although the presence of subsidies such as the GBF was welcomed, the application process for the GBF in particular was seen to be complicated, and respondents felt that the sporadic nature of the grants do not allow proper planning of LCEB into renewal strategies. Note, this is because the decision about what vehicles to purchase may follow a set process and timetable each year, and the flexibility in financial plans is not available to move this timing or find funds to co-finance particular technologies favoured by a specific round of GBF.

Whilst many diesel-electric hybrids have been purchased using the Green Bus Fund, one of the smaller operators expressed concern over the residual value of the vehicle and suggested that given the potential 5-8 year life of a battery the potential replacement costs may mean only keeping a vehicle for 8 years. This would impact on the payback time of the vehicle. This concern over potential battery replacement costs (for both diesel-electric hybrids and battery electric vehicles) was repeated by other respondents. Another respondent (from a larger operating company) suggested that there is political pressure to adopt diesel-electric hybrids as they are seen as progressive. However the respondent stated that these vehicles are much more complex than standard diesels, have maintenance restrictions due to working with high voltage, and have the high capital cost, which means that it is difficult to justify a business case to purchase them. Another respondent from a larger operating company suggested that full electric vehicles make business sense in terms of much reduced fuel bill and reduction in operating costs. On the right duty-cycle or route the payback time could be around 8 or 9 years. However, concerns were expressed about the uncertainty of replacement battery costs, particularly if that falls within the same time frame.

Respondents also reported that incorporating battery electric vehicles or compressed natural gas vehicles into a fleet requires significant investment in the necessary refuelling infrastructure. One respondent from a smaller operator expressed interest in adding battery electric vehicles to their fleet and suggested three-quarters of their routes would be suitable for these vehicles. However the high capital and infrastructure costs are the main barriers to achieving this.

A concern mentioned by several operators (both larger and smaller) was that there is little consensus on the future of the LCEB technologies, and one respondent was unsure of where to obtain further information. Another would like to see more evidence regarding the reliability of LCEB technologies. His opinion was that gas technologies are well established in Europe and have a proven track record, and that diesel-electric hybrids are reportedly not as reliable as standard diesel, but indicated there should be operational evidence available to assist with decision making. There was a concern by some operators, however, that information regarding fuel efficiency comparisons between technologies could be misleading, as manufacturer testing or European test cycles did not always reflect real world in-service drive cycles.

One of the smaller operators suggested that there appears to have been a lot of trialling of the new technologies on double deck buses but not on single deck vehicles, which are more appropriate for the respondent's operation. In addition, one respondent from a smaller operator commented that the technology is often trialled by the larger operating groups, as they have the financial ability to take some risks with technology.

3.2.6 Financing

Respondents were asked to describe the payback periods considered when purchasing new vehicles, and what factors fed into this. Respondents were also asked whether their fleets were leased or purchased. Some respondents were unwilling to reveal this information.

- Whole life costs generally included consideration of fuel, refuelling infrastructure, maintenance, mileage.
- Large operators reportedly required payback times of between 5 to 15 years.
- Smaller operators reported required shorter payback periods of 3 to 8 years.

There was a mix of purchasing styles among the respondents, with some buying new vehicles outright, and others leasing a percentage of their fleet. Payback times were required to be between 5 and 15 years for the larger operators whilst smaller operators reported required payback times of 3 to 8 years. It should be noted that the payback times and observed difference between large and smaller operators is not a statistically significant results, merely a reported outcome from the selected sample of interviews.

For retrofitted technologies one respondent suggested that a payback time of 3 years would be likely, as they would be generally of a lower cost. One operator with mostly leased vehicles did not consider whole life costs of the fleet.

3.2.7 Incentive mechanisms

Respondents from the bus operator group suggested various support mechanisms that would potentially provide encouragement to purchase LCEB:

- Financial incentives such as GBF and BSOG were strongly supported.
- Manufacturers should be encouraged to reduce purchase price of vehicles.
- There was a need for open sharing of data from in-service trials of LCEB.
- Public Authorities should specify a requirement for LCEB in tenders.
- Leasing companies should be encouraged to provide LCEB.
- Government could play a stronger role in encouraging the use of LCEB.
- Government could provide information and resources to operators.

Financial incentives

The continuation of financial incentives to subsidise the purchase of LCEB was strongly supported and is seen by some as a lead-in for using battery electric vehicles in the long-term. Whilst several respondents expressed regret that financial incentives should be necessary, in the short to medium term funding like the GBF was thought to be the most likely way to counter the high additional investment costs in LCEB technologies and a greater level of uncertainty. Obtaining funding towards the purchase prices mitigates some of the risk for operators. One respondent from the larger operating companies stated that his organisation is not willing to consider vehicles with high purchase price and high infrastructure costs unless the costs are heavily subsidised. Similarly a respondent from a smaller operating company would not purchase a LCEB if there were no support structure from the Government.

Possible improvements to the GBF were suggested, such as a greater level of assurance in the longevity of the grants offered as this would greatly help in new vehicle procurement planning. Additionally, it was suggested that the GBF should take into consideration the whole technology costs (vehicle plus infrastructure), and include retrofitted technologies. One of the respondents from the smaller operating groups reported a feeling that larger companies have taken advantage of the GBF to update their fleet, as they have greater resources than the smaller operators. It was suggested that the bidding process should take into account company size.

Other financial incentives mentioned included:

- Revising the certification for BSOG allowances to reflect what a bus does in service rather than generic duty cycles.
- Increasing the level of BSOG available if operating a very low carbon fleet (i.e. increased level of LCEB BSOG over the current 6ppkm).

Reduction in purchase price

It was suggested by several respondents that the price of new LCEB should be reduced to a commercially acceptable level. The purchase price is one of the main barriers to uptake cited by respondents and there was a concern from several respondents that, for diesel-electric hybrids, the cost was continuing to rise.

