LowCVP Low Carbon Vehicle Partnership
Connect Collaborate Influence

Technology developments and experiences in the UK

26 April 2017

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LowCVP
Low Carbon Vehicle Partnership

Connect
Collaborate
Influence

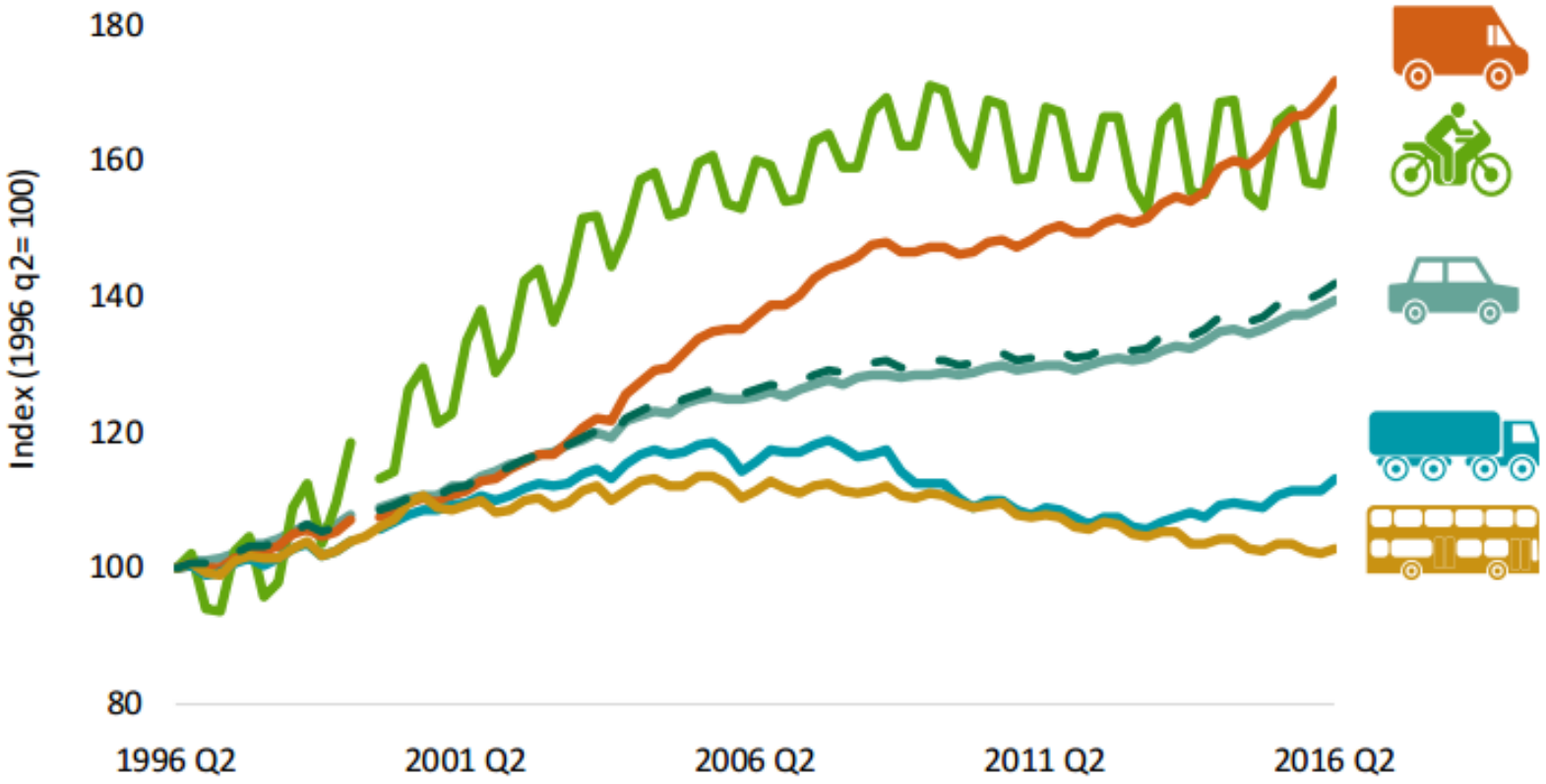
Public Private Partnership

"To accelerate a sustainable shift to low carbon vehicles and fuels in the UK and thereby stimulate opportunities for UK businesses".

Commercial goods vehicles: The next big (low) carbon opportunity?

