Biomethane for Transport
Key points and questions

Andy Eastlake

Managing Director - LowCVP

ADBA- 23 Sept 2015

LowCVP
Low Carbon Vehicle Partnership

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Objectives for road transport policies must:-

1. WORK - Keep UK moving! And growing – Solutions need to work in operation and be economically viable
2. BE LOW CARBON - Reduce climate impact – reduce GHG 80% by 2050 Climate act mandates target, Carbon budgets set interim targets, Current model says we will exceed targets in 2023
3. BE CLEAN - Minimise environmental Impact (NOx (NO2, NO), PM, PN)
4. BE SUSTAINABLE - Transition to renewable energy options

STEPS:

1. DfT Model the options – Biomethane highlighted
2. Industry agree roadmap for fuels
3. Road Map for Infrastructure
4. Trial the Technology
5. Provide the Evidence (Clean, Green, Practical, Sustainable)

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Update on 5th Carbon Budget

Low Emission HGV Sherpa Group, 21st September 2015

Holly Greig, Head of Climate Change Strategy

Department for Transport

5^{th} Carbon Budget: Background

- Climate Change Act 2008 established a framework to develop an economically credible emissions reduction path in the UK.
- **Three pillars:**

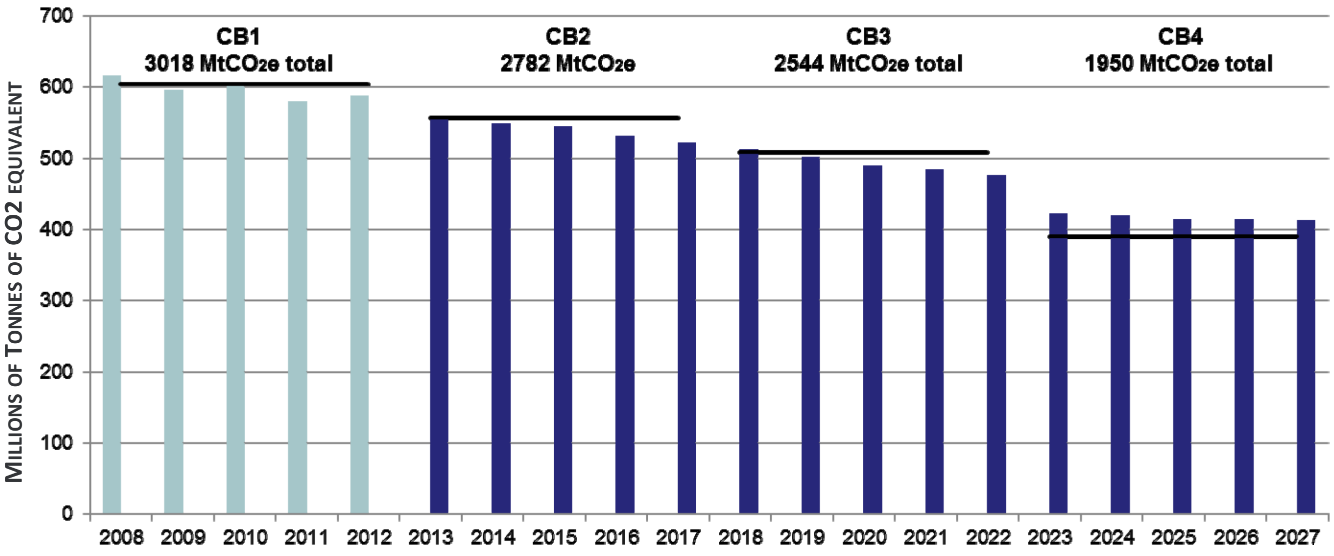
Ambitious climate change targets for 2050	Binding carbon budgets	Clear accountability framework
The Act commits the UK to reducing greenhouse gases by 80% by 2050 (compared to base year levels).	The Act requires that Government caps emissions over successive 5-year periods set 12 years in advance.	The Act established an independent Committee on Climate Change to provide advice and scrutiny.

Carbon Budgets: How are we doing so far?

The UK has met the first carbon budget.

Projections indicate we are on track to meet the second and third budgets.

There is currently an expected shortfall over the fourth budget.



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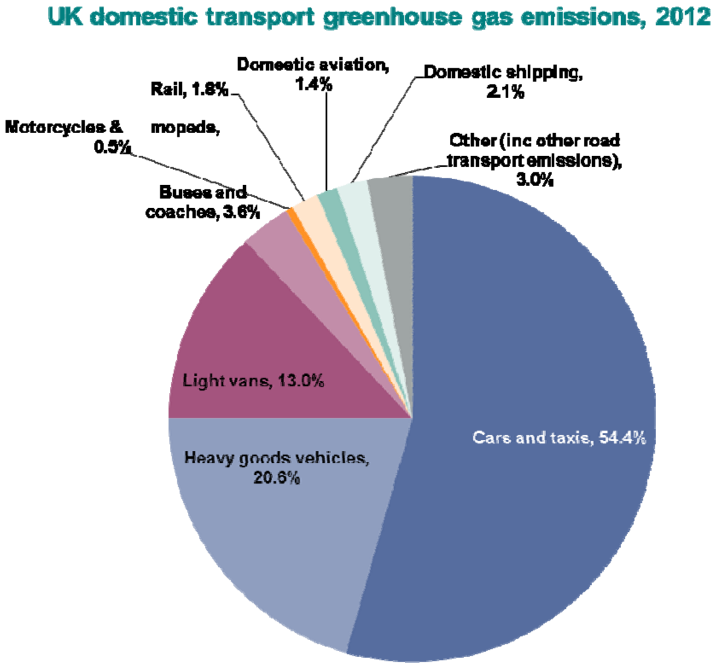
5th Carbon Budget: Relevance to freight

- Transport makes up around a quarter of UK carbon emissions, and reductions are likely to be needed in all modes.
- The chart illustrates how this breaks down across the different modes, with HGVs being the second largest contributor.



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5th Carbon Budget: What happens next?

- The Government needs to set level of Carbon Budget 5 by June 2016. This will cover the period 2028-2032.
- Department for Energy and Climate Change (DECC) has commissioned relevant departments to produce analysis to inform the setting of Carbon Budget 5 - this includes Department for Transport.
- In addition, the Government will need to publish a Carbon Plan by December 2016 which sets out the likely policy interventions that will be used to meet the Carbon Budgets.
- DfT is considering a range of measures to reduce HGV emissions, including:
  - Alternative fuels and infrastructure
  - Aerodynamic kit
  - Modal shift
  - Operational efficiencies
- Our analysis will feed into DECC's wider 5th Carbon Budget work.
- We will seek industry input through the Low Emission HGV Task Force and would welcome engagement from interested parties.