Shared information

Some of the respondents (from both larger and smaller operating groups) suggested that the sharing of operational trial data between organisations would help aid understanding of how successful the technologies have been, and enable the industry to learn lessons. Currently there is a lack of transparency in the industry because manufacturers are unable to share trial data from operators concerning in-service performance of technologies, leading to a risk of not discovering operational issues until the new-technology vehicle is in service. There is potentially an opportunity for Government or an other independent organisation (such as LowCVP) to manage the verification and ensure the results were anonymous where necessary in order to avoid compromising sensitive operational information, to enable these data to be shared.

In addition, it was suggested that organisations (such as local authorities) should seek to work in partnership with others to bring LCEB into service. One respondent expressed concern that there is a risk when one party is excluded from the decision making processes which could lead to unintended consequences, such as reduction in bus services or increase in car ownership.

Assistance from Public Authorities

Several respondents suggested that, if a grant was not available, it would be difficult to make a business case to buy a hybrid vehicle unless forced into doing so by an air quality management area or low emission zone. Therefore it was suggested that public authorities look to specifying LCEB requirements for their routes. One respondent suggested that a norm needs to be established of an expectation for the use of LCEB technology. This could be achieved by building a requirement for this into tendering requirements (where there are supported services). However, caution was also raised that if operators are 'forced' into buying LCEB it might lead to a reduction in bus services from operators unable to operate commercially under LCEB requirements.

One respondent commented that public authorities do not always appear to understand the cost involved in operating LCEB buses or expect bidders to absorb the extra cost of LCEB so that the service cost is unaffected. Another requested that there should be an understanding from contract providers that LCEB be operated on the same cost as Euro 5 or Euro 6 vehicles and commercial considerations must apply.

It was also suggested that public authorities could play an additional role in aiding the use of CNG and battery electric vehicles through assistance with refuelling infrastructure costs.

Leasing companies

Several respondents suggested that leasing companies should offer LCEB options. A business case would still need to be made to ensure fuel savings could be balanced against the potential extra expense of leasing cost. Additionally, there was a suggestion that leasing companies could also offer retrofitting of LCEB technologies to aid reducing the carbon output of currently leased vehicles.

Role of Government

Respondents suggested several ways in which the Government could take an enabling role in making it easier for Local Authorities or operators to increase the uptake of uptake of LCEB. This could be by simplifying the application process for grants and subsidies, encouraging manufacturers to lower cost, and providing clarity of political strategy with regard to future carbon targets from this sector.

It was suggested that in order to assist compliance with the aims for reducing carbon emissions, the Government could encourage operators to have a 'green' policy.

A respondent from a smaller operating group expressed a lack of knowledge regarding methods for reducing carbon emissions, and a desire to find out more. They suggested that it would be helpful if the Government distributed information, via white paper or emails, as a trusted source.

One respondent commented that if Government wanted to introduce LCEB nationally, there was a need to provide central funding for the whole of the operation, including technology, kits, installation and training of the workforces.

A few respondents considered that there needed to be increased publicity regarding the requirement for LCEB technologies to inform public opinion. It was suggested that positive public opinion towards LCEB use would increase uptake by operators, particularly if there was a possibility of increasing passenger numbers by using LCEB. One respondent reported that they conducted a recent passenger survey and 'green issues' or the use of low carbon buses was rated as a lower consideration than fares and comfort.

Given some of the suggested initiatives mentioned as useful by bus operators interviewed during the study already exist there would be a benefit from increased communications and marketing of existing policy actions.

3.3 Bus manufacturer, technology developer and leasing company

3.3.1 Overview

A range of 'supply side' organisations participated in the interviews using a topic guide similar to that used for the bus operator and local authority participants. The participants included:

- Three bus manufactures;
- One technology developer; and
- One leasing company participated.

The manufacturer and technology developer/supply organisations had experience of bringing to market were:

- diesel-electric hybrid (parallel and series);
- hydraulic hybrid;
- full electric;
- flywheel;
- ethanol;
- CNG/biomethane; and
- light-weighting, plus smart ancillaries and controls.

Therefore while most current technologies were covered battery electric vehicle were not explicitly represented by a manufacturer or supplier. However, whenever energy storage issues were raised in discussion of diesel-electric hybrid there was regular cross-reference to BEV, and therefore it is thought adequate coverage was made.

3.3.2 Current status of LCEB technologies

This section is based on statements and views of the interviewees, and while these are well-informed it should be noted that the statements have not then been separately verified other than via the research teams existing experience and knowledge. The reader should bear this in mind when relying on this information.

Diesel electric hybrid vehicles are being supplied worldwide, but the largest market outside the UK was the UK. It was perceived that the vast majority of these vehicles were purchased with GBF support, although initial orders were made before the Government support was available. The majority of vehicles are double-deck, although some single deck being sold particularly outside London.

Gas vehicle purchases and those on on-order vehicles had benefited from GBF, in the view of the gas bus supplier interviewed, but with 50% of these were not supported by grants so this funding stream may be less important than for other technologies . All gas vehicles are single deck at present (due to gas tank weight and configuration).

Two different flywheel technologies are currently under production version testing with manufacturers and a number of operators so are expected to be available in standard model ranges and/or in-service in most of the large operating groups in the next 6-12 months. This includes a retrofitting option, working in partnership with a bus manufacturer.

Smart ancillaries and improvements to drive-train and controls were seen to be a normal evolution for the bus maker practices (via truck making experience). These are proving to be of great interest to operators (customers) and seen as an inevitable progression for successful supply companies. Light-weighting and smart ancillaries are being seen as the obvious option for fuel saving if / when GBF not repeated.

