Low Carbon HGVs - Technology Accreditation and Whole Vehicle Integration Study

Final Report

by B Robinson, S Greenshields, D Pickavance & C Bowser

FLD401Q

CLIENT PROJECT REPORT

Transport Research Laboratory

CLIENT PROJECT REPORT CPR879

Low Carbon HGVs - Technology Accreditation and Whole Vehicle Integration Study

Final Report

by B Robinson, S Greenshields, D Pickavance & C Bowser (TRL)

Prepared for:	**Project Record:**	**FLD401Q**
		Low Carbon HGVs - Technology Accreditation and Whole Vehicle Integration Study
	Client:	**Department for Transport, Freight & Logistics Division**
		(James Williams/Joanna Bertoni)

	Name	Date Approved
Project Manager	Mike Ainge	03/09/2010
Technical Referee	Marcus Jones	03/09/2010

Contents

List of Figures

List of Tables

Executive summary

With HGVs accounting for about 20 per cent of the UK's domestic transport emissions, the DfT is eager to support and encourage the decarbonisation of freight and logistics movements. Central to this aim is the assessment of new technologies.

Building on some preliminary work (by Ricardo) to identify a range of technologies with the potential to significantly decarbonise HGV movements, this current project (carried out on behalf of the Low Carbon Vehicle Partnership, Commercial Vehicle Steering Group, supported by DfT) aims to propose test procedures for a range of low carbon technologies and linking mechanisms to assess whole vehicles. The procedures and framework developed should form the basis for DfT to encourage the cost-effective uptake of low carbon technologies within the HGV fleet. It will also provide evidence for DfT in support of its assessment of which approach to accreditation for low carbon HGV technologies should be used in the UK.

This report describes the findings with regard to the technology accreditation and whole vehicle integration project. The major tasks for this project were:

Task 1: Review of existing test procedures, with recommendations as to which low carbon technologies would be best suited to the subsequent tasks and which tests offer the most cost effective potential for incorporation into a wider accreditation framework;

Task 2: Development of a draft accreditation procedure, that defines, for the agreed range of technologies, what tests should be carried out and how they should link together to establish the low carbon credentials of the technologies to be tested;

Task 3: Development of a methodological framework that establishes how best to adapt the accreditation procedure for individual technologies and combinations of technologies (defined in Task 2) into a comprehensive, strategic framework for the assessment of whole vehicles;

Task 4: Validation, to check as far as possible (within the constraints of the project) the extent to which the accreditation procedures developed in Tasks 1-3 represent real-world, whole vehicle conditions.

The analyses have identified three main types of heavy vehicle fuel consumption and emissions tests; in-use (road or test track), engine dynamometer and chassis dynamometer. The technologies assessed as part of this work (in conjunction with a separate but linked technology testing project) relate to:

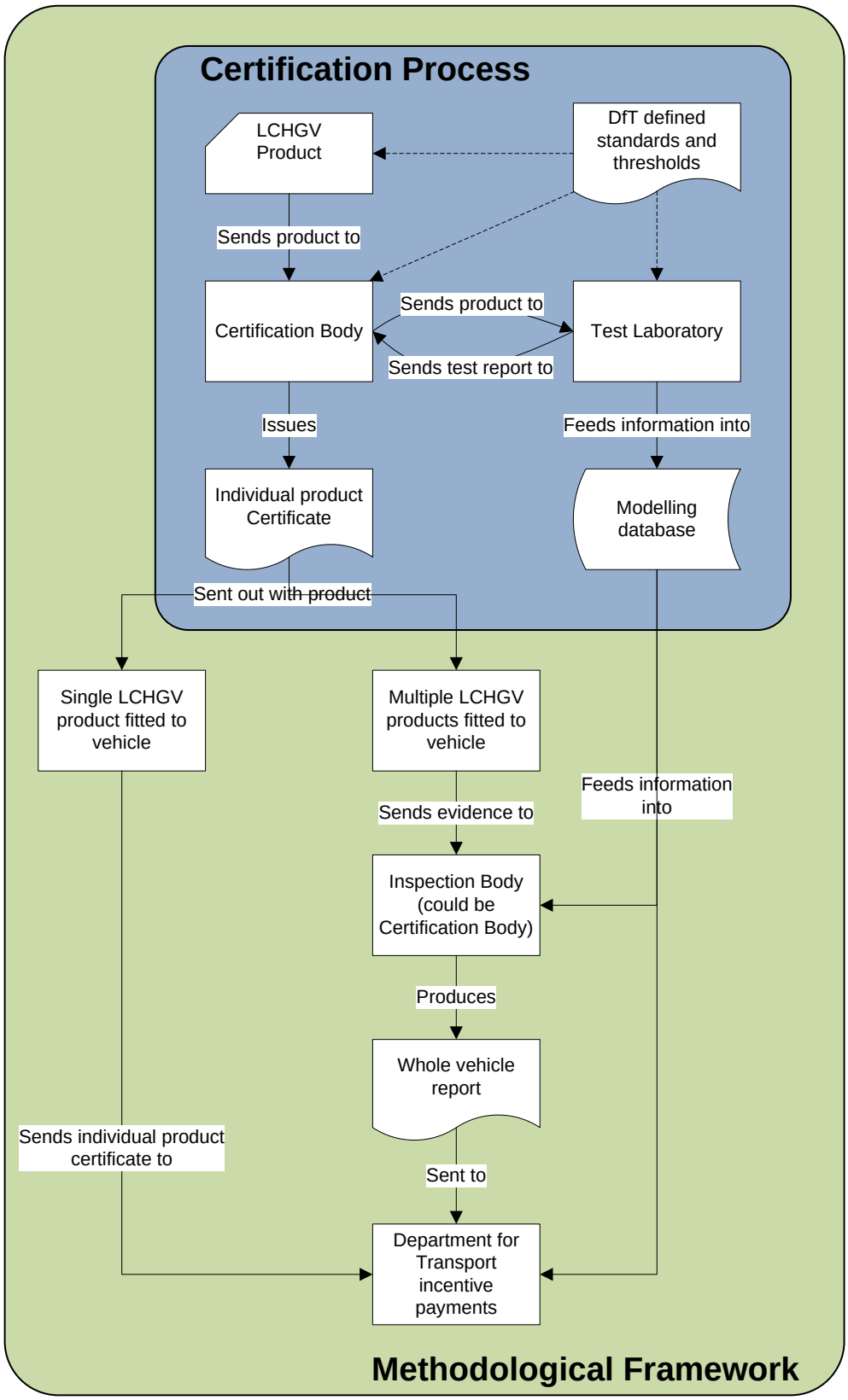
- Aerofoil/lower aerodynamic drag effects;
- Lower rolling resistance (tyres);
- Weight-saving;
- Electric vehicle (EV) technologies.

The analyses and testing suggest that track testing is particularly well suited to the aerodynamic and low rolling resistance products, while both track testing and/or chassis dynamometer testing can be applied to the weight saving and EV technologies.

The choice of metric, in particular its normalisation by load carried and/or by load carrying volume, is vital to the overall success of the scheme and needs further exploration to define the circumstances in which one or the other should be used.

The project team have identified various certification schemes for energy/fuel saving products in the UK and other jurisdictions, in use and under development, which provide useful potential models for UK application. None, though, offer all the advantages of a bespoke scheme aimed specifically at decarbonising the UK road freight sector. The bespoke scheme developed, in consultation with interested parties, provides a potentially

suitable certification process and methodological framework (Tasks 2 and 3), and many of its detailed working characteristics have already been defined. The certification process for individual products and its fit within the wider methodological framework for low carbon HGV certification is shown in the following diagram.



Outline of suggested Certification Process and Methodological Framework

It should be noted that the Framework described here is based on an assumption that any incentive payments would go to the vehicle operator; it is conceivable that incentives could (instead or as well) go to the technology suppliers, but these options have not been explored in detail within the constraints of the current project.

Only limited validation was envisaged at this early stage in the development of a certification scheme for low carbon HGVs. The testing carried out by Millbrook, under TRL's guidance, has shown that HGVs can be tested in a variety of ways and that, generally speaking, those procedures can distinguish technologies likely to have the potential to aid fuel and emissions savings from those without such potential. Further work is needed, including to assess more technology and vehicle combinations and to ensure that a product certified as "low carbon" is likely to save fuel when applied across the fleet, in appropriate circumstances. Like the main certification procedure, the validation procedure will itself need to be defined as part of the overall methodological framework.

The report concludes with a brief summary of the work done and a short, strategic guide for policy makers.

The work carried out for this project has highlighted the fundamental importance of the quality of the evidence available to support the certification of individual products, combinations of products or whole vehicles. Without reliable, trustworthy and appropriate evidence of the technologies' ability to save fuel and carbon in real world usage, a credible certification scheme is simply not feasible.

Of lesser significance, but still crucial to a credible scheme, is the matter of recognition, i.e. how the "low carbonness" of a product, group of products or vehicle is assessed and communicated to potential users.

While a certification scheme for low carbon HGVs might operate successfully without additional financial incentives (over and above the fuel cost savings), they may well be vital in giving confidence to the market and helping to overcome barriers such as long payback periods and high upfront capital costs. They are thus relevant to the overall development of a methodological framework.

A credible scheme can be defined as one that achieves operator buy-in, supports UK Government policy and achievement of climate change/energy targets, and that adds value to the development of a market for low carbon HGVs.

Within all three relevant areas (evidence, recognition and incentives), there are a wide range of possible options and the final choice of which option will inevitably involve some compromise and striking a balance between the needs of the market, the policy objectives and available resources. While an outline certification scheme and methodological framework have been developed within this project, further work is needed to define the precise details of the evidence gathering, the recognition procedures and the incentive mechanism, in consultation with the various interested parties. Amongst the key issues to be resolved are:

- how the test and modelling procedures can be designed to cost-effectively ensure sufficient credibility;
- whether a bespoke UK scheme should be designed specifically for low carbon HGVs or whether something already in existence (but not designed specifically for HGVs) can be more cost-effectively adapted;
- whether a UK scheme should be DfT-led or private-sector led (the main potential advantages and risks with each option are defined in the report);
- whether any incentives should be targeted at the vehicle operators or the technology manufacturers, or a mixture of both, to best influence the uptake of the technologies in the market.

1 Introduction

With the Climate Change Act of 2008 and its setting of progressively tightening carbon budgets to achieve an 80% overall emissions reduction from 1990 levels by 2050, action across Government is being taken forward to identify and implement cost effective carbon reduction measures, as set out in the *UK Low Carbon Transition Plan* published in July 2009. The DfT's contribution was set out in *Low Carbon Transport: A Greener Future* published at the same time. With HGVs accounting for about 20 per cent of the UK's domestic transport emissions, the DfT is eager to support and encourage the decarbonisation of freight and logistics movements. Central to this aim is the assessment of new technologies.

Building on some preliminary work (by Ricardo) to identify a range of technologies with the potential to significantly decarbonise HGV movements, this current project (carried out on behalf of the Low Carbon Vehicle Partnership, Commercial Vehicle Steering Group, supported by DfT) aims to propose test procedures for a range of low carbon technologies and linking mechanisms to assess whole vehicles. The procedures and framework developed should form the basis for DfT to encourage the cost-effective uptake of low carbon technologies within the HGV fleet. It will also provide evidence for DfT in support of its assessment of which approach to accreditation for low carbon HGV technologies should be used in the UK.

This project (ref FLD401Q) is one of an initial group of five inter-related projects aimed at assessing and developing the market for low carbon HGV (LCHGV) technologies (Table 1-1). Four organisations (TRL/Millbrook, Ricardo and AEA), between them, led these projects, while working in close collaboration and co-operation with each other under the guidance and assistance of the Low Carbon Vehicle Partnership (LowCVP).

Table 1-1. First phase DfT/LowCVP Low Carbon HGV projects

	Project Title	Led by
1	Technology Road Map	Ricardo
2	LCHGV Market Study	AEA
3	Technology Testing	TRL/Millbrook
4	LCHGV Technology Accreditation and Whole Vehicle Integration	TRL/Millbrook
5	LCHGV Efficiency Modelling	Ricardo

This report describes the findings with regard to the technology accreditation and whole vehicle integration project. The major tasks were agreed at the outset to be:

Task 1: Review of existing test procedures, with recommendations as to which low carbon technologies would be best suited to the subsequent tasks and which tests offer the most cost effective potential for incorporation into a wider accreditation framework;

Task 2: Development of a draft accreditation procedure, that defines, for the agreed range of technologies, what tests should be carried out and how they should link together to establish the technologies' carbon credentials;

Task 3: Development of a methodological framework that establishes how best to adapt the accreditation procedure for individual technologies and combinations of technologies (defined in Task 2) into a comprehensive, strategic framework for the assessment of whole vehicles;

Task 4: Validation, to check as far as possible (within the constraints of the project) the extent to which the accreditation procedures developed in Tasks 1-3 represent real-world, whole vehicle conditions.

2 Task 1 – Review of existing test procedures

2.1 Testing and Modelling

Some form of standard or specification is needed for any type of Certification. This can encompass any required testing and/or modelling needed to assess the capabilities or performance of the product, process or system being certified.

For the purposes of this project, the items under consideration would come under the general heading of 'Product Certification'. Product Certification is distinct from other forms of Certification, such as 'Management Certification' (which is more systems and process focused, e.g. ISO 9001).

The products in question are various devices fitted to HGVs for the purpose of lowering fuel consumption and CO_2 emissions, and have now been defined as those products relating to:

- Aerofoil/lower aerodynamic drag effects;
- Lower rolling resistance (tyres);
- Weight-saving;
- Electric vehicle (EV) technologies (changed from hybrid technologies).