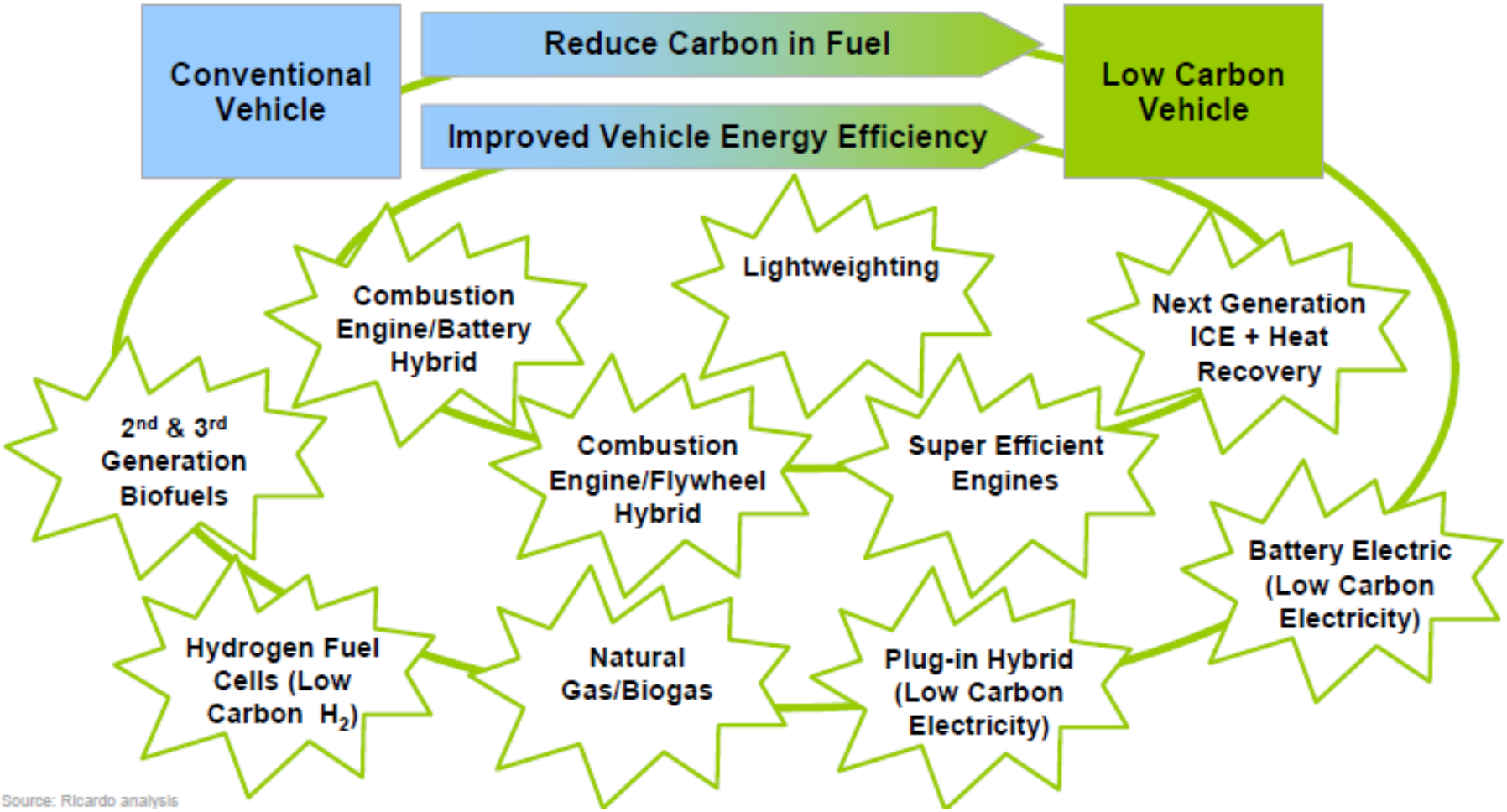
LowCVP
Low Carbon Vehicle Partnership

Figure 5: Licensed vehicles by type, GB: Q2 1996 - Q2 2016



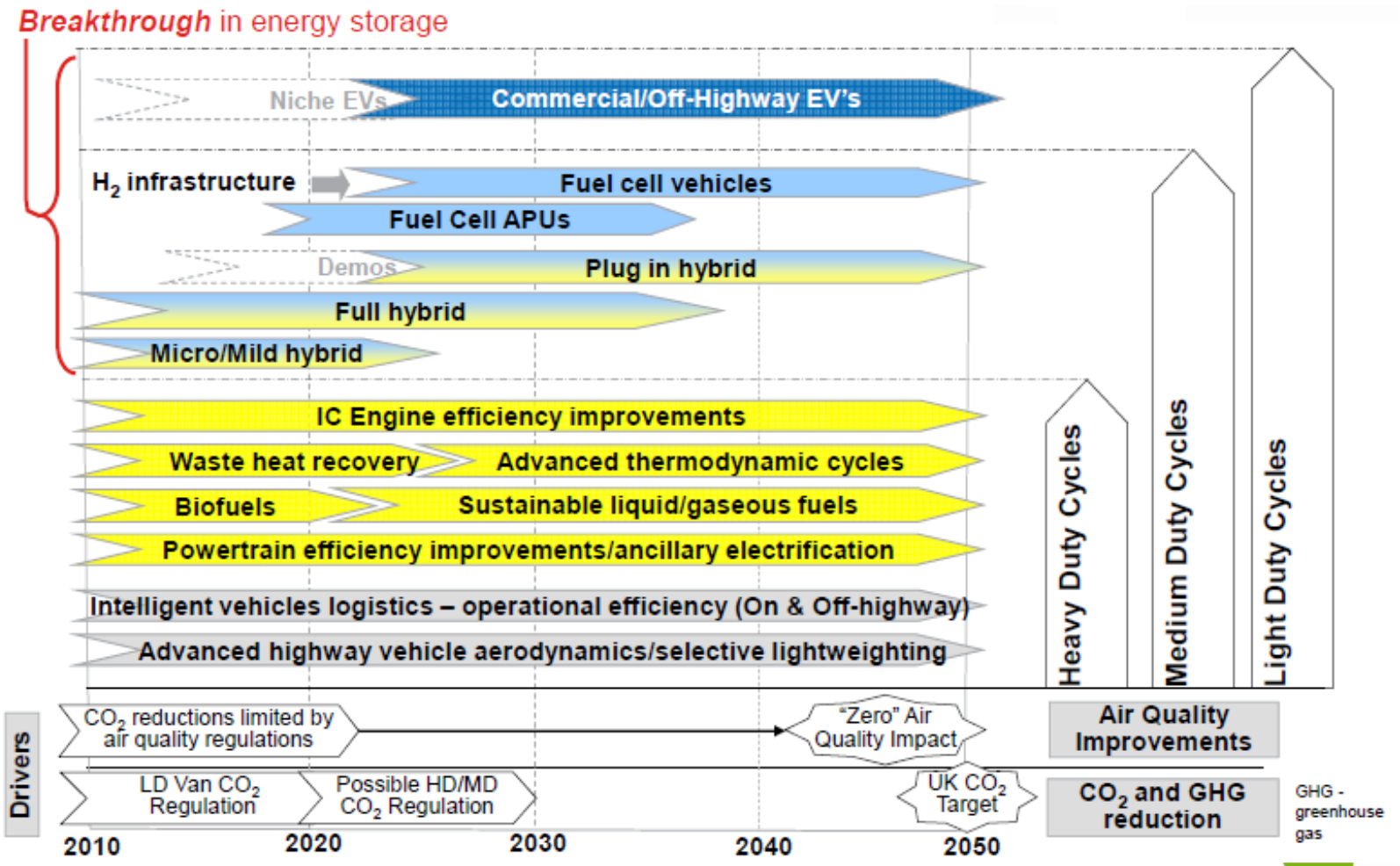
There are many technical options to reducing vehicle CO2 and improving air quality. All have challenges and are suitable to different applications. We are likely to need all of them.