The experience of ethanol buses being converted back to diesel fuel use after withdrawal of duty derogation for ED95 was raised as a warning on how wasteful changes in policy support can be, and need for a long-term position to encourage investment beyond the norm.

3.3.3 Perceptions of LCEB performance

Various perceptions and viewpoints from those on the supply side were shared with the interviewers to provide insight into different suppliers views of the technologies they provided, including some acknowledge challenges.

Diesel electric hybrid were showing some very good fuel economy figures (regularly 30% plus, and up to 50%) and fitted with a wish from within the bus industry to move to more electrification. The challenges were primarily longevity and cost:

- Battery life was an unknown (although few reported failures to date according to OEMs) which meant major expenses mid-life on even best-case duration.
- Cost increment was extremely high, particularly so for single deck vehicles.
- Fuel saving (through regenerative braking) less effective on single deck vehicles.
- Safety issues (of 600v power cables) meant more limited servicing options by bus operator maintenance staff.

Gas bus were perceived as a reliable and well tested technology, but one which operators perceived as risky due to different nature of the fuel and its handling. Infrastructure requirement perceived as a major barrier, as cost and time taken to get a connection to medium/high pressure grid very off-putting. The current single-deck only offer for CNG needed addressing to enable its true potential to be realised. The fact that natural gas is available from grid means that bus operators do not have to store (bunker) it, which reduces tied-up finance.

Electric buses were perceived as relatively expensive due to batteries, lower size/payload, and mid-life cost. However despite these disadvantages the view was that increased electrification of the bus power train and ancillaries was a major goal was also held by this group.

Light weighting and smart ancillaries seen as way of achieving LCEB performance reliably and for whole life of bus.

3.3.4 Key drivers for uptake of LCEB (in decision making)

The leasing company representatives view was that the number one and clear priority consideration for bus operators was reliability, followed service support, then fuel consumption with other factors were some way below. Much testing and discussion of fuel consumption was undertaken between manufactures vehicles and options to understand how vehicles performed in different bus operations.

In terms of LCEB, the key drivers towards their uptake has ranged from generic aspects to ones specific to a particular technology:

- Fuel saving/cost.
- BSOG 6ppkm payment (and Scottish Government approach) has been key.
- TfL has been highly influential, with longer contracts being particularly helpful.

There was some acknowledgement that offering a higher quality vehicle (which can include low floor, leather seats etc) can lead to increased patronage and also a change in attitude and attention by travelling public (e.g. leather seats not being vandalised as much as previous cloth seating).

3.3.5 Financing

A range of insights were provided on financial and support mechanisms that OEM could offer. Manufacturers and leasing organisations reported a wish to focus on whole-life costs, but that is not always important to customers (bus operators). The perception was that vehicle technologies would ideally pay back in 5 years or less, whether hybrid or other technologies, in order to make a sale possible to a reasonable share of bus operators.

Comments on finance and leasing included:

- Manufactures have been able to offer financing on vehicles to support customer purchases, including financing necessary infrastructure. This has been necessary to keep interest in face of leasing industry disinterest.
- Leasing industry got badly 'burned' by London bendy-bus withdrawal. That, combined with global recession, means leasing industry perceived to be very wary of bus industry as a profitable customer base.
- Producing lease terms on diesel-electric hybrids and gas buses that are attractive to customers can be difficult to impossible given assumptions required on value of vehicle in second user market. For hybrids this is primarily due to battery life and availability of upgrade parts (if necessary) and for gas this is due to narrow market that has to be prepared to find infrastructure to combine with vehicles.

In terms of the potential for cost reductions then:

- There is a barrier to reducing costs (e.g. for diesel-electric hybrids) because the components required to build the vehicle need to be ordered in excess of 10,000's to get economies, and that scale is not being achieved for vehicle sales for these models in the UK market (of less than 3,000 single and double deck buses per annum).

In order to reduce anxiety about mid-life costs then:

- Warranty periods were typically longer on some LCEB technology (elements of the vehicle) to offset customer reluctance on risk, and to shift to manufacturer.
- The take-up of extended warranties and service contracts had been much higher on diesel-electric hybrids compared to standard diesel buses (where Operators wish to keep skills and maintenance capacity in-house rather than contract out).
- Training of bus operator staff (on maintenance, including when to call the Dealer) and support (through truck-dealer network) seen as essential in terms of supporting LCEB.

In order to market LCEB with different refuelling infrastructure requirements:

- Gas infrastructure barriers were being overcome through close attention and support from vehicle manufacturer and partnerships able offer complete refuelling packages, including temporary filling for vehicles at outset.
- Payback period on gas does need a different view on vehicles and filling station, so it's a long term commitment to move to gas. Linking with other users (e.g. LA RCV fleets) was actively being pursued by bus operators with interest in gas in order to increase throughput of refuelling stations and reduce price per kg.

3.3.6 Incentive mechanisms

A range of potential changes or improvements to existing incentive mechanisms were made by the supply side organisations interviewed.

Key amongst these was that any subsidy (such as 6ppkm for LCEB) needs to be in place for lifetime of any given vehicle, because there is uncertainty and some loss of confidence over an investment decision by the bus operator.

Moreover, future subsidies/support should be more flexible, with the potential for a product showing a greater fuel saving gaining greater support or incentive.

Based on the experience of GBF5, with a 50% subsidy on additional cost (for qualifying technologies), the under application indicated the level of costs the industry would accept in the current policy / support environment. Providing more certainty, though long term commitments, may mean the operator would be comfortable taking on a greater share of the up front cost of LCEB.

There was some expectation that BSOG will become increasingly unavailable to operators (via more use of Better Bus Areas) or totally withdrawn in life of next Parliament. Removal of BSOG would expose bus operators to full implication of fuel price (and price rises) which may drive them to prioritise fuel efficiency more highly… and/or withdraw services.

