Commercial Users – The First Frontier (A UK Perspective)

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Business of Plugging In Conference
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Scope of Presentation

- Background
  - Introduction to Cenex
  - Drivers for Plug-In Vehicles in the UK
- Assisting the Commercial (Fleet) User
  - Process options deployed
- Learning about Fleet Users EV Overview
  - Lessons learnt from trials on vehicles and infrastructure
- Helping establish a business case
  - Approaches to aid planning
- Conclusions

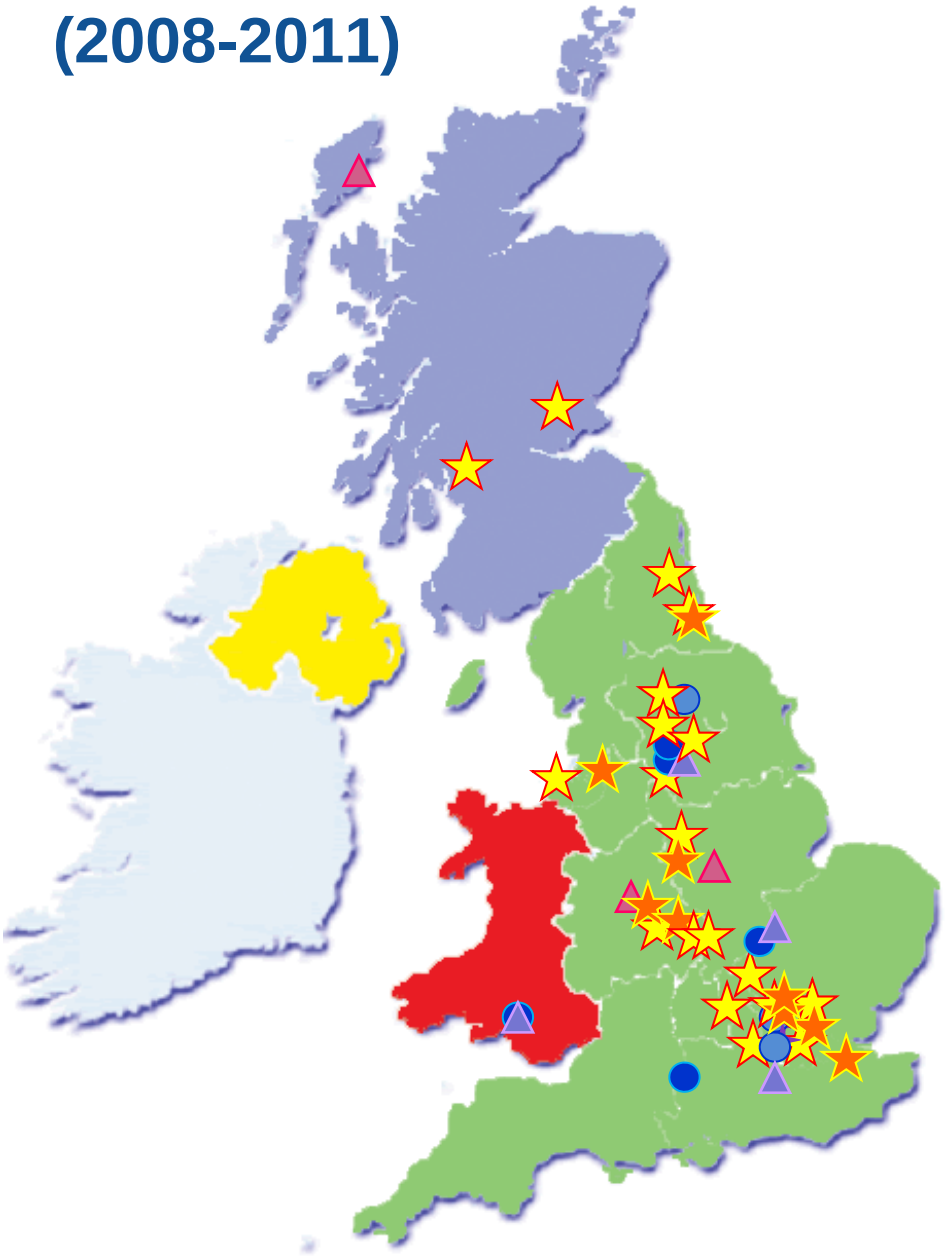
Background to Cenex

- Not for Profit formed in 2005
  - ‘Centre of Excellence’ tasked with leveraging UK motor industry supply chain and market development opportunities arising from transition to a low carbon economy
  - Cenex track record of assisting delivery of Government initiatives for Low Carbon Vehicle innovation (R&D, Demonstration and Deployment)

- Cenex as of 2011
  - Consultancy, focused on low carbon vehicle innovation, working for a range of public and private sector clients on planning and implementing low carbon vehicle and refuelling infrastructure projects
  - Research organization studying the factors driving LCV market transformation

- Cenex –Client projects in the following areas;
  - Trialing low carbon vehicles and fuels to cut carbon emissions in fleet operations
  - Planning and implementing alternative fuels infrastructure roll out
  - Assisting partner progress by leveraging RD&D support
  - Conducting techno-market research to increase knowledge in sector
  - Running showcase events for Low Carbon Vehicle community as platform for disseminating learning

Cenex low carbon vehicle projects in the UK (2008-2011)



Hydrogen Vehicles

Vehicles
Birmingham, Loughborough and Stornoway

Infrastructure
Sheffield, Bedford, Surrey, Glamorgan

Electric and Hybrid Vehicles

Vehicles
Newcastle, Glasgow, Leeds, Gateshead, Perth & Kinross, Liverpool, Nottingham, Birmingham, Wakefield, Doncaster, London, Warwick, Coventry, Hackney, Sheffield, Camden and Islington

Infrastructure
Birmingham, Westminster, Greenwich, Camden, Hackney, Coventry, Manchester airport, East midlands airport, Barnet , Stockton-on-Tees

Bio-methane

Vehicles
London, Leeds and Middlesex

Infrastructure
Sheffield, Glamorgan, Milton Keynes, Barnsley, Andover

Twin Policy Drivers for Plug-In Vehicles

- Environmental
  - UK Climate Change Act (2008)
    - GHG emissions to be cut by 80%@ by 2050
    - CO_2 emissions to be cut by 26%@ by 2020
  - Air quality management
    - Transport PM and NOx still an issue for many city centres

- Economic
  - UK Industrial Competitiveness
    - Jobs in the UK knowledge economy, especially advanced engineering and manufacturing (motor industry) via organic growth and inward investment
    - Energy security and energy efficiency as a platform for the competitiveness of the UK economy

Background to Plug-In Vehicle Market in the UK

- Latent market due to
  - Crowded urban island – low typical daily mileages
  - High fuel costs via taxation (savings from electricity vs petrol\diesel)
  - Environmental drivers (urban air quality management)

- First attempted expansion
  - ZEV ripple effect led to French (Peugeot-Citroen ‘La Rochelle’ experiment) encouraged into UK via European and UK National Government funding

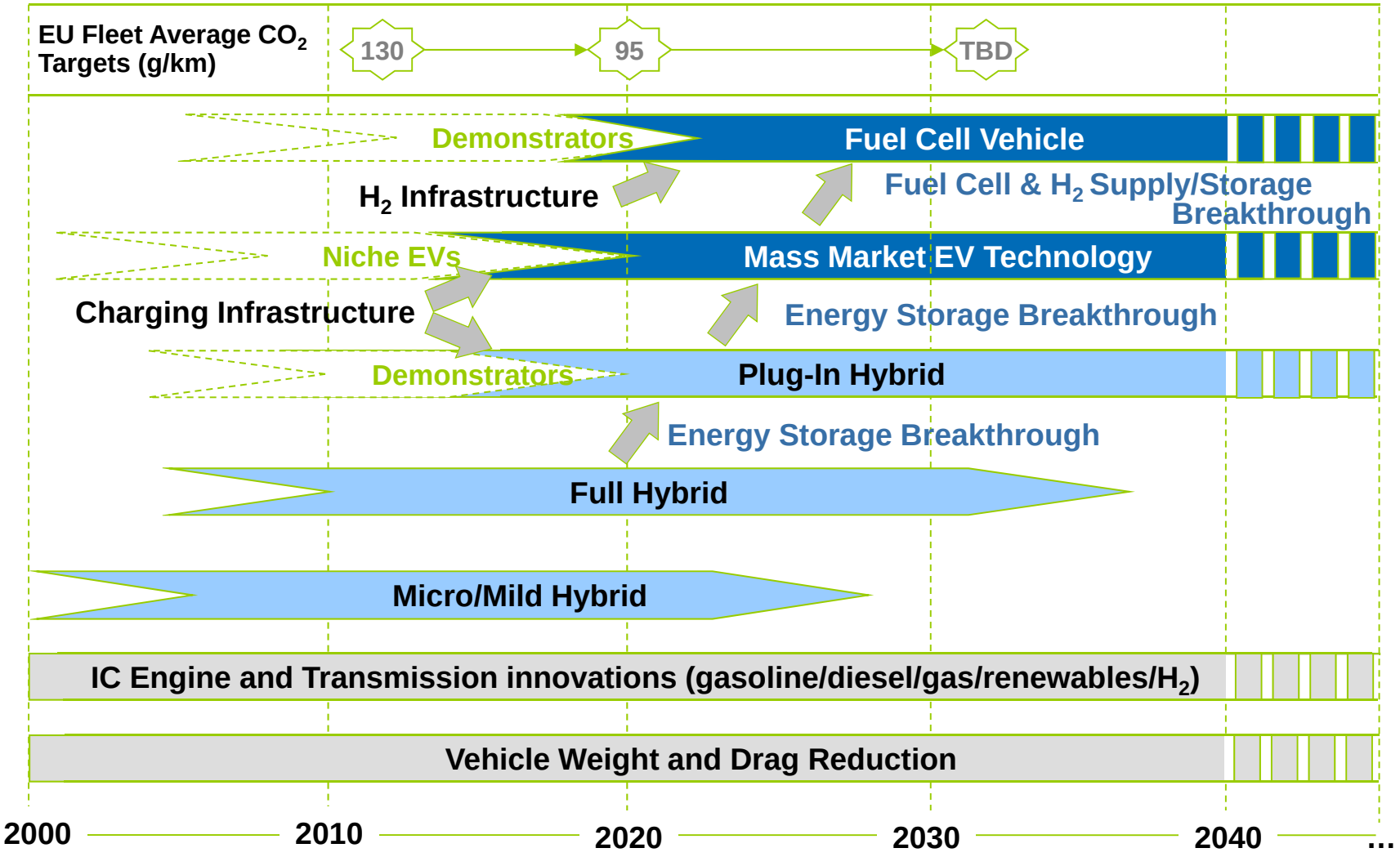
- Second coming
  - Entrepreneurs pioneering plug-in vehicles aided by incentives (London Congestion Charge exemption)
    - G-Wiz (Reva), Zytek (Smart), Modec, Smith Electric Vehicles
  - Twin policy drivers (environment and energy) plus mainstream car company encouragement (direct and indirect) leads to wave of National Policy initiatives (Innovation Orientated Procurement , grants, infrastructure deployment support, inward investment support, etc)
  - Mainstream car companies entering commercial vehicle market via car derived vans then scaling up

