BWG-P-08-15

Promotion of a common Low Carbon Bus specification – COMPRO response

This paper provides a report on progress with promoting the low carbon bus specification and in particular comments received from the COMPRO project members.

Background

This project seeks to promote the low carbon bus performance specification (annex 1) which was an output of the "Low Carbon Bus Procurement Feasibility" report which the LowCVP commissioned from STS Ltd.

The objective was to engage with Transport for London, the TRUS project, the COMPRO project and with other national bus procurement schemes seeking to establish demand for environmental buses. The purpose of the project being to prevent a proliferation of specifications for environmental buses springing up.

Of the identified groups developing specifications for environmental buses, TfL co-operated in the development of the spec and the TRUS project has yet to proceed. Therefore the main focus has been on the COMPRO project.

Engagement with COMPRO

The COMPRO project, "COMmon PROcurement of clean and collective public service transport vehicles", aims to enhance the development of the market for clean buses through common procurement of these vehicles on a European scale. The consortium comprises cities from France, Germany, Italy and Sweden, developing a specification for the common procurement of buses to take place in 2009/10.

LowCVP held discussions with the COMPRO group during 2007 and in early 2008 was invited, to participate in the project. Jonathan Murray took a seat on the project's Procurement Management Group (PMG). The LowCVP low carbon bus performance specification was presented to the COMPRO PMG at their meeting in March 2008 and was adopted as a starting point for developing COMPRO's detailed specification. To this end it was circulated to the participating authorities for comment. A summary of the comments are shown below and a full list of comments received are shown in annex 2.

The COMPRO project members, at their latest meeting in September, have voted to adopt the LowCVP specification as the basis for their procurement, which is now being developed into a full specification for the group using the UITP framework.

Summary of COMPRO comments

- Agree with staying within framework set out by EU directives
- Welcome objectivity of performance specification

- Agree economies of scale will be difficult to achieve
- Total harmonization of specification will be difficult
- Basis of specification should translate into national procurement, issue with MLTB drive cycle is not widely known.
- Target for GHG should be expressed in full rather than with reference to Euro 3
- Some call for engine only emissions requirements, in addition to whole vehicle e.g. engines to be Euro 5 or EEV
- In a number of countries there are annual targets for regulated emissions reducing year on year e.g. Sweden
- Sweden's environmental procurement programme classifies fuels and minimum blend of biofuels.
- Recommendation that life cycle costs be considered along with life cycle assessment
- Suggestion to include CNG as well as biogas in relative technology cost table as it is a route to biogas (perception that CNG has been omitted)

Next steps

The secretariat will be drafting a response to the comments made by the COMPRO group and would welcome input from the BWG.

The next version of the COMPRO specification will be reported to the BWG when it s produced.

Annex 1

Low Carbon Bus Specification

Introduction

The Low Carbon Vehicle Partnership in the UK has been working to develop a specification for an environmentally enhanced bus, referred to below as a low carbon bus. This paper sets out the draft specification for the critical performance elements of the bus specification.

The specification was developed as a basis for a joint procurement of these buses in the UK, but is also intended for to be shared with stakeholders across Europe and in particular the COMPRO project. It was developed as part of a larger study to assess the feasibility of a joint procurement of low carbon buses in the UK, this document will be published shortly by the Low Carbon Vehicle Partnership.

Draft Specification for Low Carbon Bus

Below is a summary for the proposed draft specification for a low carbon bus. This is the result of the discussions with stakeholders based upon the review of technologies, costs, carbon dioxide emission reduction and performance requirements. The result presents two proposals for CO2 reduction based upon what would be achievable with and without reform of the bus subsidy. How the specification was derived is presented in detail in the section below.

Parameter	Requirement
Tier 1 greenhouse gas carbon-dioxide equivalent performance	- 40% (minimum) c.f. Euro 3 equivalent bus on MLTB drive cycle See Table 1 for targets
Tier 2 greenhouse gas carbon-dioxide equivalent performance	- 20% (minimum) c.f. Euro 3 equivalent bus on MLTB drive cycle See Table 1 for targets
Gradeability (with maximum load)	10%
Range / Endurance	250 miles / 400 km
Range (zero emissions) - optional	4 miles / 6.4 km
Drive-by noise performance (exterior)	80 dB(A) as per EU Directive
Drive-by noise performance (interior)	As per current TfL requirements (data to be supplied)
Air quality emissions	Reductions to be obtained on the MLTB drive cycle See Table 2 for targets
Exhaust position (if appropriate)	Non near-side
Refuelling	Once a day
Construction & Use	EU Bus & Coach Directive 2001/ 85
Life cycle assessment (LCA)	ISO 14000 series

Methodology

The proposed specification for a low carbon bus was developed from an assessment of current practice in bus procurement, analysis of previous procurements of new technologies applied to the buses, and a wide stakeholder review within the Low Carbon Vehicle Partnership's members and the wider stakeholders involved in the UK bus market. Specifically the follow process was followed in developing the specification:

- Research basis for specification: Detailed interviews and assessment of the procurement practices and case studies for trials of new bus technology were undertaken of both Transport for London and MerseyTravel.
- Stakeholder review amongst LowCVP members: Initial findings were presented to the LowCVP's Bus Working Group in November 2007 and January 2008.
- Workshop to develop low carbon bus specification concept: The draft proposals for the specification were presented to a wider group of stakeholder in the UK bus market including: bus operators, local authorities and operators.

Stakeholder engagement

Preliminary data was presented to the LowCVP Bus Working Group meeting on 15 November 2007.

A workshop was held at the DfT premises on 18 January 2008. Attendees first met in a common plenary session and then split into Policy and Specification break-out groups.

Prior to the workshop a preliminary specification had been drawn up and circulated to the attendees to form a basis for discussion.

Companies and organisations represented in the Specification break-out group were as follows:

- Alexander Dennis Ltd. (ADL)
- Arriva
- Cummins Westport
- Merseytravel
- Sciotech (also representing the TRUS programme)
- TfL-London Bus Services Limited (TfL-LBSL)
- Traction Technology Limited (TTL)
- Transdev
- Volvo

Attendees were invited to correspond by e-mail should there be any revisions or clarifications required following the workshop.