- Low carbon vehicles achieved through improved efficiency and/or low carbon fuels:

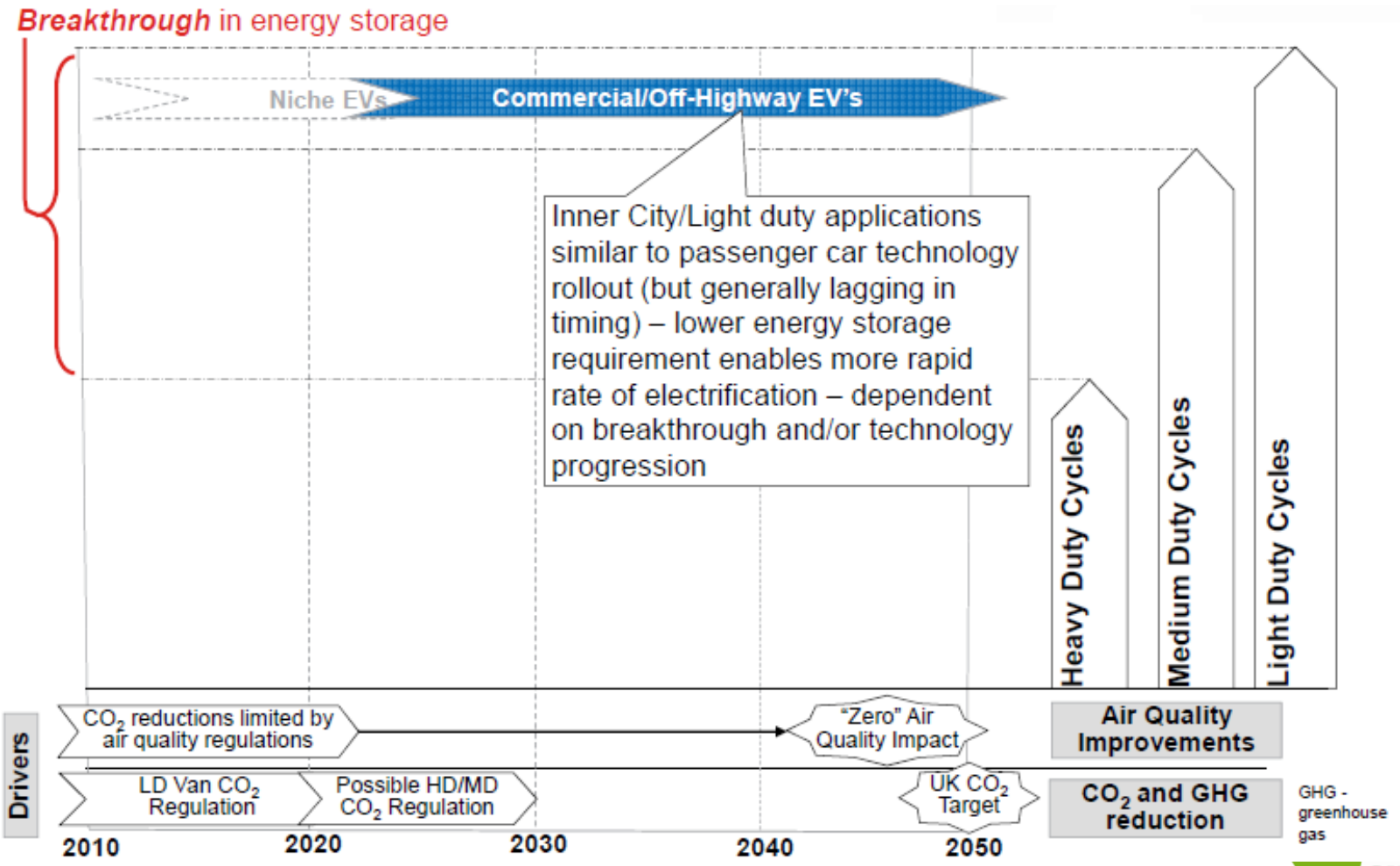


Source: Ricardo analysis

A number of technology roadmaps have been developed for CVs. The Automotive Council UK's provides the UK consensus view driving investment.



Battery electric vehicles are seen as being limited to duty cycles with lower range and GVW.

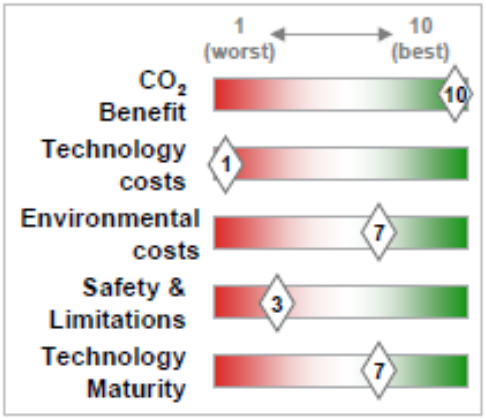


Electric commercial vehicles are available up to 12t GVW and benefit from lower taxes and running costs

Electric Vehicles

- **Concept:** Vehicle which is driven by a battery powered electric motor
- **Base Functioning:** Vehicle is driven by an electric motor powered by batteries which are charged from mains electricity. The vehicle has no other power source other than the battery
- **CO_2 Benefit:** Tailpipe CO_2 emissions are 0g/km and overall emissions are estimated to be 40% lower than conventional diesel, but this is dependent on fuel source used to generate electricity
- **Costs:** Smiths Newton electric 7.5t vehicle (very similar to medium duty benchmark) is between £78,387 and £80,886
- **Environmental Benefit:** Electric vehicles have societal benefits in that they reduce road noise

Powertrain



Safety and Limitations

- ✓ Less stressful driving
- ✓ Lower maintenance and servicing requirements
- ⛔ Lower vehicle payload than comparable diesel vehicle
- ⛔ Limited to GVW of 12t
- ⛔ Low residual vehicle values
- ⛔ Operation limited to central depot based fleets
- ⛔ Reduction in road noise needs to be handled carefully to ensure no adverse effects for vulnerable road users