Technology provider Perspective

- Part of meeting regulatory drivers
  - EU 2020 CO_2 (US CAFE, etc)
- Electrification of vehicle systems is key trend
  - Increased hybridisation\electrification of vehicle systems is key consensus feature on the passenger car and commercial vehicle roadmaps
  - EV = one part of the portfolio (urban, city car, etc) – strategic niche market
  - Momentum in system – Candidate consumers like electric drive vehicles, government like electric drive vehicles, investor interest.....
  - Supply chain TRL\MRL immaturity needs to be factored in to motor industry investment strategy along with consumer uptake forecasts
- Need for Partnership approach (Government, Utilities for Infrastructure, fleet operators\customer groups, etc)
  - Pioneering ‘community’ with shared vision

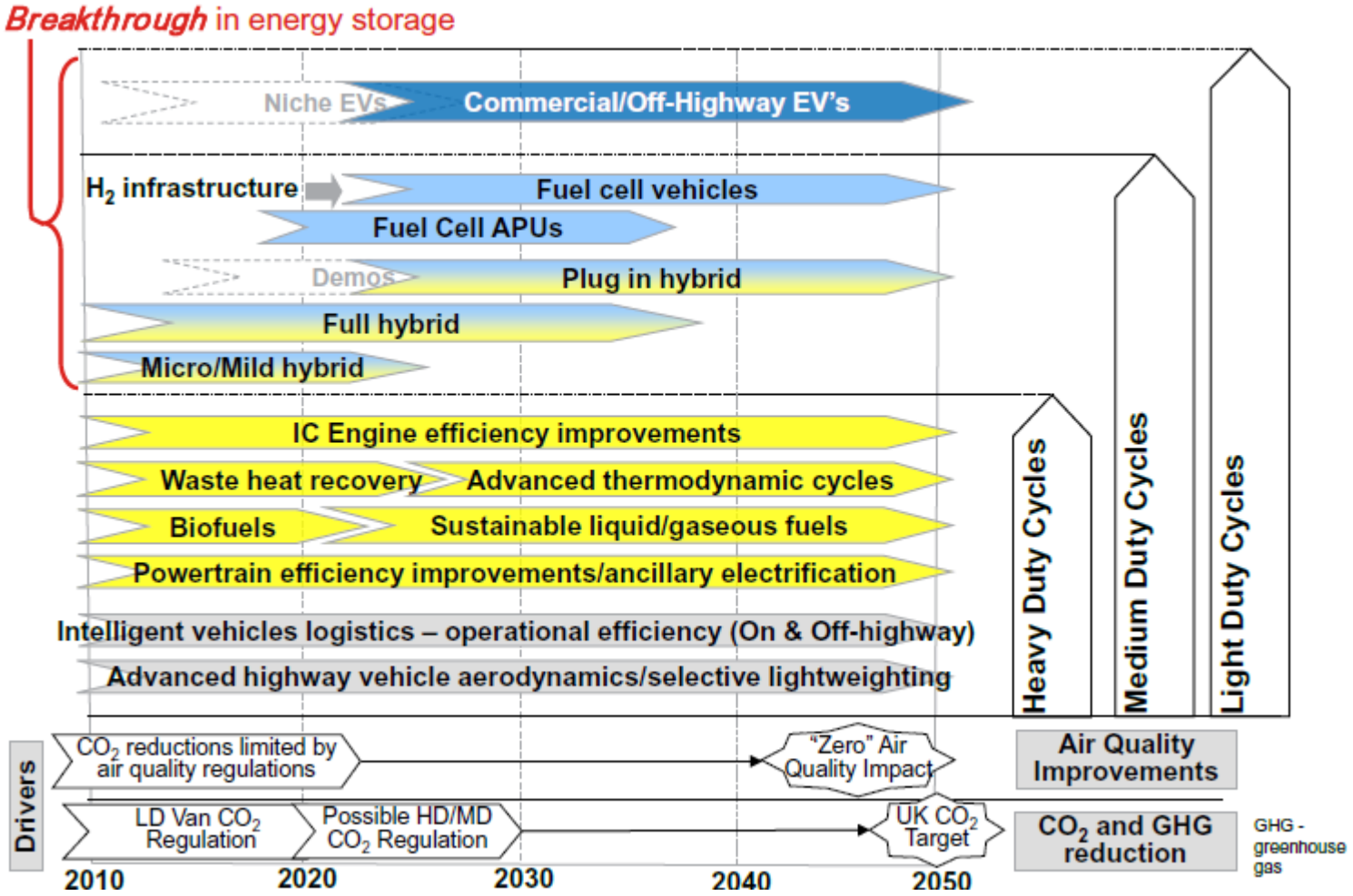
TRL – Technology Readiness Level, MRL – Manufacturing Readiness Level

Passenger Car Technology Roadmap



Source: AutoCouncil

Commercial Vehicle and Off-road Technology Road



Source: AutoCouncil

Government Engagement of UK Fleets

- Recognised weak demand signal as a barrier
  - But the sectors that engage most with Government = Social Responsible Corporates and Local Government show a level of interest if only price premium could be overcome
  - Technology providers report niche market development and request Government assistance
  - Major car companies say they will invest on the evidence of a market

- Interest in role of Innovation Orientated Procurement
  - Use of public sector buying power to pull forward environmentally innovative goods and services
  - Vans identified as sector worthy of experimentation via a Low Carbon Vehicle Public Procurement Programme (commenced 2008) focused on vans

- Plug-in car proposition more consumer orientated
  - Ultra Low Carbon Vehicle Demonstration Programme sees >330 vehicles deployed in field trials
  - Launch of commercial car offerings encourages supporting policy for car sales (Plug-In Car Grant and Plugged in Places Programme for Infrastructure roll-out)

Commercial Fleet Buyers Perspective

- Drivers
  - Interest because fuel price hikes impacting budgets (and in some areas impacting front line services)
  - Good for Corporate Social Responsibility (CSR) – where pressure for cuts in carbon and pollutant emissions as well as fossil fuel use + rivals winning business based on CSR credentials
  - Recognised as the future

- Barriers
  - Operational inertia to change
  - Budget restrictions and often no budget for these type of ‘R&D’ activities
  - Lack of supply options from mainstream car companies
  - Lack of cost effective solutions (first generation electric vehicles have higher capital costs not offset by lower fuel costs within typical period of ownership) from niche vehicle sector
  - Technology still expensive due to immaturity and low volume production
  - Lack of good quality information about performance of new technology
  - Risks to delivery of front line services (due to technology immaturity and hidden costs)
  - Reputational risk associated with past environmentally friendly vehicle investments (e.g. Liquid Petroleum Gas, etc)

Low Carbon Vehicle Public Procurement Programme (LCVPP)

- LCVPP is a government funded programme, managed by Cenex

- Aim is to accelerate the market introduction of new and emerging lower carbon vehicle technologies:
  - Uses public sector procurement to create demand for lower carbon vehicles
  - Promote both innovation and unit cost reduction
  - Test and validation of lower carbon vehicles in high-profile fleets

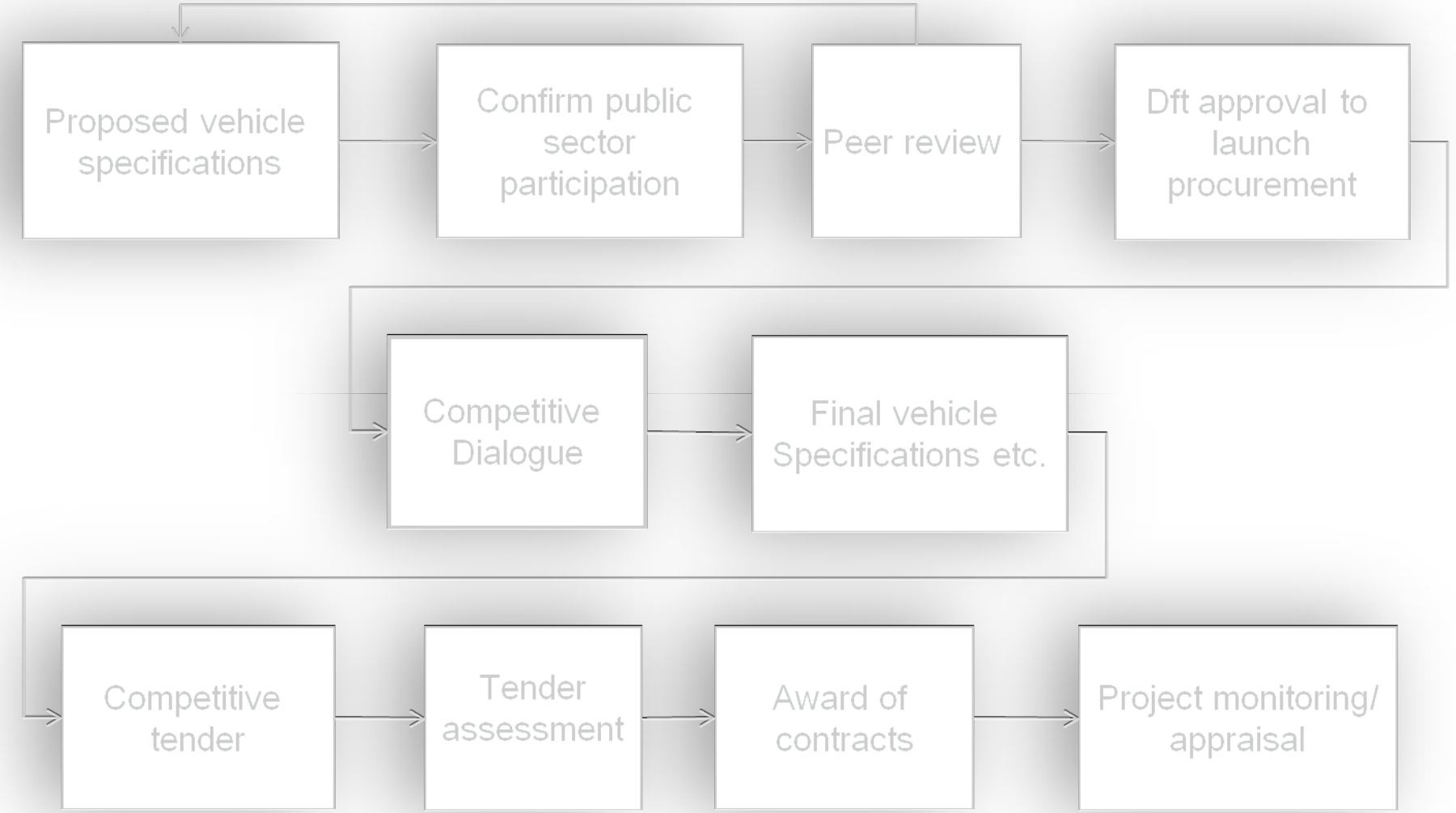
- Integrates a grant scheme with a procurement framework to control the risk for the fleet operators
  - Incremental cost of the new technology is covered with grant funding (NO COST BARRIER)