Some technology providers (gas, flywheel, light-weighting) were broadly comfortable with what incentives had been available to date and did not feel they were necessary for the future for such technologies. Conversely, for diesel electric hybrid, a lack of GBF looked disruptive to ongoing sales at similar volumes. However, there was broad agreement that if incentives were to be in place for fuel efficient technologies these should be applied fairly, and incentives further improvements.

It was agreed that demonstrations are important: once a technology is proved reliable and how it addresses the doubts, then there can be relatively quick adoption (e.g. of low floor vehicles).

Finally, some focus on encouraging removal of the oldest vehicles (E.g. scrappage, or variable VED [acknowledging low range so not currently workable]) may be a sensible tactic to ensure carbon and air quality benefits accrue going forward. Equality Act compliance for the UK local bus fleet by 2015 will mean no (legislative) drivers to remove oldest vehicles, and the bus industry may then keep their oldest vehicles for some time to come.

3.4 Public sector (Transport Authority, PTE, ITA)

3.4.1 Overview

Representatives from five public sector organisations were interviewed. One of the participants managed a small fleet of vehicles for Park & Ride, free transportation between public transport hubs and a service to hospitals. The remainder non-London Authorities procured bus services to fill a local need where no commercial operation existed. Those services included evening or Sunday services, services to villages or suburbs, and school services. One authority (TfL) contracts all of the services, and encourages operators to use LCEB technologies through the service level agreement.

All organisations either enabled the use of LCEB through partnerships and grants or were investigating and promoting the use of low carbon technologies.

3.4.2 Current status of LCEB (by local authority)

The low carbon technologies currently being used within this respondent group are:

- Battery electric vehicles
- Diesel-electric hybrids

Most of the respondents had some experience with applications for the GBF to purchase battery electric vehicles and diesel-electric hybrids. Some authorities have a strategy promoting a multi-technology approach whilst others are concentrating on supporting one LCEB technology.

As this is a small respondent group, their varying experiences with LCEB technology are explained as follows:

- Authority 1 is introducing battery electric vehicles with induction charging, which has required investment in charging infrastructure and maintenance training. As this is a demonstration project, resources are being directed to support this in the short term.
- Authority 2 supports battery electric vehicles as this fits with the air quality requirements of the city centre, and also with the current electric tram system. The authority is able to install charging points at any council owned facility, and battery electric vehicles are used on local links to transport hubs and hospitals.
- Authority 3 has taken part in six rounds of Green Bus Funding, mainly to support the purchase of diesel-electric hybrids by the main commercial operators, although two battery-electric vehicles for supported services have also been obtained. The hybrid vehicles are seen as reliable and have achieved better fuel savings than expected, particularly on the city centre routes. The use of hybrid vehicles is seen as a stepping stone to future technologies.

- Authority 4 has applied for two electric vehicles to service a new housing development. It is hoped that the use of electric vehicles will provide a pleasant customer experience, which will encourage increased use, and will benefit the Council/citizens in terms of air quality improvements. The use of other technologies has been considered (such as increased efficiency standard diesel vehicles and those using compressed natural gas) but a feasibility study showed that over 80% of bus traffic (50% of vehicles) could be delivered using battery electric vehicles and a roadmap has been developed to deliver this over five years.
- Authority 5 has primarily supported procurement of and funding applications for diesel-electric hybrids, with two battery electric vehicles due shortly. The authority has provided support with the charging infrastructure for these two vehicles. The aim for the future is for all relevant routes to use battery electric buses where the authority can influence the market to do so (either by supported services or other means).

3.4.3 Future developments (trialling or testing)

Key future developments that were anticipated or suggested as important were:

- Full battery electric fleet.
- Kinetic energy recovery systems.
- Conversion of older diesel buses to electric powertrains.
- Diesel electric hybrid vehicles with a longer duration on electric duty cycle.
- Greater efficiency for standard diesel buses.

Local authority respondents were asked whether they would consider supporting retrofit low carbon technologies. Three respondents would not consider this. For one, this was because the manufacturer of the vehicles used on the routes did not recommend retrofitting to their vehicles. The other two respondents preferred to specify new vehicles for contracts they intended to award or support, because of the additional customer benefits from new vehicles.

However, of the final two respondents, one was actively monitoring the retrofitting of kinetic energy recovery systems, and the other was investigating retrofitting of electric drive technology into an older standard diesel double decker. The latter is the basis for a demonstration project for extending the life of older vehicles with poor emissions and fuel efficiency (if funding is gained).

One local authority respondent would like to see future development of the batteries in diesel-electric hybrid vehicles to allow longer duration on the electric duty cycle so that more of the city routes can be driven in full electric mode.

It was suggested that there is a role for more fuel efficient diesels, such as Euro 6, and the potential for flywheels, which could give a quick return on investment. The Industry is perceived to be very interested in weight reduction of vehicles as way to drive down fuel economy, rather than choosing just LCEB drive-trains.

One local authority respondent commented that he would like to see more information on the tailpipe emissions of LCEB It was suggested that the reduction of carbon at the tailpipe does not mean a reduction in air quality pollutants to the same degree. This respondent stated that in diesel-electric hybrids the opposite effect may be seen. It was therefore important to seek options that can increase air quality and fuel efficiency, and decrease greenhouse gases.

3.4.4 Key drivers for uptake of LCEB (Decision making)

The main motivators for influencing the use of LCEB were as follows (in no particular order):

- Meeting carbon and air quality targets.
- Availability of subsidies.
- Public image / marketing of the (Local Transport) authority.
- Reduce congestion by encouraging greater public transport use.
- Ability to assist/encourage bus operators to explore LCEB options.