Technology Applicability

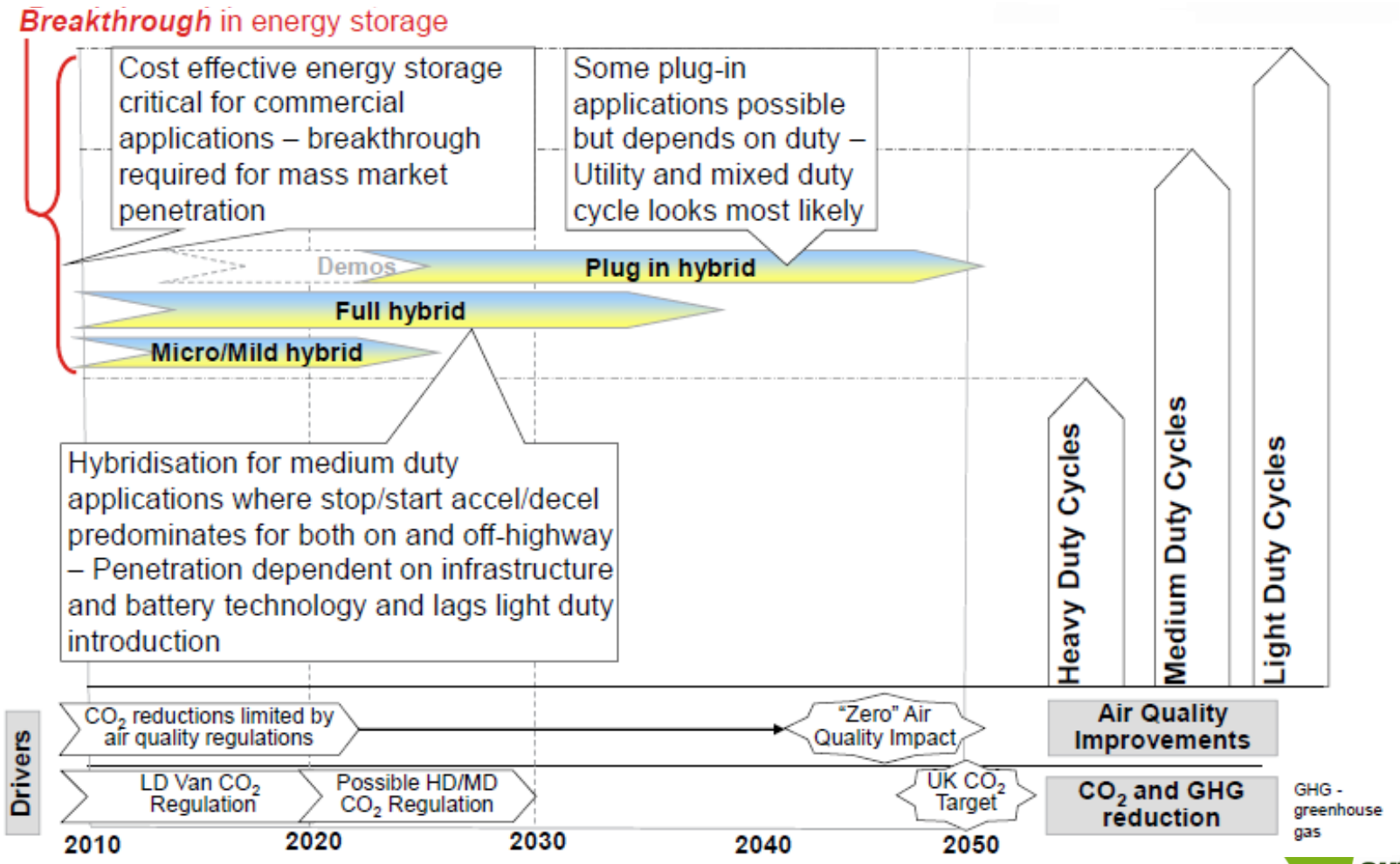
- Limited to vehicles up to 12t
- Best suited to vehicles operating from a single depot and with daily mileage of <100miles
- Greatest benefit for urban applications where exemption from congestion charge and low emission and noise operation is beneficial

Visualisation

Picture: Smith Newton from sev-us.com

Source: Smiths Electric Vehicles; The Benefits of Operating an Electric Vehicle in an Urban Environment, Freight Best Practice, April 2009 – Full sources available on detail slides in the attached annex

Greater opportunities for electrification of the drive train are anticipated through hybrid and range extender technologies.

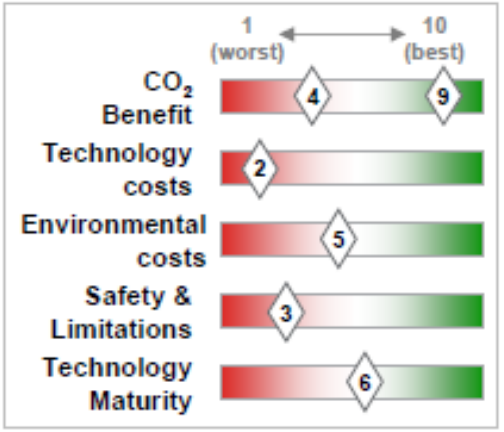


Hybrid and range extended vehicles offer high CO2 reductions in urban applications but are expensive and require maintenance training

Hybrid Powertrains – Full Hybrid

- **Concept:** A powertrain which can use more than one fuel source to provide energy to propel the vehicle
- **Base Functioning:** Typically implemented as hybrid electric vehicles where electrical energy is stored in batteries which can be used to drive an electric motor to power the vehicle or supplement engine power
- **CO_2 Benefit:** Ranges significantly dependent upon vehicle operation but averages 20% for medium (urban) and 7% for heavy duty (long haul) applications
- **Costs:** Significant technology on cost of additional hybrid components. Some environmental impact in terms of battery manufacture and disposal

Powertrain



Safety and Limitations

- ✓ Lower brake wear due to use of regenerative braking – leads to lower maintenance costs
- ✓ Makes use of existing fuel infrastructure
- ✓ Vehicles have better acceleration
- ⛔ Some vehicles have a reduction in payload
- ⛔ Engine stop/start unsuitable for some applications
- ⛔ Requires training of maintenance staff to safely work with high voltage systems