A standard for any of these products should be formed of two parts, which define:

- How the product is used;
- How the product is tested.

While this initial project aims to develop a standard relevant to these four specific technology types, based on testing of a small number of individual products, it should also be broad enough to cover any technology in those areas that may arise (i.e. it should be generally applicable and not discourage innovation). It should also be expandable and adaptable, so that other types of de-carbonising technologies can be covered by the standard in future.

Whatever its ultimate scope, it must be credible - to the HGV freight and haulage industries, and to policy makers. It must, therefore, be based on rigorous, reliable and repeatable testing and/or modelling that can identify those technologies that will genuinely help vehicle operators using them (under clearly defined conditions) to save fuel, money and CO_2.

The following sections discuss the key testing and modelling elements of various existing Standards and Certification/Accreditation schemes, relevant to low carbon HGV technologies and identified by the project team.

2.2 Existing Standards

2.2.1 SAE Standards

Various Society of Automotive Engineers (SAE) standards exist relating to vehicle emissions, including SAE 1264, SAE 1321, SAE 1526, and RP 1109. These define the procedures to be followed during in-use fuel consumption tests of heavy vehicles, i.e. with each vehicle operating on public roads over its normal route (typically of 400 miles or more for each test run). They are particularly useful for direct comparison between two similar trucks, e.g. to assess whether Truck A can perform the same task while using more or less fuel than Truck B.

In-use performance can also be assessed (and more closely controlled) by using a test-track, with the driver instructed to follow a specific duty cycle.

2.2.2 UNECE regulations

A recent UNECE Regulation 49 deals with gaseous and particulate pollutants from compression ignition (Diesel) engines. Section 5 of the Regulation deals with the tests available for such vehicles, known as ESC (European Stationary Cycle), ELR (European Load Response), and ETC (European Transient Cycle) tests, all of which are achieved on an engine dynamometer. The regulations are thus only relevant to the engines, and cannot consider any other (vehicle-based) effects on fuel consumption.

2.2.3 EC Directives

The present emission standard for Heavy Duty Diesel engines under European legislation is Euro V, which uses the ESC and ELR test cycles (and so is also engine-, not vehicle-specific). Carbon dioxide is not regulated directly, but the emissions of CO (carbon monoxide), HC (hydrocarbons), NO_X (oxides of nitrogen) and PM (particulates) are measured as functions of the engine power delivery, in grams per kilowatt hour.

2.2.4 Procedures for the accreditation of low carbon buses

Millbrook and LowCVP developed the standards and procedures for accreditation/certification of low carbon buses. The procedures derive from a variety of sources, including experience gained by the Energy Saving Trust, SAE J2711, UNECE Regulation 101 and BS EN 1986-1. The net result is a test procedure using a whole vehicle (chassis) dynamometer, run in accordance with the Millbrook London Transport Buses (MLTB) duty cycle. Well-to-Wheel (WTW) emissions are calculated by adding the calculated test-cycle (tank to wheel, TTW) emissions to the embedded emissions of the fuel (well to tank, WTT, expressed in g per MJ of fuel delivered). The emissions are then normalised according to the total passenger carrying capacity of the vehicle.

Summary

The analyses have identified three main types of heavy vehicle fuel consumption and emissions tests; in-use, engine dynamometer and chassis dynamometer. The applicability of these methods are summarised in Table 2-1.

Table 2-1. Summary of test procedures

Type of test	applicable technology	test procedures	duty cycles	vehicle types	repeatability	Potential performance with a range of vehicle and uses.	Potential relevance
In - use test/ track testing	All types of technology	Testing of two vehicles, one following the other, normally on the public road but can be on a track. This can measure relative performance (such as fuel use), but not absolute performance unless a reference vehicle performance is known. Several standards exist for this (SAE 1264, SAE 1321, SAE 1526, RP1109). This test procedure also relies upon accurate measurement of some metric. For example this parameter could be fuel usage, emitted CO2 emissions and the like.	In theory any duty cycle can be devised that a suitable route can be found for or simulated. Also auxiliary equipment such as power take-offs can be used.	Can be used with any vehicle type, but only in comparison with a 'similar' reference vehicle. This could create a difficulty relating to the meaning of 'similar'.	Test is dependent upon the road conditions, therefore would not be reliably repeatable. Track testing helps, but variations due to weather and driver still exist.	This test would be useful for testing the impact of one or more technology against a reference vehicle (such as an identical vehicle bar the additional technologies). Some duty cycles may not be reproducible by different test tracks, e.g. hill circuits.	This test procedure could be highly useful to gauge the relative impact of a particular technology, however given the difficulties of repeatability, to form the basis of scientific certification may require several repeat runs. Not well suited to measuring absolute values of fuel consumption.
Engine Dynamometer	Powertrain only	Euro V tests may prove suitable for engine dynamometer tests. The regulation sets out the various settings and duty cycles required, as well as the mathematics and science of the metrology.	In theory any duty cycle can be devised for an engine dynamometer. As with all duty cycles the difficulty is choosing the correct one(s).	Independent of vehicle type.	As the tests are undertaken under scientific conditions, the tests are very repeatable.	The engine is tested independently of the vehicle. Substantial additional tests would be needed to accurately simulate transmission, rolling resistance and aerodynamic effects.	This test procedure would be of limited value to whole vehicle testing unless the addition of different technologies could be adequately simulated. Not relevant to finished vehicles from which the engine cannot be removed.
Chassis dynamometer	Whole vehicle (in combination with a coast down test)	The chassis dynamometer is a step up from the engine dynamometer, in that a whole vehicle is placed on a dynamometer therefore the impact of transmission losses may be accurately determined.	In theory any duty cycle can be devised for a chassis dynamometer. As with all duty cycles the difficulty is choosing the correct one(s).	Providing that an adequate dynamometer is provided, any vehicle type could be tested.	As the tests are undertaken under scientific conditions, the tests are very repeatable.	This test is more suitable for whole vehicle tests than the engine dynamometer, but additional (coast down) tests are needed to simulate aerodynamic effects.	This test procedure would be of relatively good value to whole vehicle testing, as it tests the whole vehicle, and is repeatable, but is more expensive than track testing alone.

2.3 Testing of the interactions between different types of product

Whole vehicle testing is by its very nature a time consuming and costly process. It also relies on the tested vehicle being as close as possible to the "in-use" condition, in this case with all its de-carbonising aids fitted. It is conceivable, however, that a vehicle tested with one particular combination of aids might exhibit very different fuel consumption characteristics if that combination changed slightly, e.g. if another aid were added or one removed. This is because different aids may interact with each other in ways that are either mutually beneficial or mutually counteracting, i.e. their individual de-carbonising potential is wholly or partially cancelled out when used together.

Although the basic product groups are already known, the interactions between the various technologies is not yet fully understood, and cannot be until such time as they are tested or assessed. To avoid the financially prohibitive scenario of testing every product in every combination with every other product, it is suggested that the option of using engineering judgement be used to provide a likely, first order impact assessment, informed by relevant testing and modelling experience.

2.4 Metrology

The characteristics of the in-use duty cycle are crucial determinants of a vehicle's fuel consumption when issues such as rolling resistance and aerodynamics are being considered. Aerodynamic aids have a weight penalty which will have a detrimental impact upon fuel consumption and CO_2 emissions below an effective speed. Similarly other technologies such as hybrids may have a lower efficiency at higher speeds. For this reason several duty cycles which match operating conditions may be required.

Although fuel consumption and CO_2 emissions are closely correlated, just measuring fuel consumption is not sufficient to accurately predict the emissions. This is because not all the carbon within the fuel is converted to carbon dioxide, but instead can remain unburnt and/or be transformed into various other chemical pollutants. It is therefore necessary to perform a carbon balance calculation, based on known quantities of fuel and of the various (non CO_2) tail-pipe emissions to derive the CO_2 emissions. Standards exist that define exactly how to perform these calculations.

2.5 Metrics

Defining appropriate emissions metrics for Heavy Goods Vehicles is complicated due to the wide variety of vehicle types and ways in which they are used. Passenger car emissions are reported as a simple grams per kilometre, under certain defined operating conditions. Although the published figures are not a perfect indicator of the actual emissions performance of the vehicle in use (which will depend on the journey types, loading condition, driver behaviour, weather conditions, etc), they are a useful indicator of the average emissions for vehicles of that type over the wide range of actual conditions.

Such a metric would not, however, make sense for HGVs which can vary massively in size to carry large goods, and can vary massively in weight. The smallest, lightest vehicles would inevitably have the lowest per kilometre emissions figures, but favouring them over much larger vehicles (able to carry far more goods) would be counter-productive because so many more of these small vehicles would be needed to carry the same weight or volume of goods.

In the same way, therefore, that the low carbon bus scheme is normalised to passenger carrying capacity (i.e. grammes per passenger-kilometre is the preferred metric), some form of normalisation by load carrying capacity, either by weight or volume, or both, is likely to be needed.

2.5.1 Normalisation by vehicle size (load volume)

In simple terms due to the economies of scale of HGVs, a single large HGV may carry, say, 20 times more volume of goods than a smaller truck or van, whereas the CO_2 emissions would be far less than 20 times. Therefore the effective carrying volume of a vehicle is important, with better economies coming from larger vehicles (provided that this carrying capacity is actually used). For this reason a CO_2 measure of **g/km/effective m^3** metric is potentially useful.

There are also further issues, such as the determination of the effective carrying volume with certain vehicles (such as flat-bedded or open ones). There is also no guarantee that the vehicle would be used sensibly. A high carrying volume vehicle could be purchased on the grounds of an incentive, however for most of the time a lower capacity vehicle might be more fuel efficient if that extra volume is rarely used. Normal freight operator economics should mitigate this risk, provided the incentive is not set so high as to distort the market, so that even with the incentive, the non fully-utilised high carrying capacity vehicle would still be more costly to run, overall, than a full, lower volume equivalent.

2.5.2 Normalisation by vehicle weight (tonnage capacity)

HGVs are often used to carry heavy loads, and thus reach their maximum weight before filling their effective carrying volume. A simple measure of CO_2 in **g/km/tonne-carried** metric is useful for this scenario.

Similar issues, though, arise as for the volume capacity metric, in that vehicles would be incentivised on the grounds of their low emissions per tonne capacity, but would have relatively high emissions per tonne-km if they are often used at much below their gross weight (and very probably higher emissions overall than a lower GVW vehicle used to transport the same goods over the same mileage). Any low carbon HGV incentive scheme offering financial encouragement to operators would have to be designed carefully to ensure the lowest overall emissions options are also the most cost-effective.

Summary

Both forms of emissions normalisation (by volume and by weight) have advantages and disadvantages dependent on the operational characteristics of the vehicle. Further work is needed to fully assess under which circumstances one can sensibly take priority over the other, but the most likely outcome is that some combination of the two will be needed.

3 Task 2 – Accreditation/Certification of CO_2 saving products

3.1 Review of existing schemes

The project team have identified various certification schemes for energy/fuel saving products of a similar nature and/or in other jurisdictions, both in use and under development, which provide useful models and are described below.

3.1.1 SmartWay

SmartWay is a brand which "identifies products and services that reduce transportation-related emissions", specifically for ground-based vehicles. Presently there is large HGV programme which certifies products on the basis of a third party SAE J1321 test report.

The United States' Environmental Protection Agency runs SmartWay as a voluntary scheme for private enterprise. SmartWay runs in the US, and was launched in 2004, but "the programme has established an international benchmark for freight transportation" (Cummins Inc, 2009), with its results and tools being used in Mexico, China and Canada and under consideration in Europe and Australia. SmartWay offers models, analysis, testing and tools for its (2,000+) partner companies to quantify the costs and benefits of operational and technology options to reduce emissions and fuel consumption. It covers line-haul trucks only, i.e. those used for long inter-city journeys, generally at high average speed and at high load factors. The SmartWay label provides recognition for participating operators and fleets, while the programme is driven by the cost savings participants gain through fuel efficiency.

3.1.1.1 Smartway Operation

SmartWay operates in two ways:

- A fuel and emissions tracking program for fleet operators; and
- by certifying vehicles and trailers.

The scheme is not restricted to HGVs, it also covers things such as private cars. However it deals with HGVs as a specific group, but only those defined as US Class 8 type vehicles (combination tractor-trailer trucks used in line-haul service).

There are 4 types of low carbon HGV technology which are verified:

- Idle Reduction Technologies
- Aerodynamic Technologies
- Low Rolling Resistance Tyres
- Retrofit Technologies

Lists of SmartWay verified products exist for each type and the incentive for manufacturers and end users is that government grants are available for using SmartWay products.

The EPA produces a list of verified products and state the basic conditions under which it will generate results. It also lists the likely fuel saving as a % across the board, but does not do this for individual items (only for the generic technology types). This is called 'equipment' based specification and obviously lacks the ability to drive the market towards more efficient designs within each of the four categories.

3.1.1.2 SmartWay Testing

SmartWay presently measures fuel economy using a modified version of the Joint TMC/SAE Fuel Consumption Test Procedure – Type II (SAE J1321 Surface Vehicle Recommended Practice, October 1986).

Where testing is undertaken, the manufacturer bears the cost. The EPA presently only requires that it receives a copy of the test results and a statement from the product manufacturer and the test facility that it was a valid SAE J1321 test.

However, SmartWay is moving across to a new standard (currently in draft form[1]), which is of interest to HGV testing as it addresses the lack of tests available for measuring the fuel efficiency of a whole HGV rather than just its components. The new testing regime is designed to move SmartWay away from an 'equipment' specification and move it towards a 'performance' specification, and expands its coverage into other duty cycles, e.g. local pick up and delivery vehicles, refuse trucks and buses.