The results from the workshop were presented to the subsequent LowCVP Bus Working Group meeting on 23 January 2008 where, in addition to those companies and organisations represented at the workshop were the following:

- Capoco Design
- Confederation for Passenger Transport (CPT)
- Ove Arup
- Technology Strategy Board (TSB)
- Torotrak

Technologies

There are many possible low carbon technologies that could be supplied to the bus market. The following technologies were assessed in drawing up the low carbon bus specification:

- Series hybrid
- Parallel hybrid
- H2ICE
- H2FC
- Novel gearbox
- Stop-start
- Regenerative braking
- Renewable fuel (e.g. biodiesel, bioethanol, biogas and hydrogen)
- Battery-electric
- Catenary
- Combinations of the above

Additionally, there are several hybrid energy storage media possibilities including the following:

- Batteries (several technologies available)
- Ultra capacitors
- Flywheel
- Hydraulic
- Pneumatic

In the UK the following bus low carbon technologies have been recently trialled or are in service:

- H2FC
- Battery-electric
- Series hybrid battery energy storage
- Micro-turbine

- Diesel

In the UK the following designs are in development or are likely to be introduced or re-introduced:

- Parallel hybrid
- H2ICE
- H2FC
- Novel reduced losses gearbox
- Flywheel energy storage

In the USA low carbon buses have made a large impact under very different fiscal arrangements to those of the UK with national, state and city government subsidies - the main technologies are as follows:

- Series diesel-electric hybrid
- Parallel diesel-electric hybrid
- Methane

There were over 1300 diesel-electric hybrids by the end of 2006 compared to only 18 in the UK.

Relative costs
The following table was shown at the Workshop to give samples of different technologies, their GHG performance and relative costs for both vehicle premium and, if appropriate, infrastructure.

Table 2: Relative technology costs

Technology	Technology Relative cost	Infrastructure Relative cost	GHG Reduction
Catenary	Medium	Very high	30% - 100%
H2FC	High	High	Up to 100%
Hybrid	High	None	30% - 40%
H2ICE	Medium	High	Up to 100%
Biogas	Medium	Medium high	75% - 243%
Battery-electric	Medium	Medium	30% - 100%
Stop-Start	Low	None	5% - 25%
Regenerative braking	Low	None	5% - 30%
Low loss transmission	None	None	10% - 20%

Effect of Bus Service Operators' Grant

Some technologies are much more attractive if BSOG is reformed, for example:

- Fuel cost saving is much less with BSOG qualifying operations with 80% of fuel duty rebated (staged routes)
- Break-even point not reached in an acceptable period of time on some technologies such as diesel-electric hybrid
- For any fuel saving technology the Government actually save rebating considerable fuel duty

At the LowCVP Bus Working Group meeting on 18 January 2008 the DfT presented an overview of a consultation process to be undertaken on BSOG. This will run from March 2008 for 12 weeks.

Two tier approach
In the light of the effect of BSOG and the fact that there may be cost-effective technologies that meet a lesser GHG reduction, the workshop attendees were asked the following:

- Should there be a two tier specification?

A possible approach could be as follows:

- Tier 1: X% GHG reduction compared to Euro 3 baseline, well-to-wheels
- Tier 2: 0.5X% GHG reduction compared to Euro 3 baseline, well-to-wheels

The workshop attendees debated the definition of the baseline and whether to be on a well-to-wheels or tank-to-wheels basis. Clearly, to be technology neutral, well-to-wheels had to be the case. As the LowCVP Bus Working Group already had a well defined Euro 3 baseline it was agreed to remain with that. Note that TfL are preparing a Euro 4 baseline for their specifications on a tank-to-wheel basis.

It was also agreed that the two tier approach should be carried forward due to the uncertainty regarding BSOG and the length of time that may be necessary should a reform be undertaken; for example, EU State Aid negotiations may take upwards of 18 months. Note that BSOG pre-dates the UK entry to the EU and is, therefore, not subject to these regulations.

The following was therefore agreed:

- Tier 1: 40% GHG reduction compared to WTW Euro 3 baseline
- Tier 2: 20% GHG reduction compared to WTW Euro 3 baseline
- Baseline defined in LowCVP Bus Working Group document BWG-P-05-04 (February 2005)

See Table B of the Specification (Appendix 4) for tabulated targets versus passenger capacity.

GHG baseline

The original bus baseline was calculated against a characteristic curve derived for diesel Euro 3 types as tested on the MLTB cycle (see Appendix 2) using TTW CO2 measurements adjusted for the additional WTT component. For this Specification to allow for all possible technologies, the same results will now represent total GHG CO2 equivalent emissions. The original target line was expressed by the following equation (30% GHG reduction):

GHG CO2 equivalent (well-to-wheel) g/km =

(7.25 x total number of passengers) + 480

See LowCVP Bus Working Group document BWG-P-05-04 (February 2005). See also Appendix 3 for original curve fit.

At the workshop the issue about route specific nature of hybrids' fuel consumption performance was raised whereby the MLTB cycle was deemed not necessarily representative. For the forward procurement process there should be an allowance to undertake fine tuning during initial trials to optimise fuel consumption on the target route.

Air quality emissions

At the workshop the following air quality emissions requirement was debated - should target air quality emissions be set and if so at what level?

- Euro 4?
- Euro 5?
- EEV?

An issue that was noted was that given that the basis for emissions testing was agreed to be whole vehicle tests on the MLTB cycle, then the question was raised how could equivalence to heavy duty emissions legislation be determined as this is applied to an engine on test bed?

After discussion it was decided that an EEV level of emissions should be the basis of the target.

Note that the basis for emissions testing has been whole vehicle tests on the MLTB cycle and an attempt was made from existing Euro 3 data to define a NOx and Pm target line versus passenger capacity. This was then factored by the ratio of EEV to Euro 3 legislation. The results are shown in Table C of the Specification (Appendix 4).

A zero emission mode was discussed and it was agreed to be an optional requirement of 4 miles range. This reflects the fact that some authorities may require this feature but that not all technologies are able to achieve zero emission performance.

Note that TfL have no plans for a zero emissions zone for London bus operations.

Table 3: European Heavy Duty engines emissions legislation

Legislation	CO	NMHC	CH4	NOx	Pm
	g/kWh	g/kWh	g/kWh	g/kWh	g/kWh
Euro 3	5.45	0.78	1.6	5.0	0.16
Euro 4	4.0	0.55	1.1	3.5	0.03
Euro 5	4.0	0.55	1.1	2.0	0.03
EEV	3.0	0.40	0.65	2.0	0.02

Noise
The workshop attendees agreed that exterior noise should follow current EU legislation of 80 dB(A) but that interior noise should follow the TfL-London Buses requirements (to be supplied by TfL-London Buses).

Vehicle specifics
The workshop attendees agreed to use the whole vehicle approval EU Bus & Coach directive 2001 / 85 to cover the following:

- Performance
- Access
- Disability requirements
- EMC
- H & S
- Etc.