All of the respondents indicated that a requirement to comply with air quality or carbon targets would be an important driver in decision making for encouraging the use of LCEB. Several of the respondents stated that battery electric vehicles were a particularly good fit for the environmental targets of their authority. One respondent explained that there is a strong local political appetite for low carbon initiatives, and this enables schemes to be implemented. Encouraging operators to consider LCEB was seen as key.

The availability of grants and subsidies was seen as essential. One respondent stated that there would be fewer diesel-electric hybrid buses in service if not for the Government grants and subsidies. Another stated that the presence of subsidies was key to their purchase of battery electric buses and this would not have happened without grants. For another respondent, grants were used to assist with refuelling infrastructure costs.

Hybrid vehicles were seen as being easier to introduce into fleets as they are mechanically quite similar to standard diesel buses and do not require additional refuelling infrastructure. However it was suggested that operators would continue to require subsidies as the price differential is still large.

Another driver in the decision making process for public authorities was the opportunity to create an iconic location for tourism or other marketing aims, or to gain reputation for trialling new technology in a demonstration project. Investing in LCEB technologies can therefore be seen as a method of creating uniqueness and a positive way to promote the authority and the area it represents.

Respondents expressed a hope that the use of LCEB, particularly battery electric vehicles, would encourage greater public transport use, with the benefit of reducing congestion from cars. It was suggested that the use of electric vehicles may also cushion passengers from the expected rise in diesel prices.

A further consideration in encouraging the uptake of LCEB was the opportunity for the public authorities to provide support to operators wishing to apply for funding. One respondent's authority had only to supply advice and time and significant management of the application for the Green Bus Fund, which gave them the option to trial new technology with low financial commitment. Several respondents expressed a desire to work in partnership with other organisations to provide support for increasing the use of LCEB.

3.4.5 Barriers to uptake

The main barriers to the uptake of LCEB were:

- High capital cost.
- On-going costs and uncertainties with the technology.
- Reluctance of operators.
- Uncertainty regarding environmental benefits.
- Confusion over which technology is the best.

A repeatedly-mentioned barrier to the uptake of LCEB was the significant capital cost. It was noted that no cost reduction has been demonstrated with diesel-electric hybrid vehicles, and the respondent commented that this might have been expected with the number of vehicles which have been purchased. Operators from smaller operating groups are perceived by respondents to be unable to purchase LCEB without financial assistance, and the larger operating companies more likely to consider their purchase. One respondent commented that local operators have shown no interest in LCEB, and it was suggested that there is less risk in continuing to use the technology they know (that is, standard diesel buses).

Other factors that respondents felt would increase operators' reluctance to purchase were the complexities and cost of installing refuelling infrastructure for both battery electric and compressed natural gas vehicles, and the size of electric vehicles. The biggest electric vehicle currently contains 33 seats which, it was suggested (by some respondents, but not all agree) that this is a compromise for many city operations, and may require additional vehicles to comply with the route requirements.

One respondent mentioned that it is not desirable for authorities themselves to buy the LCEB for supported services (for example Park & Ride) as at the end of the contract period there may be difficulties with liability on handover to a different operator. This means that an Operator investing in low carbon technology has to be comfortable that they wish to keep the vehicle after the minimum contract period, or ensure payback on any additional investment takes place within the same term. One respondent suggested that there can be a business case for purchasing electric vehicles without grants if the payback considered over 15 years, but there remains reputational and reliability risks, in addition to the significant capital outlay. It was noted that the technology for battery electric vehicles is still evolving rapidly and there is uncertainty regarding the whole life cost and battery life.

With regards to the stated environmental benefits of using LCEB, it was reported that there is uncertainty concerning the improvements for air quality. It was suggested that on certain routes diesel-electric hybrids could produce higher nitrogen dioxide levels, and the heavier weight of these vehicles could promote greater road wear.

One respondent reported a large barrier to uptake to be the range of technologies available, as this can produce a lack of clarity in which technology to invest in. It was suggested that the results from the various vehicle trials will provide some information but currently, without a steer regarding which technology to invest in, operators will be reluctant to make a commitment.

3.4.6 Incentive mechanisms

Respondents were asked what incentive mechanisms would enable their (public sector) organisation to provide encouragement to increase the uptake:

- Continued availability of subsidies or reduction in purchase price.
- Encouraging manufacturers to reduce costs.
- Working in partnership to share knowledge.
- Guidance on the future of low carbon vehicles.
- Government could provide a stronger steer on information regarding LCEB.

Financial incentives
Respondents suggested that the continuation of grants and subsidies was important to encourage operators to move towards adopting LCEB. The GBF was seen as essential in the purchase of both hybrid and battery electric buses and it was considered the existence of the GBF has enabled LCEB to be advanced. Where the purchase cost is being offset by GBF it was suggested that operators are prepared to explore LCEB technologies further.

In order to assist with business planning it was suggested that any subsidies should offer a long-term commitment, particularly with regard to BSOG (of 6 ppkm). One respondent recommended that funding such as GBF and BSOG continue, but that it was envisaged that this could reduce over time.

One respondent suggested that a fund be introduced for retrofitting technologies to improve air quality as in his opinion retrofitted technologies can give a better return on investment and are relatively low risk.

Reduction in purchase price
Public sector respondents reported a view that manufacturers should be encouraged to reduce costs. One respondent commented that diesel-electric hybrids have the widest exposure, but there is still a significant premium to purchase the vehicles. It was suggested that although the gap is closing between the costs of diesel-electric and standard diesel, more could be done. One respondent asked if there was a role for the Government in this.