3.1.2 Cummins Inc proposals for a regulatory framework

As its contribution to a (US) National Academy of Sciences (NAS) project, Cummins Inc outlined a proposal for a regulatory framework for greenhouse gas emissions from commercial vehicles in August 2009 (Cummins Inc, 2009). They suggest a two-tier framework that involves engine/powertrain only testing for "vocational" vehicles (defined as non line-haul vehicles), including those with a hybrid powertrain, and whole vehicle testing, modelling or design-assessment for line-haul vehicles. The logic of this is argued on the grounds that the engine and powertrain are the key technologies to cut emissions from vocational vehicles, because aerodynamic and rolling resistance effects are relatively minor contributors at low speed, low load and with frequent stops/starts.

Cummins Inc describe the advantages and disadvantages of the various approaches (both performance and design-based), and the desirability of defining a baseline from which to set progressive future standards. Three options are presented:

Option 1 – Design-based: certification based on the specific technologies fitted to the vehicle. Individual components certified to relevant standards and a whole vehicle performance category assigned to indicate the level of greenhouse gas (GHG) reduction expected for specific groupings of component technologies.

Option 2 – Modelling: requiring the development of a computer model to determine the emissions of a given vehicle, based on input data relating to engine emissions, aerodynamics, transmission and rear axle ratios, accessory loads, rolling resistance information, etc. Relies crucially on the creation and maintenanace of accurate sub-system and component data.

Option 3 – Whole vehicle testing: Acknowledged as being expensive and unlikely to be sufficiently accurate and repeatable enough for regulatory purposes.

The authors suggest that options 1 and 2 are the most suitable, with option 3 only being appropriate for small vehicles not subject to significant variations in body type.

3.1.3 Energy Saving Trust

The Energy Saving Trust is a partnership of government and industry which, amongst other activities, certifies household appliances, heating, insulation etc based upon various factors primarily relating to their energy use. Certification via a type test allows the products to carry a graduated label from A (best) to F (worst) to act as a guide to consumers. This may offer a model for product promotion that is slightly more useful than the SmartWay mark, and could be used in conjunction with a simple mark.

[1] *SmartWay Fuel Efficiency Test Protocol for Medium and Heavy-Duty Vehicles* http://www.epa.gov/SmartwayLogistics/transport//documents/tech/420p07003.pdf

3.1.4 Carbon Trust

The Carbon Trust is similar to the Energy Saving Trust in that it is a partnership of government and industry which aims to reduce CO_2 emissions, except rather than an emphasis on the home; it offers specialist advice and assistance to larger businesses. As well as providing a potentially useful funding resource for the LCHGV project, the Carbon Trust is responsible for the Energy Technology List (ETL) – a list of approved technologies which also qualify for the Government's Enhanced Capital Allowance (ECA) scheme. The ECA scheme allows businesses to claim a full 100% capital allowance on equipment in the first tax year, as opposed to the usual 20% for plant and machinery investments. Technologies on the list (mainly building services and process equipment, but not vehicles or their components) are certified as being energy efficient, against a variety of prescribed standards depending on the specific type of technology.

3.1.5 Toprunner

Toprunner is a Japanese fuel economy labelling scheme (with regards to vehicles, but also covering energy efficiency ratings for household appliances). The incentive is via the label to push sales, with the label relating to how much the product reaches (or does not reach) that year's performance target in percentages, and there are ever increasingly difficult performance targets on each financial year. This means it is not just a single standard to reach (such as Euro V), but encourages further development over and above this. Note that it does not appear to offer financial incentives.

3.1.6 EC (Lot 2) Project

A consortium of (non-UK) organisations are currently engaged in a Lot 2 EC framework project "development and testing of a certification procedure for CO_2 emissions and fuel consumption of Heavy Duty Vehicles (HDVs)". It is being led by the Technical University of Graz (Austria) and also involves research, testing, industrial and consultancy organisations from Holland, Germany, Finland and Sweden. The project started in 2010, builds on earlier testing and analyses, and aims to develop a certification procedure that:

- Incentivises the application of relevant, fuel efficient technologies;
- Is repeatable and reproducible;
- Has high sensitivity for fuel saving measures;
- Produce realistic results at reasonable cost;
- Is applicable to the vast majority of HDV categories and technologies;
- Is simple and robust.

The project is covering test procedures (whole vehicle, engine and simulation), duty cycles, metrics, classification schemes and applicability to components and whole vehicles. The consortium members expect to report their findings and produce a draft certification method in late 2011 or early 2012.

Summary

Certification is generally a rather similar process regardless of the product being certified; it is only the detail that changes and the need for ongoing certification, which is often neglected by regulatory schemes. However, within the above are models for CO_2 emissions labelling and certification which could provide useful ideas. There are four schemes in use or in development that seem to offer the greatest potential for UK application, and that may present a lower cost and/or lower risk option than the development of a bespoke UK scheme along the lines described in the remainder of this report. Some of the main advantages and disadvantages of all five options are summarised in Table 3-1.

Table 3-1. UK scheme options

Scheme	Advantages	Disadvantages
SmartWay	Costs of testing are borne by manufacturer Endorsed by industry Uses certification recognisable logo	Does not measure CO2 (it measures fuel emissions only) Is based on an equipment rather than performance specification, so does not measure the whole vehicle Limited range of duty cycles. US based scheme, so will need to be re-validated for UK vehicle types and duty cycles.
Energy Saving Trust	Certifies household products to a grade (A to F) rather than a simple benchmark	Setting level of grade is difficult.
Carbon Trust	Runs the Enhanced Capital Allowance scheme for certified products which reduce CO_2, through the Energy Technologies List.	Currently not set up to cover vehicle-based technologies.
EC (Lot 2) Project	Could provide technical input to the development of a UK scheme. Could provide a certification methodology for the scheme	Timescales mean that results and recommendations are unlikely before 2012.
Bespoke	No need to compromise the key features of the scheme by fitting to an existing scheme can be optimised for UK road freight transport sector.	Costs and timescales of producing a bespoke scheme.

The detailed investigation of these options is outside the scope of the current project, but it is suggested that such further investigation would be appropriate and help to ensure that the final version of the scheme for low carbon HGVs is as cost effective as possible, within ongoing public expenditure constraints.

3.2 Suggested testing procedures

The TRL and Millbrook programme of vehicle trials has provided a clearer picture of the suitability of the various test procedures to each product group. The results allow relevant duty cycles and methods of measurement to be suggested. Further work is needed relating to the metric of measurement, which covers both of the key freight transport issues of weight and volume in a fair manner for CO2.

Based on the reviews of existing procedures and schemes carried out for this project, and the TRL/Millbrook test experiences, a summary of the most suitable tests is given in Table 3-2. The main effect of the testing programme, over and above the literature review, in this regard is to highlight that track testing can be highly repeatable and actually more cost effective than a chassis dynamometer test – which in any event requires some track testing (coastdown).

Table 3-2. Common test procedures by product group

Product Groups	Metrology	Metric	Issues
Aerofoils	Coast-down tests from 56mph and constant speed tests.	% reduction in CO2/weight/distance or volume on a range of duty cycles.	Correct setting of aerofoil.
Tyres	Coast-down test from 56mph and constant speed tests.		Difference of tread depth over life of tyre. Consistency of test under different conditions.
Weight	Coast-down test from 56mph and constant speed tests and/or chassis dynamometer test.		Choice of duty cycle
EVs	Coast-down test from 56mph and constant speed tests and/or chassis dynamometer test.		Choice of duty cycle

The TRL/Millbrook test programme is using appropriate combinations of track tests (coast down and constant speed) and chassis dynamometer tests, with a preference for track tests where a choice between them and chassis dynamometer tests exists.

3.3 An accreditation scheme for low carbon HGV products

3.3.1 Introduction

The aim of the accreditation scheme is to produce a certification methodology or process which will identify products or systems which meet certain requirements under an LCHGV scheme. This section describes and discusses the key features of such a scheme, including:

- A process for certification of technologies;
- Evidence of performance of technologies or whole vehicles;
- Recognition of eligibility by the Department for Transport;
- Scheme levels and issues for further investigation.

3.3.2 Process

As described in the project proposal, and reflected in Figure 1, the overall plan is to create a robust and permanent methodological framework and accreditation procedure (the upper Tier 1 of the diagram) through which low carbon technologies can be certified both now and in the future, accepting that the technologies, duty cycles, test procedures and vehicle types may well change over the lifetime of the scheme (Tier 2).

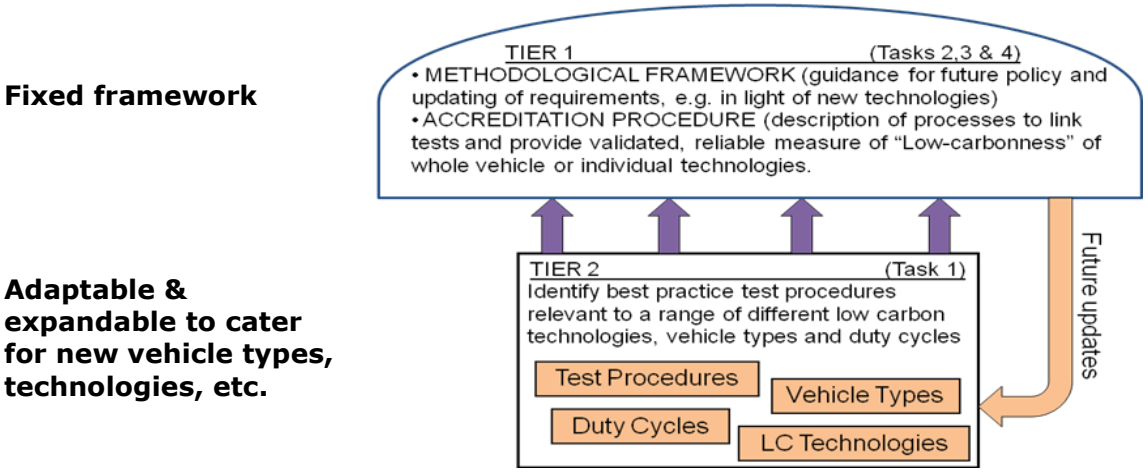


Figure 1. Methodology for accreditation system

The aim of this framework is to build a process for assessing and verifying (and ulimately certifying) the CO_2 reducing capabilities of technologies, or groups of technologies. These capabilities can be found by testing, modelling using known data, or by combining both.

The methodolgical framework should comprise three major elements; evidence, recognition and incentives, as shown diagrammatically in Figure 2. The relative weighting and prioritisation between these elements can vary, depending on the aims of the scheme and the needs of the market. Each element is discussed individually in the following sections. Evidence and recognition are elements of the accreditation/certification scheme, whereas incentives fit into the broader methodological framework.

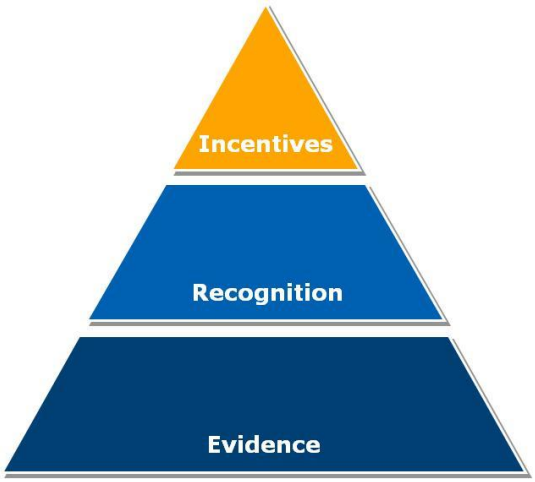


Figure 2. Elements of the Methodological Framework

3.3.3 Evidence

Certification decisions need to be based upon sound evidence, usually obtained via audit or test. Any audit or test must result in a trail of relevant and verifiable evidence against which a third party (i.e. someone different from the auditor or test engineer) is able to make a final certification decision. The challenge, therefore, for any test regime is to ensure that verifiable and repeatable results can be generated and recorded from tests which are accepted by all parties as suitable for purpose. An additional challenge within this test regime is to have the ability to test individual LCHGV products (which could be a component, device or whole vehicle), and their interaction with other LCHGV products,

the impact of different vehicle types and duties, and the addition of new types of products and innovations.

The form of evidence will vary depending on whether the technologies' performance can be determined from a model or whether it requires testing, or a suitable combination of modelling and testing to gain this information.

3.3.3.1 Testing and Modelling

The physical testing of various technologies has been carried out by Millbrook, and performance data generated. Ricardo are using these data in their development of a test data based modelling process. This process will be valid for certain products or groups of technologies but might not be valid for other technologies, where testing will become necessary. This process will give the Certification Body the tools required to make an assessment of the technologies' performance via a variety of routes.

A potential impact of one product's interaction with another product is that a large amount of testing could be required. The plan for the testing regime is to understand the CO_2 reductions gained by the use of LC HGV products in such a way as to allow for computer modelling of interactions in the future. This can be derived from:

- type testing of individual products which gathers sufficient data for a model;
- an engineering assessment of the impact of the product under consideration on other LCHGV products (with additional testing to provide evidence where necessary) which produces data suitable for modelling.

Following initial testing, certification is also based upon the confidence that the product as produced and sold is the same as that tested. For this reason some form of check on production, such as a Factory Production Control (FPC) audit, is also undertaken on a regular basis, or is integrated under conformity of production clauses within type approval legislation. Thus two certifications may be required:

- for individual products and the manufacturer's ability to control manufacturing and product consistency
- for whole vehicles upon which single or multiple products are used.