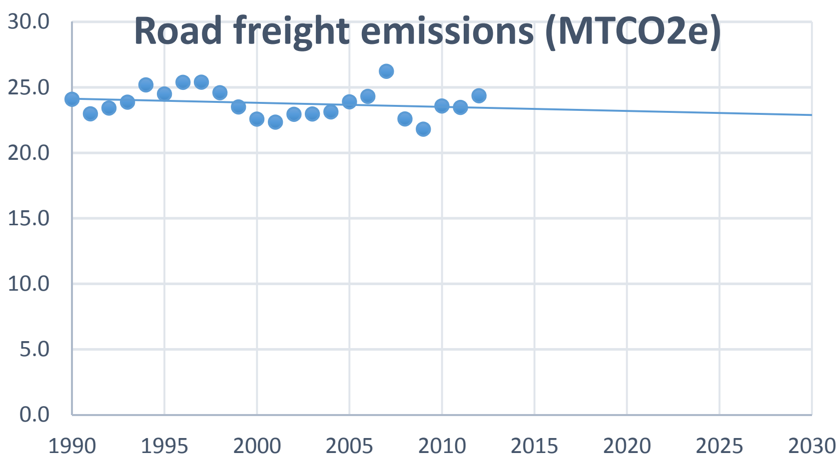
Handover to Brian

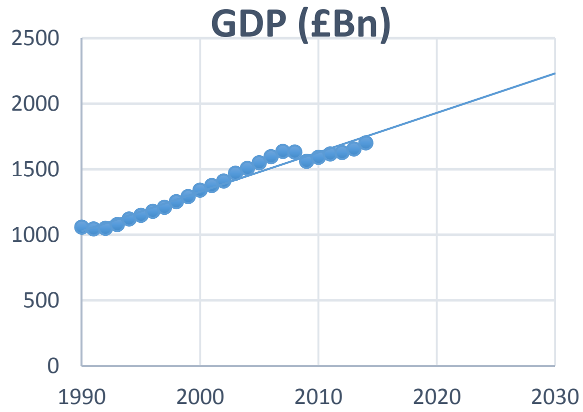
Road Freight Emissions – CB5 modelling

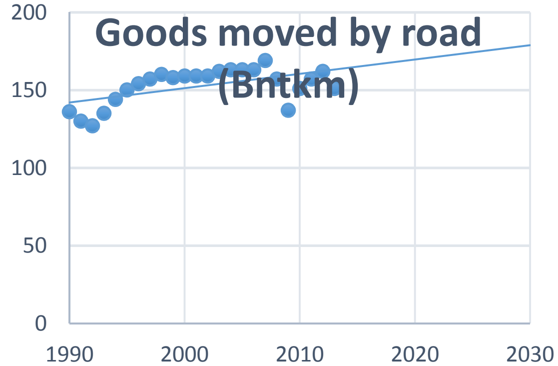
Low Emissions HGV Sherpa Group, 21st September 2015
Brian Robinson, Freight Policy Team

Official stats used to define current situation and trends…

- Road freight emissions, goods moved and GDP, since 1990.
- Despite 60%+ GDP growth since 1990, road freight activity has gone up much more modestly (c. 15%) and emissions have flat-lined.



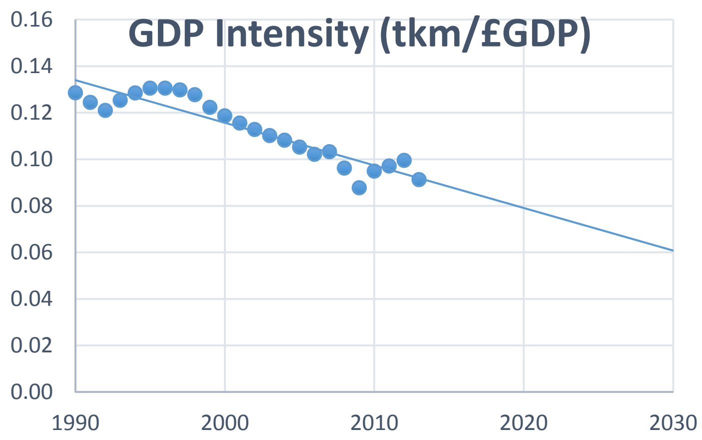




Sources:
- Emissions – National Atmospheric Emissions Inventory
- GDP – ONS (ABMI data)
- Goods moved – Transport Statistics Great Britain (Table TSGB0401). 2011-13 estimates based on RFS0101.

Two key metrics derived and used in model, based on established sustainability principles.

- **GDP Intensity** shows the link between road freight activity and the overall size of the economy.



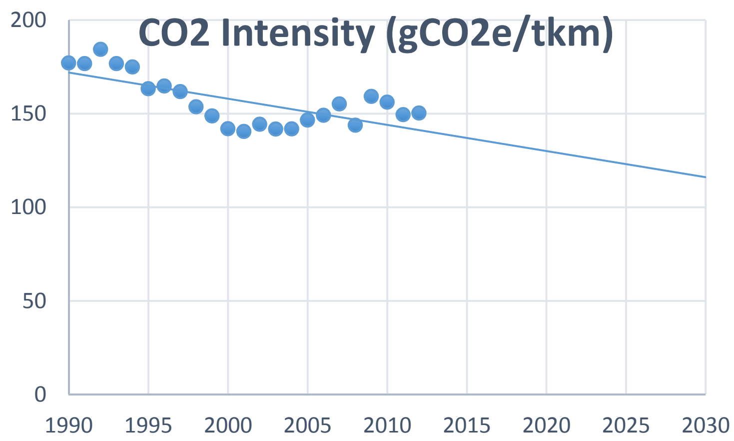
AVOID, SHIFT

- For GDP Intensity, measures considered are aimed at avoiding un-necessary or unproductive demand for freight, and shifting road freight to other (cleaner) modes (rail/water):

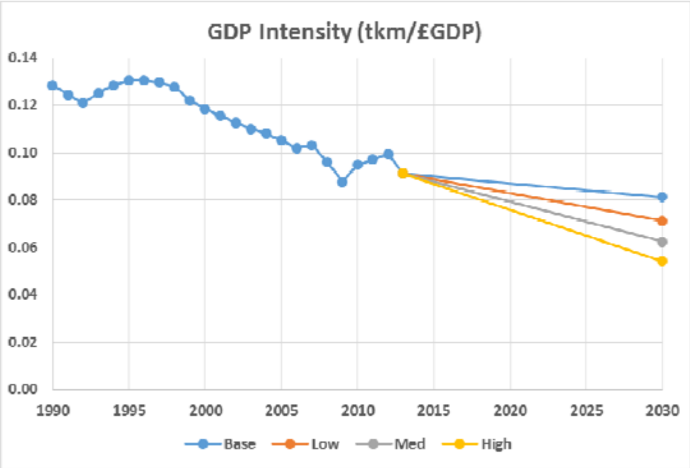
- **CO2 Intensity** shows the link between road freight emissions and a given level of road freight activity.

IMPROVE

- For freight that cannot be avoided or shifted, CO2 Intensity measures are aimed at improving the energy efficiency of the vehicles (mpg), improving the carbon intensity of the energy consumed, and improving operational efficiency (tonnes moved per unit of energy consumed).