Technology Applicability

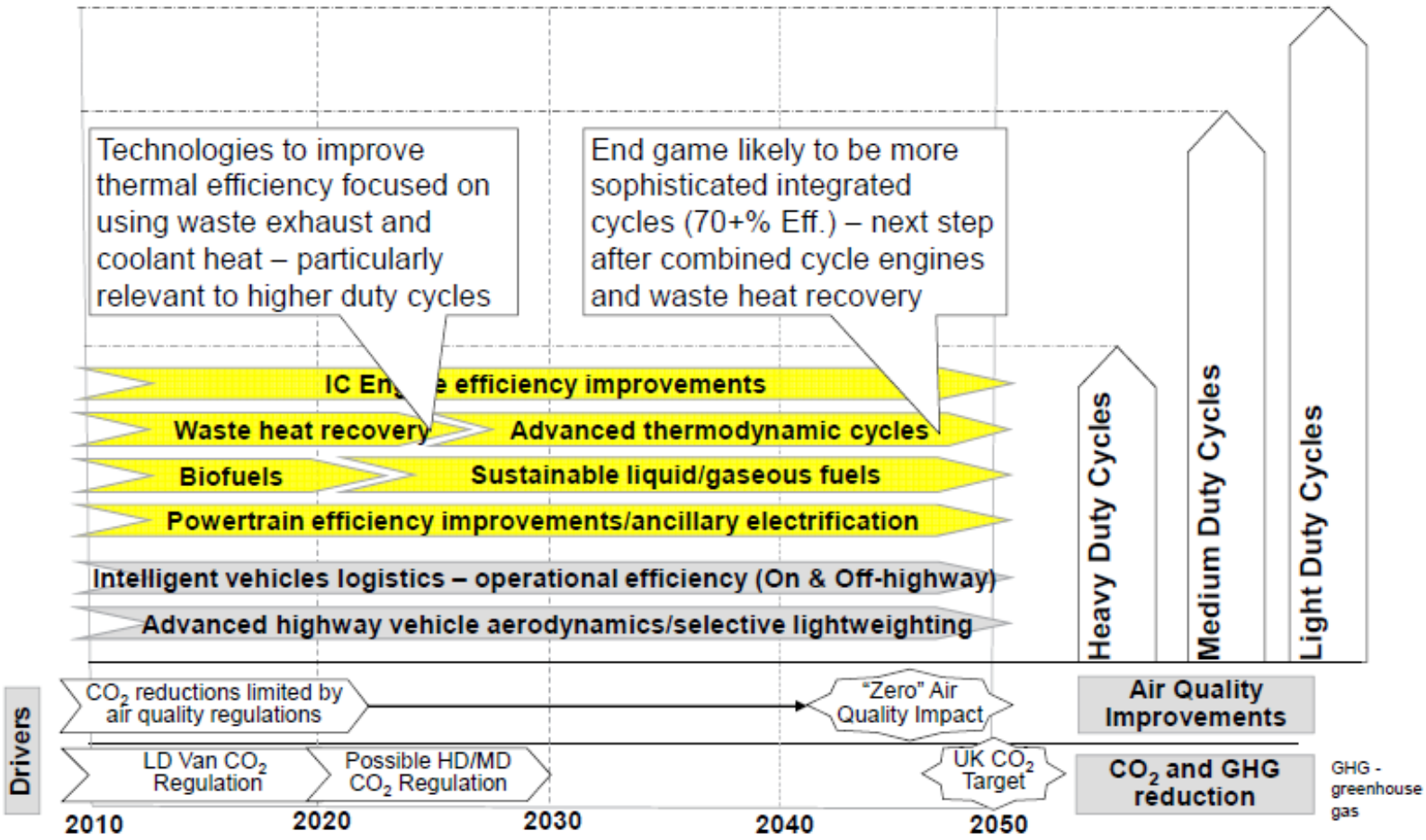
- Greatest CO_2 reduction potential for vehicles operating over an urban duty cycle
- CO_2 savings still possible for long haul applications but business case requires more consideration

Visualisation

Picture: DAF LF Hybrid

Source: OEM corporate websites and press releases – Full sources available on detail slides in the attached annex

There are also opportunities for electrification in delivering efficiency gains in ICEs and electrification of ancillaries.

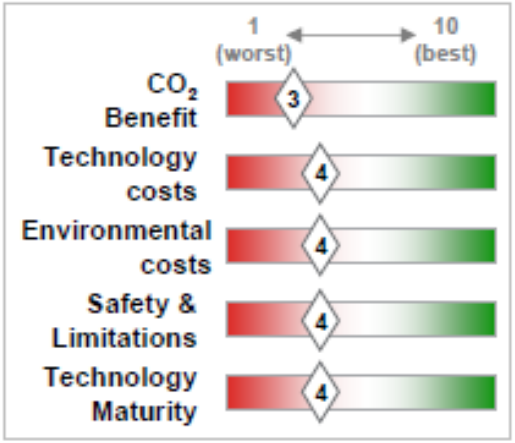


Waste heat recovery can provide moderate CO2 benefits – electrical turbocompounding

Waste recovery systems – electrical turbocompound

- **Concept:** Exhaust gas energy recovery
- **Base Functioning:** Exhaust turbine in combination with an electric generator / motor to recover exhaust energy
  - Recovered energy can be stored or used by other electrical devices
  - Motor during transients to accelerate
- **CO_2 Benefit:** Fuel economy benefit of 10 % achieveable at maximum power point[1]. Real world benefit closer to 3% depending on duty cycle. ETC perhaps best suited to off-highway applications like ploghing tractor which runs a long time at max power
- **Costs:** Increasing costs for turbocompound system

Powertrain



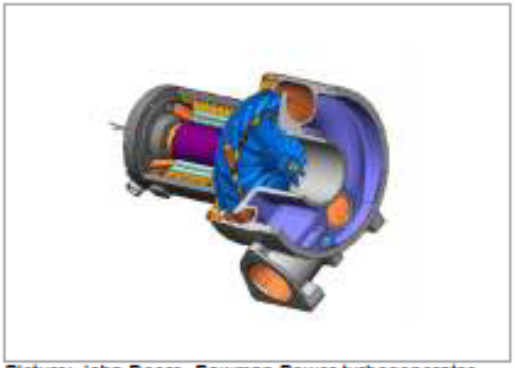
Safety and Limitations

- ✓ Moderate potential in reduction of fuel consumption and CO_2 emissions
- ✓ Primary for new engine designs
- ⛔ Added complexity for energy storage, control
- ⛔ Increased costs generator turbine, energy storage, crank mounted motor
- ⛔ High voltage system