It is suggested that the results of any test might be added to the modelling database and a designation number assigned to the product to assist with whole vehicle modelling. How such certification might operate and be recognised is discussed below. If any innovation or new LCHGV product comes onto the market, the testing standards can be expanded as long as data required by the model is generated.

3.3.4 Recognition

In simple terms, certification is generally confirmed by the issue of a certificate which provides some form of recognition of performance or compliance, and often indicated by some form of mark on the product (the BSi kitemark on window glass being a classic example). The relative importance of this certificate and any mark is very much dependent upon the target market.

In this case, individual products will require a certificate which simply states that the LCHGV product is certified, complete with a designation number which can be used to model CO_2 reduction. A mark could also be affixed to such products and the accompanying literature, instructions for use, or operating manual.

Whole vehicles might also be certified based upon modelling of the various LCHGV products fitted to them (and of other factors such as the basic vehicle and duty cycle), or could be treated as an individual product.

Given the relatively low number of LC HGV products and their requirement for marking, the certification of these individual products would be best handled by a suitably experienced Certification Body using the process shown in Figure 3. It should be noted that this is one part of a larger methodological framework, described in later sections.

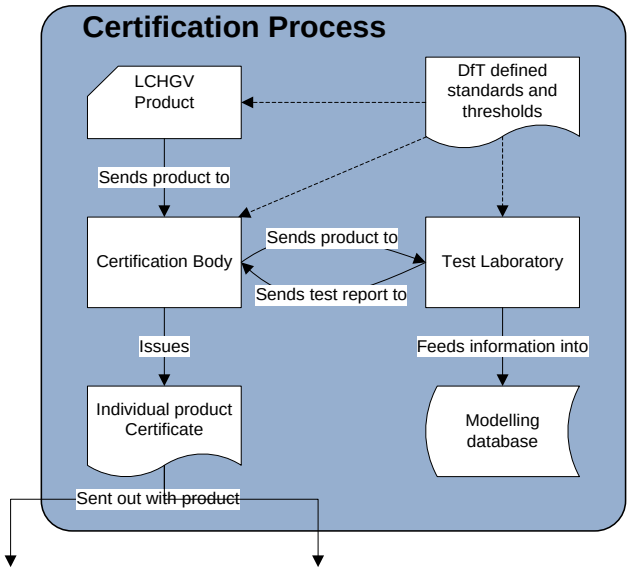


Figure 3. Certification and Recognition Process for LCHGV technologies

Under such an arrangement, an operator who has fitted a single certified technology could apply direct to the Department for Transport (or other funding body) for an incentive payment, based on submission of an application and evidence of fitting the certified technology, device or system (copy of certificate and other evidence yet to be defined). To allow for the possibility that fitting two or more products may be counter-productive in terms of carbon emissions reductions (because of the ways they interact with each other), the certification process will need to work slightly differently in this case, to avoid incentivising increased carbon emissions.

The Certification of whole vehicles comprising multiple LCHGV products could also be handled by the same Certification Body. The Certification Body would take information from the individual products' certificates and input that, and other, data into the model, then issue a certificate with an absolute CO_2 reduction metric on it for use by an operator to submit a claim for incentive payments (or a modelled performance beyond a certain threshold, e.g. at least a 15% reduction over a baseline vehicle, or other relevant benchmark defined by Department for Transport). Photographs could also accompany this submission to substantiate appropriate fitment.

This approach covers both the product certification and vehicle certification enabling the Department for Transport to have visibility of the whole process. The approach also allows DfT to accurately monitor the effect of the scheme. An option to allow certified whole vehicles to carry a certification mark is also available.

An absolute CO_2 saving metric could be used as the basis for incentivising vehicle operators, as could a measure of the return on investment.

3.3.5 Incentives

The aim of an incentive based process would be to achieve maximum buy-in from the vehicle operators and develop the market for low carbon technologies. Whilst simple economics should already encourage vehicle operators to fit such technologies, where the fuel cost savings outweigh the fitment costs, lengthy payback periods or high upfront capital costs may well discourage many from doing so. It is therefore important that the

process sets an initial entry level which is easily achievable and is populated with sufficient products to achieve real savings in CO_2 which can be reported. Once this process becomes established and operators realise financial savings due to fuel saving, the process should perpetuate, driven by commercial imperatives.

At a progress meeting with project interested parties on 28th April 2010, the principle of a 2-stage incentive system was proposed, where operators could opt for higher specifications of technologies and achieve higher incentive by testing (this is by definition a more costly route). However, in light of the need for a well-populated list of certified products to launch the scheme, it might be more valuable to use the resources that would be required to fund higher incentives to encourage (as a pump-priming process) product manufacturers to gain certification. They will be reluctant to go through a potentially costly certification process without some level of certainty that the scheme will achieve widespread application and there will be a payback.

Further work will be needed to establish whether any incentives should be targeted at the vehicle operators or the technology manufacturers, or a mixture of both, to best influence the uptake of the technologies in the market.

Summary

The success of a certification scheme for low carbon HGVs will be crucially dependent on the credibility, reliability and trustworthiness of the evidence gathered by the testing and modelling procedures.

Recognition is also crucial, though its extent can vary in response to market demands, e.g. simple certificate only or more complex grading and/or marking.

Incentives are not essential for the certification process to work, but can help to develop markets for the certified products and are thus considered to be part of the overall methodological framework.

4 Task 3 - A Methodological Framework

The methodological framework (Figure 4) is the overall process for the granting of incentives to promote products which reduce CO_2 output from HGVs. This incentive scheme is reliant on certified products which can be scientifically and reliably demonstrated to reduce fuel consumption and/or reduce CO_2 emissions from HGVs.

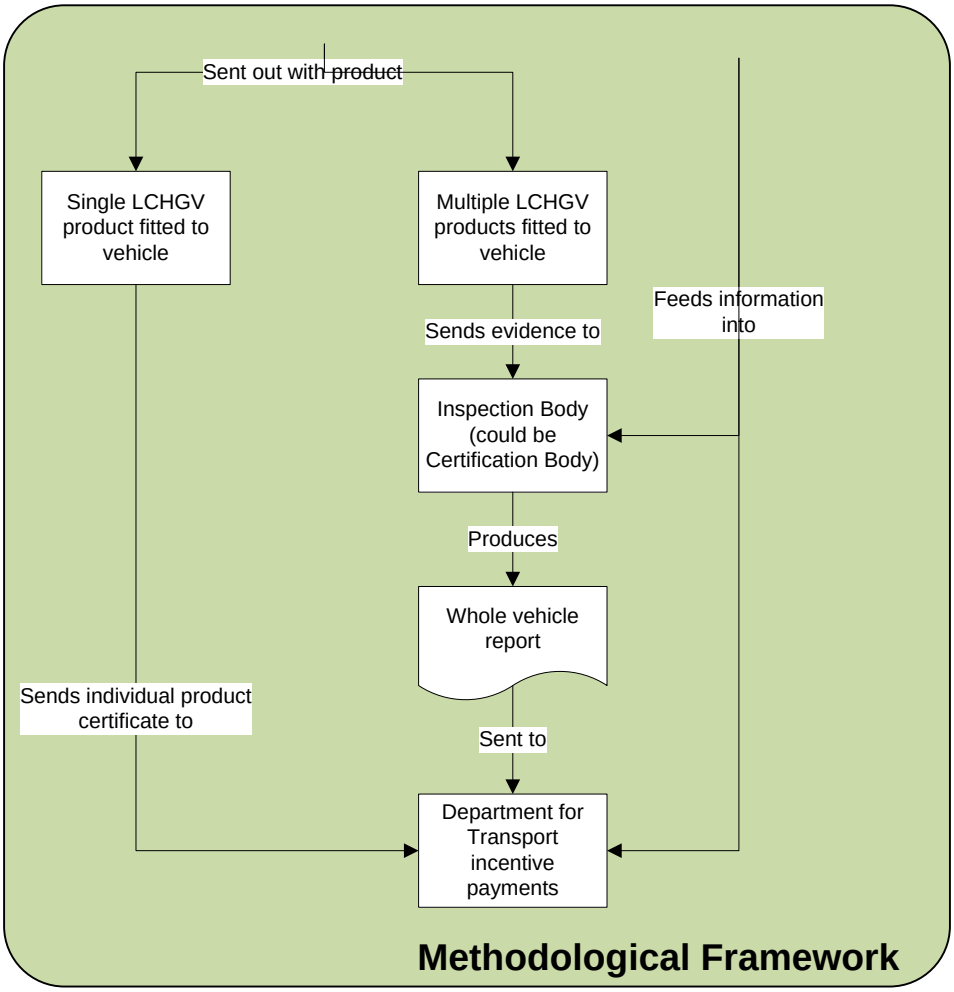


Figure 4. Methodological Framework

The Certification Process which handles the Certification of products (Figure 3, described in the preceding section) sits inside the Methodological Framework. The remainder of the Methodological Framework relates to the incentives given by the DfT (or other funding body) for the use of these products. The following sections describe how this Process and Framework might function together. It should be noted that the Framework described here is based on an assumption that any incentive payments would go to the vehicle operator; as discussed in the preceding section, it is conceivable that incentives could (instead or as well) go to the technology suppliers, but these options have not been explored in detail within the constraints of the current project.

The Certification Process element of the Framework could exist regardless of any incentive scheme operated by the Department, as long as a market for certified products exists. This kind of certification process is relatively common across many industries, though they inevitably differ widely in detail. The following sections scope out the various pertinent points which need to be addressed to fully define this detail for low carbon HGVs.

Figure 5 shows this relationship and the ways in which the various aspects interact.

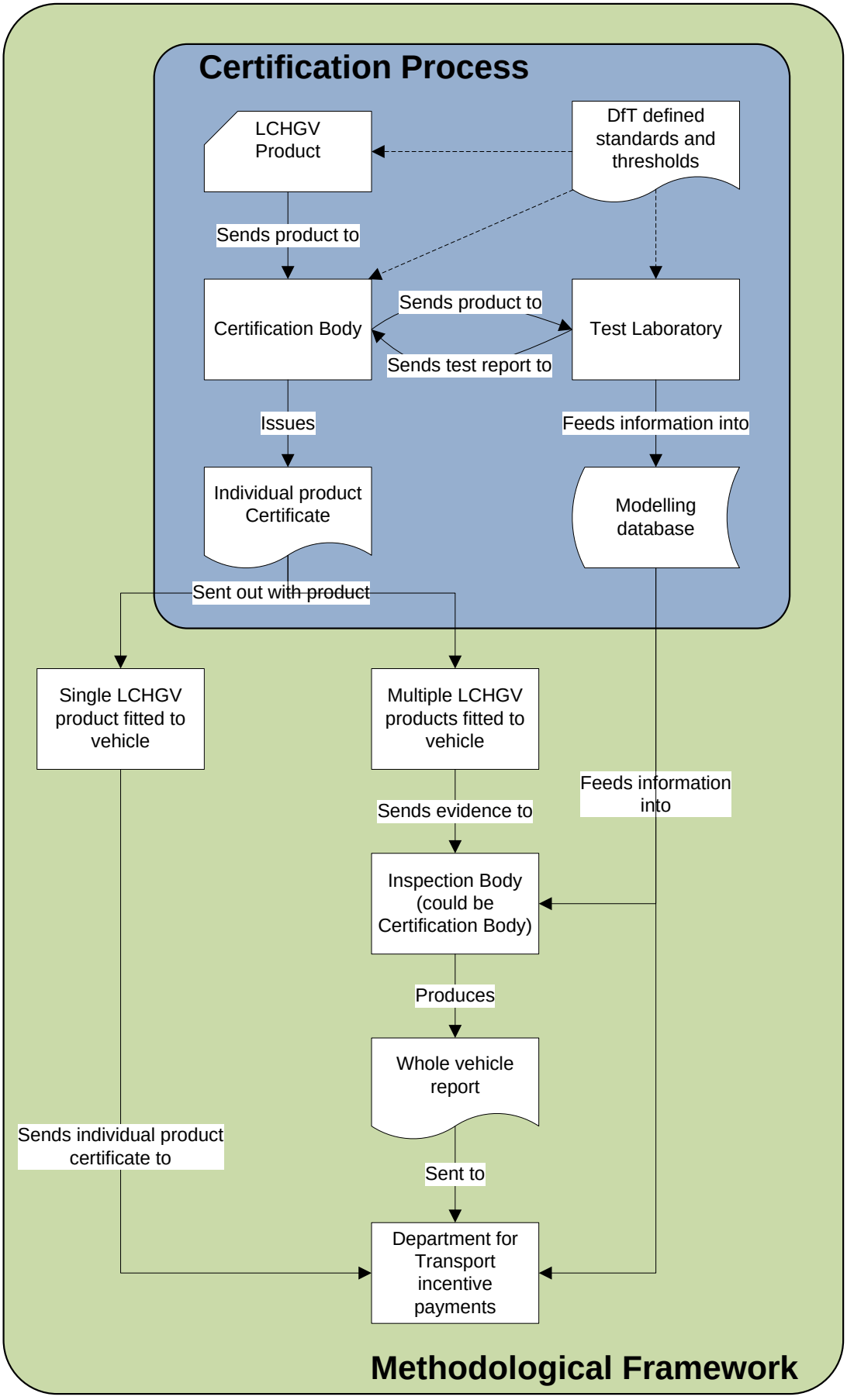


Figure 5. Methodological Framework and Certification Process

4.1.1 Methodological Framework – points for consideration

4.1.1.1 LC HGV products

Due to the variable nature of potential technologies, devices, systems etc, we will give these the generic title of 'product'. LCHGV products falling within the remit of this project include:

- Aerodynamic devices
- Low rolling resistance tyres
- Weight-savings
- EV technologies

It is assumed that these products will be made by manufacturers (either OEM or aftermarket) as either:

- A single, standalone product (such as an aftermarket air-dam); or
- A whole vehicle (perhaps with many individual LCHGV components) counted as a single product, to allow:
    - Many small products which individually may not pass a threshold value for 'low-carbonness' can be measured together to pass the threshold: and
    - A reduction in testing and certification costs for highly bespoke vehicles.