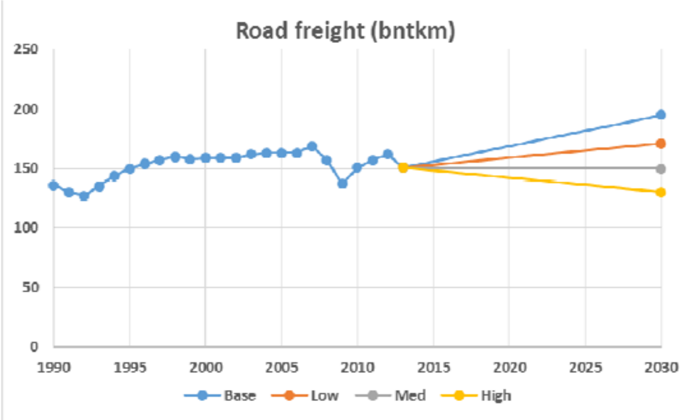
A range of GDP Intensity measures identified, some dependent on actions in OGDs…



AVOID & SHIFT

- AVOID measures focus on food, health and manufacturing; Defra, DoH and BIS, including:
  - Actions to reduce food waste
  - Actions to address overconsumption of both food and alcohol
  - Actions to reduce the logistics and supply chain impacts of manufacturing, e.g. via 3D printing & local sourcing.
- SHIFT measures focus on supporting growth in rail and maritime (port to port) freight movements.

- All scenarios assume economic growth to £2,400Bn by 2030, equivalent to 2.15% compound annual and in-line with historic, long term trends.
- Baseline projection is 195 Bntkm of road freight, equivalent to GDP Intensity of 0.08.
  - Low/Med/High Ambition scenarios assume 10/20/30 Bntkm of this can be avoided.
  - Low/Med/High Ambition scenarios assume 14/25/35 Bntkm of this can be shifted to rail/water.
  - Projected GDP Intensities are 0.07/0.06 and 0.05 in Low/Medium and High Ambition Scenarios.



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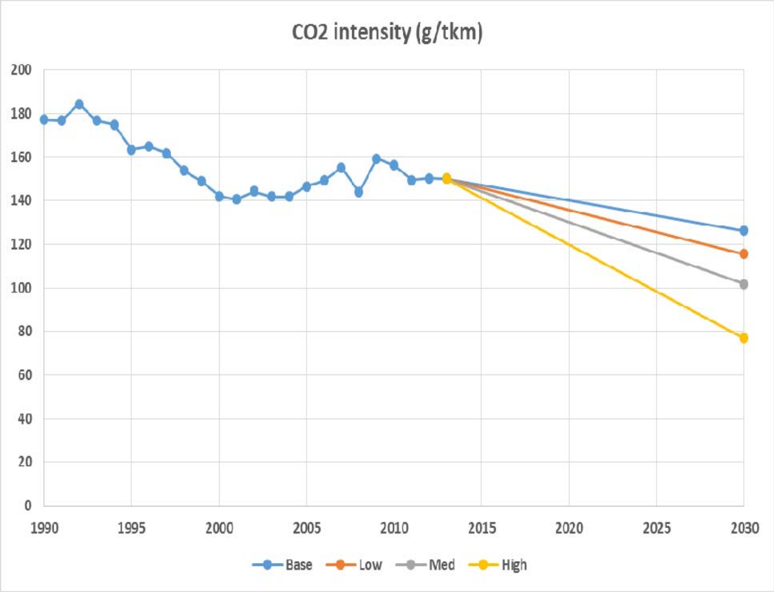
A range of CO2 Intensity measures identified, improving efficiencies and utilising low carbon energy sources…



- Baseline projection is fuel efficiency improves broadly in line with historic trends, by 1% p.a. reducing CO2 Intensity to 126 g/tkm in 2030. Baseline further assumes no improvements in operational efficiencies, minimal take up of electric vehicles and no take up and/or no TTW CO2 benefit from gas vehicles running on fossil gas.
- Low/Med/High scenarios assume actions to accelerate fuel efficiency improvements; by 1.25/1.5 and 1.75% per annum.
- Take up of electric vehicles highly constrained by capital cost, network and production scale up issues; 3/5/10% penetration into urban vehicle market.
- Operational efficiency improvements projected to deliver 4/8/12% improvements in fuel consumed per tonne moved.
- Gas vehicles deliver only modest savings unless bio-methane is available for use in HGVs. Medium scenario assumes 33% of energy consumed by gas trucks (10% of all energy consumed by trucks) is bio-methane. High scenario has 20% gas vehicle penetration and assumes 100% bio-methane use.
- Hydrogen considered but assumed not to be applicable to HGVs in meaningful numbers by 2030.
- Liquid biofuels to be incorporated later via blending with fossil diesel for HGVs.

IMPROVE

- Improvements to the carbon intensity of energy consumed can be achieved through actions to support the use of electric urban vehicles and bio-methane in gas vehicles.
- Improvements in operational efficiencies deliverable via actions to reduce empty running and increase average payload through, for example, greater supply chain collaboration and use of higher capacity vehicles.
- Vehicle fuel efficiency improvements can come from a combination of actions, e.g:
  - OEM innovations to improve new vehicle fuel efficiency, driven by market and regulatory pressures.
  - Operator actions to retrofit fuel saving technologies and train drivers in fuel-efficient techniques, to drive down costs and improve environmental performance/image.

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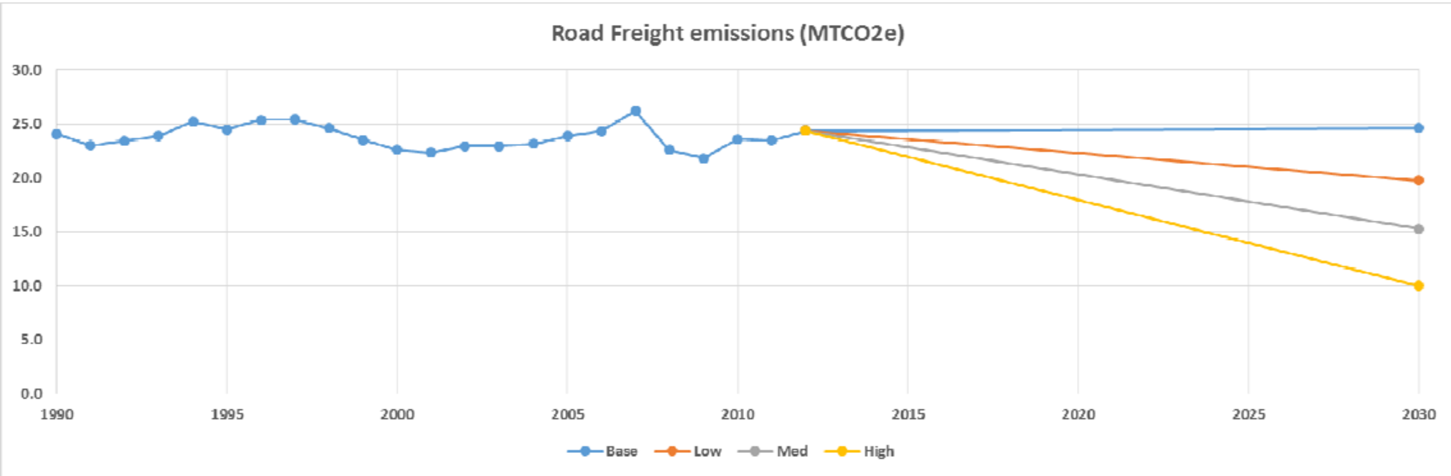
Combining the two sets of measures…



2030 Scenarios				
	Baseline	Low Ambition	Med Ambition	High Ambition
CO2 Intensity (g/tkm)	126	116	102	77
GDP Intensity (tkm/£GDP)	0.081	0.071	0.062	0.054
2030 MTCO2e	24.6	19.8	15.3	10.0
% reduction on 1990 base	-2%	18%	37%	58%

Note: Modelling covers only 2030 outcomes (assumed to be average annual figures for CB5). Trajectories from 2013 to 2030 may not be linear.