Technology Applicability

- Electric turbocompounding systems for medium and heavy duty application in developement phase
- Fuel / CO_2 benefits confirmed

Visualisation



Picture: John Deere- Bowman Power turbogenerator
Source: http://www1.eere.energy.gov DEER 2006

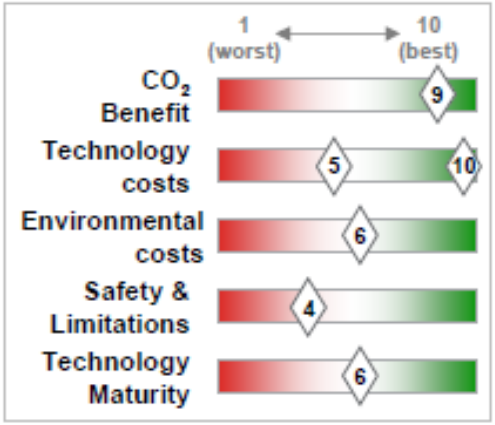
Source: Ricardo Research, Ricardo Evaluation; 1) *http://www1.eere.energy.gov;* Electric turbocompounding; John Deere; DEER 2006 – Full sources available on detail slides in the attached annex

Refuse trucks are being developed that use electric motors to drive hydraulic lifting and compacting mechanisms

Electric/ Alternative Fuel Bodies

- **Concept:** Replacement of existing power sources for vehicle bodies which use diesel for power
- **Base Functioning:** Electrification or use of an alternative power source, e.g. nitrogen to drive systems requiring power instead of diesel
- **CO_2 Benefit:** Varies between 10% and 20% depending on the body power system being replaced
- **Costs:** Up to 15% vehicle on cost, but some systems are lower cost

Vehicle



Safety and Limitations

- No limitations on vehicle usage
- Electric and nitrogen systems offer quieter and smoother operation
- Electric and nitrogen systems have low operating and maintenance costs
- Nitrogen system, unlike mechanical – will not 'top freeze'
- Safety of nitrogen system

Technology Applicability

- Suited to applications where electrical motors have sufficient torque to drive load
- For use in hybrid vehicle applications where hybrid battery can be used to power trailer

Visualisation

Picture: Volvo Hybrid Refuse Truck (gizmag)

Source: Ricardo Research, Ricardo Evaluation; http://www.gizmag.com/worlds-first-hybrid-refuse-truck-volvo-sweden/9131/ – Full sources available on detail slides in the attached annex

VECTO – HDV CO2 tool

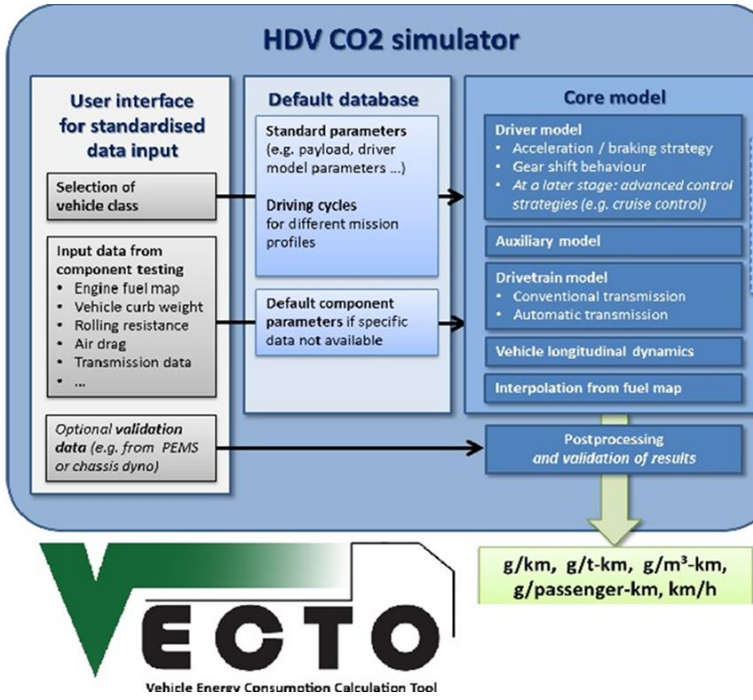
The EC has developed a computer simulation tool, VECTO, to measure CO2 emissions from new HDVs.

The EC will use VECTO to propose legislation which would require CO2 emissions from new HDVs to be certified, reported and monitored.

Vecto has three purposes

1. OEM – robust and objective tool to assess vehicles
2. Legislator – to assess emissions and develop measures to improve CO2 from HDV
3. Member states – to implement additional measures for more energy eff vehicles