Life cycle assessment (LCA)
At the suggestion of the workshop attendees it was agreed to add the requirement for full LCA documentation of the vehicle and systems' components. ISO 14000 series standards apply.

Harmonisation of specifications
Despite the intention to share information and ideas on developing a low carbon bus specification with TfL and TRUS, it became apparent during discussions that a harmonisation of the specification may be problematical.

The TfL approach is focused on reducing GHG tailpipe emissions. This will be achieved by hybridisation and / or use of hydrogen as an energy vector. TfL has on order the following vehicles:

- 5 hydrogen internal combustion engines types (H2ICE)
- 5 hydrogen fuel cell types (H2FC)
- 50 diesel-electric hybrids of differing configurations

Consequently TfL are developing specifications for specific vehicle types rather than a technology neutral approach. TfL are considering a radical approach regarding GHG targets (based on tank-to-wheel) whereby, rather than against a passenger capacity, it will be on a per vehicle type:

- Single decker
- Double decker
- Articulated

Clever design may accommodate more passengers within the envelope accordingly without incurring a baseline GHG penalty.

The TRUS programme has at its heart a driveline sub-system consisting of a battery pack plus electric motor. This enables a modular approach to be taken for three types of bus:

- Battery-electric
- Hybrid
- Catenary

The COMPRO project has yet to develop a specification although they are interested in procuring two broad types of low carbon bus technologies, these being gas and hybrid technologies.

As far as possible the specification proposed has been designed to be broad enough to incorporate the aspects of both approaches to developing a specification. To this end all of these technologies are accommodated within the technology neutral specification described here.

Volumes
Significant cost break points are expected to be achieved with around 1000 units. This was based upon stakeholder input and an analysis of the economics of bus drivelines undertaken for DfT by Sciotech.

The ability of TfL or the UK as a whole to influence the European bus production is questionable given that new bus sales in the UK of buses greater than 8.5 tonnes range between 2000 and 3000 vehicles per annum. As a consequence it was recommended that the UK should seek collaboration with stakeholders in the European bus market with regard to developing a common specification.

Hybrid test protocol
It was noted that TfL were reviewing the hybrid test protocol as a result of inconsistencies in results reported using the MLTB test cycle. This is thought to be due to the strategies being employed by hybrid bus manufacturers. The findings will be reported to the LowCVP Bus Working Group in due course.

Fleet trials
It is envisaged that there will be 3 acceptance phases within the Forward Commitment process and covered by the contract – satisfactory performance to be achieved at each phase before taking the programme to the next level. The likely structure is as follows:

- Phase 1 – individual demonstration vehicles
    - Bus to achieve near to target performance on MLTB
    - Some refinement of calibration / set-up during phase
- Phase 2 – small fleet trials of the order of 10 buses on one route
    - Further refinement of calibration / set-up and vehicle to vehicle performance variation assessment
- Phase 3 – large scale procurement of circa 500 buses

Conclusions

- There was sufficient OEM / Operator / PTA interest shown in the workshop exercise to indicate that a forward commitment programme for low carbon bus procurement may go forward
- Cost-effectiveness is a major issue; e.g. with the present BSOG structure there is no commercial incentive to operate hybrids in the UK. However, this is likely to change during 2008.
- European emission test cycles were seen as inappropriate for defining fuel consumption and GHG emission reduction targets. A real world test cycle is required for this and the MLTB was proposed. It was recognised there were other real world test cycles which could be used which as an equivalent.
- A two tier GHG target system was agreed; with 40% and 20% GHG reductions as tested on the MLTB drive cycle.
- Final pass-off performance on GHG / fuel consumption will be route specific and based upon in service fuel consumption.
- It will be dependent on the future structure of BSOG whether Tier 1 or Tier 2 should be used for a forward commitment process; there may even be scope for them to run in parallel.
- For significant cost reductions component levels need to run at 1000 systems p.a.
- UK sales of >8.5 tonne buses has recently varied between 2400 and 3000 p.a.
- Pooling of component purchase and / or pan-European collaboration will be required to reduce unit costs for some of the technologies.