The manufacturer or their representative (such as a distributor) must provide design and other technical information that will allow testing laboratories and Certification Bodies to make an accurate determination of the product's efficacy. This will involve:

- Sending individual products directly to a Certification Body (which will arrange for suitable testing); or
- Sending test reports directly to a Certification Body (which are acceptable to that Certification Body).

4.1.1.2 Role of DfT

The role of the DfT in the framework is to provide decisions on initial input limits (i.e. the thresholds beyond which certification as "low carbon" should be given), and (at least initially) on an on-going basis to provide the output incentives.

Certification is dependent upon a confidence that a product reaches a certain standard. As the ultimate arbiter of the incentive scheme, the Department should specify the standards that LCHGV products should reach to qualify for the incentives.

A standard will usually contain both quantitative and qualitative factors, and is used by both a Test Laboratory and a Certification Body in their examination of products.

4.1.1.3 Exclusion of low performing products

The Department could prevent extremely low performing products from claiming 'low-carbon-ness', and thus devaluing any associated marks/brand, by operating a threshold system of Certification, i.e. only including products which achieve a carbon reduction of X amount and excluding those below it.

Further work will be needed to make recommendations as to appropriate threshold levels. These will need to be set carefully – too high and the scheme risks excluding too many products, too low and the scheme risks losing credibility as a genuine indicator of meaningful carbon savings.

4.1.1.4 Graduated Scheme

Graduated ratings could allow for easy user understanding of CO2 reductions and a simplified incentives structure. The scheme could operate a graduated scheme, potentially titled "Carbon Reduction Ratings", perhaps over and above a threshold, or indicate a percentage change form a benchmark as per the Japanese Toprunner scheme.

4.1.1.5 Determining Savings

Determination is needed of how much carbon any individual product may save in real-world use. Such a saving could be difficult to calculate if there is no direct comparison with a vehicle without such a product (such as a bespoke hybrid vehicle for which no conventional version exists). To achieve this the Department (with assistance) could set a benchmark for vehicle performance over various duty cycles in units that make sense over a range of vehicles, usage patterns, load characteristics, fuel type, mileage and type of use e.g. urban, extra urban, motorway etc against which products are rated. Achieving this may mean that restrictions need to be placed on allowable vehicle types, duty cycles, loading patterns, etc.

4.1.1.6 Qualitative limits

To ensure that the products being sold are as tested, and that the products are suitable for use beyond the test, qualitative limits on products relating to manufacturing quality could be set.

4.1.1.7 Incentive regime issues

A regime of incentives, related to the results of testing and/or modelling could drive the take-up of the certification scheme. Incentives could be financial at first and directly payable to the operator (it is assumed, though, as previously stated, they could also be paid to the manufacturers instead or as well). This could either be a single payment for any performance over a certain threshold, or a graduated amount based upon the amount of carbon reduction. The aim of the incentive system would be to offer the best long-term return of tonnes of carbon saving vs. cost. As a general principle, whoever the incentive scheme is targeted at will need to pay for the tests, either directly or indirectly.

4.1.1.8 Publication

The method of publication of the scheme requirements to all parties can impact upon the time taken to launch the scheme. The writing of a full new standard may take years, whereas an over simplistic set of requirements may not adequately take into account the needs of all interested parties. A compromise is therefore needed between time, cost, and quality. New requirements could be set (and indeed may be necessary), however quicker acceptance would be to base requirements around existing standards and protocols.

4.1.1.9 Modelling

The aims of the model in the Methodological Framework are to provide a repository for product performance test data, allow open access to all parties to assess for themselves the benefits of fitting a single or multiple product to their vehicle (via a web-interface), and to allow for Certification Bodies to formally undertake calculations so that they may issue Certificates.

4.1.1.10 Testing Laboratories

The role of the testing laboratories is to provide reliable and proper testing or modelling of LCHGV products in a way which will allow meaningful data to inputted to and used by the model, and to provide usable test reports to the certification bodies.

Issues that will need to be addressed to allow testing laboratories to fulfil this role include:

- When to test, and when to model single products;
- Can data from single tests be extrapolated reliably and consistently by the model to predict the performance of other similar products?
- When to test, and when to model multiple products;
- Can data from single tests be reliably and consistently extrapolated by the model to understand the interaction with other LCHGV products in all, some, or any, cases?
- Are there limits to extrapolation?
- Which duty cycles to test and which to model;
- Can all duty cycles be modelled by combining other duty cycles (e.g. by varying the proportions of motorway, urban and extra-urban driving)?
- Should all products be modelled against all duty cycles, or should they be limited to their likely use?

4.1.1.11 Testing Laboratory Accreditation

Accreditation for test houses (to ISO 17025 by UKAS) assures a high quality of testing, but accreditation may not be available for all tests and takes time to organise. This may limit the number of Test Laboratories available to do any given test. A simpler method, whereby the Certification Body evaluates each Test Laboratory where ISO17025 accreditation is not available may be an acceptable compromise.

4.1.1.12 Test Reports

A regular format of test report will ensure that Certification Bodies have the required information in an easy to understand format that can enable swift certification decisions to be made. The reports could also hold useful information for the manufacturer and consumers should they wish to see it.

4.1.1.13 Certification Body

The role of the Certification Body (CB) is to assess test reports from the Test Laboratories, audit the companies making products to ensure consistent quality, issue Certificates for individual products and for whole vehicles with multiple LCHGV products. To fulfil this role, each CB (there may be more than one) will need to have appropriate expertise, systems and credibility with interested parties. Similar issues arise as for the testing laboratory accreditation, i.e. that the CBs themselves will need to go through some form of accreditation process to ensure they are competent and capable of doing their job.

4.1.1.14 Funding of Certification

Certification Bodies normally operate on a commercial basis (i.e. in competition with others) where there are a large number of potential clients with guaranteed work for a long period. With LCHGV the number of products is likely to be relatively low, and the work may not remain available after any market incentives are withdrawn. This has two

risks for the Department; that no Certification Body is willing to operate the scheme, and even if one or more are so willing, that the costs of Certification need to be set at relatively high levels to give those organisations an acceptable return on their initial investments. A single Certification Body contractor would help to mitigate these risks, e.g. by reducing the uncertainties about future market share, and DfT taking on the risk that there is actually insufficient work for the Certification Body to operate the scheme in a commercially viable way.

4.1.1.15 Recognition

The traditional method of recognising certified products is via a paper certificate. Occasionally this is backed up by an on-line registry (although if a model database is available this could be used in lieu of an on-line registry). The function of the certificate is to build confidence in the purchaser and the Department that the product meets needs.

Individual products are also often allowed to use a mark to promote the product.

Issues to be resolved include:

- What format of certificate would be needed?
- Would one certificate for each group be necessary, or would a separate certificate be given out with each sold product?
- What security markings/numbering would be required to prevent fraud?
- What would be the required format of the certificates?
- Would a designation number, which can be used to identify products on the model database, be useful?
- Would a product mark on each LCHGV product be useful?
- What is the design of any product mark?
- How can any certificate and mark be used in promotional materials?

4.1.1.16 Points of contact for producers

Traditionally products are taken directly to a Certification Body which sub-contracts a Test Laboratory or has their own. However a different method is available whereby the manufacturer benefits from competition by taking a product directly to a Test Laboratory and then allows the Certification Body to use the resulting test report – although this only works if the Certification Body accepts such a report (i.e. accepts that the Test Laboratory was competent).

4.1.1.17 Certification Body Rules

The Department may wish to control the activities of Certification Bodies over and above that provided by UKAS (if indeed the Certification Bodies are UKAS accredited at all). This can include such items as reporting, and which products can and cannot be certified under the incentive scheme. Therefore a key question is what rules should govern the activities of the Certification Bodies?

4.1.1.18 Incentive payment claimant

A general assumption has been that the operator would claim any incentive payments. Clarity to the various parties in the system which may wish to claim would be essential including:

- Manufacturers
- Distributors

- Vehicle Builders
- Vehicle Owners
- Vehicle Operators

4.1.1.19 Mechanism for incentive payment

Any incentive payments must include a method of receipt. Key points in determining this include:

- Process and location (postal, on-line, in person)?
- Forms required?
- Evidence required by the Department for claims?

4.1.1.20 Calculation of incentive payments

The Certification process assesses what level of CO_2 savings is likely, based on the stated duty cycles, vehicle types and technologies. It cannot determine the amount of any incentive payment. The basis on which payments are calculated and made will need to be defined, e.g. as a £ per % carbon reduction or per tonne of carbon saved (actual or expected)? As discussed previously, payments could be banded or infinitely variable, and the choice will have implications for the overall administrative costs of the scheme.

An alternative, potentially cost-neutral approach, is to follow the example of the Carbon Reduction Commitment (CRC) scheme, which applies to large energy users and works basically by creating a fund from payments from all participants which then gets recycled back to participants in amounts depending on the level of carbon savings achieved (mainly through gas and electricity use). Companies high in the "league table", i.e. that have made the greatest savings, get proportionately more of the fees back (and more than they paid in), subsidised by those lower down the league who have not made as much savings. Subject to further investigation, in principle such a scheme could be extended to large HGV fleet operators, with the certification scheme serving to inform them of the carbon/fuel saving opportunities available.

Summary

The methodological framework is the overall process for the operation of the incentive scheme for Low Carbon HGVs and utilises the outputs of the Certification Process. The ultimate goal of the methodological framework is to provide the Department with the correct information to allow for incentive payments to operators who use LC HGV products and so lower their CO_2 output.

For the Department to make such an incentive payment, it needs:

- Certificates for products - certificates issued by the certification bodies, either for single products (which may be a whole vehicle counted as a single product) or for vehicles fitted with multiple products for which an overall CO_2 reduction has been calculated.
- Evidence of fitment – operators would presumably have to provide evidence that the products have actually been fitted – this would be covered by the Certification Body in the event of a vehicle fitted with multiple single products.
- Usage information - the type of vehicle a product is fitted to and the duty cycle being operated. This is because products will have different, and occasionally negative, effects on different vehicles and different duty cycles.

A wide variety of other issues pertaining to the establishment of a certification process and wider methodological framework have been identified, including the roles of the various interested parties, the standards to be followed and the metrics to be used.

Further details of the draft certification procedure and methodological framework are provided in the Annex.

Figure 6 presents a summary of the main issues pertinent to the final development of a successful, credible methodological framework for low carbon HGV certification.

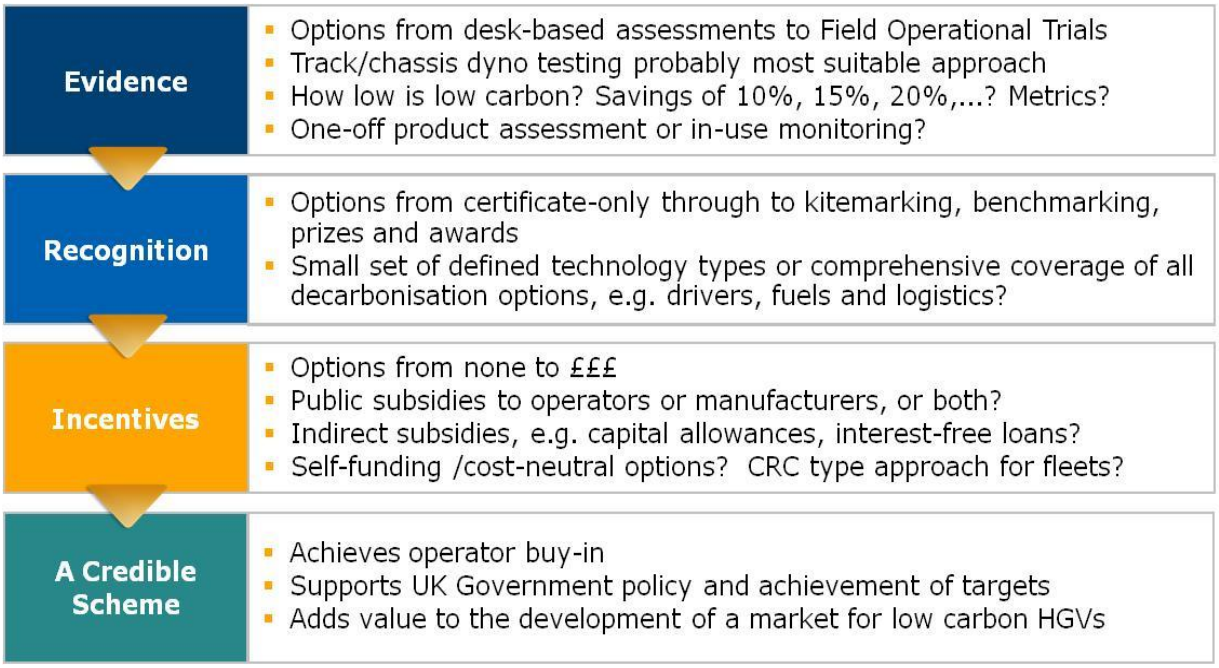


Figure 6. Summary of Methodological Framework Issues

5 Task 4 – Validation

Within the confines of the existing project timescales and budgets, only limited validation was envisaged at this early stage in the development of a certification scheme for low carbon HGVs. The testing carried out by Millbrook has shown that HGVs can be tested in a variety of ways and that, generally speaking, those procedures can distinguish technologies likely to have the potential to aid fuel and emissions savings from those without such potential. Some results of the Millbrook tests, in terms of the technologies assessed, the test procedures used and the fuel savings measured, are summarised in Table 5-1. The Electric Vehicle testing is not summarised here due to the lack of a comparison vehicle.