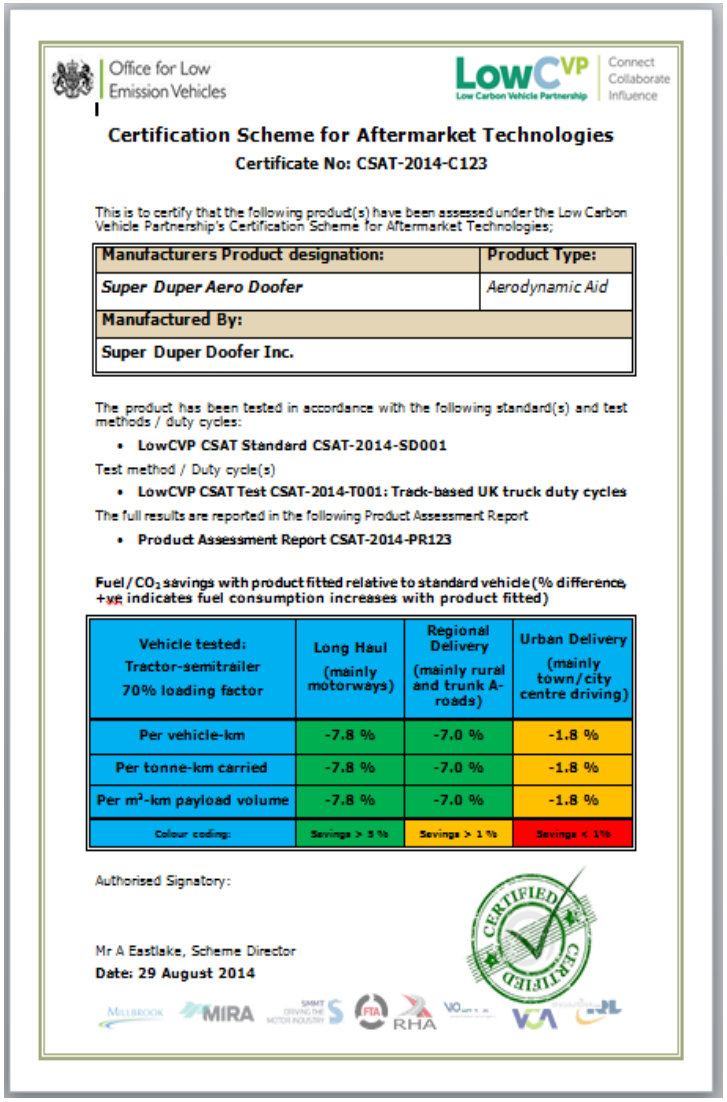
Likely to be simulation approach (VECTO) for certification, but conformity and post validation see vehicle testing benefits



LowCVP Initiative – Accreditation scheme for low carbon technologies

Carbon saving technologies face a major hurdle to penetrate the market.

- Operators are highly sceptical of technology manufacturer performance claims
- There is no widely accepted process to test technology and validate claims
- Vehicles are used for a range of operations (driving cycles) and testing for every situation is prohibitive.



Office for Low Emission Vehicles

LowCVP Low Carbon Vehicle Partnership — Connect Collaborate Influence

Certification Scheme for Aftermarket Technologies

Certificate No: CSAT-2014-C123

This is to certify that the following product(s) have been assessed under the Low Carbon Vehicle Partnership's Certification Scheme for Aftermarket Technologies;

Manufacturers Product designation:	Product Type:
Super Duper Aero Doofer	*Aerodynamic Aid*
Manufactured By:	
Super Duper Doofer Inc.	

The product has been tested in accordance with the following standard(s) and test methods / duty cycles:

- **LowCVP CSAT Standard CSAT-2014-SD001**

Test method / Duty cycle(s)

- **LowCVP CSAT Test CSAT-2014-T001: Track-based UK truck duty cycles**

The full results are reported in the following Product Assessment Report

- **Product Assessment Report CSAT-2014-PR123**

Fuel / CO_2 savings with product fitted relative to standard vehicle (% difference, +ve indicates fuel consumption increases with product fitted)

Vehicle tested: Tractor-semitrailer 70% loading factor	Long Haul (mainly motorways)	Regional Delivery (mainly rural and trunk A-roads)	Urban Delivery (mainly town/city centre driving)
Per vehicle-km	-7.8 %	-7.0 %	-1.8 %
Per tonne-km carried	-7.8 %	-7.0 %	-1.8 %
Per m^3-km payload volume	-7.8 %	-7.0 %	-1.8 %
Colour coding:	Savings > 5 %	Savings > 1 %	Savings < 1%

Authorised Signatory:

Mr A Eastlake, Scheme Director

Date: 29 August 2014

CERTIFIED

LowCVP Certification Scheme for Aftermarket Technologies

The scheme will help to build the market for low carbon HDVs

Evidence

- Operators get reliable, trustworthy and relevant information on likely effectiveness for their duty cycles
- Suppliers can demonstrate realistic savings, independently evaluated

Recognition

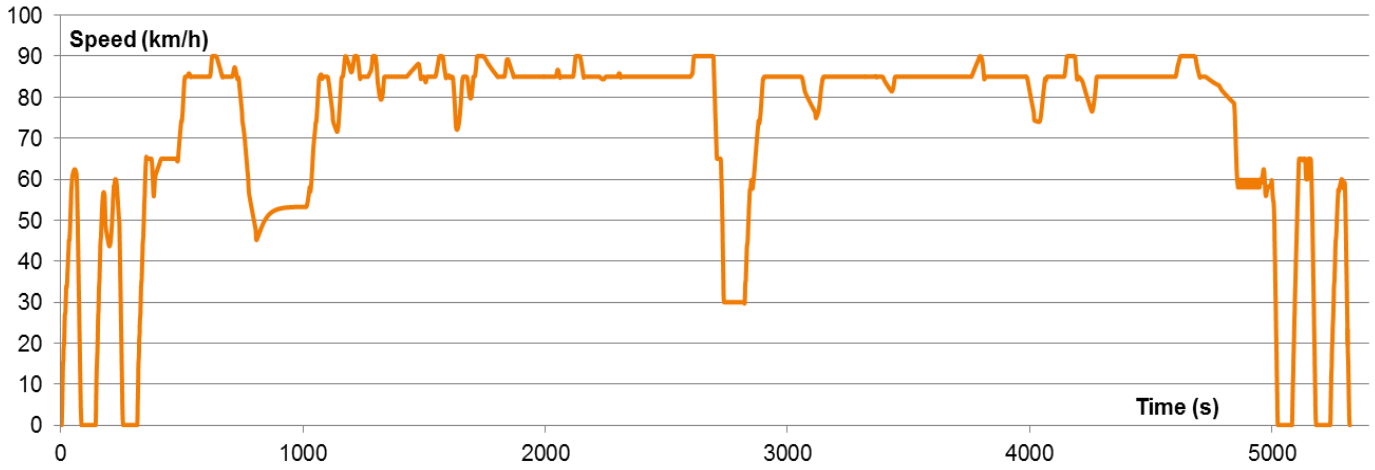
- Suppliers gain marketing opportunities, able to distinguish themselves from the snake oil salesmen
- Innovative and genuinely effective products encouraged
- Certificate issued for products that meet the mark