LCVPP: A Two Phase Programme

- Phase 1
  - Controlled introduction of demonstrator vehicles in high profile fleets
  - Operate vehicles in real-world conditions
  - Assess performance
  - Build confidence

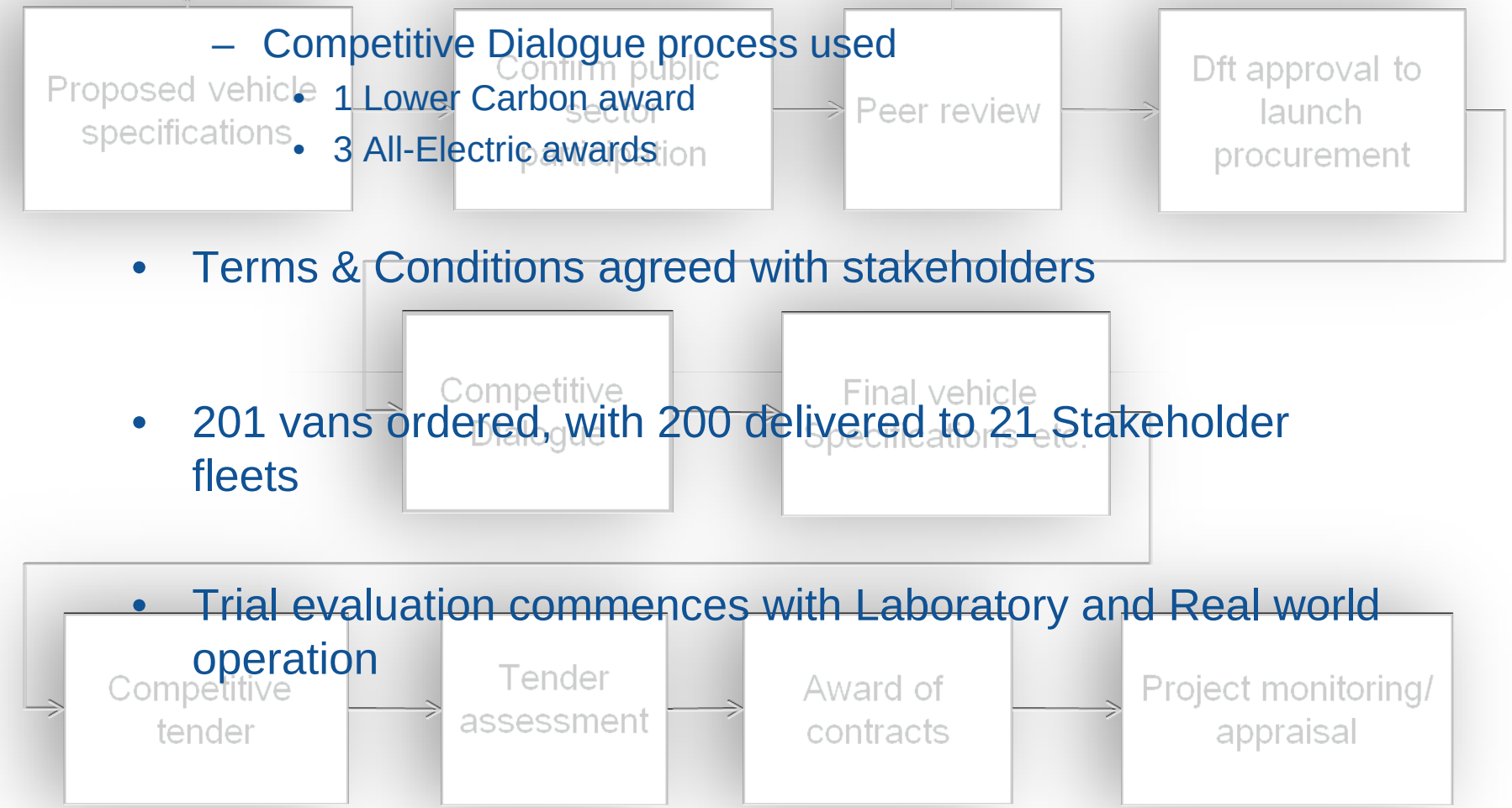
- Phase 2
  - Higher volume roll-out across the wider public sector
  - Fully commercial vehicles
  - Higher production volumes
    - Economies of scale

Phase 1 Process Flow



Phase 1 Process Flow

- Van Procurement Completed
  - 2 ‘lots’: Lower Carbon & All-Electric
  - Competitive Dialogue process used
    - 1 Lower Carbon award
    - 3 All-Electric awards
- Terms & Conditions agreed with stakeholders
- 201 vans ordered, with 200 delivered to 21 Stakeholder fleets
- Trial evaluation commences with Laboratory and Real world operation



The Vehicles

- Ashwoods Hybrid Transit
  - Diesel/Electric powertrain
  - Assistance motor - 17 kW
  - Battery - 1.4 kWh LiFe