Working in partnership
Some respondents gave consideration as to how they might encourage smaller operators to increase their uptake of l LCEB. It was felt that generally these operators will not be the early adopters and they are likely to be the operators with older vehicles. It is felt that, setting aside the significant capital cost, the risks are higher to smaller fleets of adopting LCEB as there is a greater impact if these buses should prove to be unreliable. It was suggested that Authorities could assist with

the gap in knowledge for operators by providing information on mitigation strategies for financial and operational risks, thus enabling them to feel 'de-risked'. One respondent suggested that authorities could provide experience and staff time, a forum for discussion of LCEB, and inform operators by taking them to see demonstration projects and bus manufacturers.

Respondents stated that Authorities are willing to engage in partnerships with operators, manufacturers and research organisations to support LCEB.

Guidance on which technologies are the way forward

One respondent suggested that there is a need for a steer on which technologies are considered the way forward. Currently there are a range of technologies being trialled and it was suggested that it was important to share information from the various demonstration projects to assist with decision making.

Role of Government /others

Several respondents suggested the lead in encouraging further uptake of LCEB should come from the Government, whether by controlling subsidies or by means of legislation. If the latter, it was emphasised there should be consequences (such as fines) if they are not adhered to.

Government is also well placed to educate the public regarding the benefits of LCEB to influence public opinion towards seeking low carbon options. One respondent commented that decisions are required at a national level to invest more in infrastructure that will assist bus operators to move in the right direction.

Another respondent suggested that greater clarity be provided regarding the aims of low carbon initiatives. The bus industry is looking more to reduce the weight of vehicles to improve fuel efficiency, and this is seen as being as fuel-efficient as buying LCEB. In the opinion of this respondent, the focus should now be on bringing down the cost of LCEB.

It was suggested that Government should provide visible and transparent data on performance of LCEB including range and fuel consumption, and should facilitate sharing of information and good practice. This has the potential to encourage more operators to consider their use.

4 CONCLUSIONS

4.1 Introduction

The aim of Task 1 - Identification of barriers and levels of interest to LCEB technology (options and packages) - was to gain input from a range of types of organisation that collectively impact upon vehicle purchasing and retrofitting choices within the bus industry.

Structured telephone interviews were used to gather data from key stakeholders on a number of topics related to the key research questions. The key research questions fell into the following categories:

- Experience and awareness
- Decision making processes for purchasing (including barriers and opportunities)
- Financing
- Incentive mechanisms (financial and non-financial)
- Future considerations

Findings were obtained from a range of groups, with the largest three groups being:

- bus operators
- bus vehicle and technology suppliers (i.e. vehicle manufacturers, technology suppliers and leasing companies)
- local transport authorities (i.e. public sector)

The aims of this task have been met, the results reported in detail in the previous chapters and now a summary of key findings are set out below.

4.2 Experience and awareness of low carbon emission buses

The range of experience of LCEB ran from two smaller operators with no current experience (but a wish to adopt if grants/finance allowed) to representatives from three of the five major national operating groups. Between the bus operators and suppliers of vehicles the participants had experience with all major current technologies, plus historical experience of others.

Perceptions of LCEB were specific to the individuals interviewed, and used as background information to explain current levels of understanding and viewpoints taken.

4.3 Key drivers for uptake of LCEB (in decision making)

The main considerations that appeared to feed into the decision making process for purchasing LCEB by operators and their suppliers were:

- Fuel savings and efficiencies.
- Availability of funding such as the GBF to assist with purchase price;
- Enhanced BSOG (6 ppkm) for LCEB;
- Opportunity to upgrade vehicle fleet (taking advantage of funding);
- Ease of adopting the new technology (refuelling / maintenance);
- Confidence in the technology (particularly reliability being key);
- Meeting environmental targets (both organisational and external);

- The perceived competitive edge from using 'Green technology'; and
- Public Image / Reputation.

For the local authority participants the main motivators for influencing the use of LCEB were as follows (in no particular order):

- Meeting carbon and air quality targets.
- Availability of subsidies.
- Public image / marketing of the (Local Transport) authority.
- Reduce congestion by encouraging greater public transport use.
- Ability to assist/encourage bus operators to explore LCEB options.

4.4 Barriers to uptake

The main barriers to the uptake of LCEB by operators and their vehicle suppliers, as perceived by the research participants were:

- High capital cost of some technologies, including concern over battery life and in-life replacement costs;
- Infrastructure for CNG and battery electric vehicles requires significant / long-term investment;
- Concern over performance in real-life vs. standard test cycle (used to define LCEB);
- Insufficient steer/guidance on future of the LCEB technologies and longevity of Government support;
- Application process for funding can be complicated and the response time does not always fit existing financial planning.

From the local authority perspective the main barriers to the uptake of LCEB were perceived to be:

- High capital cost;
- On-going costs and uncertainties with the technology;
- Reluctance of operators to adopt these options;
- Uncertainty regarding actual environmental benefits;
- Uncertainty over which technology is the best;

Overall there was some concern about levels of interest in the higher cost technology options, given current uncertainty about a future round of GBF. The impression was gained that operators were not expecting major capital subsidies for LCEB in the near future.

4.5 Financing low carbon emission bus

It was clearly stated that for many LCEB in use or on order for the UK that GBF and the 6ppkm enhanced BSOG had been crucial. This was particularly the case for diesel-electric hybrid options, given their additional cost over other technologies and standard diesel bus.

A range of finance, warranty and training/support options have been put in place by the manufacturers to encourage purchase of LCEB products, including:

- Manufacturers have been able to offer financing on vehicles to support customer purchases, including financing necessary infrastructure.

- Warranty periods were typically longer on some low carbon technology (elements of the vehicle) to offset customer reluctance on risk, and to shift to manufacturer.
- Training of bus operator staff (on maintenance, including when to call the Dealer) and support (through truck-dealer network) seen as essential in terms of supporting LCEB.