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The evidence base…

- For each metric, Baseline, Low Ambition, Medium Ambition and High Ambition scenarios have been developed reflecting increasing levels of intervention and using effectiveness assumptions based, where possible, on published evidence and, where not, on assumptions considered reasonable, and tested via peer review and some limited external stakeholder/expert dialogue.
- Sources of evidence/data include:
  - Rail Freight Market Study, Network Rail, 2013 - http://www.networkrail.co.uk/improvements/planning-policies-and-plans/long-term-planning-process/market-studies/freight/
  - Global Food: Waste Not Want Not, IMechE Report 2013 - http://www.imeche.org/docs/default-source/reports/Global_Food_Report.pdf?sfvrsn=0
  - Defra statistics on average food consumption - https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/385694/familyfood-2013report-11dec14.pdf
  - WRAP Food Waste resources - http://www.wrap.org.uk/content/household-food-and-drink-waste-uk-2012
  - House Of Lords European Union Committee Report "Counting the Cost of Food Waste" - http://www.parliament.uk/documents/lords-committees/eu-sub-com-d/food-waste-prevention/154.pdf
  - 3D printing growth potential and impacts - http://www.forbes.com/sites/louiscolumbus/2015/03/31/2015-roundup-of-3d-printing-market-forecasts-and-estimates/
  - 3D printing impacts report - http://assets1.csc.com/innovation/downloads/LEF_20123DPrinting.pdf
  - Logistics 2050: Moving freight by road in a very low carbon world (A.C. McKinnon & M.I. Piecyk, 2010) - http://www.greenlogistics.org/SiteResources/c8798abe-1987-4e16-a918-00658c7d8844_Logistics%202050.pdf
  - Longer and/or Longer and Heavier Goods Vehicles (LHVs) _ a Study of the Effects if Permitted in the UK: Final Report by I Knight, W Newton, A McKinnon et al. TRL Report PPR 285, 2008 - http://www.trl.co.uk/reports-publications/report/?reportid=6309
  - Impact Assessment: High Capacity Vehicles (D.Z. Leach & C.J. Savage, 2012). University of Huddersfield - http://eprints.hud.ac.uk/15769/1/High_Capacity_Vehicle_Impact_Assessment_Final_version.pdf
  - Logistics Carbon Reduction Scheme 5th Annual Report (FTA, 2015) - http://www.fta.co.uk/export/sites/fta/_galleries/downloads/logistics_carbon_reduction_scheme/logistics_carbon_review_2015.pdf
  - Opportunities to overcome the barriers to uptake of low emission technologies for each commercial vehicle duty cycle. Ricardo-AEA, 2012. Available from the Low Carbon Vehicle Partnership (LowCVP) - http://www.lowcvp.org.uk/projects/commercial-vehicle-working-group.htm

Fuels Roadmap

Inputs to the roadmap included recent UK & EU studies and the Pass Car, Commercial Vehicle & ICE roadmaps

automotive council UK

- Inputs:
  - ERTRAC roadmap “Energy Carriers for Powertrains”
  - E4Tech “A Harmonised Auto-Fuel Biofuel Roadmap for the EU to 2030”
  - Element Energy (LowCVP) “A Fuel Roadmap for the UK”
  - Auto Council Passenger Car & Commercial/Off-Highway Vehicle Roadmaps

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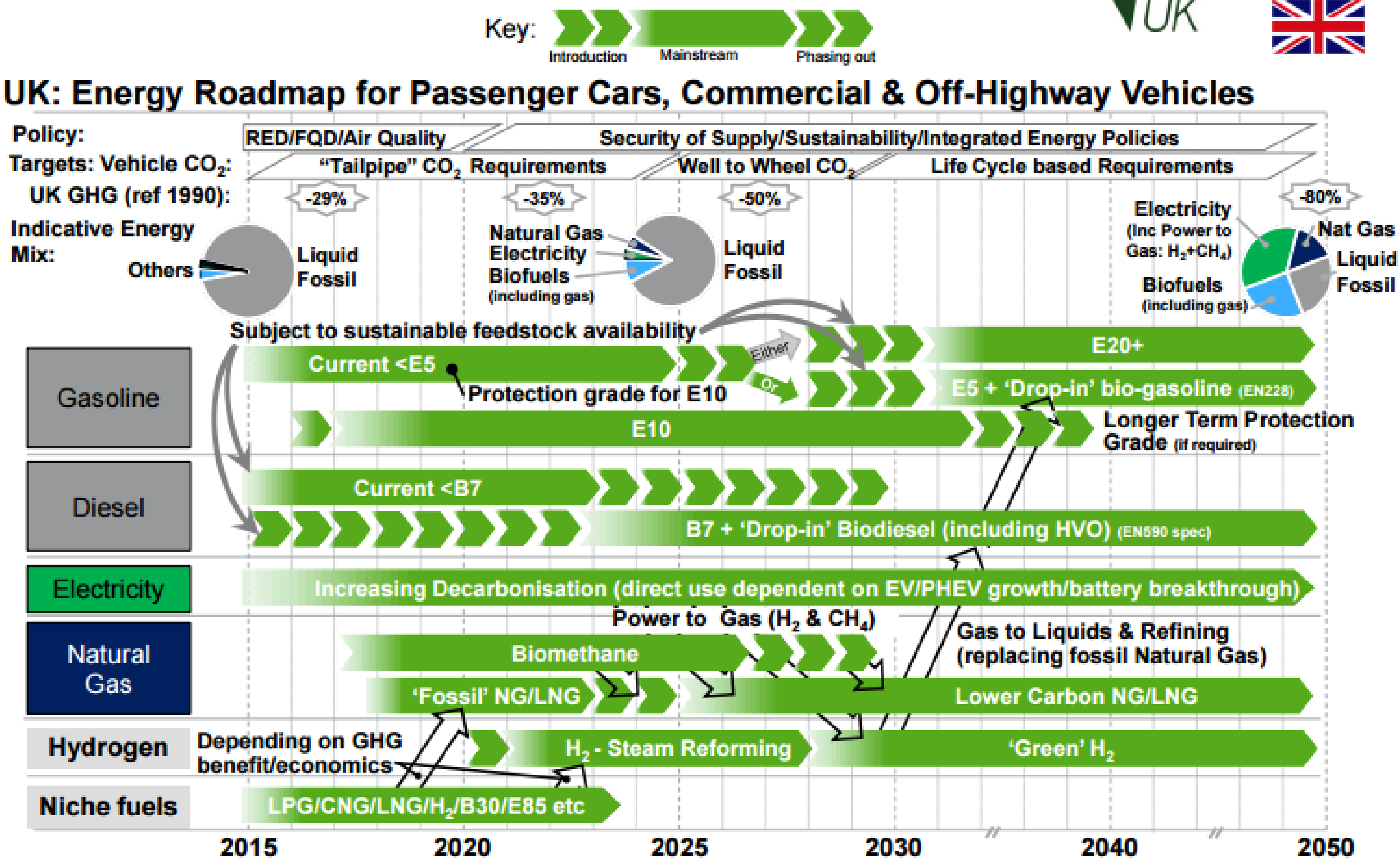
Energy Roadmap shows long term transition from gasoline & diesel fuels to a majority renewable energy portfolio