- Allied Electric Boxer
  - Motor - 60kW
  - Battery - 62kWh LiFe

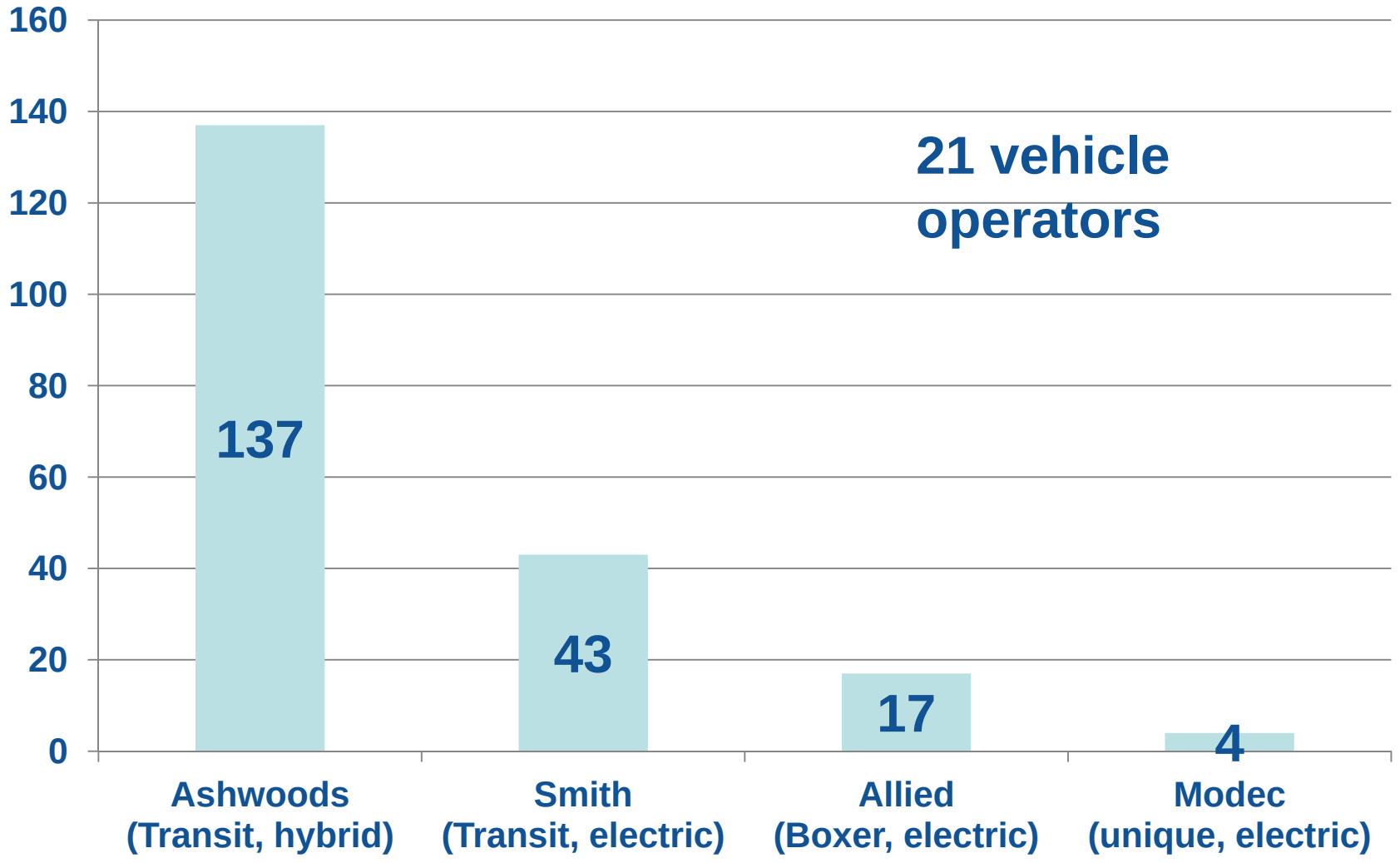
The Vehicles

- Modec Van
  - Motor - 76 kW
  - Battery – 84 kWh
    Sodium Nickel Chloride

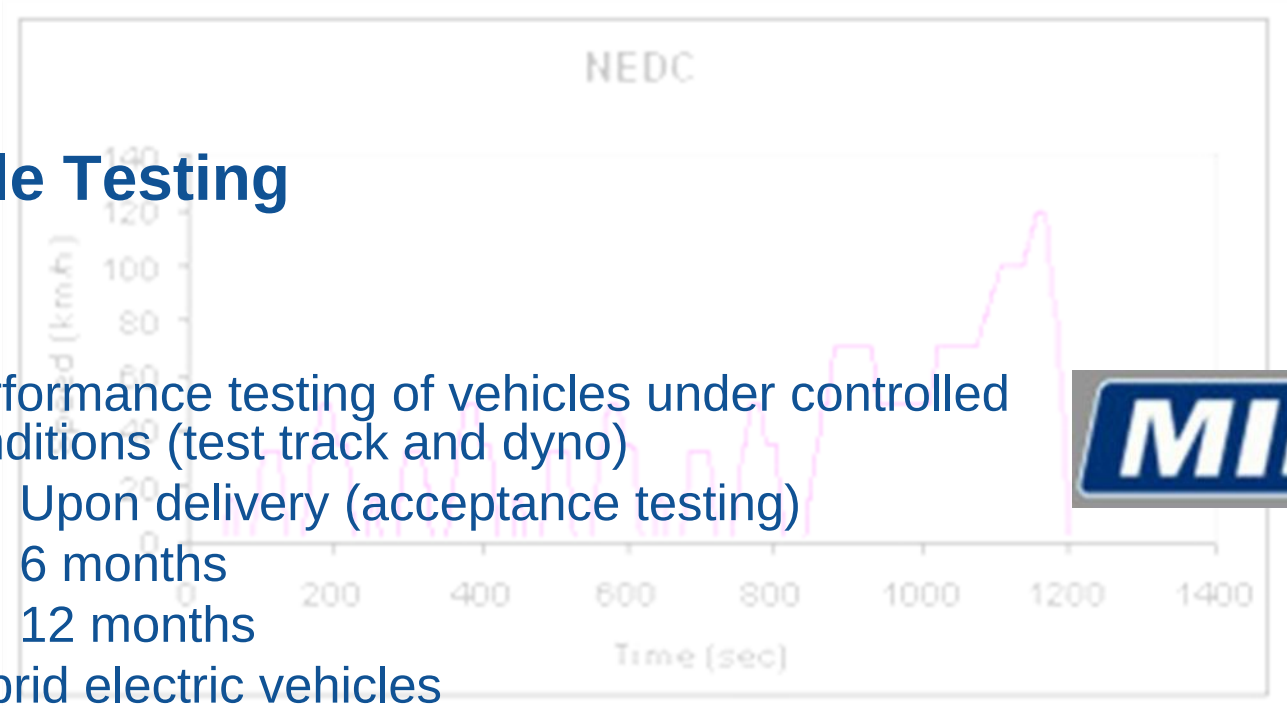
- Smith Electric Edison
  - Motor - 64 kW
  - Battery - 51 kWh LiFe

LCVPP

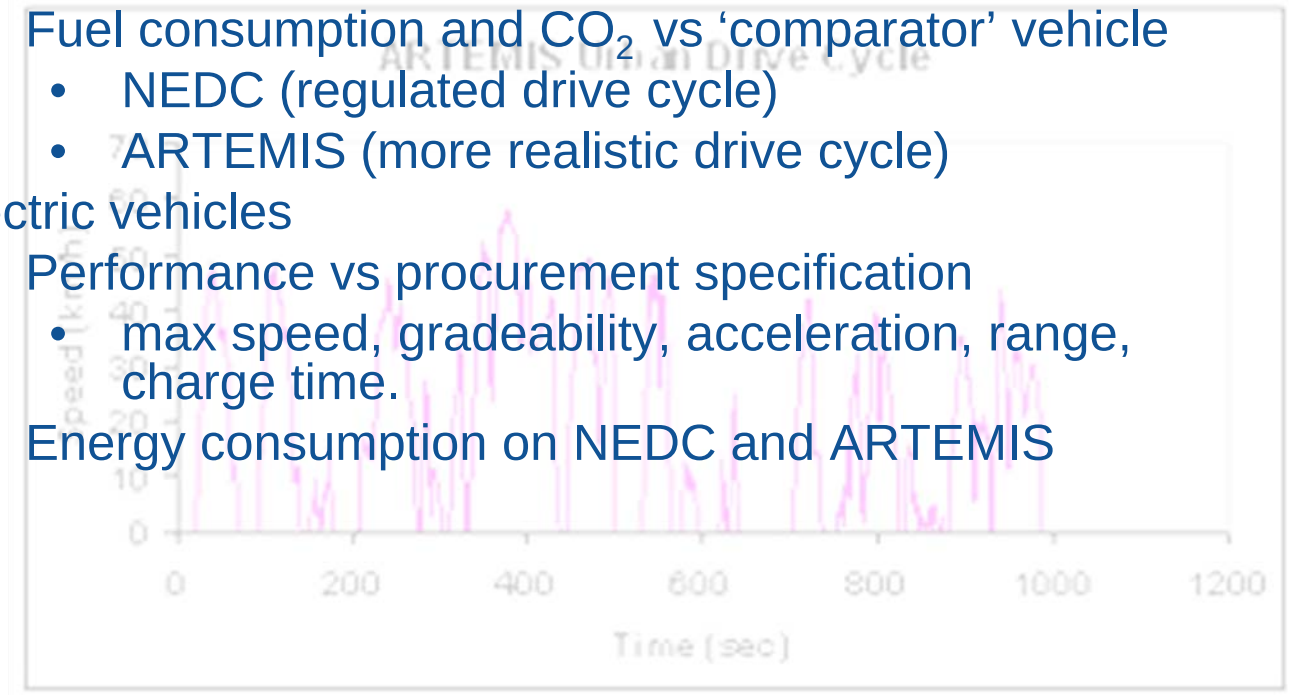
Vehicle order quantities by manufacturer



Vehicle Testing



- Performance testing of vehicles under controlled conditions (test track and dyno)
  - Upon delivery (acceptance testing)
  - 6 months
  - 12 months
- Hybrid electric vehicles
  - Fuel consumption and CO_2 vs 'comparator' vehicle
    - NEDC (regulated drive cycle)
    - ARTEMIS (more realistic drive cycle)
- Electric vehicles
  - Performance vs procurement specification
    - max speed, gradeability, acceleration, range, charge time.
  - Energy consumption on NEDC and ARTEMIS

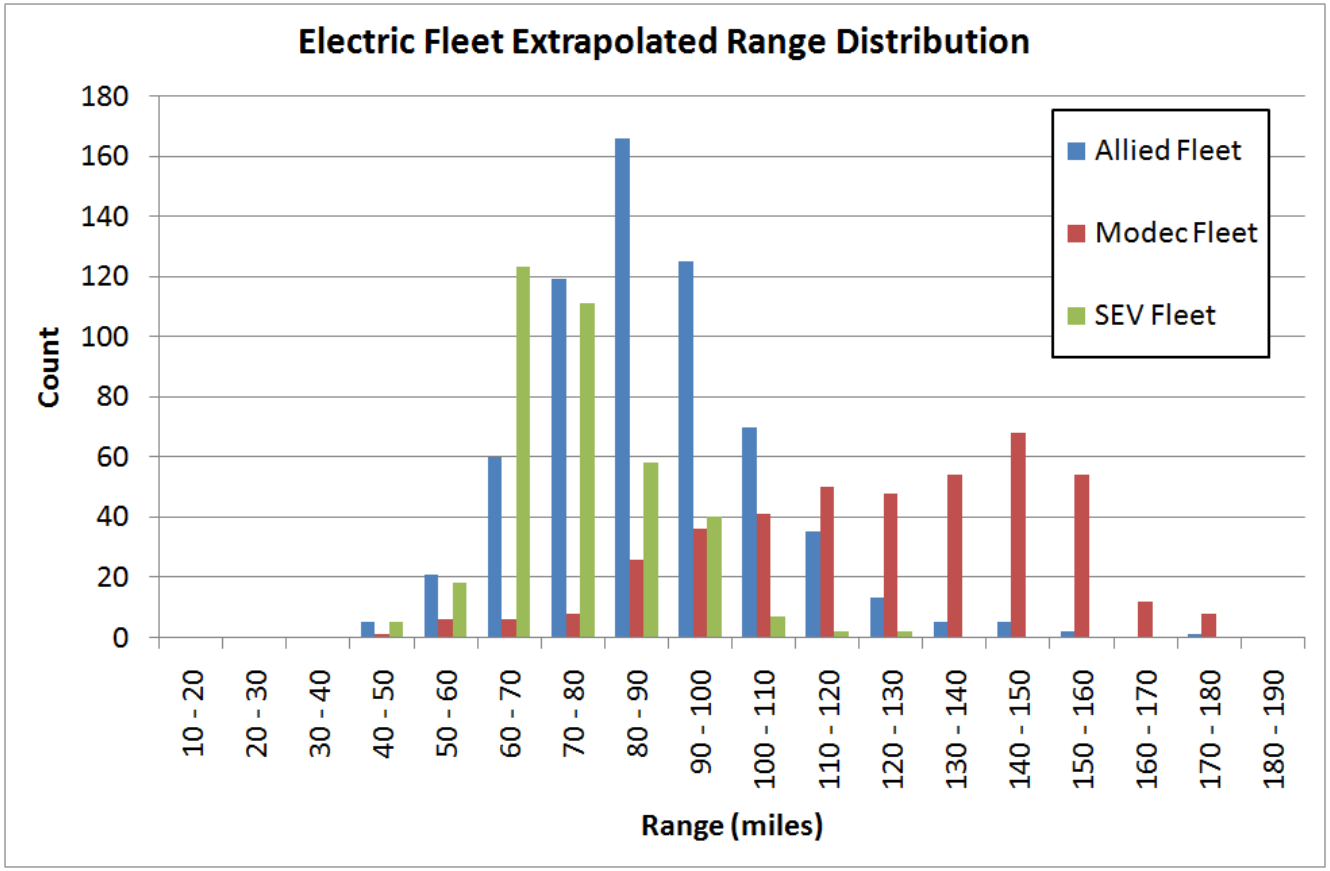


Real-World Use

- Data gathered from operational vehicles and drivers
  - Objective data collection
  - Subjective data collection

