Vehicle Accreditation Requirements

Low Carbon Bus Programme

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Introduction

"The Low Carbon Bus Programme" is the name given to a government funded programme run by the Low Carbon Vehicle Partnership (LCVP) which offers grants to companies to assist them with the cost of purchasing Low carbon Buses (as defined by LCVP) or converting existing vehicles to reduce carbon emissions.

This document sets out the requirements and conditions for manufacturers and converters of Low Carbon Buses, that wish to apply for Low Carbon Bus "Vehicle Approval" i.e. for approval of a Vehicle Type under the Low Carbon Bus programme. A Vehicle Type is defined by its make, model and variant and by its powertrain and fuel system. A Low Carbon Bus Application Form, supplied with these guidelines, should be completed for each Vehicle Type for which approval is sought.

To obtain Vehicle Approval a Low Carbon Bus must meet legislative and safety requirements, its emissions over a given test cycle must meet LCVP requirements, and details of the powertrain and fuel system fitted to the vehicle and of how the equipment is installed must be provided.

Additional information as detailed in this and its associated documents must be made available to LCVP

Approved vehicles and details of which companies are approved to supply them will be listed on the Low Carbon Bus Register at [website address if appropriate]

Completed application forms should be returned to:

The Low Carbon Vehicle Partnership
17, Queen Anne’s Gate
London,
SW1H 9BU

Scope

This document sets out the requirements and conditions that must be met by providers of Low Carbon Vehicle technologies that wish to apply for approval for a Low Carbon Bus.

Definition of a Low Carbon Bus

The specific definition of a Low Carbon Bus is as follows:

"A Low Carbon Bus produces at least 30% fewer Greenhouse Gas Emissions than a current Euro 3 equivalent diesel bus of the same total passenger capacity. The Greenhouse Gas (GHG) emissions will be expressed in grams of carbon dioxide equivalent measured over a standard test, and will cover "Well-to-Wheel" (WTW) performance, thereby taking into account both the production of the fuel and its consumption on board".

The principal Greenhouse Gases (GHG) of interest are Carbon Dioxide (CO_2) Methane (CH_4) and Nitrous Oxide (N_2O). The relative "global warming potentials" for these 3 gases are 1:21:310 respectively.

Low Carbon Technologies

The probable means of producing a Low Carbon Bus is by one of the following, either individually or in combination:

a) Use of a rechargeable energy storage system (RESS) to augment the primary power produced by an internal combustion engine e.g. diesel-electric hybrid. This may be either charge sustaining or charge depleting.

b) Electric drive vehicles using a sustainable source of electricity.

c) Use of fuels that are inherently low in greenhouse gases e.g. Rapeseed Methyl Ester (RME)

d) Use of fuel cells using sustainable sources of Hydrogen.

Eligible Vehicles

These guidelines apply to OEM vehicles, OEM approved and warranted conversions, and after-market conversions.

All road-licensed buses complying with Directive 2001/85/EC Classes I and II (from 22 passenger capacity and upwards) may apply for Low Carbon Bus approval.

Low Carbon Bus Emissions Requirements

The LCVP Bus Working Group has defined the target to be met to achieve Low Carbon Bus status. This is shown in Appendix 2. Target fulfilment must include an objective test of vehicle

performance. The test will be carried out on a whole vehicle chassis dynamometer to determine "Tank-to-Wheel" (TTW) emissions and energy consumption. The gas values of methane and nitrous oxide, if measured, will be converted to carbon dioxide equivalent by applying the weightings given earlier.

The whole vehicle emissions results will be used to calculate the GHG emissions performance of the vehicle on a WTW basis appropriate to the fuel as used in the approval test and as used in service.