Appendix 1

Emissions Data

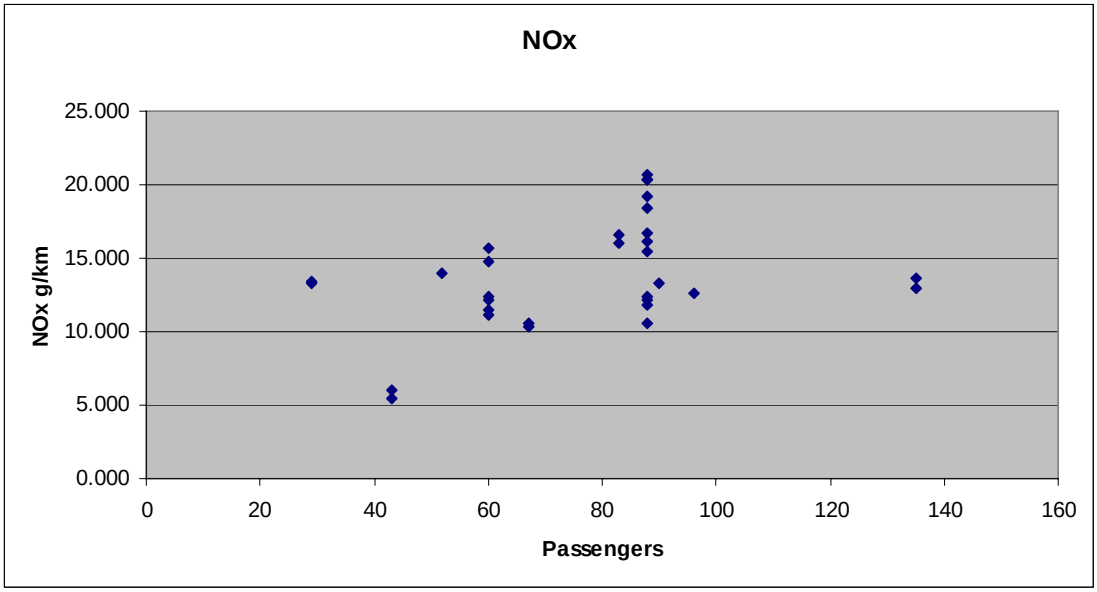
NOx calculations

Table 4: NOx Euro 3 buses with no NOx after treatment

Make	Model	Engine	Type	Passenger total	NOx (g/km)
Dennis	Dart	Cummins ISBe3	SD	60	15.674
Mercedes-Benz	Citaro 12m		SD	96	12.600
Dennis	Dart	Cummins ISBe3	SD	60	12.350
Dennis	Dart	Cummins ISBe3	SD	60	11.127
Dennis	Pointer Dart	Cummins ISBe3	SD	52	14.029
Optare	Solo	M-B OM904LA	SD	43	5.430
DAF	SB120	Cummins ISBe3	SD	90	13.267
Dennis	Trident	Cummins ISCe3	DD	88	16.099
Dennis	Trident	Cummins ISCe3 260 hp	DD	88	20.287
Dennis	Trident	Cummins ISCe3 225 hp	DD	88	19.213
Dennis	Trident	Cummins ISCe3	DD	88	15.474
Dennis	Trident	Cummins ISCe3 225 hp	DD	88	18.438
Volvo	B7TL		DD	88	12.130
Leyland	Olympian	Cummins	DD	83	16.060
Dennis	Trident	Cummins ISCe3	DD	88	20.392
Volvo	B7TL		DD	88	11.767
Dennis	Trident	Cummins ISCe3 225 hp	DD	88	20.733
Volvo	B7TL		DD	88	12.420
Scania		DSC902	DD	88	10.578
DAF	DB250		DD	88	16.695
Mercedes-Benz	Citaro G	OM906LLA	Artic	135	13.613

Mercedes-Benz	Citaro G	OM906LLA	Artic	135	12.984
Optare	Solo	M-B OM906	SD	43	6.020
Dennis	Dart	Cummins ISBe3	SD	60	11.490
Dennis	Dart	Cummins ISBe3	SD	60	12.170
Dennis	Dart	Cummins ISBe3	SD	60	14.730
Leyland	Olympian	IVECO	DD	83	16.610
Optare	Excell	Cummins ISBe3	SD	67	10.360
Optare	Excell	Cummins ISBe3	SD	67	10.570
Marshall	Midi Bus	Cummins ISBe3	SD	29	13.340
Marshall	Midi Bus	Cummins ISBe3	SD	29	13.440

Figure 1: NOx versus passenger numbers



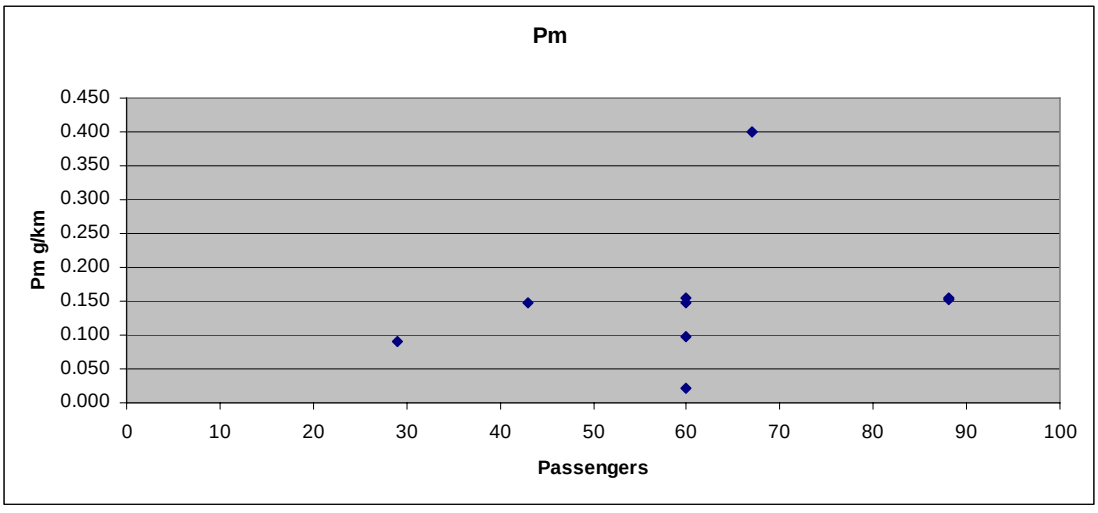
slope 0.054667
intercept 9.697988
r^2 0.380212
NOx (g/km) = (0.0547 x passengers) + 9.698

Particulates calculations

Table 5: Euro 3 buses with no Pm after treatment

Make	Model	Engine	Type	Passenger total	Pm (g/km)
Dennis	Dart	Cummins ISBe3	SD	60	0.148
Dennis	Trident	Cummins ISCe3 260 hp	DD	88	0.153
Dennis	Trident	Cummins ISCe3 225 hp	DD	88	0.154
Optare	Solo	M-B OM906	SD	43	0.148
Dennis	Dart	Cummins ISBe3	SD	60	0.021
Dennis	Dart	Cummins ISBe3	SD	60	0.097
Dennis	Dart	Cummins ISBe3	SD	60	0.154
Optare	Excell	Cummins ISBe3	SD	67	0.4
Marshall	Midi Bus	Cummins ISBe3	SD	29	0.09

Figure 2: Pm versus passenger numbers



slope 0.001342
intercept 0.068888
r^2 0.244346
Pm g/km = (0.001342 x passengers) + 0.069

Appendix 2

Millbrook London Transport Bus (MLTB) Drive Cycle

Figure 3: MLTB Phase 1 (Outer London)