In terms of leasing LCEB then key findings were that:

- The leasing industry received a shock from the withdrawal of bendy-buses London. That, combined with the global recession, means the leasing industry is perceived to be wary of bus industry as a profitable customer base.
- Producing lease terms on diesel-electric hybrids and gas buses that are attractive to customers can be difficult to impossible given assumptions required on value of vehicle in second user market. For hybrids this is primarily due to battery life and availability of upgrade parts (if necessary) and for gas this is due to narrow market that has to be prepared to find infrastructure to combine with vehicles.

4.6 Incentive mechanisms and policy support

The relevant context to designing future incentive mechanisms are set out below.

- GBF has been very important to sales of more expensive LCEB technologies (hybrid, electric), a major factor being cost (and uncertainty) over energy storage element;
- However, current grant uncertainty and short notice leads to rapid reaction rather than considered fleet renewal plans;
- Some perception that current financial incentives (GBF) are easier to access for larger operators compared to smaller businesses;
- Reduced Pollution Certificates (and reduced VED) stays with vehicle for lifetime and this principal could be valuable to apply to other subsidies to ensure certainty;

A number of considerations raised by the research are relevant to changes or additions to the financial support of LCEB:

- Reduction of BSOG on fuel (within London and in Better Bus Areas) may stimulate operators to focus more on fuel efficiency… but might in fact lead to a withdrawal of services as overall income shrinks (so care is required in adjustment);
- Suggestion was that any additional operating subsidy (such as the enhanced LCEB BSOG payment of 6ppkm) needs to be in place for the lifetime of any given vehicle (or a defined portion thereof), or it creates uncertainty and reduces confidence.
- Strong support was shown for a change to a graduated (i.e. sliding scale) subsidy rate (which could apply to one or both of operating costs and capital costs), based on the level of carbon saving achieved by the technology. This to ensure fairness but also encourage technology developers to maximise fuel efficiency beyond any artificial threshold *and* to justify milder carbon reduction options available to retrofit on existing older vehicles;
- Adjusting the subsidy rate to a fairer or more accurate system may require a test regime and reference case (i.e. duty cycle) that better represents the variety of vehicles and operations in the UK than the current method of certifying LCEB;
- Support should be available for refuelling/charging infrastructure to complement any vehicle purchases as that is where barriers/costs arise;
- A focus on oldest vehicles (through scrappage or changes in VED) may be more useful in future as no legislative drive to remove oldest vehicles once Equality Act compliance complete.

A number of findings from the research relate to policy side support, information and enabling collaboration:

- Demonstration of technology performance are important, for others to learn and have confidence to follow. There is a role for a independent broker of the information gained by pilots and in-service operation to ensure the whole industry benefits and avoids repeating same mistakes or learning process if it is unnecessary;
- Information and knowledge about what technologies are available can be difficult to access (potentially more so for smaller operators who do not have such close relationship with manufacturers). This indicates a need for accessible guidance on LCEB options and performance, noting that the market is moving rapidly and latest information can be superceded quite quickly;
- Partnerships between Operators and Local Authorities viewed as important by all, and have been instrumental in many LCEB deployment to date. They should be encouraged and facilitated through the various partnership and contract routes made available to Local Transport Authorities which to engage with commercial bus operators;
- Transport policy measures directed at improving air quality, such as low emission zone(s), are seen as useful by all Stakeholders in order to drive change due to pollutant emission benefits of many LCEB;
- Government should set targets for carbon reduction (from road transport and the bus sector) to demonstrate ambition and clarify overall strategy.

Supporting Documentation

Annex 1 Initial email to participants

Annex 2 Interview Topic Guide

Annex 1- Invitation email to participants

Dear,

Research to explore barriers & opportunities to expand the UK low carbon bus market

I am writing to ask for your help with an important research study to inform DfT policy on low carbon buses. The Low Carbon Vehicle Partnership (LowCVP) are conducting a review of the barriers and opportunities to expand the low carbon bus market in the UK following the announcement of the 2012/13 tranche of the Green Bus Fund. We are interested in exploring your views on low carbon buses, including any experiences of buying and using these vehicles. This will help the government understand how the Green Bus Fund, enhanced BSOG and other support mechanism have supported purchase and use of these vehicles and what incentive mechanisms may be most appropriate in the future. If you do not have direct experience of low carbon bus we are still interested in your views.

LowCVP has appointed independent research companies, TTR (working with TRL), to conduct this research. We rely on your voluntary co-operation in this study and I do hope that you (or a colleague) will be able to take part.

The study is relying for stakeholder input at two distinct points:

- telephone interviews (of 45 min) during October to discuss barriers and opportunities for low carbon bus from your organisations perspective, and experience to date; and
- self-completion surveys, available from early January, asking for feedback on the cost/performance mix and level of interest in selected low carbon bus technologies.

We are writing to a large number of stakeholders such as yourself to make you aware of the study.

An interviewer, working on behalf of TRL/TTR, will contact a number of you to arrange an appointment to take part in a short telephone interview. If you are not contacted in the next 2 weeks it means that the Researchers have filled all the sample quotas for the initial interviews. However, there will be the opportunity for *all* stakeholders to use self-completion questionnaires later in the study, and you will be informed by email when this is ready. Also, if you would like to be kept in contact about other opportunities to engage in the study (e.g. webinar, workshop) then do let me know and you will receive an invite to those events.

All information you give during the interview will be treated in the strictest confidence. No information identifying you or your organisation will be passed to LowCVP, or to any other organisation, without your consent.