- Trip data collected through:
  - Log books
    - trip date, location, driver and mileage
    - fuel added / electrical energy used in charging
    - any pertinent notes relating to operation/weather
  - On-board telemetry
    - Position (GPS), distance, velocity and acceleration (1 Hz)
    - Pedal position (driver demand)
    - Ancillary electrical load
    - Energy consumption
    - Wireless data transmission

LCVPP: Vehicle Range Performance



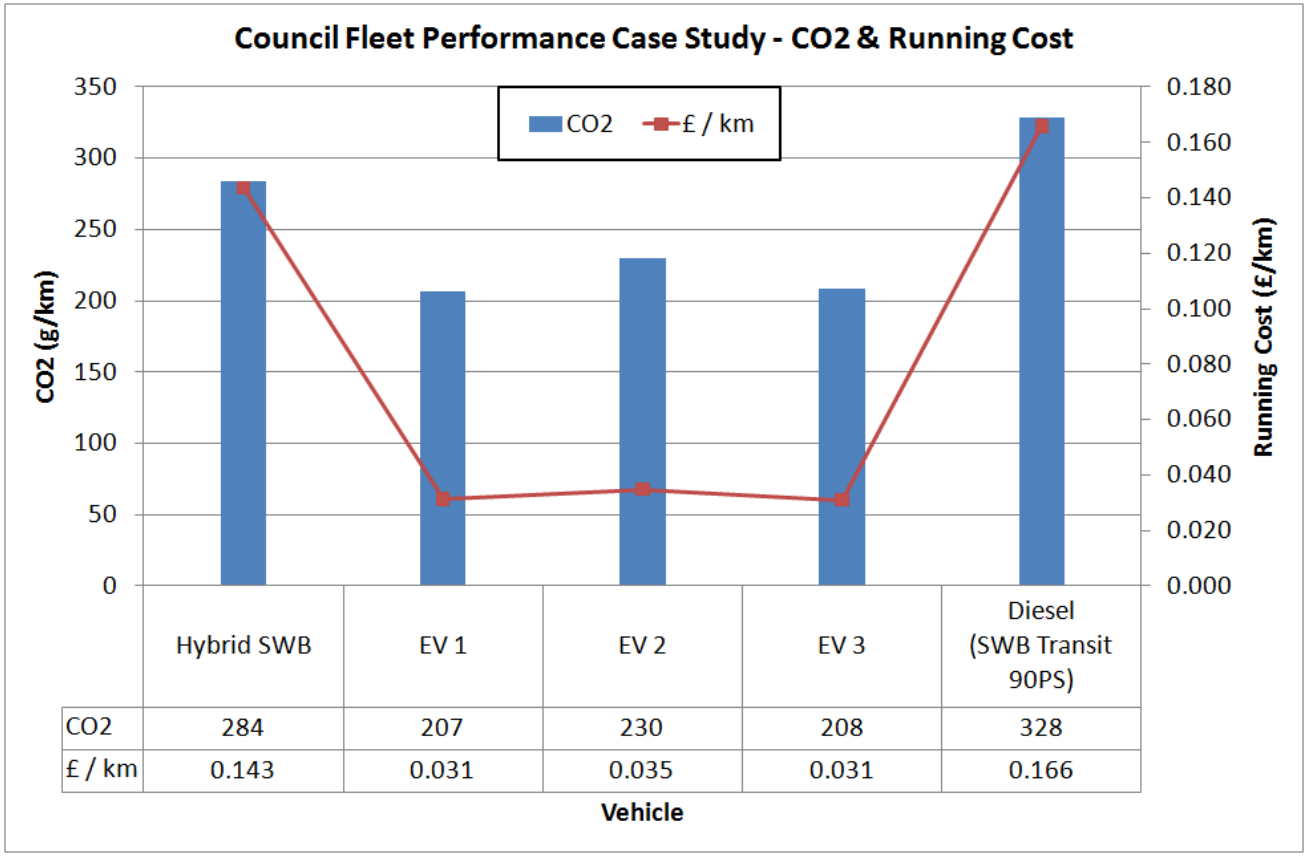
Vehicle	Avg Range (miles)
Allied	86
Modec	124
Smiths	75

NB: Real world range dependent on duty cycle

LCVPP: Council fleet operations case study

- Relative performance of different vehicles in similar roles across the LCVPP fleet – urban council operations

Vehicle type	CO2 Saving	Running cost saving*
Hybrid	13.5%	13.5 %
EVs	30 to 37%	79 to 81 %



* Running cost calculation are base purely on diesel and electricity supply costs

Diesel £1.328 / litre http://www.theaa.com/onlinenews/allaboutcars/fuel/2011/january2011.pdf

Electricity £0.0924 / kwh http://www.decc.gov.uk/media/viewfile.ashx?filepath=statistics/source/prices/qep341.xls&filetype=4&minwidth-true

Emission factor 0.532kg CO2/kWh http://www.defra.gov.uk/environment/business/reporting/pdf/20090928-guidelines-ghg-conversion-factors.pdf

LCVPP: Coventry City Council Usage Case Study

- This case study looks at the operational characteristics of different vehicle types within the same stakeholder fleet

Manufacturer	Total Distance (km)	No. Trips	Average Trip Length (km)	Average Trip Speed (km/h)	Average Trip Duration (hrs)	Role
Ashwoods LWB	14,637	2,653	5.52	22.1	0.25	Trades Vehicle
Modec	7,237	332	21.8	12.5	1.74	Wheelie Bin Delivery

- Relative roles of the vehicles are apparent:
  - Hybrid vehicles (trades vehicles – mobile workshops) – occasionally reactive and unplanned workload, higher frequency of trips
  - EV (wheelie bin delivery) is being driven over planned routes with lower load and high cargo area requirements. Removes concerns over range and charge planning

Observations (Operators)

- Fleet Operators
  - Public sector keen ‘in principle’, but initial uptake was low as only prepared for limited disruption to operations
  - Stakeholders use a diverse range of van-derived vehicles leading to fragmented demand
  - Risk aversion heightened due to pressure on Public Sector finances
  - Risk aversion to niche vehicle as opposed to mainstream car company vehicles
  - Time delays getting sign up to Stakeholder Agreement and Procurement Framework but once in place allows much higher volumes through phase 2

- Van Suppliers
  - Timescales too short for OEMs to alter product plans but niche vehicle sector could respond (albeit with immature supply chain and scale-up issues)
  - Immaturity of support services (difficult to offer lease options to fleet operators)

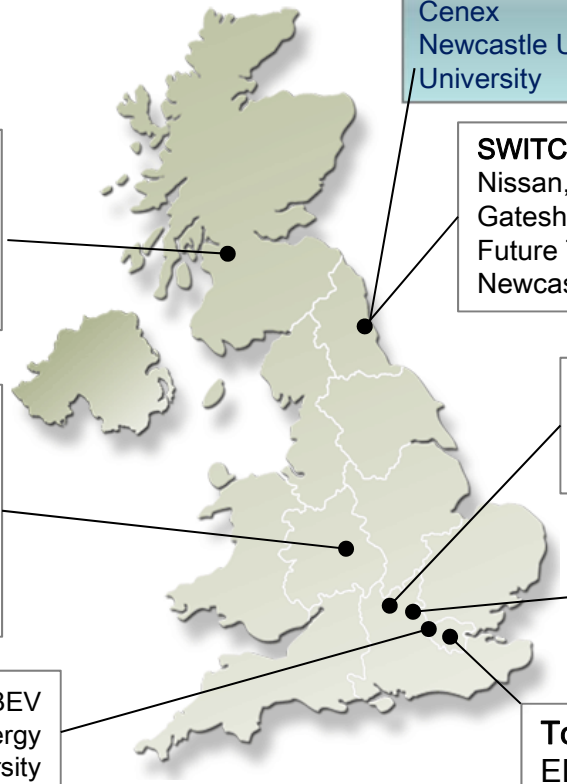
Plug-In Car Demonstration Projects in the UK

- SMART MOVE is a Cenex project and Cenex provides quantitative analytic support for the Technology Strategy Board Ultra Low Carbon Vehicle Demonstration Project
- > 400 lug-in vehicles under trial

SMART MOVE
Smart EV, Mitishishi,
Cenex
Newcastle University (TORG), Cranfield University, Sheffield University

Allied Electric Vehicles
Scottish Power
Axeon Batteries
Strathclyde University,
Glasgow City Council

SWITCH EV
Nissan, Smith Electric Vehicles, AVID, Liberty Electric Cars
Gateshead Council
Future Transport Systems
Newcastle University (TORG)



CABLED
Jaguar Land Rover (Tata), Smart, Mitsubishi, LTI Vehicles, Microcab
Eon Energy
Arup
Coventry and Birmingham City Councils
Aston and Coventry Universities

BMW Mini
Scottish and Southern Energy
Oxford Brookes University

EEMS Delta Motorsport, Westfield Sports Cars, Ecotricity Cars, Lightening Car Company
AEA Technology
Green Motion Eco Car Hire

Ford BEV
Scottish and Southern Energy
Strathclyde University

Toyota
EDF Energy
MET Police, Transport for London, GCDA

- Opportunity to understand customer perceptions and concerns
- Identify challenges with infrastructure interface
- Inform future demonstrator activity

Sample fleet work on passenger cars

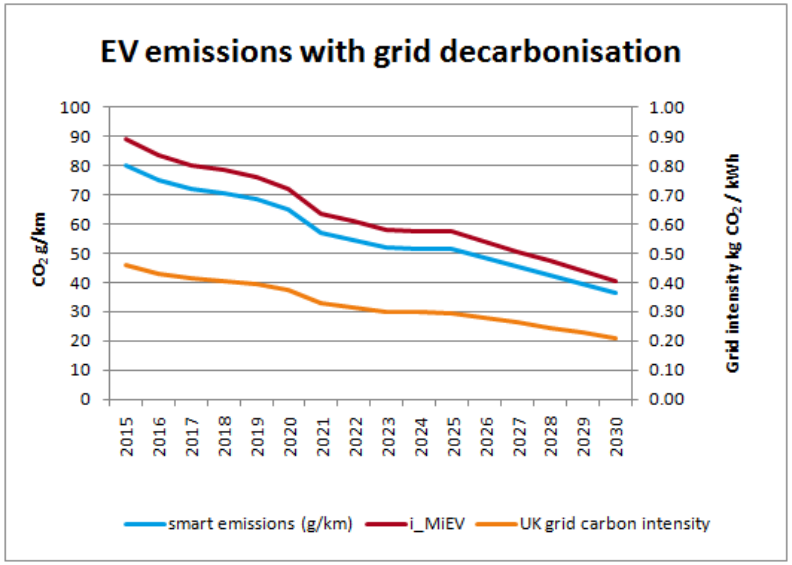
- **In-depth fleet Trials using - 7 * smart 451 & 1 * Mitsubishi I MiEV**