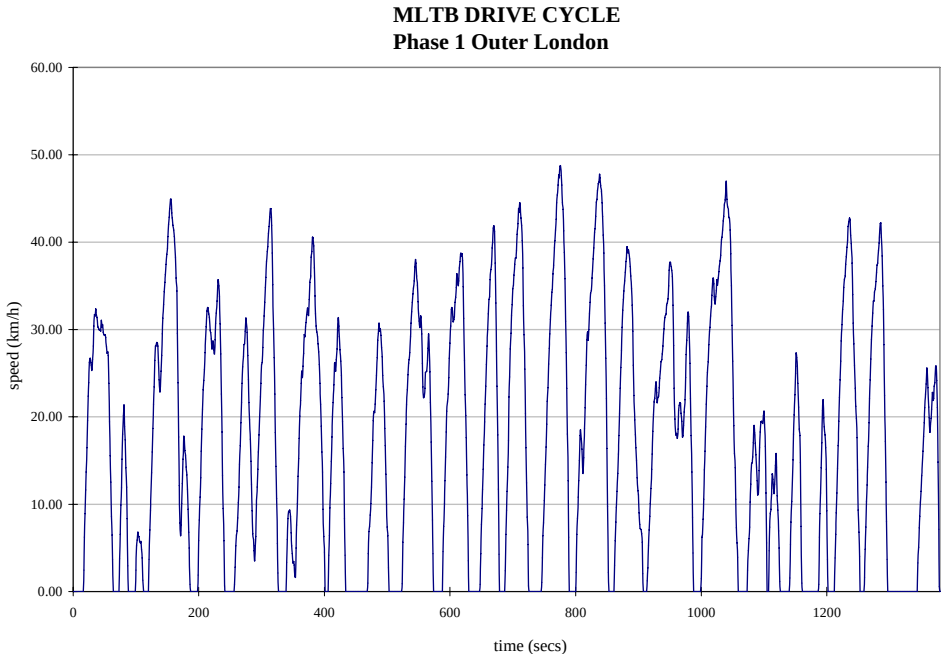
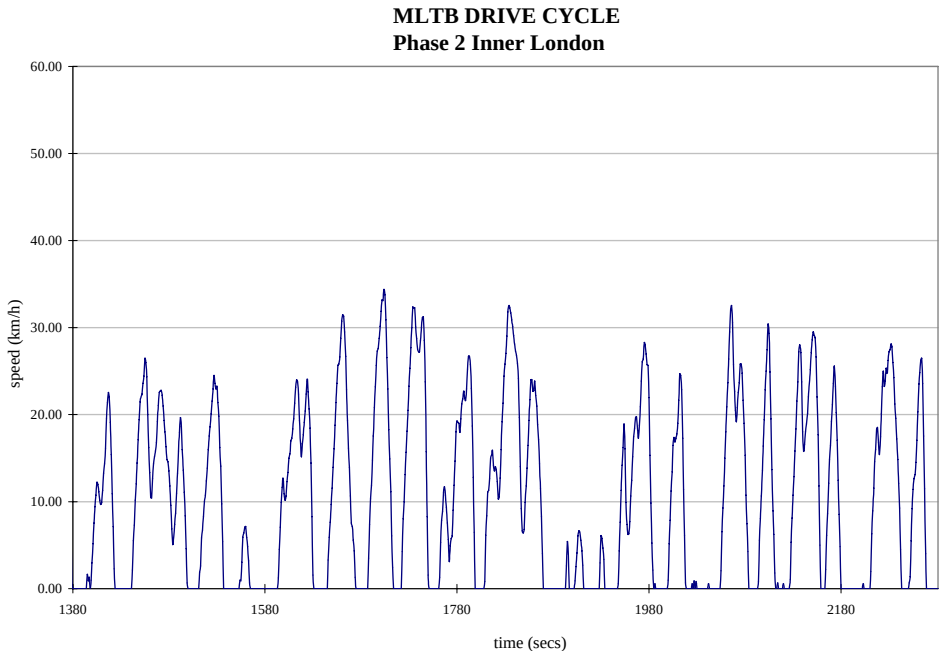


Figure 4: MLTB Phase 1 (Inner London)



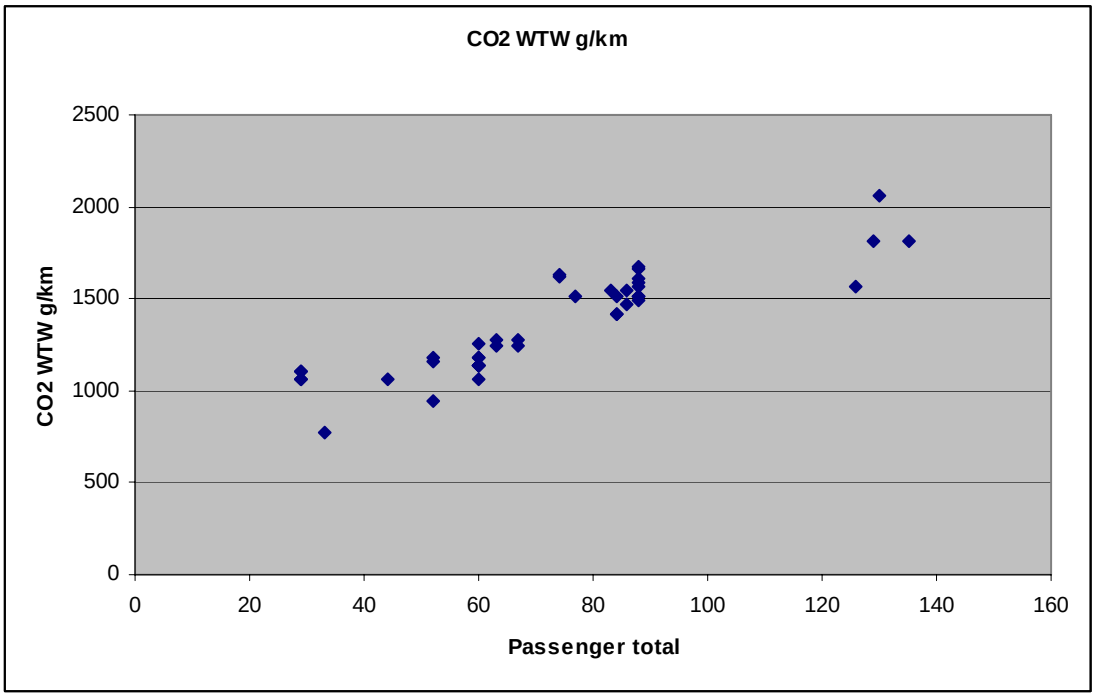
Appendix 3

CO2 Target Line
(From LowCVP BWG-P-05-04)

Table 6: Euro 3 CO2 WTW baseline data

Make	Model	Engine	Type	Passenger total	CO2 WTW g/km
Mercedes			SD	33	774
Dennis	Dart		SD	44	1063
Dennis	Dart		SD	52	1157
Optare	Solo		SD	52	1179
DAF	DB250		DD	84	1513
Volvo	B7TL 2 axle		DD	88	1589
DAF	DB250		DD	84	1412
M-B	Citaro		SD	74	1626
Scania	L94		DD	77	1509
Dennis	Trident		DD	88	1566
Volvo	Olympian 3 axle		DD	130	2056
M-B	Citaro		Artic	135	1809
Volvo	Olympian	IVECO	SD	83	1545
Optare		ISB	SD	67	1278
Optare		ISB	SD	67	1244
Marshall		ISB	SD	29	1064
Marshall		ISB	SD	29	1107
Dennis	Dart		SD	60	1133
Dennis	Dart		SD	60	1141
Dennis	Dart		SD	60	1138
Dennis	Dart		SD	60	1178
Dennis	Trident		DD	88	1670
Dennis	Trident		DD	88	1664
Dennis	Trident		DD	88	1513
Dennis	Trident		DD	88	1495
Dennis	Trident		DD	88	1509
Dennis	Trident		DD	126	1569
Dennis	Dart		SD	60	1259
Dennis	Dart		SD	60	1063
Volvo	B7TL		DD	88	1607
M-B	Citaro		SD	74	1625
M-B	Citaro		Artic	129	1812
DAF	DB250		DD	84	1415
Volvo	Olympian	Cummins	DD	86	1472
Volvo	Olympian	IVECO	DD	86	1545
Optare	Optare		SD	63	1278
Optare	Excell		SD	63	1244
Optare	Solo	M-B	SD	52	947
Marshall		ISB	SD	29	1064
Marshall		ISB	SD	29	1107
Dennis	Dart		SD	60	1133
Dennis	Dart		SD	60	1141
Dennis	Dart		SD	60	1138
Dennis	Dart		SD	60	1178