Source: Automotive Council, ERTRAC, E4tech, Element Energy

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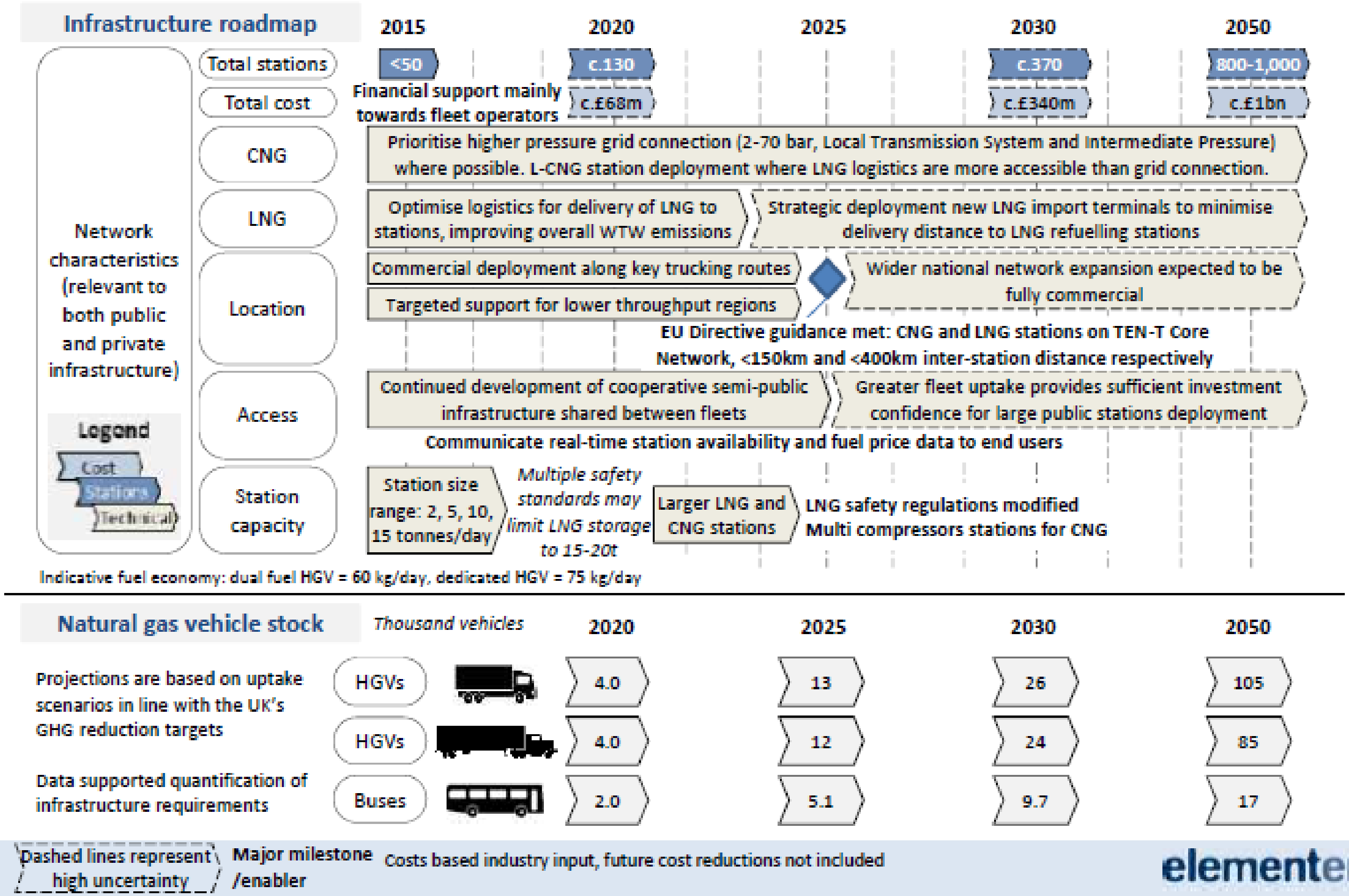
Regulatory barriers will be the primary focus for enabling natural gas infrastructure, whilst a number of technical issues must also be resolved



elementenergy 14

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6 Well-to-Tank (WTT) emissions

- In keeping with national targets for reducing transport GHG emissions, emissions relating to logistics and dispensing of gas should be minimised
- Current analysis is incomplete and UK non-specific, however some emission factors are well understood:
  - CNG station siting activities should aim to access **high pressure grid** connection points
  - LNG / L-CNG station siting activities should aim to **optimise delivery logistics** and adopt state-of-the-art **venting prevention** and capture systems
- Biomethane achieves greater WTT emission savings than natural gas but UK production is limited and incentives in place divert it to applications other than transport

Recommendations

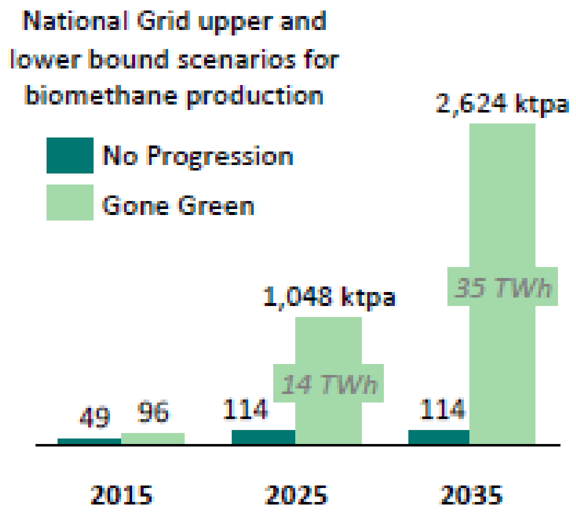
Local Authorities: Consider WTT emission factors in conjunction with planning guidance when approving natural gas station installations

Central Government: Future infrastructure strategy should consider UK specific findings (on-going ETI led analysis)

R&D bodies: Reduce costs for venting prevention / methane capture technologies

UK biomethane production potential

Graph units: ktpa (TWh shown as reference)



- National Grid has developed several scenarios of biomethane production, in the highest case it's 35TWh/year i.e. <5% of total gas demand
- Under present incentives, the 'No progression scenario' is the most likely case