Table 5-1. Summary of tested fuel savings

Technology	Test procedure	Measured % fuel saving (bold indicates statistical significance)
Aerodynamics (cab deflector)	Track tests	**3 – 9%** (depending on test route)
Low rolling resistance tyres	Track tests	**4 – 11%** (depending on test route)
Weight reduction (7%)	Track tests	**2 - 3%** (depending on test route)
	Chassis dyno	0 – 1% (depending on test cycle)

The two major limitations of the test programme to date are, firstly, that only a very limited number of technologies and vehicles could be tested and, second, that individual technologies could only be tested on one vehicle. In further developing the certification scheme, and in particular to validate its potential usefulness, it will be necessary to test a wider range of technologies, on a wider range of vehicles and, crucially, to fit individual technologies to various different vehicles (to ensure that a product certified as "low carbon" is likely to save fuel when applied across the fleet, in appropriate circumstances).

A further limitation is that testing has been carried out at only one venue – different test facilities will inevitably have varying characteristics, e.g. road surfaces, gradients, drivers, etc, so part of the validation requirements will be to quantify the variations in measured results under nominally similar conditions between test facilities. Some duty cycles, e.g. hill circuits, will inevitably be very difficult to reproduce accurately at differing venues. Further work is needed to assess the requirements for measurement compatibility between venues.

Further work is also likely to be needed to provide reassurance to the scheme administrators and potential users that the test results can be used to predict real-world fuel consumption and emissions performance with an acceptable degree of accuracy, particularly the ability of the model to predict the effects of interactions between different products applied in combination.

Like the main certification procedure, the validation procedure will itself need to be defined as part of the overall methodological framework. Figure 7 presents an outline validation procedure.

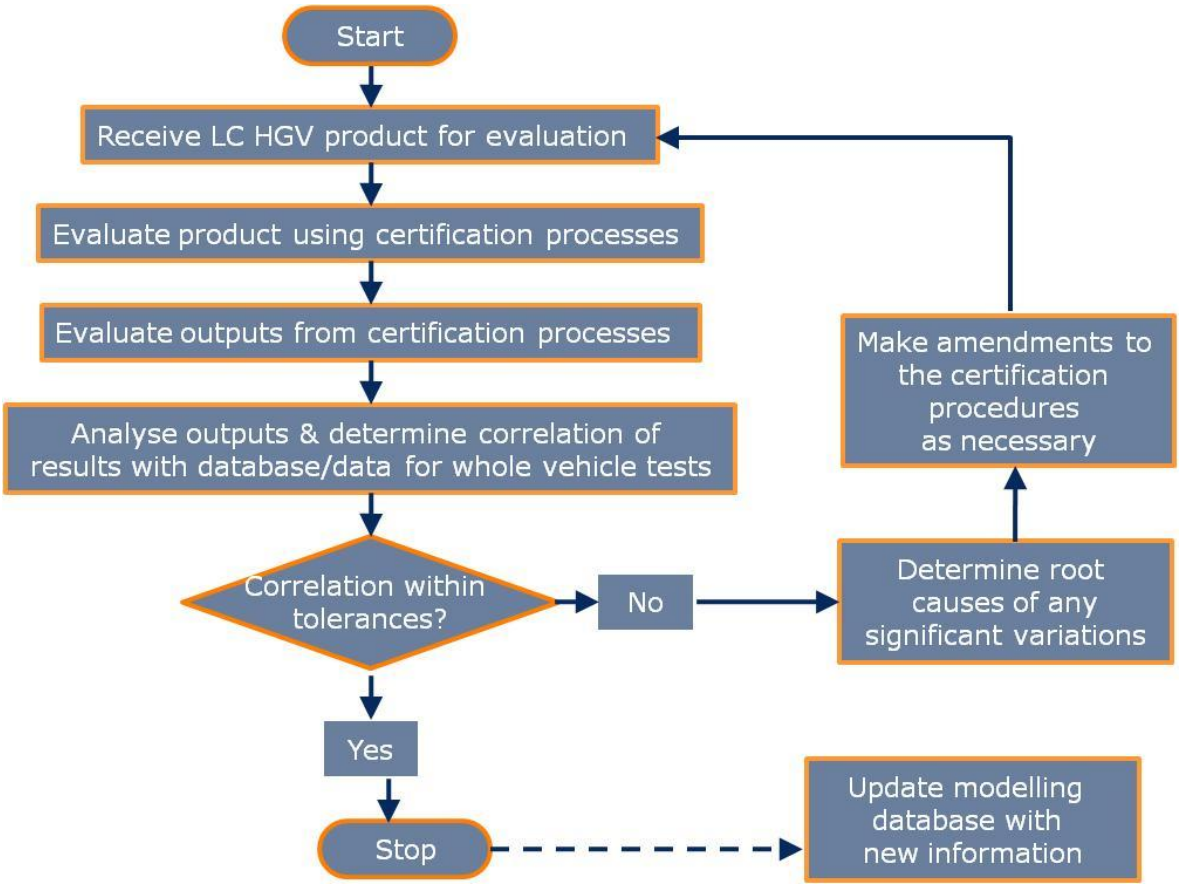


Figure 7. Outline process for validating certification procedures

6 Summary discussion and guide for policy makers

The work under project FLD401Q, described fully in the preceding sections of this report, has:

- Reviewed a wide range of existing test procedures and accreditation schemes (Task 1);
- Developed, in consultation with interested parties, a potentially suitable certification process and methodological framework (Tasks 2 and 3), and defined many of its detailed working characteristics;
- Identified various issues to be addressed before any scheme and framework could be launched and reviewed other existing schemes that appear to offer the most relevance and potential usefulness to the certification of low carbon HGVs;
- Defined the detailed test procedures to be followed for the technology types under consideration (based on the TRL/Millbrook tests);
- Ensured as far as possible that the outline framework proposed is validated against appropriate test results (Task 4).

6.1 Guide for policy makers

The following is a strategic guide to the options for the use the certification of Low Carbon Heavy Goods Vehicle (LC HGV) technologies to reduce overall CO_2 emissions.

6.1.1 Aims of the scheme

The Climate Change Act of 2008 sets out progressively tightening carbon budgets to achieve an 80% overall emissions reduction from 1990 levels by 2050. The certification scheme will act as a market driver for the purchase and use of Low Carbon HGV technologies with known carbon reduction performance in defined applications, in order to decarbonise freight movements.

The amount of saving from domestic transport emissions that can actually be achieved will depend upon both the efficacy of LC HGV products and industry's take-up of the certification scheme.

6.1.2 Vehicles and technologies covered by the scheme

The scheme is designed to be applicable to all HGVs (goods vehicles over 3.5 tonnes gross vehicle weight), which account for about 20 per cent of the UK's domestic transport emissions.

The technologies assessed in the preliminary development of the scheme relate to:

- Aerofoil/lower aerodynamic drag effects;
- Lower rolling resistance tyres;
- Weight-saving;
- Electric vehicle (EV) technologies.

The scheme has been designed to have sufficient flexibility for other technologies to be added in the future, e.g. as they develop or as suitable test procedures and metrics are developed for them.

6.1.3 Vehicle operator, and supplier/manufacturer involvement

The extent of involvement from vehicle operators and supplier/manufacturers is on one side fixed (vehicle operators purchase certified products produced by manufacturers),

and on the other side variable depending upon the type of incentive model adopted by the Government. In all cases certified products are required and it is suggested that there are three basic models:

6.1.3.1 Model 1

Under this option, the DfT financially incentivises the vehicle operator to purchase certified products, which in turn drives the manufacturers to supply certified products. The level of the incentive could be linked to the anticipated absolute level of CO_2 reduction, for example, or to the anticipated payback period/return on investment. It will be crucial to set the incentives at a level that is high enough to convince operators who can benefit from the technologies to adopt them, but not so high as to reward their fitment in inappropriate circumstances (e.g. duty cycles not suited to the particular technology). For the operator, therefore, the scheme should only work to make genuine CO_2 reducing measures cost effective for them (at an appropriate cost per tonne of CO_2 saved), but leave options that would not reduce emissions as non cost-effective; in other words, an operator should only achieve a positive financial return on his investment if he achieves meaningful fuel cost savings, and not just through the incentive payment alone.

Under this model, no monies would flow directly to the low carbon technology manufacturers. This could hinder the development and success of the scheme because they might be reluctant to commit to the costs of product development and certification until the market for those products has itself developed.

6.1.3.2 Model 2

This model works as per model 1, but with assistance instead going directly to manufacturers via funding of testing and certification. This can ensure a ready availability of products on the market at timing to suit the Department and could help to ensure a rapid take-up of approved technologies and, therefore, a rapid reduction in road freight fuel consumption and emissions. An option to carry out publicity to vehicle operators would help drive this model.

6.1.3.3 Model 3

Both models 1 and 2 are open to potential criticism that public funds are being used to subsidise industry to do things that, in many instances, they should already be doing, because fitting the low carbon technologies would already be cost effective for them. Such critics may argue, for example, that significant savings could be achieved if operators were simply given access to better information about what fuel saving technologies are available, with the certification scheme providing the reassurance to operators that they can expect savings to be achieved in practice (assuming the technologies are used in appropriate circumstances). In model 3, therefore, there are no direct financial incentives, all incentives occur via publicising the savings from best practice of certified products. Operators would gain through fitting cost-effective technologies and manufacturers would gain through increased demand for their products. The drawback, of course, with this model is that it relies on the messages about the savings getting through to operators, and in ways that they feel compelled to act on them. It would also be very difficult to measure the effectiveness of the communications campaign and to quantify up front the emissions likely to be saved over any given period of time.

6.1.4 Administration

Such a scheme can be administered by a private organisation working on a commercial basis under contract to or by approval of the Department, with its ongoing fees paid by producers through application fees or directly by the Department. The administrators would ensure that all certification and information relating to the scheme is correct, and

monitor the activities of any testing and certification bodies involved. The administrators could also handle any financial incentives depending upon the model chosen.

6.1.5 Costs and Funding

Net costs to each party depend very much upon the model used. Each product requires testing and certification, either payable by the manufacturer or the Department. Per product, costs are likely to be approximately £8-10k for a series of track tests (with and without the technology fitted), whereas a similar series of chassis dynamometer tests might be approximately £12-15k. The number of products on the market is unknown. The total cost depends upon the number of products sold and manufacturers would look to recoup this cost from increased sales.

Were the Department to financially incentivise vehicle operators to purchase products the costs would be entirely dependent upon take up and the rate of financial incentive. The correlation between incentive value, take up amongst operators, and ultimately the cost vs carbon saving remains to be established.

The Government's Enhanced Capital Allowance scheme for businesses using certified technologies that reduce CO_2 could provide a financial incentive framework for operators.

6.1.6 Beneficiaries and benefits

The potential beneficiaries and benefits of the certification scheme are likely to be:

- Increase in the purchase of Low Carbon HGV products leading to economic benefits (jobs and economic growth);
- Decrease in CO_2 emissions that will last for many years (thus assisting the government targets);
- Increase in work for testing laboratories and certification bodies (jobs);
- Increase in innovation within the LC HGV product leading to better and cheaper products;
- Decrease in fuel costs to vehicle operators using LC HGV products.

6.1.7 Scheme introduction

The scheme could be introduced once scheme rules have been written alongside finalised testing procedures. A certification scheme written in conjunction with industry will naturally take time, however the process could be completed within 6 months. A pilot of the scheme could be undertaken over a 1-3 month period.

6.1.8 Other options

Certain parts of the LC HGV scheme will be consistent regardless of the model option chosen, e.g. the performance criteria (standards/specifications) against which products are tested (including how they are tested). Given the ongoing tightening of public expenditure budgets, it may be sensible to look for ways that existing activities could be applied to the scheme at lower overall cost than the establishment of dedicated new facilities and services.

Testing, for example, can be undertaken by any suitable UKAS-accredited testing laboratory. As the test procedures are already likely to exist with various testing laboratories, the most likely option is for testing laboratories to compete for business on the open market.

6.1.8.1 Use of existing resources

The validation of equipment can be undertaken by a certification body (explained below) or an existing government Agency such as VOSA. VOSA presently inspect HGVs on a regular basis and is likely to have the skills required to validate the correct fitment of certified LC HGV products. As many items are likely to be fitted to newly built vehicles, which are not subject to VOSA inspection until their first MoT test, some changes to their procedures and/or remit would be likely to be required.

The scheme could be administered by any one of a number of parties. This could include a Government body or agency (such as VOSA, or the Department), a private organisation under competitive tender, or an existing low carbon organisation such as the Energy Savings Trust or Carbon Trust (which already run energy/fuel saving products scheme for household and industrial products and that which might be expandable to cover LC HGV products, too).

Providing financial incentives for manufacturers and/or operators could potentially be organised through the proposed Green Investment Bank, from existing Departmental initiatives such as the Freight Best Practice programme, or from other pre-existing mechanisms such as the Carbon Trust's Enhanced Capital Allowance scheme for certified products.