"Well-to-Tank" (WTT) emissions and energy consumption will be determined using an appropriate analysis such as those carried out by CONCAWE or by L-B-Systemtechnik GmbH or similar body, subject to approval by the Fuels Working Group of LCVP. The results are expressed in grams of carbon dioxide equivalent per MJ of fuel delivered. Knowing the fuel consumption of a vehicle in MJ/km, the WTT GHG figure can be expressed in g/km.

WTW emissions and energy consumption will be determined from the sum of TTW and WTT performance with greenhouse gas emissions expressed as grams of carbon dioxide equivalent per kilometre and energy consumption expressed as MJ per kilometre. Both measures will be assessed against passenger carrying capacity.

In order to be accredited as a "Low Carbon Bus", vehicles must have GHG emissions either on the target line, or below that determined for their passenger carrying capacity. The target line will be used to accredit the bus in "worse case" condition i.e. at the minimum payload corresponding to its CO_2 equivalent emissions performance. Buses found to have CO_2 equivalent emissions higher than that corresponding to its passenger capacity will not be afforded Low Carbon Bus status.

To qualify as a Low Carbon Bus, the vehicle must be certified as a PCV and have a Certificate of Fitness. The whole vehicle emissions when tested on an appropriate chassis dynamometer to LCVP Low Carbon Bus test requirements must be reported.

Low Carbon Vehicle status will be conferred on all vehicles similar to those presented for test, as long as the vehicles use similar fuels and energy management strategies

Whole vehicle testing

The test cycle used will be the Millbrook London Transport Buses (MLTB) cycle based on Route 159 in London. This is described in Appendix 1. In the case of vehicles fitted with internal combustion prime movers, both GHG and air quality emissions (HC, CO, NOx and PM) will be determined over the cycle by use of a full-flow constant volume sampling (CVS) system and appropriate analysis equipment. Fuel consumption will be derived from carbon dioxide and other carbon containing emissions by the carbon-balance method. In the case of vehicles fitted with catalysed particulate traps, Selective Catalytic Reduction (SCR) systems, or those powered by lean-burn natural gas engines NOx speciation will be carried out by use of Fourier Transfer Infra-red Spectroscopy (FTIR)

The Low Carbon Bus Target Line is shown in Appendix 2. Green House Gas emissions are defined against total passenger capacity by the following linear relationship:

$$\mathbf{CO_2\ (WTW) = 7.25 \times \text{total number of passengers} + 480}$$

The mass of a passenger is defined as 68 kg.

The mass of the vehicle in running order will be determined by weighing each bus prior to test.

The mass of the vehicle in running order is defined in Directive 97/27/EC as:

The mass of an unladen vehicle with bodywork, and with coupling device in the case of a towing vehicle, in running order, or the mass of the chassis with cab if the manufacturer does not fit the bodywork and/or coupling device (including coolant, oils, 90% of fuel, 100% of other liquids except used waters, tools, spare wheel, driver (75kg), and, for buses and coaches, the mass of the crew member (75 kg) if there is a crew seat in the vehicle).

For the purposes of these guidelines the mass of a bus in running order is defined as:

The mass of the unladen vehicle with bodywork, in running order, (including coolant, oils, 90% of fuel, 100% of other liquids except used waters, tools, spare wheel [if carried] and driver (75kg), and the mass of the crew member (75 kg) if there is a crew seat in the vehicle).

Total passenger capacity will be calculated by subtracting the measured “mass in running order” from the manufacturer’s declared plated gross vehicle weight (GVW) and dividing by 68. Any differences between the calculated passenger capacity and that declared by the bus manufacturer/supplier will be discussed between the technical service carrying out the test and the manufacturer.

The specific test requirements for vehicles will be dependent on the type of powertrain technology employed and is described below

Test Requirements

Vehicles fitted with conventional powertrain drivelines

The test requirements are described in Annex A1 – Determination of Energy Consumption and Pollutant Emissions from Low Carbon Buses fitted with Conventional Powertrains.

The test is required, in essence, to be repeated 3 times and an average of the three valid tests presented for accreditation. For the tests to be valid the CO_2 emissions must be within 5% across all three tests.