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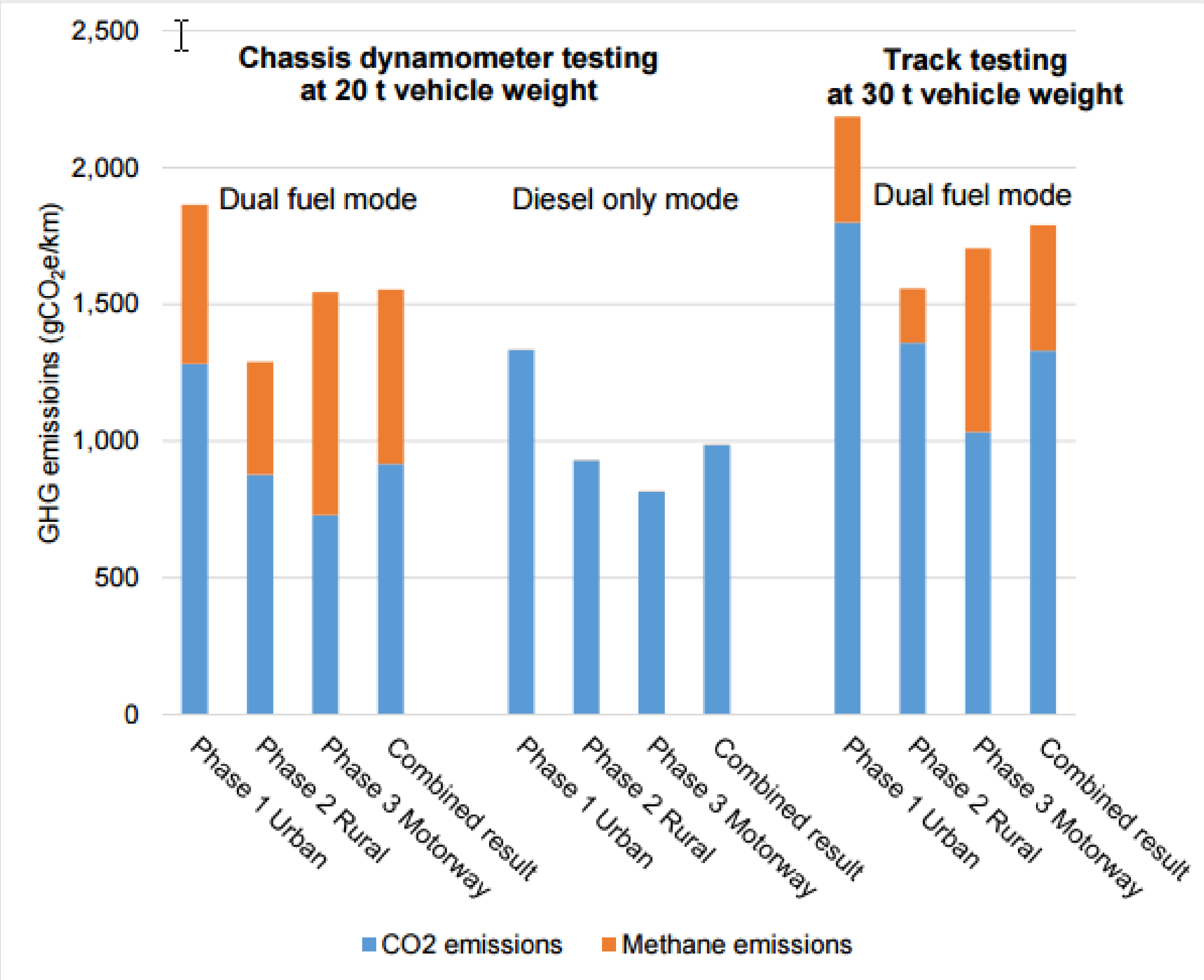
Early performance indicators

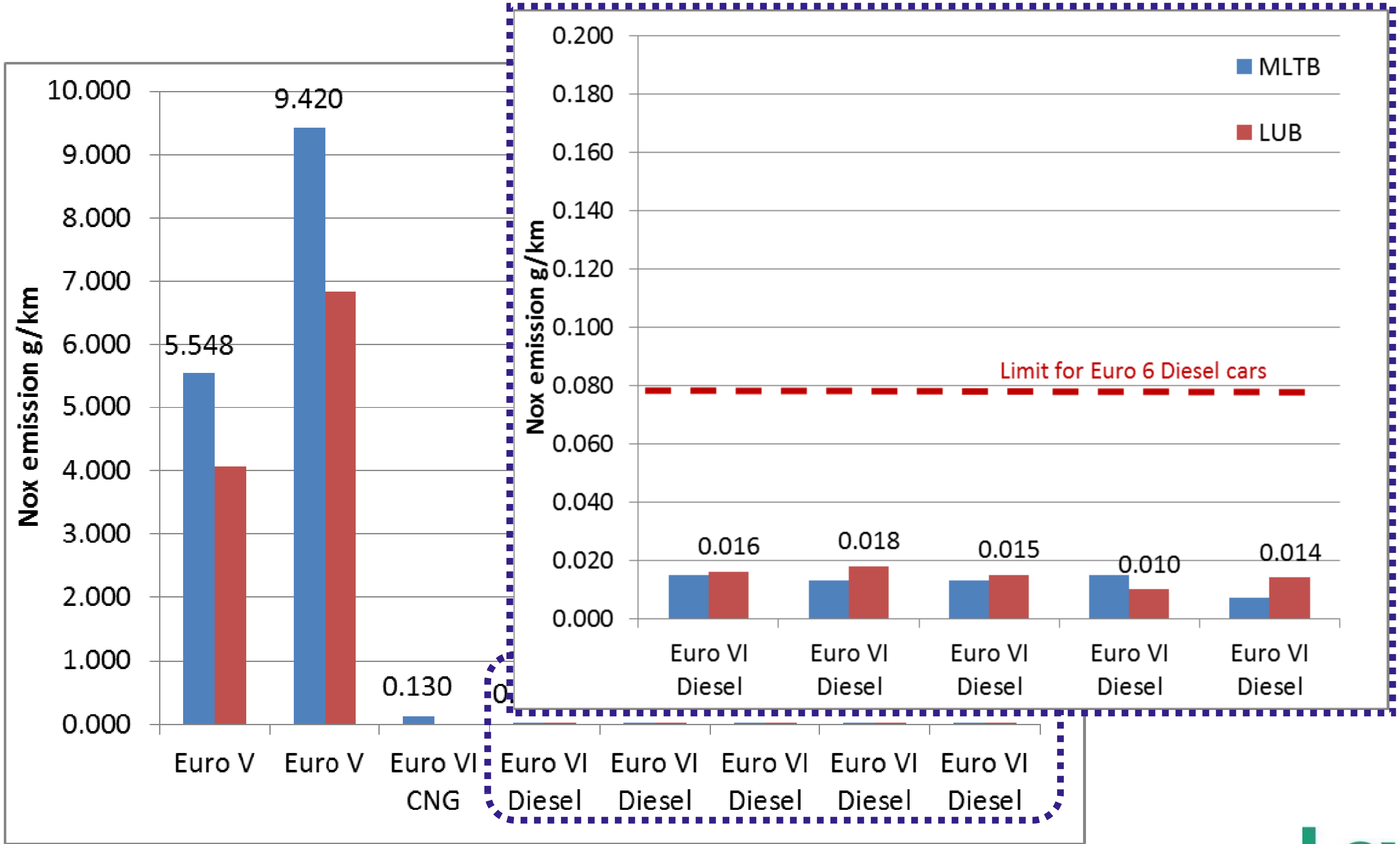
- Average **dual fuel gas** performance figures of
  - 40% Substitution ratio (range 30% to 50% dependent on system)
  - 6% engine efficiency loss
  - 5% TTW CO_2 savings (up to 12%)
  - 2% WTW CO_2 savings (up to 8%)
- Average **dual fuel UCO** performance figures of
  - 86% Substitution ratios
  - No engine efficiency loss
  - 86% TTW CO_2 savings
  - 84% WTW CO_2 savings
- Average **dedicated gas** performance figures of (3 months only)
  - 100% gas use (dedicated gas)
  - 22% engine efficiency loss
  - 14% TTW and 11% WTW CO_2 savings on 15% biomethane blend
  - 0% TTW and WTW CO_2 savings on natural gas

Dual Fuel retrofit vehicle methane slip



Air Quality – is it clean?