6.2 Summary of options and requirements for further work

The work carried out for this project has highlighted the fundamental importance of the quality of the evidence available to support the certification of individual products, combinations of products or whole vehicles. Without reliable, trustworthy and appropriate evidence of the technologies' ability to save fuel and carbon in real world usage, a credible certification scheme is simply not feasible.

Of lesser significance, but still crucial to a credible scheme, is the matter of recognition, i.e. how the "low carbonness" of a product, group of products or vehicle is assessed and communicated to potential users.

While a certification scheme for low carbon HGVs might operate successfully without additional financial incentives (over and above the fuel cost savings), they may well be vital in giving confidence to the market and helping to overcome barriers such as long payback periods and high upfront capital costs. They are thus relevant to the overall development of a methodological framework.

A credible scheme can be defined as one that achieves operator buy-in, supports UK Government policy and achievement of climate change/energy targets, and that adds value to the development of a market for low carbon HGVs.

Within all three relevant areas (evidence, recognition and incentives), there are a wide range of possible options and the final choice of which option will inevitably involve some compromise and striking a balance between the needs of the market, the policy objectives and available resources. While an outline certification scheme and methodological framework have been developed within this project, further work is needed to define the precise details of the evidence gathering, the recognition procedures and the incentive mechanism, in consultation with the various interested parties. Amongst the key issues to be resolved are:

- how the test and modelling procedures can be designed to cost-effectively ensure sufficient credibility (addressing issues such as repeatability, reproducibility and validation);
- whether a bespoke UK scheme should be designed specifically for low carbon HGVs or whether something already in existence (but not designed specifically for HGVs) can be more cost-effectively adapted;

- whether a UK scheme should be DfT-led or private-sector led. Table 6-1 summarises the main potential advantages and risks (from DfT's perspective) with each of these options;
- whether any incentives should be targeted at the vehicle operators or the technology manufacturers, or a mixture of both, to best influence the uptake of the technologies in the market.

Table 6-1. Public vs Private Scheme Issues

DfT Scheme	Private Sector Scheme
Potential advantages (for DfT) • Can be fully aligned to policy and regulatory goals; • Credibility a given (market will expect DfT scheme to have been thoroughly researched and planned before launch); • Capability of existing agencies could be utilised; • Take-up, and CO_2 savings, likely to be high.	**Potential advantages (for DfT)** • Self-funding; • Competition can be built-in to ensure cost-effectiveness for industry;
Potential risks (to DfT) • Difficult to charge for use of the scheme, so net costs likely to fall on DfT; • Costs to develop a suitably high credibility scheme may be quite high. • Adverse publicity and lost credibility if procedures fail to recognise some genuinely fuel efficient solutions and/or encourage sub-optimal solutions.	**Potential risks (to DfT)** • DfT backing likely to be needed; • Competing schemes may conflict/confuse; • Resource constraints and commercial risk factors may limit scheme scope and thus overall take-up and CO_2 savings; • The initial development costs may be difficult to justify without funding and future income guarantees from DfT.

Acknowledgements

The work described in this report was carried out in the Safety Division, Centre for Sustainability (C4S) and Transportation Division of the Transport Research Laboratory. The authors are grateful to Marcus Jones who carried out the technical review and auditing of this report.

References

Cummins, Inc, (2009). *Framework for the regulation of greenhouse gases from commercial vehicles.* Cummins Inc, Columbus, Indiana, USA, August 2009.

Annex A - Low Carbon HGV Certification Scheme Procedure Draft 1

A.1 Introduction

This procedure describes the outline processes for the certification of LG HGV technologies and whole vehicle certification where several technologies are applied.

This procedure is the output from Tasks 2 and 3 of Low Carbon HGVs – Technology Accreditation and Whole Vehicle Integration Study

It is assumed that all evaluation of products shall be undertaken by UKAS accredited testing laboratories or other laboratories that have been specifically approved by the Certification Body.

A.2 Scope

This procedure applies to the following:

- Individual LC HGV technologies
- Whole vehicles flitted with several LC HGV technologies
- Feedback of evaluation and testing results to the Modelling Database

A.3 Applicable Standards

To enable the broadest possible acceptance of this procedure the processes and procedures described in this procedure are designed and implemented to satisfy the requirements of the following accreditation standards:

- BS EN 45011:1998 General requirements for bodies operating product certification systems

A.4 Responsibilities

A.4.1 Responsibilities

A.4.1.1 Certification Applicant

The client organisation is responsible for compliance with the standards relevant to the specific Low carbon Heavy Goods Vehicle (LC HGV) technology to be certified.

A.4.1.2 Certification Body

The Certification Body is responsible for ensuring that there is sufficient objective evidence of compliance with the respective standards and specification to support the certification decision.

All assessment, evaluation, certification, surveillance and re-certification activities are performed by the Certification Body and shall be in accordance with EN 45011.

A.4.2 Confidentiality

Details relevant to all LC HGV certification activities shall be treated as confidential at all times.

Processes and procedures will be implemented to ensure the requirements of the Data Protection Act are addressed.

All persons involved in the operation of the LV HGV certification activities, including all directors, management, staff (including subcontractors) including any external committee members involved with the Certification Body shall have signed a legally binding agreement that requires them to keep all information obtained in the process of their activities confidential.

A.4.3 Competence of management and personnel

Processes shall be developed that ensure all personnel (including subcontractors and where any evaluation activity is outsourced) have the relevant competencies to perform their duties with regard to the LC HGV Technology Certification Scheme. These include:

a) Identification of competencies for:
    - Types and application of LC HGV technology being certified
    - Their various roles with regard to the LC HGV Technology Certification Scheme
b) Appraisal of competence against a) above
c) Records of a) and b) above

A.4.4 Records of applicants and clients

The Certification Body shall retain secure, accurate and confidential client specific records. Records shall include (as applicable to scheme requirements):

- Certification application details
- The formal certification agreement
- Initial certification assessment report
- Re-certification reports
- Surveillance activity reports
- Product evaluation reports
- Product testing records and reports
- Records of certification file reviews and decisions
- All assessment & surveillance planning documents (programmes etc)
- Formal justification for the FPC audit times determinations
- Details of verification of all corrective actions relevant to NCRs raised during Certification Body audits
- All records relevant to complaints and/or appeals
- Certificates issued

All records and correspondence associated with certification activities are maintained as quality records and held for at least ten years or as required by law.

Records may be electronic, paper or on any other media that can be securely stored and retrieved. Access shall be limited to ensure they are kept secure and meet the requirements of the Data Protection Act.

A.5 Product Evaluation

LC HGV technology evaluation shall be carried out according to the specific requirements determined for their type, class or application.

Evaluation must confirm that the producer of the LC HGV technology is capable of:

- delivering conforming products consistently
- consistently applying controls to ensure ongoing conformance

Evaluation, including maintenance of certification, may consist of the following in any combination that ensures the certification body has demonstrable confidence in its ability to make an objective decision regarding the conformity of the technology with specified requirements:

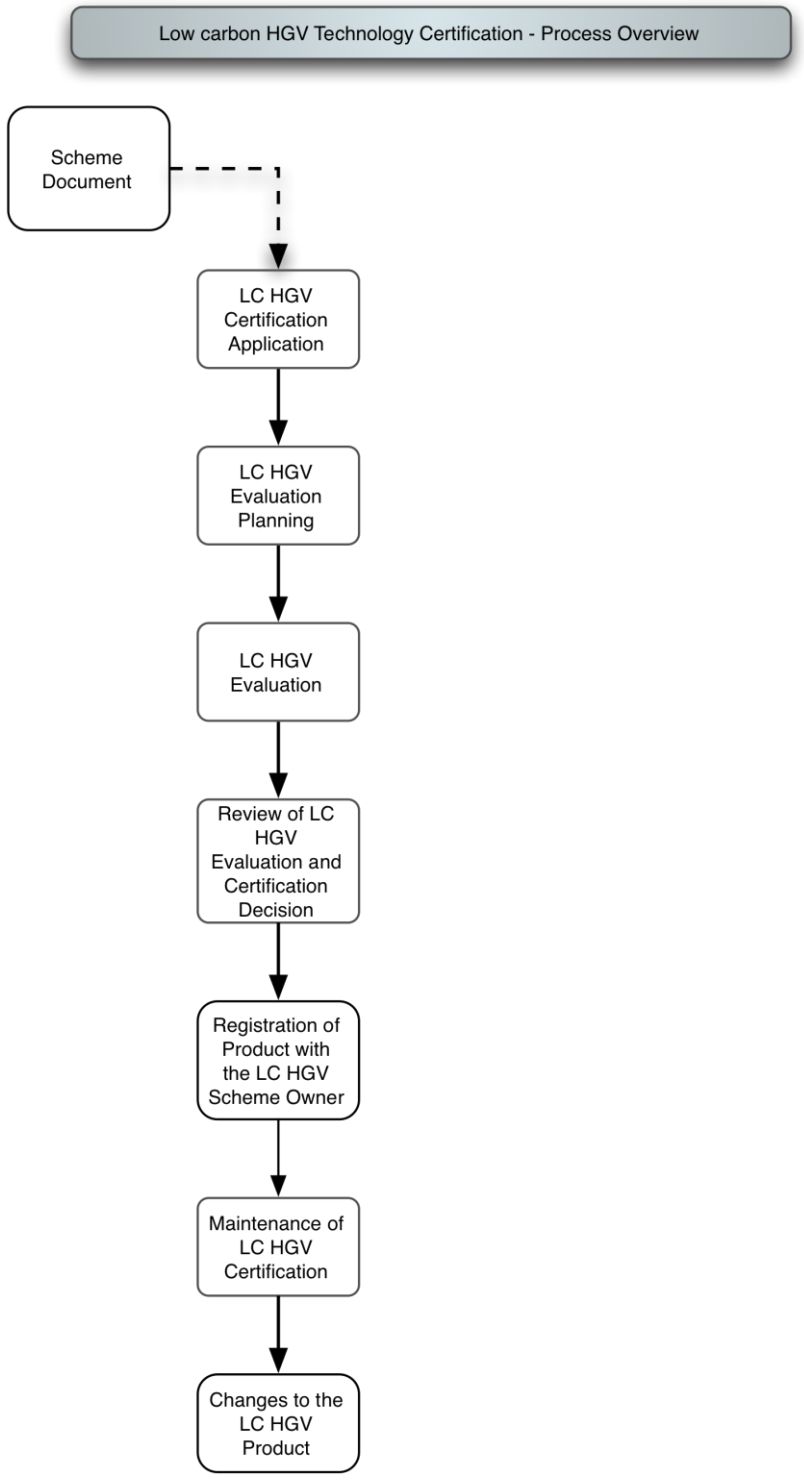
1. Evidence gathered during the evaluation process
2. Other relevant information including complaints and field data
3. Testing by UKAS accredited laboratory
4. Inspection
5. Design appraisal
6. Assessment of services and/or installation
7. Initial and ongoing assessment of the Factory Processes Control (FPC) system or quality management system

Some of this information may be historical and it is for the Certification Body or those carrying out the evaluation to determine the validity, applicability and acceptability of this information to the LC HGV Technology Certification Scheme.

Such historical information may include:

- Test reports from other test laboratories
- Research papers
- Design reviews
- Other certification

A.6 Certification Process Overview



This flow chart indicates the general process for obtaining certification to the LC HGV Technology Certification Scheme.

Each section is expanded in the following sections.

The Certification Body offering certification to this scheme shall implement and maintain procedures covering each of the sections shown.

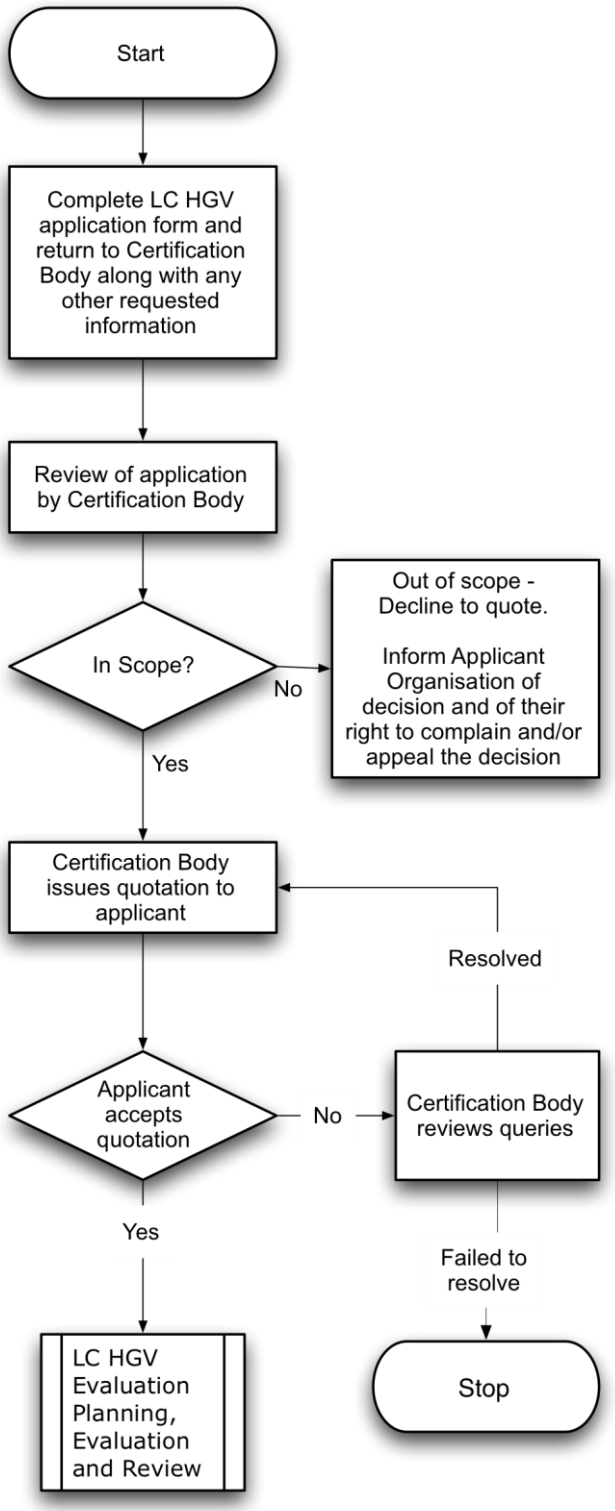
Procedures shall be supported by relevant forms and associated records.