Annex A1 includes associated appendices as follows:

Appendix 1: MLTB Drive cycle
Appendix 2: Well-to-Wheel calculations
Appendix 3: Passenger capacity vs. Greenhouse Gas Emissions (CO_2 equivalence)
Appendix 4: Essential characteristics of the vehicle powered by an internal combustion engine only and information concerning the conduct of the test
Appendix 5: Test report and Approval

Vehicles fitted with charge sustaining hybrid powertrain incorporating a rechargeable energy storage system (RESS)

The test requirements are described in Annex A2 – Determination of Energy Consumption and Pollutant Emissions from Low Carbon Buses fitted with Charge Sustaining Hybrid Powertrains.

For vehicles fitted with hybrid powertrains the state of charge of the RESS may be different at the end of the test cycle to that at the start of the test cycle. This must be considered when determining pollutant emission levels and energy use. If the Net Energy Change (NEC) of the RESS is less than 1% of total energy used over the cycle, then the emissions and energy consumption test results can be used without correction. If the NEC is greater than 1% a method of correction for change in state of charge (SOC) of the RESS during the test must be employed.

Appropriate data i.e. RESS SOC, energy inflow/outflow shall be provided from the vehicle's energy management system on a second-by-second basis during the test. This is analysed to provide a correction for emissions and fuel consumption at an equivalent zero change of SOC. This requires a minimum of three valid tests to be presented. For a test to be valid, the NEC over the drive cycle must be less than 5% of total energy used over the cycle. Tests with NEC of greater than 5% will be considered invalid.

Annex A2 includes associated appendices as follows:

Appendix 1: MLTB Drive cycle
Appendix 2: Well-to-Wheel calculations
Appendix 3: Passenger capacity vs. Greenhouse Gas Emissions (CO_2 equivalence)
Appendix 4: Essential characteristics of the vehicle powered by a charge sustaining hybrid powertrain and information concerning the conduct of the test
Appendix 5: Test report and Approval

Vehicles fitted with charge depleting hybrid powertrain incorporating a rechargeable energy storage system (RESS)

The test requirements are described in Annex A3 – Determination of Energy Consumption and Pollutant Emissions from Low Carbon Buses fitted with Charge Depleting Hybrid Powertrains.

Tailpipe mass emissions from charge-depleting hybrid vehicles are likely to be less than those of charge-sustaining hybrid vehicles because charge-depleting hybrid vehicles draw down the stored energy of the RESS, which means less energy is provided by the prime mover. Therefore, to provide a true accounting of the emissions and fuel economy of the vehicle, emissions and energy associated with consumed electricity generation for the RESS must be accounted for.

After conducting a test run, the energy required (kilowatt-hours) to recharge the RESS to the SOC at the beginning of the test run must be measured at the wall meter upstream from the vehicle charger. The energy consumed is then divided by the total distance traveled by the vehicle over the test run as noted by the dynamometer or the target cycle distance, whichever is lower. The resulting energy input (kilowatt-hours per kilometre) is then assigned a CO_2 generation value determined from the generation mix appropriate to the supply. This generation value will be added to the CO_2 results determined directly from the vehicle test.

The test is required, in essence, to be repeated 3 times and an average of the three valid tests presented for accreditation. For the tests to be valid the total CO_2 emissions must be within 5% across all three tests.

Annex A3 includes associated appendices as follows:

Appendix 1: MLTB Drive cycle
Appendix 2: Well-to-Wheel calculations
Appendix 3: Passenger capacity vs. Greenhouse Gas Emissions (CO_2 equivalence)
Appendix 4: Essential characteristics of the vehicle powered by a charge depleting hybrid powertrain and information concerning the conduct of the test
Appendix 5: Test report and Approval

Vehicles fitted with pure electric drivelines

The test requirements are described in Annex A4 – Determination of Energy Performance of Low Carbon Buses fitted with Pure Electric Drivelines.