Regulatory range testing CO_2 analysis

	smart 450 Zebra battery	smart 451 Li-ion	smart cdi	i_MiEV
Range (km)	114	142	-	116
Energy consumption (Wh/km)	290	174	-	194
TTW CO_2 (g/km)	0	0	86	0
WTW CO_2e (g/km) [1]	178	107	103	123
WTW CO_2 (g/km) [2]	113	68	90	76

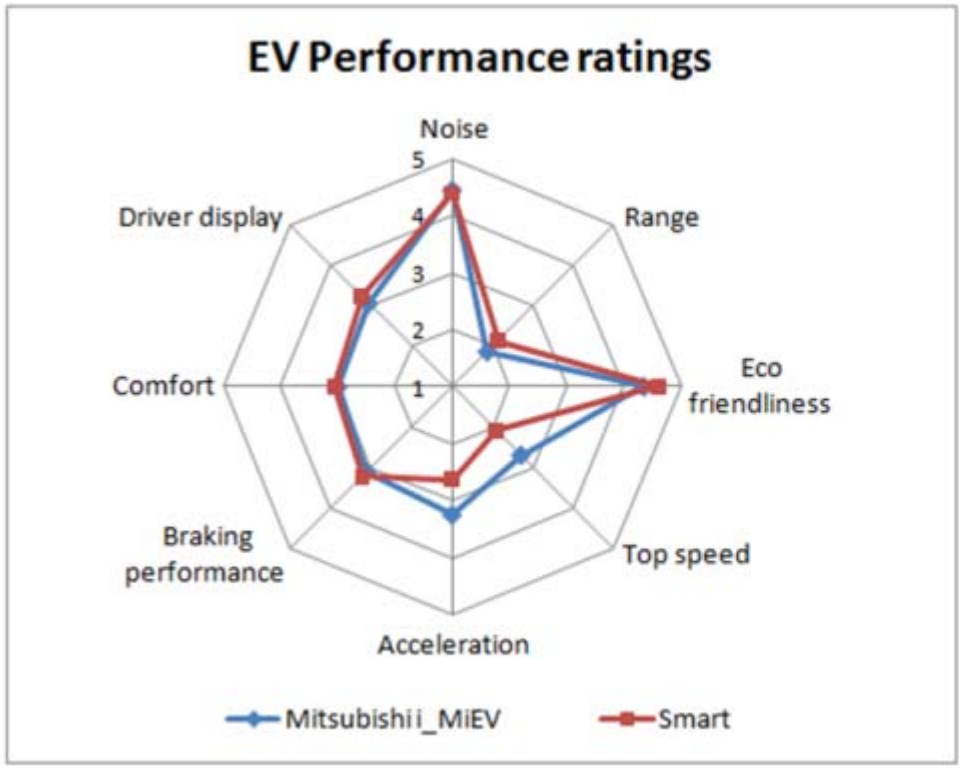
WTW analysis includes plug to battery charging efficiency of 78 %

[1] – DEFRA guidance for company emission reporting 2010
[2] – DECC Marginal emission factor used for energy policy appraisals



[1] Ref. 2010 DECC/Defra emission factors for company reporting, 617.07g CO^2e/kWh
[2] DECC Inter-department analysis guidance on valuation of energy use and greenhouse gas emissions

Smart Move Fleet Trials: Driver Perspectives



Score	Performance compared to a conventional vehicle
1	Much worse
2	Worse
3	Similar
4	Better
5	Much better

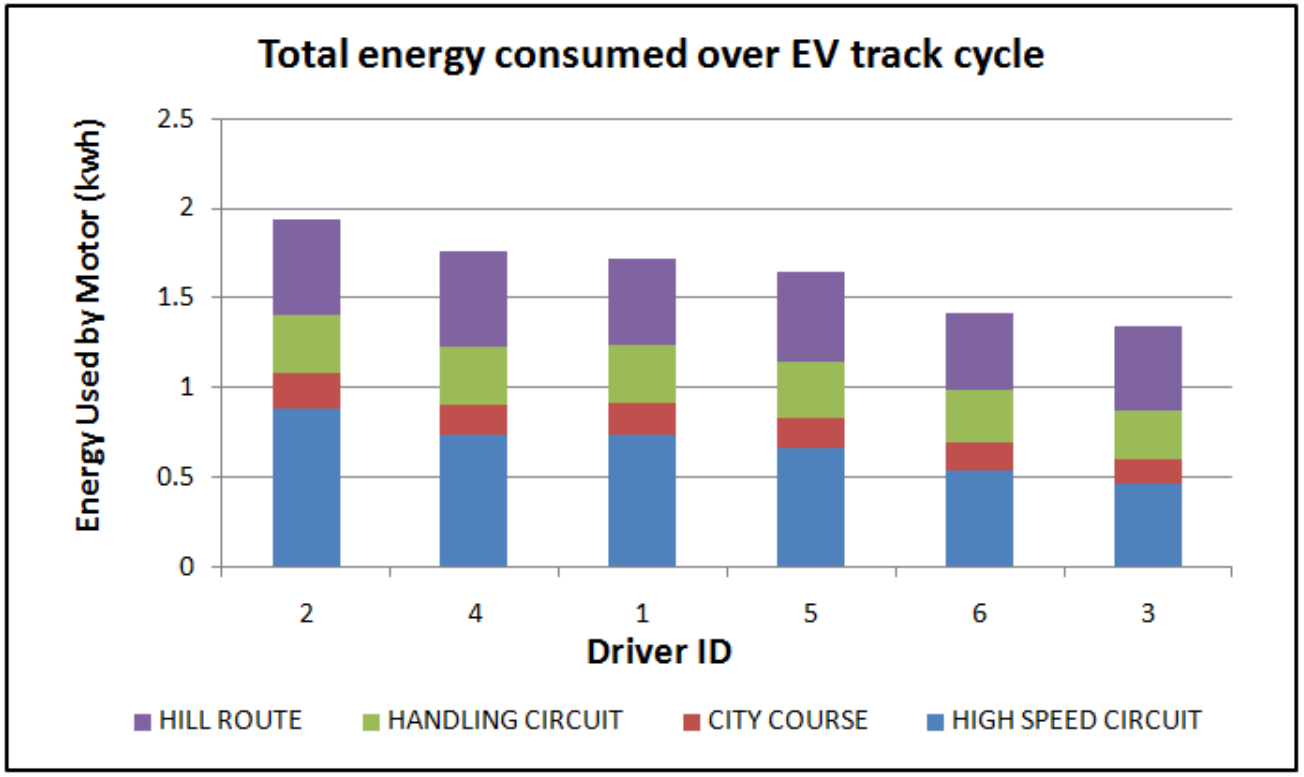
Table 6: Scoring criteria for EV performance compared to a conventional vehicle

Users rated the EVs as marginally better than a conventional vehicle

Source : smart move case studies – Cenex 2011

Range – impact of driver

EV track cycle energy use



Circuit	Min to max energy increase
Hill	23 %
HC	19 %
City	46 %
HSC	91 %

Driver behaviour impacts energy use and therefore efficiency (energy costs) and range. Therefore important role for EV-related driver training

Source : smart move trial – Cenex 2010

Commercial Fleet Interest in Plug-In Cars

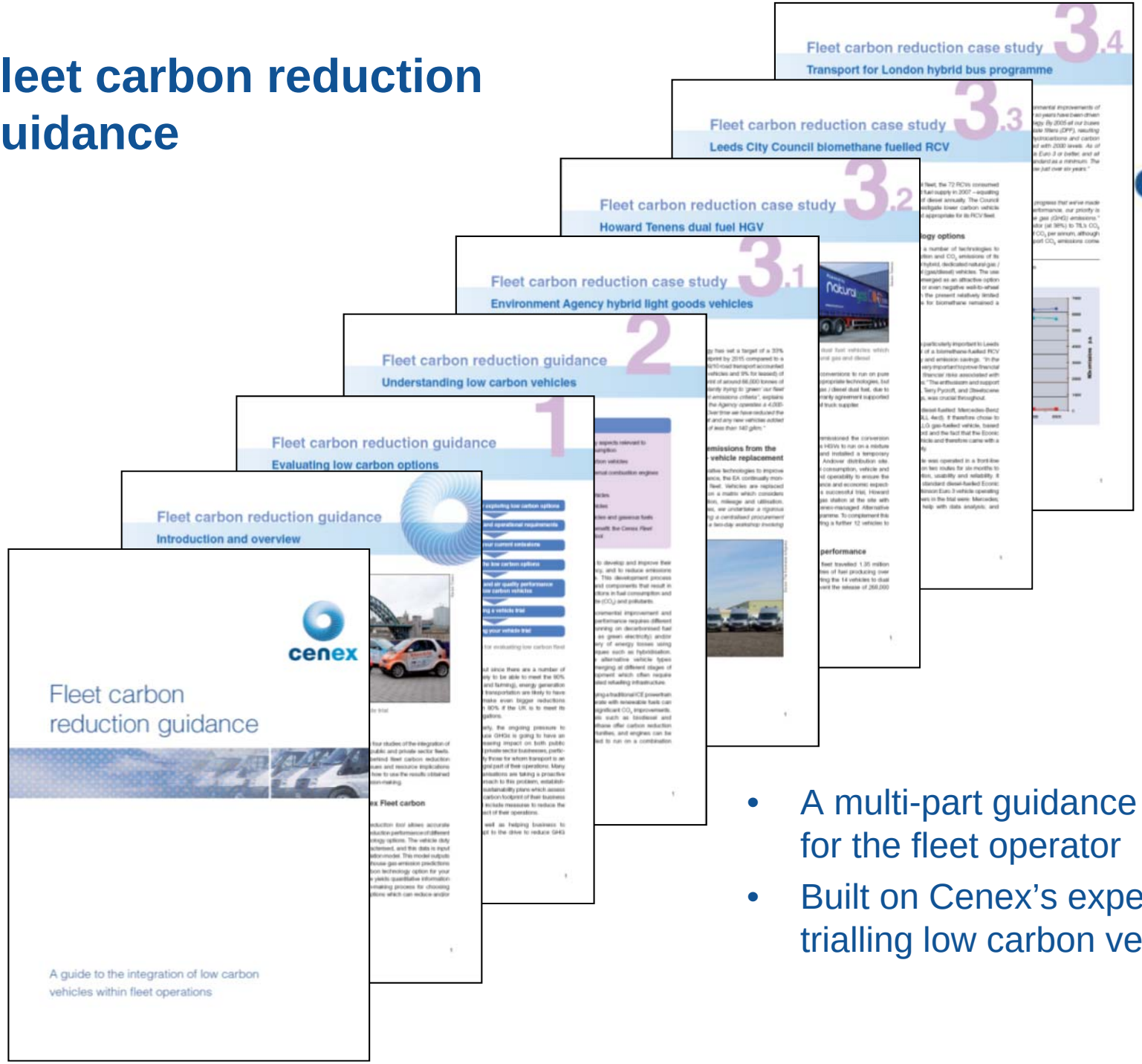
- During Trails
  - Interest among return to base fleets (Police, Councils, etc)

- Now vehicles commercially available with Plug-In Car Grant
  - Of 680 vehicles sold to January to June 2011, 75% were for commercial and public sector fleets
  - Reticence of fleet advisors to financial services sector to set competitive residual values seen as barrier to leasing
  - Fleet advisors struggling to deal with different leasing of vehicle and battery pack

How can Commercial Fleets be assisted to be early adopters of Plug-In Vehicles?