Note: This process also applies to changes to any existing certification.

A.6.1 Scheme Document

Certification Bodies offering certification to the LC HGV Technology Certification Scheme shall prepare and maintain a scheme document covering all of the requirements of this procedure. Scheme documents shall comply with the requirements of BS EN 45011:1998.

A.6.2 Low Carbon Heavy Goods Vehicle (LC HGV) Certification Application



An application form shall be obtained from the Certification Body and submitted with any supporting information required.

Application forms shall include the requirement to identify whether the application is for:

- Whole vehicle evaluation
- Single technology evaluation
- Multiple technologies evaluation

The Certification Body will review the information supplied to determine whether they can offer certification.

Applications may be for new LC HGV Technology certification, extensions or changes to scope of existing certification.

Where the Certification Body needs further information or clarification it shall request such information or clarification from the Applicant Organisation prior to producing a quotation.

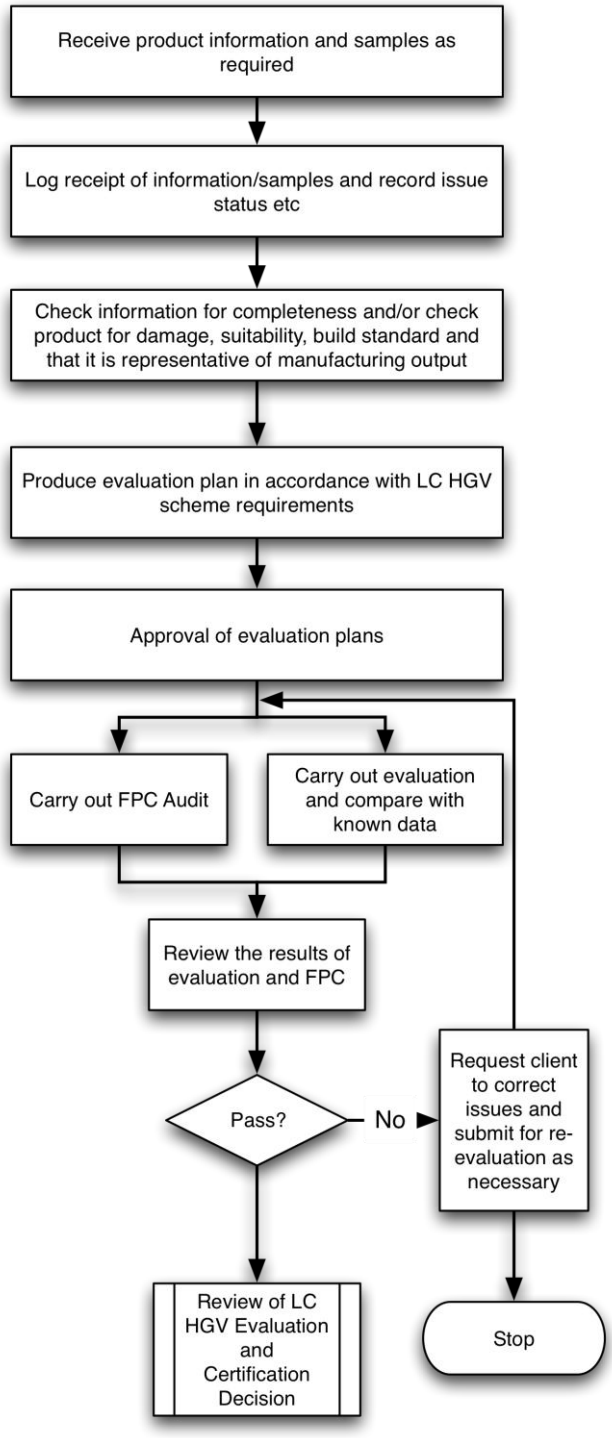
The Certification Body will determine the evaluation process and timescales. The LC HGV Technology Producer will be notified, usually as part of the quotation.

Whenever a quotation is issued a copy of the relevant scheme document shall be supplied to the applicant along with the quotation.

Amendments to quotations and queries received shall be formally recorded.

Note: This process also applies to changes to any existing certification.

A.6.3 LC HGV Evaluation Planning, Evaluation and Review



Samples of the LC HGV Technology being certified may, or may not, be required. This will depend on the type of technology.

Documentation shall clearly describe the build standard of the technology provided for the certification activity. Any instructions for the use/application of the LC HGV technology shall be evaluated as part of the certification process.

Note: This is the current state of the technology that is being certified and shall be defined by controlled documentation to the extent that the Certification Body can accurately and objectively determine its conformity with the requirements.

Any information e.g. drawings, designs etc or samples provided for the evaluation process shall be representative of normal production.

A structured plan for the evaluation of the technology shall include:

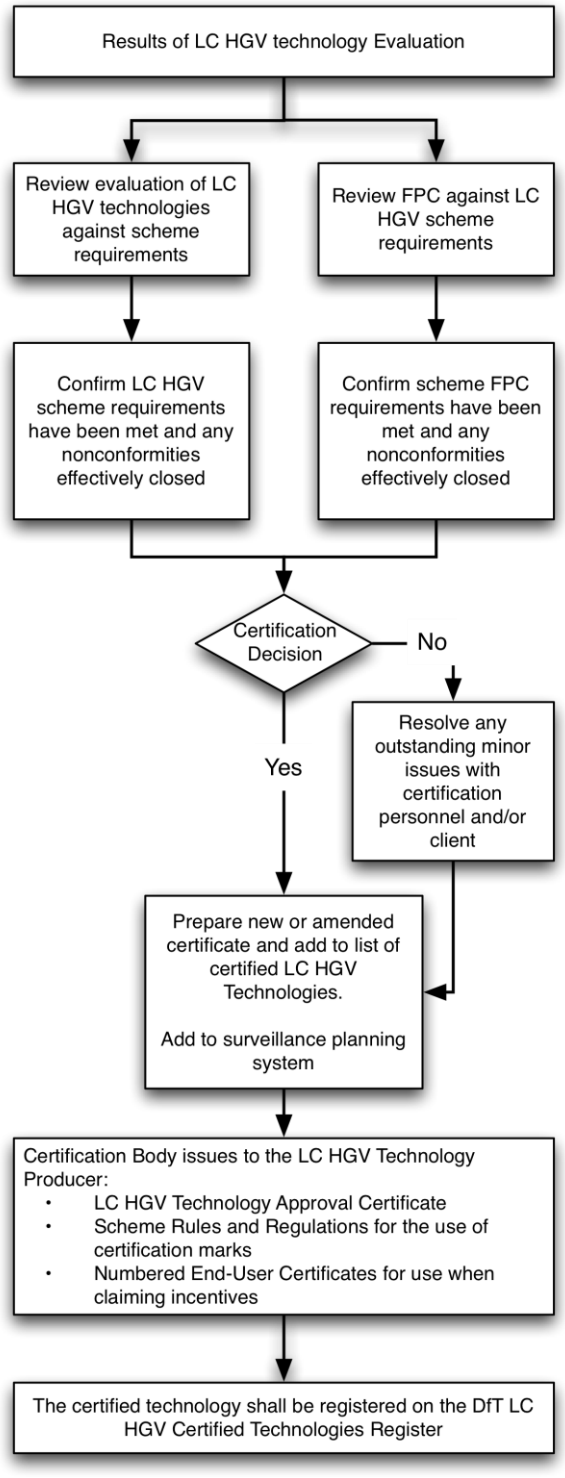
- Responsibilities
- Timescales
- The method of evaluation and steps involved specifically including requirements for:
  - Whole vehicle evaluation
  - Single technology evaluation
  - Multiple technologies evaluation
- FPC requirements
  - As a minimum FPC audits shall address:
    - Customer complaints and service/product issues e.g. warranty claims
    - Confirmation of the build standard status
    - Internal analysis of production records including nonconformities
    - A review of the FPC system, its status, and records
    - Use of subcontract facilities and personnel

Where testing is subcontracted the client shall be informed and prior agreement obtained.

The review process shall consider the results of the tests against known data, where anomalies are noted investigations shall be conducted to determine the root cause.

Note: This process also applies to changes to any existing certification.

A.6.4 Review of LC HGV Evaluation and Certification Decision



The results of the evaluation are reviewed by the Certification Body as part of the process of making the certification decision.

The results of this review shall also confirm that any correction, root cause analysis and corrective action taken resulting from any nonconformities raised during the certification process have been effective.

The Certification Body takes the certification decision – this shall not be subcontracted.

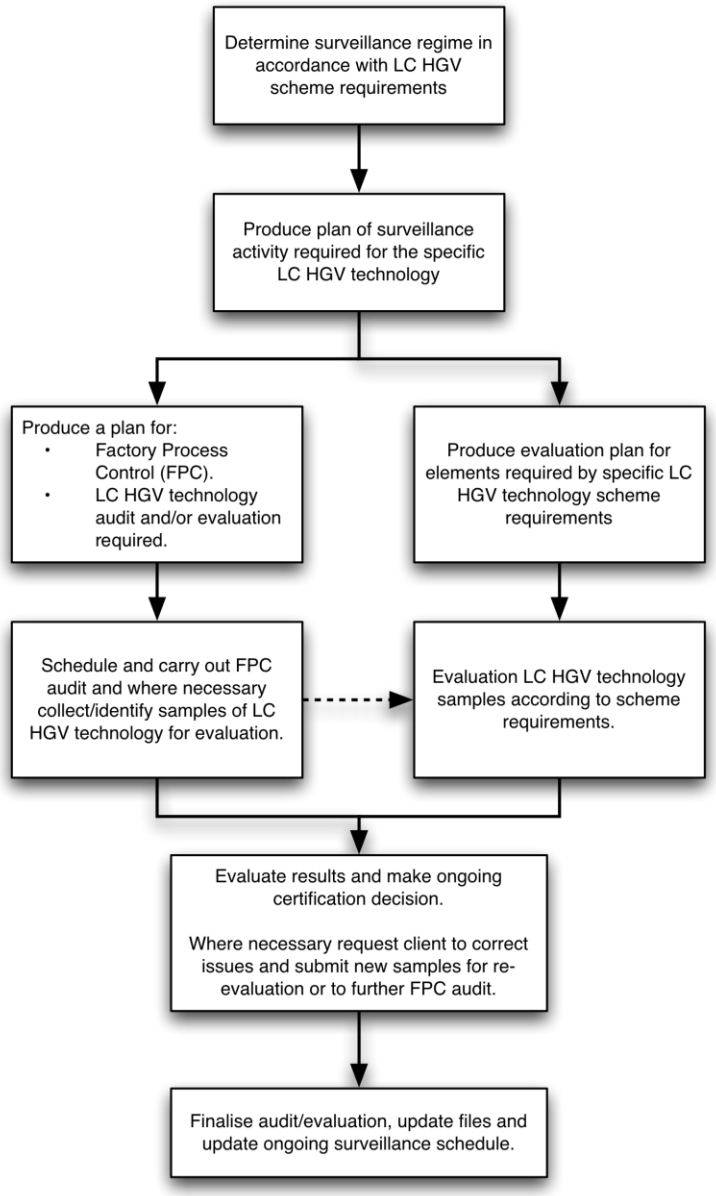
Where certification is granted a certificate shall be issued to the LC HGV Technology producer.

The build standard of the LC HGV technology provided for certification shall be included in the certification documentation. This information shall be made available to the audit team for FPC audits carried out for maintenance of certification.

The Certification Body shall issue to the Certified LC HGV Technology producer individually numbered certificates for issue to end-users. These certificates are used to claim the incentive.

Note: This process also applies to changes to any existing certification.

A.6.5 Maintenance of LC HGV Certification



Maintenance of LV HGV Technology Certification is achieved by:

- Carrying out FPC surveillance audits at planned intervals
- Periodic re-evaluation of the certified LC HGV Technology. Where required samples may be selected/identified by the audit team during FPC audits

Where periodic re-evaluation of the LC HGV Technology is required, it shall be planned and performed in a similar manner to the initial certification evaluation.

Where changes have been made to the certified technology or to the FPC system this may require additional audits/audit time.

The results of the FPC audit and any evaluation of LC HGV Technologies shall be reviewed by the Certification Body to determine whether ongoing certification is to be granted.

A.6.6 Changes to the LC HGV product

Should the producer of the LC HGV technology being certified decide to make any changes to the certified technology or become aware of any material change in circumstance that affects their Certification or inclusion on the DfT LC HGV Register they shall inform their Certification Body. The specific terms of such notification shall be included in the agreement between the Certification Body and the LC HGV technology producer. The LC HGV technology producer shall take all steps that their Certification Body shall reasonably require to notify such changes.

The LC HGV technology producer shall notify their Certification Body of any changes to its contact details, address or legal entity prior to change. The Certification Body shall pass this information to the DfT LC HGV Register.