Starting from a known RESS SOC (normally 100% of standard operating SOC), the vehicle is driven over two complete drive cycles. After conducting a test run, the energy required (kilowatt-hours) to recharge the RESS to the SOC at the beginning of the test run must be measured at the wall meter upstream from the vehicle charger. The energy consumed is then divided by the total distance travelled by the vehicle over the test run as noted by the dynamometer or the target cycle distance, whichever is lower. The resulting energy input (kilowatt-hours per kilometre) is then assigned a CO_2 generation value determined from the generation mix appropriate to the supply.

Annex A4 includes associated appendices as follows:

Appendix 1: MLTB Drive cycle
Appendix 2: Well-to-Wheel calculations
Appendix 3: Passenger capacity vs. Greenhouse Gas Emissions (CO_2 equivalence)
Appendix 4: Essential characteristics of the vehicle powered by a pure electric powertrain and information concerning the conduct of the test
Appendix 5: Test report and Approval

Additional/optional drive cycles

Whilst the MLTB test cycle is considered as a suitable test for the purposes of “benchmarking” and Low Carbon Accreditation, future vehicles and their drivelines may be designed around specific operating cycles. It is known that choice of drive cycle can have a significant effect on both the emissions and the fuel efficiency of hybrid vehicles and therefore the option of testing to alternative drive cycles may be considered as an additional, optional phase of the test. This issue will be discussed with the Low Carbon technology provider and the test cycle will be defined prior to any test work.

Eligible Test Centres

Performance and emissions testing of Low Carbon Buses must be carried out by a vehicle testing agency that is acceptable to the Type Approval Authority of an EU Member State.

Test Fuel

Composition

Emissions tests for vehicles running on conventional diesel will use commercial low-sulphur, ultra-low sulphur or sulphur-free diesel complying with BS EN590 2000.

Emissions tests for vehicles running on natural gas must use “Reference Fuel G25” as defined in Annex IX of Directive 98/69/EC.

Emissions tests for vehicles running on LPG must use “Reference Fuel B” as defined in Annex IX of Directive 98/69/EC.

For vehicles running on bio-diesel or other “alternative fuels”, the fuel specification and composition will be declared prior to the test. In order to determine Well-to-Tank GHG emissions, the fuel pathway must be known and the appropriate GHG value agreed for the method of extraction/production.

Fuel sampling

A sample of the test fuel will be obtained from the vehicle immediately prior to testing on the chassis dynamometer

Accreditation

Information contained within Appendices 4 and 5 of the test procedure appropriate the type of powertrain employed will be presented for accreditation.