- A Low Emission Bus is Euro VI certified or proven equivalent emissions
- LUB pilot tests confirm Euro VI gives exceptionally low NOx



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GHG impact – Is it green?

CNG Bus showed GHG worse than Diesel equivalent

When processed with Biomethane fuel data, GHG showed **78% reduction** compared to Diesel equivalent

Emissions and Energy consumption results from approved test facility - Average 3 tests								
Test Phase	**HC (g/km)**	**CO (g/km)**	**NOx (g/km)**	**PM (g/km)**	**CO_2 (g/km)**	**CH_4 (g/km)***	**N_2O (g/km)***	**Fuel Consumption (kg/100 km)**
Rural Estimate					*1176.79*			*42.92*
Outer London	0.0261	0.4797	0.2429	n/a	1376.36	0.000	0.000	50.20
Inner London	0.0444	0.8168	0.4392	n/a	2016.25	0.000	0.000	73.54
MLTB Average	*0.031*	*0.574*	*0.298*	*0.015*	*1555.27*	*0.000*	*0.000*	*56.72*
LUB Estimate					1385.18			50.48

Total Tank-to-Wheel GHG CO_2 equivalent				
Test Phase	**CO_2 (g/km)**	**CH_4 (g/km x 25)***	**N_2O (g/km x 298)***	**TTW GHG (CO2e (g/km)**
Rural	1176.79	0.000	0.00	1176.79
Outer London	1376.36	0.000	0.00	1376.36
Inner London	2016.25	0.000	0.00	2016.25
MLTB	*1555.27*	*0.000*	*0.00*	*1555.27*
LUB Total Average	***1385.18***	***0.000***	***0.00***	***1385.18***

Well-to-Wheel GHG CO_2 equivalent					
Test Phase	**Fuel/energy used over cycle (kg/km)**	**Total Fuel Energy (MJ/km)**	**Calculated WTT GHG Emissions (CO_2 Equivalent g/km)**	**Calculated TTW GHG Emissions (CO_2 Equivalent g/km)**	**Calculated WTW GHG Emissions (CO_2 Equivalent g/km)**
Rural	0.429	20.55	228.37	2.36	230.73
Outer London	0.502	24.04	267.10	2.76	269.86
Inner London	0.735	35.22	391.33	4.04	395.37
MLTB	*0.567*	27.17	301.84	3.11	304.95
LUB Total Average	***0.505***	24.18	268.64	2.77	271.41

Electric energy consumption and charge efficiency			
Total measured energy consumed on vehicle (kWhr)	***n/a***	***Distance covered km***	***n/a***
Measured grid energy during charging kWhr	***n/a***	***Charging efficiency***	***n/a***

Data Generated by: *On behalf of Test facility*	*Data Approved by:*

Low Emission Bus Certificate Summary		
GHG Well-to-Wheel (g CO2e / km)	***271.4***	
Euro V Average Diesel Equivalent (g CO2e / km)	***1243.0***	
Zero Emission operating range (km)	***N/A***	*****
WTW GHG saving† (g CO2e / km)	***971.6***	*****
% WTW GHG saving† (g CO2e / km)	***78%***	
Approved as Low Emission Bus? (15% saving or more)	***YES***	

****** Data to input to LEB grant fund calculator* — ***† compared with Euro 5***

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Key Next Steps

- Phase 2 of the emissions testing project (further testing, using the protocol):
  - Focus on vehicles likely to be used commonly over the coming years (Euro VI)
  - Focus on the aftermarket dual fuel conversions because, unlike the OEM manufactured vehicles, these are unlikely to have been formally type approved and their GHG emissions are currently more uncertain.
  - OEM vehicles should still be tested to build an evidence base on overall GHG performance.
  - Use evidence gathered to identify future policy priorities, e.g. innovation needs.
- LowCVP will be co-ordinating and managing this work for DfT, with expectation of significant industry/stakeholder/member engagement.

- Phase1 report available at:
  - https://www.gov.uk/government/publications/heavy-goods-vehicles-greenhouse-gas-and-air-quality-pollutant-emissions-testing-protocol

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Well to Wheel, Green House Gas (updated factors)

Test cycle Measure (g/km)		GWP factor (1)
Tailpipe CO2	x	1
Tailpipe CH4	x	25
Tailpipe N2O	x	296

} = TTW CO2e (g/km)

Energy/fuel Cons. (MJ/km) x charge. effy. x WTT CO2e (2) factor (gCo2e/MJ) = WTT CO2e (g/km)

} WTW GHG CO2e (g/km)

(1) Global Warming Potential – factors based on IPCC AR4 2007 figures – most widely used (100yr GWP) – however UK government are not consistent
(2) Well-to-Tank GHG factors are taken from DEFRA carbon smart 2014, however other sources can be used and bespoke WTT factors may be used with appropriate evidence

Electric Vehicle example

Zero emission at Tailpipe

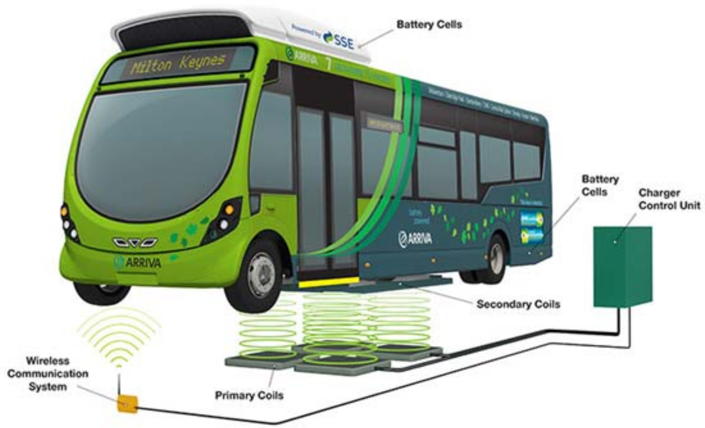
Vehicle energy consumption over cycle = 0.5kWhr/km

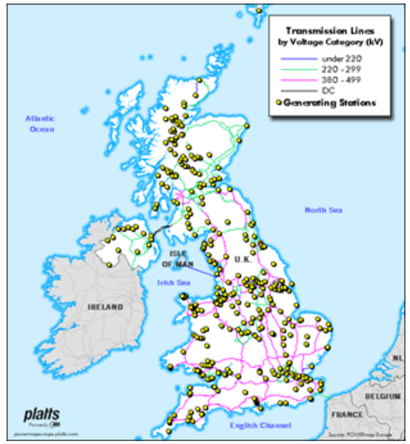
Charging efficiency – 75% = 0.66 kWhr/km consumed from grid

UK Electricity Generation = 494 g/kWhr
UK grid Transmission loss = 43 g/kWhr } 537 g/kWhr

TOTAL WTW GHG = 358 gCO2e/km

Test cycle energy x charging effy. x UK Grid Factor





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Questions

OEM dedicated and Aftermarket retrofit Dual fuel (OEM DF to follow?)

Emissions – At Euro VI is there any difference between Gas and Diesel?

Carbon/GHG – does CNG/LNG give any benefit or not?