- Need to raise awareness (and overcome myths)
- Need evidence base to aid planning (results from real world field trials)
- Need analytical tools that help can fleets build a more detailed business case

Fleet carbon reduction guidance



cenex

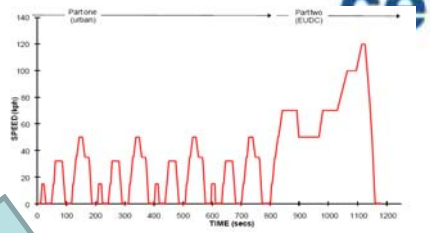
- A multi-part guidance document for the fleet operator
- Built on Cenex's experience trialling low carbon vehicles

Fleet Carbon Reduction Tool (FCRT)

- A new fleet simulation package built to provide accurate predictions of the carbon and cost impact of introducing low carbon vehicles
  - Developed with support from Mahle Powertrain

- Cost-effective answers to questions like these
  - What types of low carbon vehicles are out there?
  - How will these vehicles perform in my application, which types are appropriate for my fleet, and what are the limitations?
  - What is the whole life cost of low carbon vehicles, and by how much will they really reduce my carbon emissions?

FCRT - Method



Vehicle parameters
including
- Drag coefficient
- Kerb weight
- Frontal area

Operational parameters
including
- Purchase cost
  Payload profile
- Drive cycle

Outputs
including
- WTT and TTW CO_2
- Fuelling costs
- Ownership costs

Powertrain parameters
including
- Motor torque
- Efficiency
- Weight penalty

Calculation

FCRT - Approach

- Vehicle model is a backward facing calculation operating on a fixed time-step calculation,
  - Drive-cycle speed is imposed on the vehicle at each calculation time-step
  - Model back-calculates through the driveline to determine the instantaneous engine (or motor) speed and torque requirement.
    - If the required torque or speed is too high for the driveline, the model will determine the maximum speed that can be achieved for the current time-step.
  - The fuel consumed (or battery state of charge) is then calculated from the speed and torque input for the current calculation step.
  - Confidence intervals evaluated based on the vehicle and driveline uncertainty parameters.

FCRT - Parameters

The vehicle parameters, including

- frontal area,
- aerodynamic drag
- kerb weight.

The powertrain parameters, including

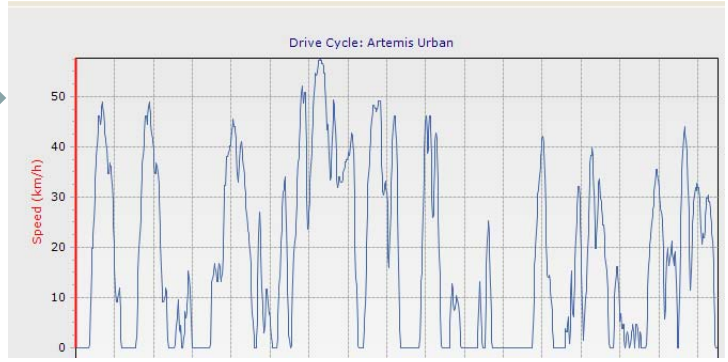
- maximum torque and efficiency data,
- transmission ratios,
- wheel sizes
- battery data for hybrid or electric vehicles.
- Potential mass penalty for driveline technology.
- Each of the powertrains assigned cost modifiers
- Each powertrain has a fuel-type associated, with a unit cost (i.e. £/litre) and infrastructure cost.
- Each fuel also has a CO_2 mass ratio associated with it and a well-to-tank CO_2 figure

The fleet vehicle parameters including

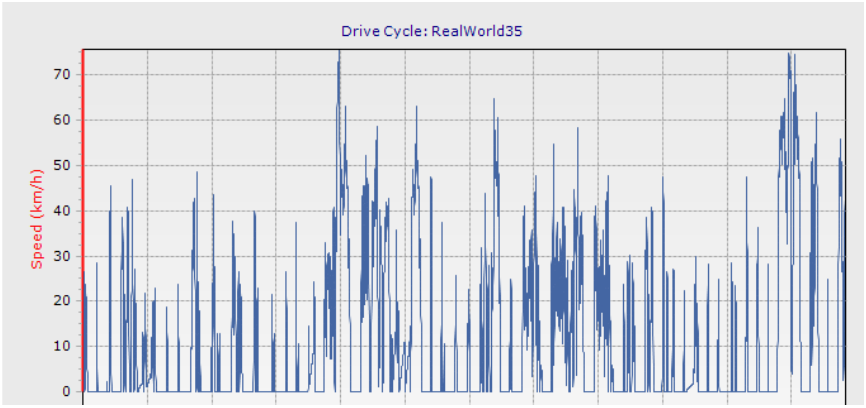
- purchase cost
- residual value
- service life
- operating cost data

FCRT - Drive cycle construction

- Two options
  - Choose from a library of drive cycles

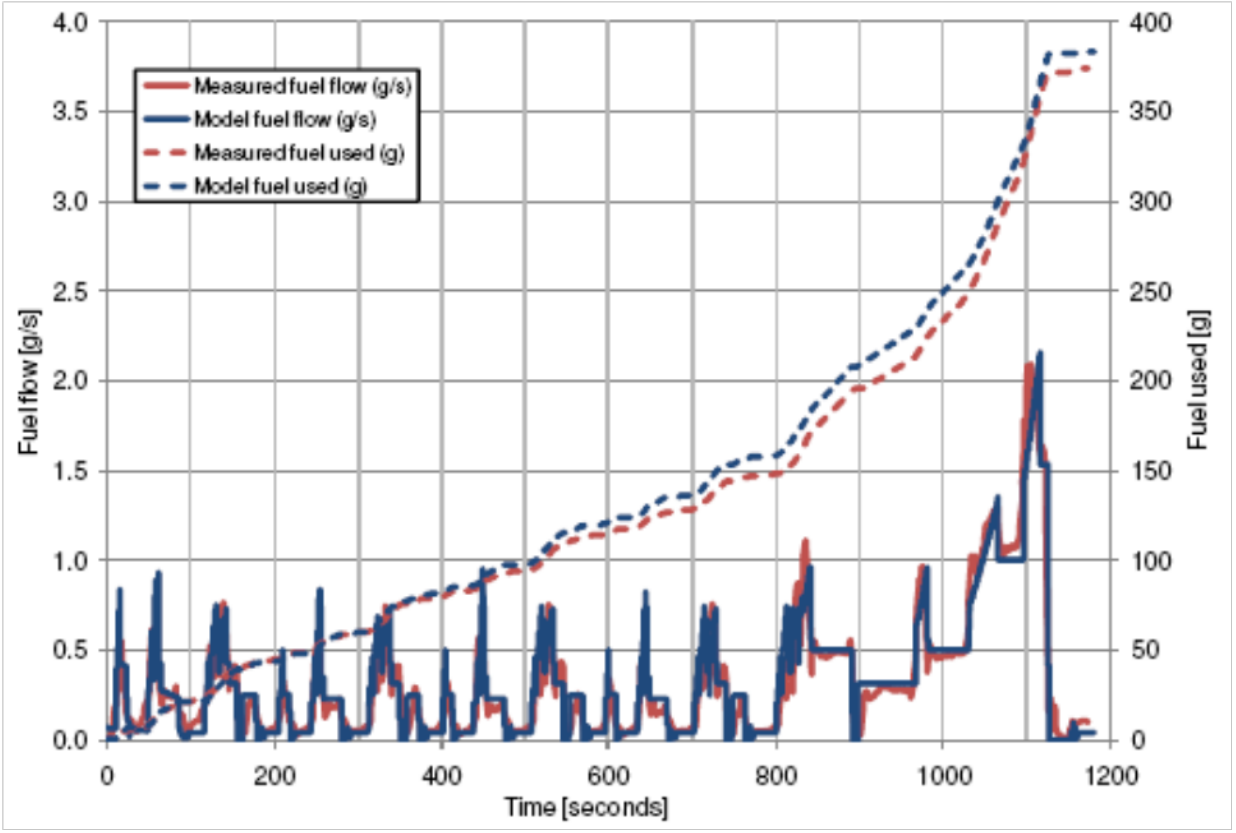


  - Create a proprietary drive cycle best suited to actual operating characteristics of that fleet.
    - Created from time-speed data logging of multiple trips