Figure 4: Euro 3 CO2 WTW baseline



slope	9.175097712
intercept	721.5941505
r^2	0.881879021

It was decided by the LowCVP Bus Working Group sub-group that there was a lack of data at the lowest capacity buses. There was a turning up of the CO2 plot and that the above data should be truncated at 44 total passengers (8m Dart). Also repowers were eliminated at this stage. The resultant baseline and target curves are displayed below as reported in LowCVP BWG-P-05-04. The target line (- 30% GHG) was expressed by the following equation:

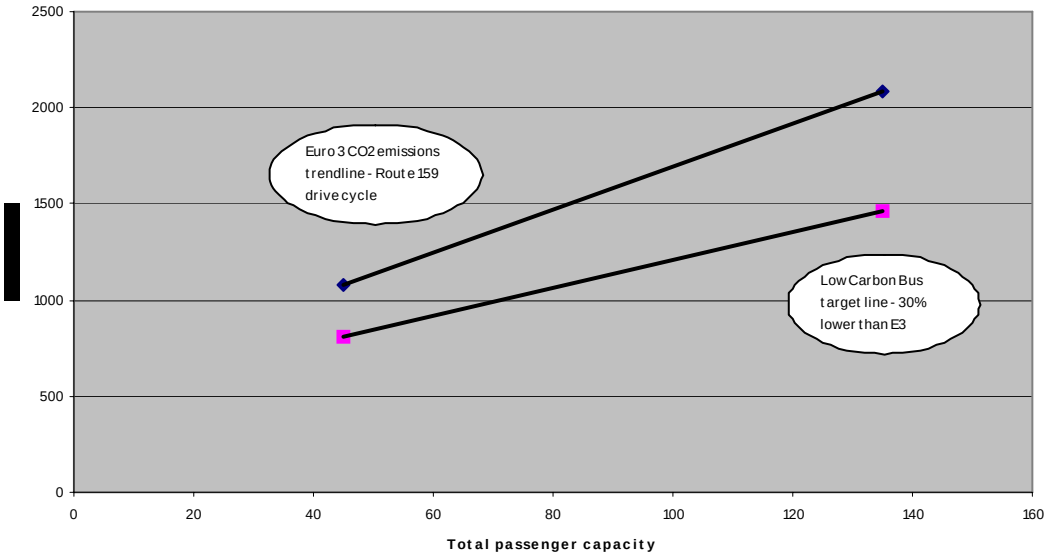
GHG CO2 equivalent (well-to-wheel) g/km =

((7.25 x total number of passengers) + 480)

WTT element was estimated at 14.286% of TTW CO2.

Figure 5 shows the resultant baseline and target line from the exercise.

Figure 5: CO2 target line (from LowCVP BWG-P-05-04)



Appendix 4

Specification
Version 5

Table A: Requirements

Parameter	Requirement
Tier 1 greenhouse gas carbon-dioxide equivalent performance	- 40% (minimum) c.f. Euro 3 equivalent bus on MLTB drive cycle See Table 1 for targets
Tier 2 greenhouse gas carbon-dioxide equivalent performance	- 20% (minimum) c.f. Euro 3 equivalent bus on MLTB drive cycle See Table 1 for targets
Gradeability (with maximum load)	10%
Range / Endurance	250 miles / 400 km
Range (zero emissions) - optional	4 miles / 6.4 km
Drive-by noise performance (exterior)	80 dB(A) as per EU Directive
Drive-by noise performance (interior)	As per current TfL requirements (data to be supplied)
Air quality emissions	Reductions to be obtained on the MLTB drive cycle See Table 2 for targets
Exhaust position (if appropriate)	Non near-side
Refuelling	Once a day
Construction & Use	EU Bus & Coach Directive 2001/ 85
Life cycle assessment (LCA)	ISO 14000 series

Table B: Well-to-wheel greenhouse gas targets

Passenger capacity	Tier 1 (40% reduction)	Tier 2 (20% reduction)
	WTW GHG g/km	WTW GHG g/km
20	535	715
40	659	881
60	784	1046
90	970	1295

Note for the above table the following formulae were used for WTW GHG emissions factors on the whole vehicle MLTB drive cycle based on the original one developed for a 30% reduction:

Tier 1 WTW GHG CO2 equivalent (g/km)

= (((7.25 x total passengers) + 480)) x 0.857)

Tier 2 WTW GHG CO2 equivalent (g/km)

= (((7.25 x total passengers) + 480)) x 1.143)

These expressions may then be simplified as follows:

Tier 1 WTW GHG CO2 equivalent (g/km)

= (6.21 x total passengers) + 411

Tier 2 WTW GHG CO2 equivalent (g/km)

= (8.29 x total passengers) + 549

Table C: NOx & Pm emissions targets

Passenger capacity	NOx	Pm
	g/km	g/km
20	4.32	0.019
40	4.75	0.024
60	5.19	0.030
90	5.85	0.038

Note that the NOx and Pm emissions factors in the above table are to be derived from the whole vehicle MLTB drive cycle.

Note for the above table the following formulae were used for NOx and Pm emissions factors on the whole vehicle MLTB drive cycle:

NOx (g/km)

= ((0.0547 x total passengers) + 9.698) x 0.4

Pm (g/km)

= ((0.001342 x total passengers) + 0.069) x 0.2

The formulae may be rationalised as follows:

NOx (g/km)

= (0.0219 x total passengers) + 3.879

Pm (g/km)

= (0.000268 x total passengers) + 0.0138

These formulae were derived from Euro 3 baseline data linear regression curve fits and application of a ratio of legislation levels for EEV / Euro 6 proposal versus Euro 3. The following ratios were used:

- Euro 6 / EEV NOx relative to Euro3 = 0.4
- Euro 6 / EEV Pm relative to Euro3 = 0.2

There nature of the data gave a poor correlation factor in both NOx and Pm cases. However it was felt that the resultant curves were intuitively close to describing the required emissions targets. Further work may be rquired on this aspect.