Biothane – How much is realistically available

Is transport the best use of Biomethane

What is the competition – Biodiesel, LPG/BioLPG, Hybrid/Plug in/Electric

We need a clear and compelling evidence base to build the case
Further testing needed.

The Low Carbon Vehicle Partnership

Andy Eastlake – andy.eastlake@lowcvp.org.uk

Connect |Collaborate| Influence

- **Connect**: With privileged access to information, you'll gain insight into low carbon vehicle policy development and into the policy process.
- **Collaborate**: You'll benefit from many opportunities to work – and network - with key UK and EU government, industry, NGO and other stakeholders
- **Influence**: You'll be able to initiate proposals and help to shape future low carbon vehicle policy, programmes and regulations

LowCVP is a partnership organisation with over 180 members with a stake in the low carbon road transport agenda.

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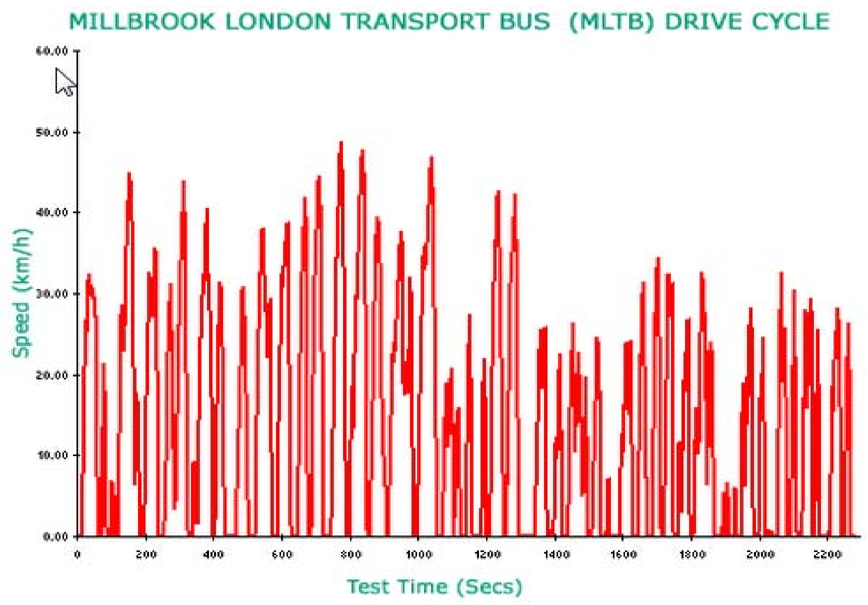
Back up Slides

The test process

The LCEB test process was originated in 1996 with Millbrook and London Transport buses!



KEY IMPROVEMENTS IDENTIFIED

- Add a “Rural” phase to the cycle
- Consider the significant ancillary loads
- Ensure all bus types are tested and energy consumed is measured (Gas, Diesel, Hydrogen, Electricity)
- Create a process to measure the range of Electric and Zero emissions vehicle operation
- Revise the baseline from Euro III
- Report Air Quality data

RETAIN THE UK LEADING POSITION

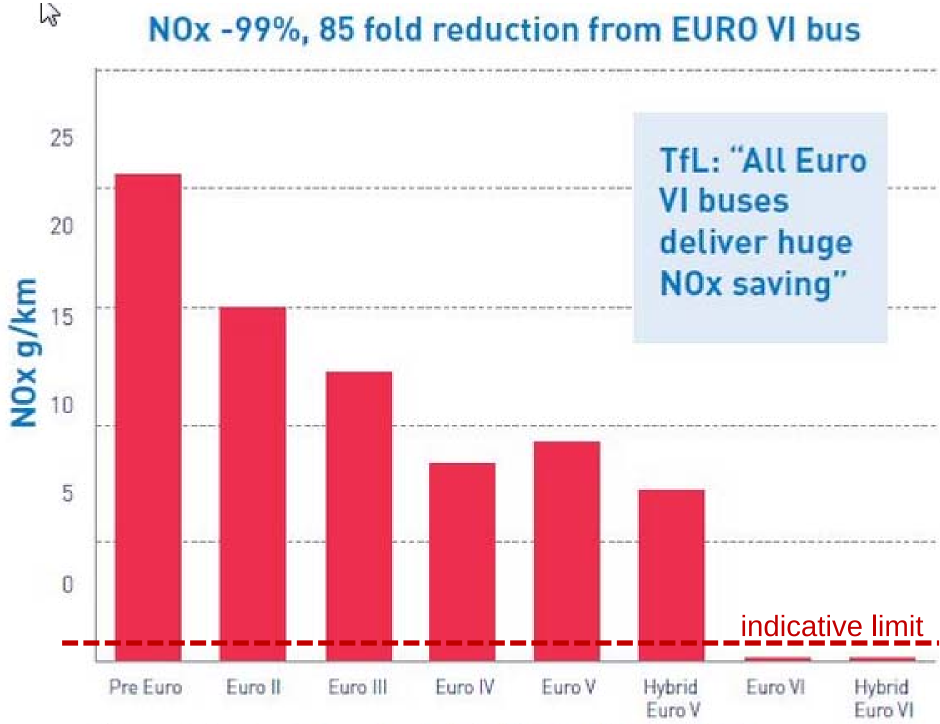
- Comprehensive WTW, GHG and Air Quality assessment
- Real-world bus specific cycle
- Cross-industry collaborative approach

Air Quality Emissions

Previous LCEB test did not require specific AQ performance, however in general the LCEB gave NOx around 10-15% lower than conventional

Euro VI certified vehicles can be as low as 0.1g/km NOx on the test (lower than the Euro 6 Diesel van limit!) . But limited is data available.

(Typical Euro V were 7 – 9 g/km, Euro III around 12g/km)



Source: independent test data for double decker bus on London 159 test route

Requirement for LEB to be certified Euro VI and/or demonstrated to show NOx lower than approx 1g/km on Bus test cycle. Final value to be developed based on available data.

It is not viable to differentiate AQ emissions below Euro VI (or equivalent) levels reliably, so AQ improvement better than Euro VI should be stipulated to be via Zero Emissions operation

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GHG (carbon equivalent)

Greenhouse gas emission from transport should include consideration of Methane (CH_4) (significant potential from Gas powered vehicles) and Nitrous Oxide (N_2O) (potential from Exhaust aftertreatment)

Global warming potential (GWP) identifies the greenhouse impact of each gas

$C0_2$ – 1

CH_4 – 21 (1gCH_4 equivalent to 21g CO_2)

N_2O – 310 (1gN_2O equivalent to 310g CO_2)

For all technologies the full GHG impact should be measured to ensure that the LEB delivers both Air Quality AND Carbon equivalent reduction in a reasonable way.

Applying any technology without considering both aspects can potentially lead to excessive specific emissions and unintended consequences

Well-to-Wheel WTW

With the variety of energy sources now used for transport (Diesel, BioDiesel, CNG, Biomethane, Hydrogen, electricity, Ethanol etc etc) each of which has a very different carbon impact in the Well to Tank phase, using a Well to Wheel approach ensure that carbon (or in the future AQ emissions) are not just displaced through the use of a LEB.

LEB carbon benefits should be measured comprehensively on a complete Well-to-Wheel basis using standard factors and include all significant Greenhouse Gas (GHG) components.

LowCVP Low Carbon Vehicle Partnership