Right of Suspension and/or Termination

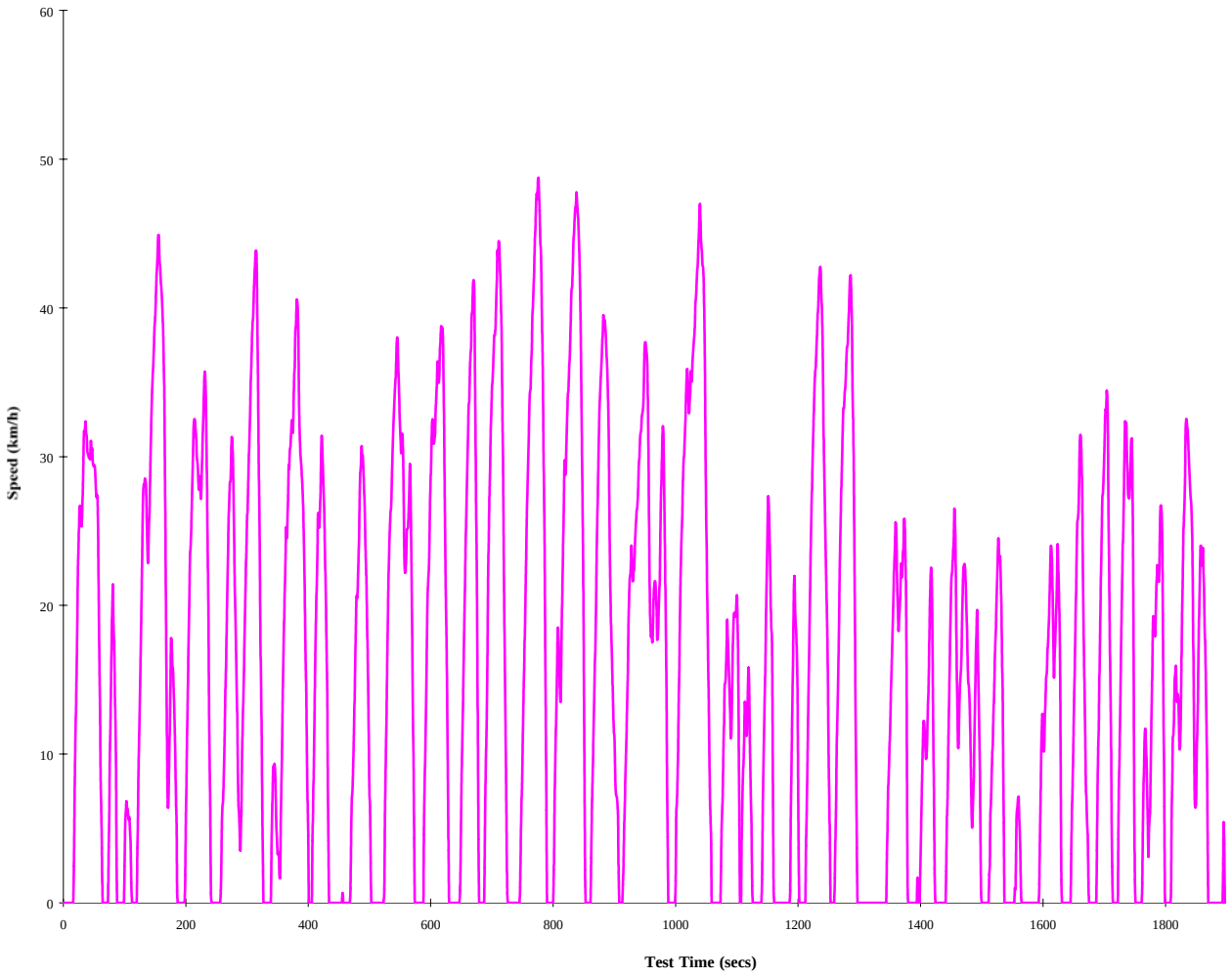
LCVP reserves the right to suspend for such period as it thinks fit, or terminate, the Vehicle Approval status of any product (and having done so, to remove the product in question from the Low Carbon Bus Register) by sending notice in writing to the relevant Company at any time if any of the information provided by or on behalf of the Company in support of its application for Vehicle Approval status is found to be inaccurate or untrue

Appendix 1 – MILLBROOK LONDON TRANSPORT BUS (MLTB) DRIVE-CYCLE

This test cycle was specifically developed for use with buses and was derived from data logged from a bus in service within inner London.
The drive cycle consists of two phases, a medium speed 'Outer London' phase simulating a journey from Brixton Station to Trafalgar Square and a low speed 'Inner London' phase simulating a journey from Trafalgar Square to the end of Oxford Street.

The cycle is composed of two phases:

(1) Outer London Phase, nominal distance 6.45 km, 1,380 seconds in duration
(2) Inner London Phase, nominal distance 2.47 km, 901 seconds duration



General information
The overall length of the test is 2,281 seconds and the nominal distance covered is 8.92 km.
Test cell ambient temperature for duration of test = 18°C ± 2°C

Appendix 2 - Low Carbon Bus CO2 emissions target line