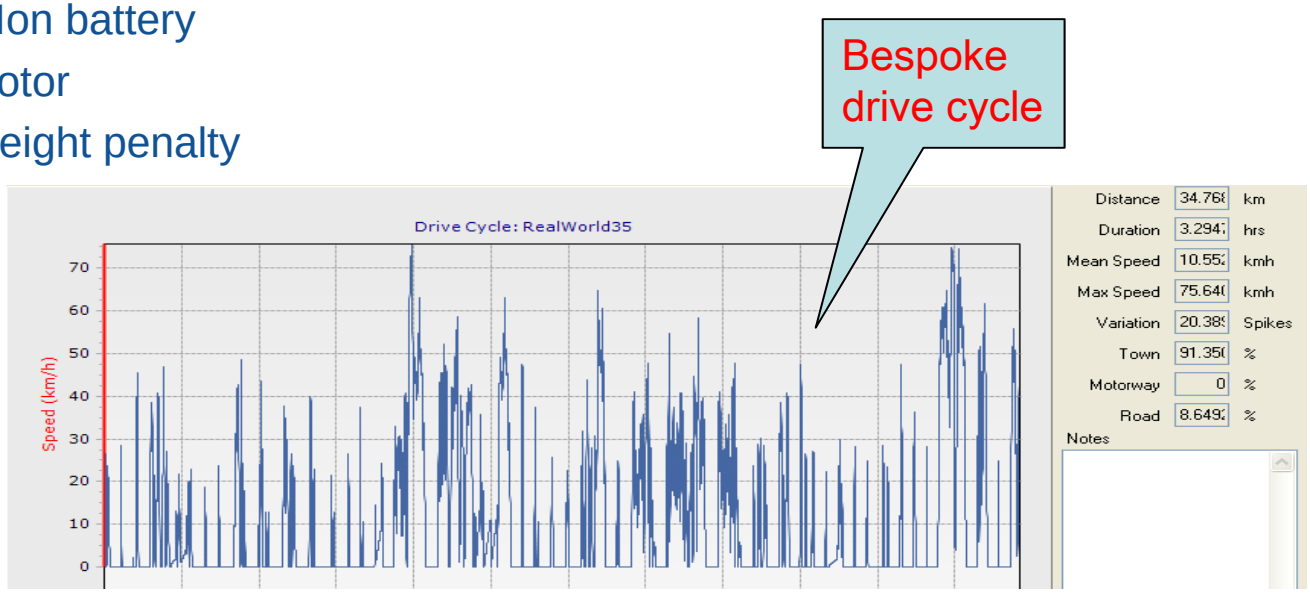
FCRT - Validation

- Comparing results with representative data obtained from dynamometer testing over drive cycles for which emissions results are known.
- Correlation of measured versus modelled fuel consumption for a Smart fortwo diesel operating over the NEDC cycle.



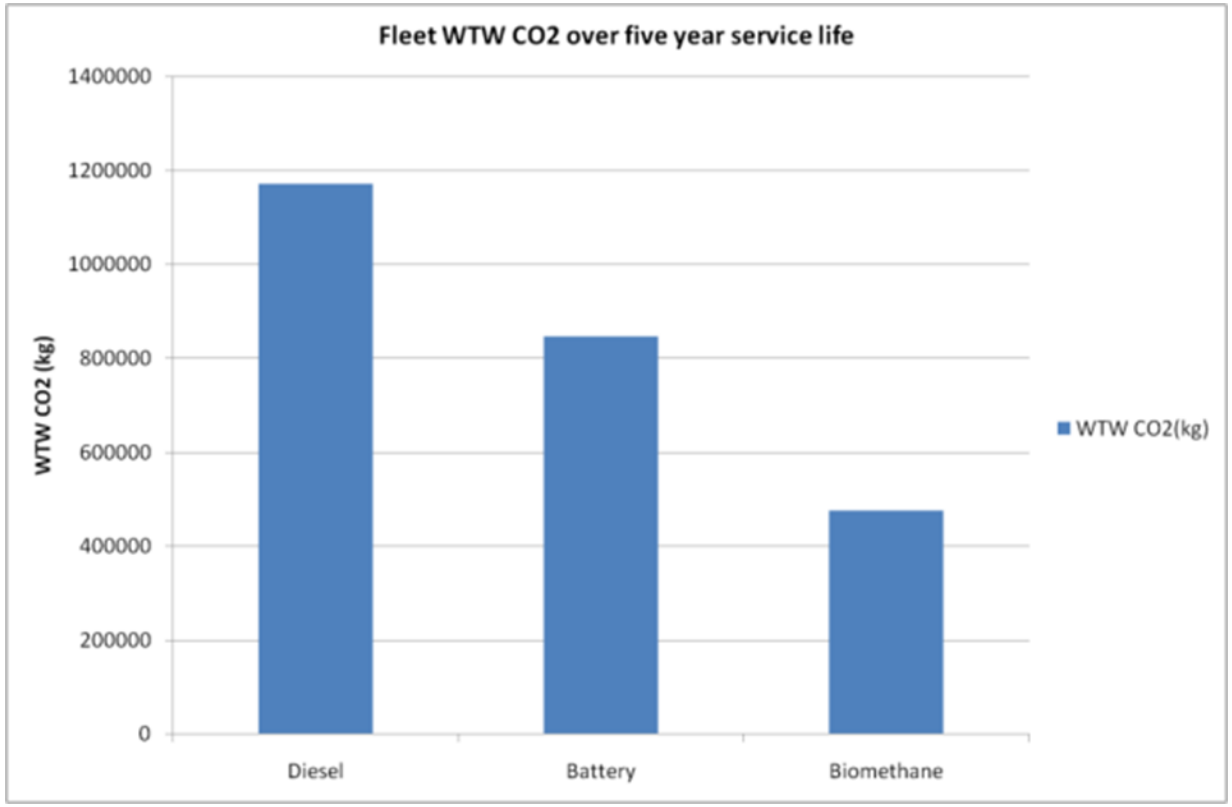
Technology Comparisons – Assumptions

- Van fleet
  - 50 vehicles
  - Return to base delivery operation
  - Drive cycle telemetry input
  - Base vehicle 2.4l diesel large panel van
  - Alternative powertrains
    - Biomethane
      - 3l, 100kW dedicated gas engine
      - 6 speed gearbox
    - Electric
      - 50kW LiIon battery
      - 64kW motor
      - 400kg weight penalty



Source : Cenex HEVC 2011

Emission Comparisons

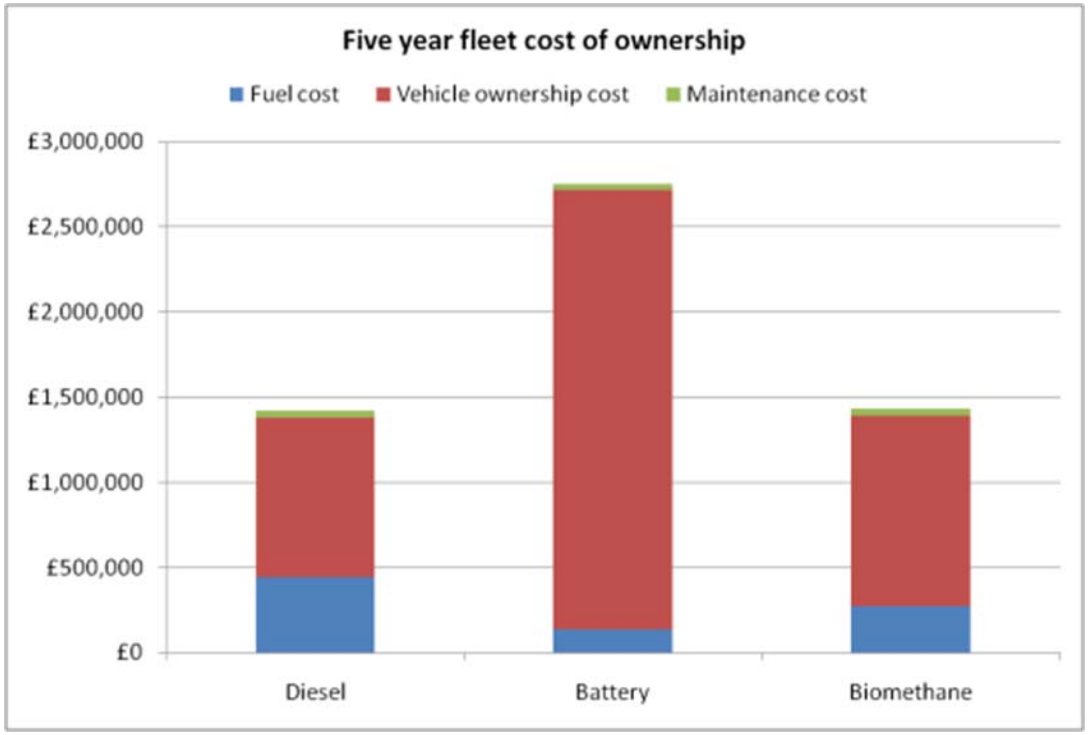


Fuel	Pathway and reference
Diesel	UK supplied diesel fuel
Biomethane	Recovered biogas from UK landfill, upgraded and liquefied at site, road distribution and on-site vaporisation and compression
Electric	Annual average carbon intensity of electricity from the UK national grid

Source : Cenex HEVC 2011

Cost of Ownership comparisons

- Simple TCO model:
  - Maintenance
  - Purchase price
  - Residual values
  - Service life
  - Depreciation
  - Service interval
  - Parts cost
  - Lease cost
  - Insurance
  - Fuel price
  - Operational days
  - Payload
  - Service cost
  - Infrastructure capital cost
  - Or additional revenue cost if a ‘pay through the nozzle’ approach is adopted
  - Etc.



Parameter	Value
Number of vehicles	50
Purchase price (diesel)	£25,000
Service life	5 years
Residual value	25% purchase price
Operation day per year	350
Distance per day	35km
Payload	200kg linear reducing load profile

Source : Cenex HEVC 2011

Conclusions

- Drivers for Government for Plug-In Vehicles >> Drivers for Commercial Fleet Operators
- Government funded fleet demonstration projects provide real world experience – help identify successes and limitations of current generation of technology
  - Key role for independent third party like Cenex to oversee field trials and report to market (stewardship role)
- Cenex has developed a range of support services to assist with the business case calculations for fleet adoption of low carbon emissions (inc. a Fleet Carbon Reduction Toolkit)
- Cenex interest to work on projects in the USA

Cenex resources : Downloads @ www.cenex.co.uk/resources

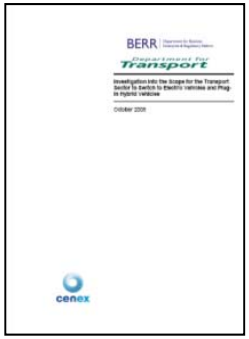
- Smart move trial report

- Electric Drive Vehicle Characteristics Study

- Electric Driving style and duty variation study

- EV studies seminar: drive cycle standards and issues
- EV studies seminar: driver variation
- EV studies seminar: range testing
- EV studies seminar: traffic flow

- Scope of the transport sector to switch to electric and plug-in hybrid vehicles



Thank you for your attention

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