Annex 2

COMPRO comments on LowCVP low carbon bus specification

During the first PMG meeting in Nantes last March, it was decided to collect expectations/needs both from local authorities/local public transport companies and from the bus manufactures, in order to test concretely the existence, on the market and on the demand side, of shared/sharable specifications for a bus joint procurement. On that occasion Regione Emilia Romagna was asked to coordinate the demand side requests and to present them at the PMG meeting scheduled in Bremen.

As promised in Nantes, Jonathan Murrey (Deputy Director, Low Carbon vehicle Partnership, London) has subsequently sent us a report named "Low carbon bus specification" that had been developed by the Low Carbon Vehicle Partnership for a joint procurement in the UK. This document was supposed to be used as a tool to identify sharable bus specifications as a basis for a low emission bus joint procurement within the COMPRO project

Here follow the comments I have received from Gotenborg and Nantes, and those I have discussed with Andrea Bottazzi, who is a manager at ATC (Bologna's public transport company, the biggest in Emilia-Romagna region). Please note that I have not changed any words of the texts I have received.

Comments from our Bremen partners are still missing.

1. **COMMENTS BY ANNALENA VIDLUND (GATUBOLAGET – GOTENBORG)**

I find the paper interesting. The relative cost (Table 2) for biogas seems to be in a good perspective as this can be used to convince e.g. Hallandstrafiken and the politicians of Halland to change their perspective from ethanol to biogas which they actually have a local production of. And the discussion of the tiers is of course of interest for us. Is there other ways to make the transportations' system more efficient concerning emissions etc than only using the fuel as subject? Other parts of a bus, other kinds of materials?

In the West of Sweden there is now a big development of biogas production so organizations and companies in that industry want the bus fleets to use biogas instead of ethanol, diesel etc. There is also a demand for testing more hybrids and electric vehicles but the production of that kind of vehicles is not meeting the wishes from the operators when it comes to access and costs. With more production a lower cost might come and then, maybe, a purchasing order of more buses might come to the manufactures table.

I have sent the table of requirements and asked people of different companies if they agree or would like to add or take away anything and so far none has chosen that last alternative.

There seems to be a general opinion that the buses should be of Euro V and other comments are dealing with the fact that the buses would be more efficient if they would be running filled with passengers and also have more bus lines to make the car drivers take the bus instead. Some people do not believe that the biggest effort now should only be in investing in new technology. Instead we should also make the public transportation service more attractive and becoming a very good alternative to the car.

Short info from Denmark:
Midttrafik in Denmark have the demand of maximum of sulphur content of 10 ppm and have the demand of having all new buses shall have a minimum of Euro V. There are also having demands on the noise level: 77 dB(A) outside the bus (for gas buses maximum of 74 dB) and maximum of 72 dB (A) inside the bus.

Many answer that their company is an operator and therefore only purchase new buses when they have a new contract demanding more buses to fill the contract. But they are interested in the subject of bringing more environmental buses to the market.

Opinions concerning the common procurement procedure:

- **An agreement on a common standard concerning the procurement** made by the different local and regional authorities **is needed at a national level** because of local differences.
- **Access to and supplies of alternative fuels vary between urban and rural areas** which gives different "starting points" in a procurement procedure. Rural areas can not perhaps have the same market of alternatives as their buses e.g. have to run long distances and then can not use only electricity as fuel.
- The legal framework ruling and concerning different demands/specifications must adjust to other countries' framework.
- The economical incitements (subsidies???) must adjust and equate between countries.
- Taxes and fees of bus transportations must adjust and be neutral in a concurrence perspective

Annalena Vidlund sent me also the following **"RECOMMENDATIONS CONCERNING EMISSIONS AND FUEL FROM *SVENSK KOLLEKTIVTRAFIK"*,** the organisation for the Swedish public transportation authorities.

In the Environmental Programme 2008, from SLTF (*Svenska Lokaltrafikföreningen*, changed the name to *Svensk Kollektivtrafik* in July 2008) the environmental demands for procurements are set up.

Recommendations concerning emissions

For buses, up to 22 passengers, there is a recommendation of the emissions levels according to the table 1:

Table 1

Year	NO_x g/KWh	Particles g/KWh
2008	4,7	0,07
2009	4,2	0,06
2010	3,8	0,06
2011	3,5	0,04
2012	3,3	0,02
2013	3,0	0,02
2014	3,0	0,02
2015	3,0	0,02
2016	3,0	0,02
2017	3,0	0,02
2018	3,0	0,02

From *Tabell 3-3 Avgaskrav för Klass A & B fordon,* SLTF miljöprogram 2008.

The levels for the last two years of a contract are kept at the level for the second last year: If a contract runs to 2009 the levels for NO_x and particles are kept at the level for year 2008 (4,7 and 0,07 above) both for the year 2008 and 2009.

For buses, more than 22 passengers, there is a minimum recommendation of the emissions levels according to the table 2:

Table 2

Year	NO_x g/KWh	Particles g/KWh
2008	4,7	0,02
2009	4,2	0,02
2010	3,8	0,02
2011	3,5	0,02
2012	3,3	0,02
2013	3,0	0,02
2014	3,0	0,02
2015	3,0	0,02
2016	3,0	0,02
2017	3,0	0,02
2018	3,0	0,02

From *Tabell 3-5 Avgaskrav för klass I, II och III fordon,* SLTF miljöprogram 2008.

The recommended requirements from *Svensk Kollektivtrafik* are:

Table 3

Year	NO_x g/KWh	Particles g/KWh
2008	3,7	0,02
2009	3,3	0,02
2010	3,0	0,02
2011	2,7	0,02
2012	2,4	0,02
2013	2,0	0,02
2014	2,0	0,02
2015	2,0	0,02
2016	2,0	0,02
2017	2,0	0,02
2018	2,0	0,02

From *Tabell 3-6 Avgaskrav för klass I, II och III fordon,* SLTF miljöprogram 2008.