If you would like to know more about the study, please telephone one of the following key contacts: [contact details removed]

Best regards,

Andy Eastlake CEng FIMechE
Managing Director
Low Carbon Vehicle Partnership
3 Birdcage Walk
London SW1H 9JJ

Annex 2 – Discussion Guide for interviews with Bus Operators

Discussion Guide: Low Carbon Bus - barriers and opportunities

Note to interviewers:* *Interviewer instructions will be presented throughout this guide in bold italic font.

Introduction

We are carrying out this study on behalf of the Low Carbon Vehicle Partnership (LowCVP). The aim of this research is to identify barriers to adoption and levels of interest in the various low carbon bus technology options and packages available. We aim to find out the motivations, views and experiences of organisations which have manufactured, bought, leased or used Low Carbon Buses, in order to understand how technologies and incentives can be improved and/or promoted to new users in the future. As part of this consultation, we are going to be talking to a range of stakeholders including representatives from bus operators, local authorities, leasing companies and bus manufacturers.

We expect this interview to last approximately forty five minutes. There are no right or wrong answers, so please be as honest as you can. It is ok if you feel that you can't or don't want to answer some of the questions.

We would like to record the interview with your permission. This will avoid me having to scribble everything down as you speak. We will only use this recording to help with writing the report. You and your organisation will not be identifiable within any reports published as part of this study. Are you happy to proceed?

A. Background

Rapport building – high level discussion about the interviewee's organisation

- Can you give us some background on your organisation (that you are representing for this discussion [I.e. a depot, a region or a national coverage]?
- What your role entails?

- What type of operation do you provide? i.e. local bus services, P&R, school buses, other?
- How many vehicles do you have in your fleet (and roughly what proportion single, double other sizes)?

B. Experience and awareness of low carbon vehicles

1. Please describe the current status of low carbon buses in your organisation. (If different for different vehicle technologies, please specify by technology)

a. If respondent struggles to answer, use the following as probes. Are you:

i. **using** any low carbon vehicle technologies in **everyday bus** operations? (E.g. hybrid technologies)? If so, what and how many

ii. **testing/trialling** low carbon bus?

iii. **investigating** low carbon bus?

b. Are you most interested in retrofit or new-vehicle based technologies, and why?

2. What Low Carbon Emission Bus technologies are you aware of? [refer to list below]

Diesel powertrain development: ▪ Smart / Clutched Compressor [R] ▪ Smart Alternator [R] Alternative powertrains: ▪ Stop-start [R] ▪ Air hybrid (Pneumatic Booster Systems) [R] ▪ High speed Flywheel [R] ▪ Mild hybrid ▪ Hydraulic hybrids (series) ▪ Diesel-electric hybrid (series or parallel technology) [R]=Technology has been, or could be, retrofitted	Alternative fuels: ▪ Battery electric ▪ Gas: Compressed / Liquefied Natural ▪ Gas: biomethane equivalent Technology 'packages': ▪ P1:Stop-start, Pneumatic Booster Systems and smart ancillaries [R] ▪ P2: Mild-hybrid with smart ancillaries ▪ P3: Flywheel hybrid with stop-start [R]

3. Which of these technologies do you think are particularly relevant in the bus sector (taking into consideration possible benefits and costs)?

- Explore confidence in the technology / concerns regarding the reliability of the technology

C. Decision making process (purchase)

4. a) What were/are the main considerations your organisation would take into account when / for purchasing Low Carbon Buses?

- ***Financial aspects:***
  - *Potential to reduce fuel costs?*
  - *Upfront capital cost*
  - *Whole life cost*
  - *Payback speed (on any additional costs)?*
  - *Availability of Grants / other incentives (state which)*
- ***Refuelling:*** *general availability of infrastructure*
- ***Servicing:*** *ability to do inhouse or availability of servicing support;*
- ***Environment:*** *climate change, pollution/air quality issues*
- ***Vehicle aspects:*** *vehicle performance, comfort, size,etc.*
- ***Public image***
- ***To gain a specific contract that required these vehicles***
- ***To gain experience of low carbon bus within organisation***
- ***Any others?***

b) How important is the role of refuelling infrastructure costs to the decision making process (if the technology requires specific new infrastructure)

5. Of the factors you've talked through, are there any that were / would be more influential than others in your organisation's decision to purchase Low Carbon Buses?

- Are there any that were essential (i.e. you would not have purchased if they had not been in place)?

D. Financing low carbon vehicle technology

6. Does your organisation think in terms of whole life costs of a vehicle, operations & maintenance package (e.g. ppkm) or is some other metric used?

7. What kind of pay-back period is required for new equipment or vehicle enhancements, to make them viable?

8. How does your organisation finance new vehicle purchases?

9. Do you lease vehicles?
- If so, does leasing have an effect on your choice of vehicles?

[Probe: is it a barrier / constraint?]

E. Incentive mechanisms

10. What support mechanisms would work for your organization if it wanted to adopt low carbon bus? [and have they accessed any of these, if so which]?

Prompt: Financial?
Prompt: Non-financial?

11. Thinking back to the list of considerations in the decision making process and the barriers/ opportunities you listed..:

a. How would the support mechanism overcome the barriers / support the opportunities?
Prompts: Explore their confidence in the consistency and durability of the support mechanisms (eg concerns about the longevity of grants (what if they are reduced or withdrawn)

Impact on business planning - how long would the support mechanism have to operate for to create confidence in the market

F. Conclusions

12. What else needs to be done to increase uptake and use of Low Carbon Buses?
[Interviewer: allow open response]

a. Who do you think should be responsible for this?
[Interviewer: Prompt for any not mentioned]
- Government
- local authorities
- manufacturers
- Fleet support / service providers
- Bus companies
- Dealers/leasing companies
- The media
- Any others?

13. Is there anything else that you would like to add about Low Carbon Buses?

Thank you for your time

Report Contact Details

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