For the Euro 5 buses the recommendations are:

Table 4

Year	NO_x g/KWh	Particles g/KWh
2008	2,0	0,02
2009	2,0	0,02
2010	2,0	0,02
2011	2,0	0,02
2012	2,0	0,02
2013	2,0	0,02
2014	2,0	0,02
2015	2,0	0,02
2016	2,0	0,02
2017	2,0	0,02
2018	2,0	0,02

From *Tabell 3-7 Utökade avgaskrav för klass I, II och III fordon,* SLTF miljöprogram 2008.

Recommendations concerning fuels

Diesel and petrol shall be of a minimum of the environmental class 1 from 2005.
If a mixed fuel is used it can be classified as environmental class 1 if it contains a mixture of environmental class 1 fuel and a renewable fuel and if

the mixture has been documented not to give any deterioration concerning other emissions.

If the Swedish environmental class system shall change through e.g. EU-harmonization the customer/PTA and the entrepreneur/operator shall have a negotiation of quality and compensation level.

The Entrepreneur shall continuously work for reduction of green house gases' emissions. The Entrepreneur shall have a Programme to reduce the use of fossil and renewable fuels e.g. through eco-driving or technical methods.

The purchased public transportation shall be running on renewable fuels with a minimum level for renewable fuel as follows in Table 5:

Table 5

Year	Share of Renewable fuel %
2008	10
2009	15
2010	15
2011	15
2012	20
2013	20
2014	25
2015	25
2016	30
2017	30
2018	35
2019	35
2020	40

From *Tabell 5-1,* SLTF miljöprogram 2008.

Svensk Kollektivtrafik recommends their member organisations the following levels:

Table 5

Year	Share of Renewable fuel %
2008	10
2009	15
2010	20
2011	30
2012	40
2013	50
2014	60
2015	65
2016	70
2017	75

2018	80
2019	85
2020	90

From *Tabell 5-2,* SLTF miljöprogram 2008.

The Entrepreneur shall report the fuel consumption to the vehicle data base FRIDA. The customer has the right to take fuel samples from the Entrepreneur's tank station and vehicles. The Entrepreneur must have documents from the fuel distributor proving the fuel type used. The Entrepreneur shall in the company environmental report give an account of how the work with reducing emissions of green house gases is performed and also account for the work for reducing the use of fossil and renewable fuels.

2. SEMITAN GENERAL AND TECHNICAL COMMENTS ON THE LOWCARBON VEHICLE PARTNERSHIP PAPER.

This working group and their recommendations usefully feeds COMPRO project, at least as far as the engine performance is concerned.
Moreover, some of their conclusions directly match COMPRO concerns, i.e.:

- For general specification, it seems important to remain within the framework of already defined EU directives (2001/85);
- The total harmonization of specifications seems difficult to achieve;
- The potential "economy of scale" is hard to achieve, as significant cost break points are expected to be achieved with around **1000 units.**

Technical comment
This document is very well documented, and is very interesting because it does not rely on false perceptions as it is unfortunately often the case.

It also has the interest of analysing all technologies which would technically be possible to develop at an industrial scale, including electric traction by **catenaries ???**, which is often put aside for tyre vehicles despite transport history has proven this mode efficiency. This result will be measured on a real cycle of vehicle use instead of measuring the engine emissions on a theoretical cycle like it is the case for euro norms.

Concerning polluting emissions, we may now consider that with the Euro 5 and EEV norms, CO and NOx emissions are not any more the real problem, and that we should concentrate on the objective of CO2 emissions. It is not possible to capture this CO2 at the engine level. The real low carbon solution would then be to totally forbid the direct combustion of fossil fuels.

ATC COMMENTS BY ANDREA BOTTAZZI

1. In the specifications described from page 1 to page 2, the Life Cycle Cost (LCC) too should be taken into account besides the Life Cycle Assessment (LCA). The reason why LCC should be added is that it features a sort of maintenance cost synthesis. More over we cannot have a proper vehicle LCA if we have not projected the vehicle considering the LCC. In other words, for example we should not evaluate only the impact on the environment of the dismissal of each single part of the vehicle (as by the LCA), but also its life duration, that is how many times we have to substitute it during the vehicle life.
If - let's say - injectors are planned to work for 1 million kilometres, it means that we have to dismiss 6 of them every 1 million km; whereas if they are projected to cover 200.000 km, to cover 1 million km with the bus we need to change them 5 times more, that is they cost 5 times more. LCA consider the "cost for the environment", while LCC considers also the management/maintenance costs, is Bottazzi's conclusion.

2. The specification on range (zero emissions) should be eliminated because it makes sense only if we deal with a small hybrid bus fleet, while a massive use of hybrid buses makes this calculation useless. On the other hand, if the fleet becomes entirely hybrid, it is cheaper to drive the bus always in hybrid function to recover energy by breaking (that means 15-20 % of saved energy), while for sensitive bus line areas, where it is preferable to avoid exhausted gas emissions, it makes sense to drive electric vehicles .

3. With reference to the greenhouse gas emission reduction (see table 2), Bottazzi has observed that it is true that the fuel cell buses and H2ICE ones (hydrogen propelled buses equipped also with an internal combustion engine) cut down 100% of fossil emissions; anyway, we should not forget to evaluate how many CO2 emissions we produce in order to get hydrogen.

4. Again with reference to table 2: hybrid technology cost is high only if it is referred to batteries.

5. Electric braking depends on a rather simple principle (the engine "turns" the other way around), and the device to recover energy by braking is not expensive. The problem is that we need a battery to store it (the exception is represented by trolley buses since they can download the recovered energy into the net). Storage devices are expensive. In the future supercapacitors could help solve this problem and on a scale economy could cost far less.

6. Bottazzi suggests to target euro 5 or EEV bus performance, and to leave out euro 3 and euro 4, since diesel buses have already reached the EEV emission standard.

7. In his opinion a rather negative aspect of the low carbon bus document is that natural gas/ CNG has been totally forgotten. He wonders why.

On the contrary, the European Union has not forgotten this technology since it is mentioned in the White Paper on Transport, which foresees a target of 15-20% of CNG buses around the year 2020.
Besides this, for public transport company, which run CNG bus fleet and have built CNG filling stations not saturized yet, it is more convenient from a management viewpoint, although it is not so much advantageous from an environmental perspective.
In few words, we can have hybrid buses as a priority but we must not forget the CNG option. It will take more than ten years before we have a significant bus fleet renewal towards the hybrid technology in order to achieve an efficient GHG (greenhouse gases) reduction. Because of their high price, few are being procured and few will be bought also in the next future. Is a ten year period acceptable? Bottazzi's answer is that it is not. This confirm that we cannot put aside the CNG option Therefore Bottazzi thinks that COMPRO should consider both hybrid, CNG and trolley buses.
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