Incentives

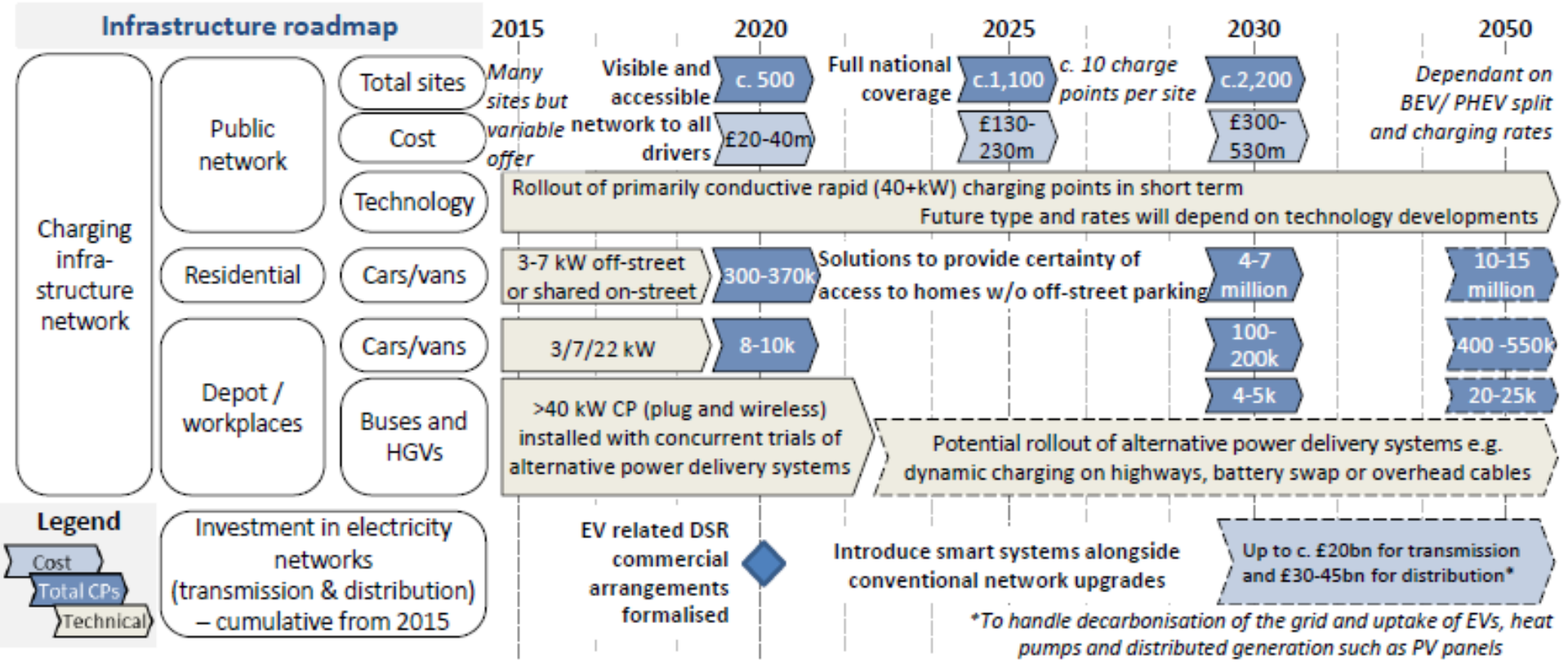
- Win-win for suppliers and operators via increased sales and fuel savings
- Government can properly target support mechanisms towards genuinely effective products

What are the schemes objectives?

- The Scheme will be designed, managed and run for the benefit of UK operators – collaboration and co-operation with them are key guiding principles. Credibility is paramount.
- The Scheme will support UK Government policy and the achievement of CO2, air quality and energy security targets
- The Scheme will add value to the development of a market for low carbon HGVs by addressing one of the key existing market failures – operators don't have a 'go-to' source of reliable information about technologies that might be useful to them and are reluctant to believe everything a supplier tells them



Millions of charge points (mostly residential) will be needed to support widespread EV deployment, with uncertainty over charging technologies



Plug-in electric vehicles stock

Projections are based on policy-led uptake scenarios presented on page 25

Data supported quantification of infrastructure requirements

Thousand vehicles	2020	2025	2030	2050
Cars	300	1,500-2,500	4,000-8,000	20,000-25,000
Vans	60	250-400	700-1,300	3,400-4,000
HDVs	<5	10	20	130

Dashed lines represent high uncertainty

Major milestone /enabler

Cost estimates are cumulative costs from 2015

CP = Charge point

Solutions to facilitate overnight charging will be required across residential areas and depots

Depots / workplaces and fleets

- Fleet operators of HDVs are likely to be faced with high local network reinforcement costs (already observed) –an investment in assets not own by the fleet operator: an unfamiliar risk and procedure

Recommendations

- Local gov. : facilitate the interface between DNOs and fleet operators and prediction of 'demand cluster' for optimised investment; socialise early adopter case studies to share lessons learnt
- Central gov. and regulator: align EV uptake ambition with network reinforcement needs to allow/encourage 'top-down' strategy (upfront investment in advance of need)
- R&D bodies: support trial of new technologies (e.g. inductive, ultra fast conductive, 'automatic plug-in' etc.) that would be more practical for fleets than current technologies

Mitigating the impact of electric vehicles on the network will require new technologies and new commercial arrangements

Impact on electricity network

- Without management of the charging time, **EVs will require large investment in new distribution infrastructure (substations, cables) and possibly new generation / interconnection capacity.** The Smart Grid Forum estimate that 'smart' technical and commercial solutions could **save in the order of £15bn** on distribution network reinforcement costs by 2050
- **DNOs will need information on EV location and uptake to plan investment** and smart solutions rollout accurately
- Research is needed to **understand relative impact of different charge point** deployments (3kW, 7kW or more)
- Although less studied **benefits to the grid could also be available**: as flexible loads, recharging EVs could provide important grid balancing services to maintain grid frequency, to manage supply and reduce renewable curtailment

Recommendations

- Central Gov. & regulators: support DNOs to access geographically disaggregated EV uptake data;
- Installers and DNOs: improve platform for compiling charge point installation notifications (as stipulated by IEC)
- Regulators, electricity suppliers and DNOs: develop new commercial arrangements and tariffs required for the uptake of smart charging solutions and for customer engagement [Ofgem's Low Carbon Fund already supports these activities]
- On-going trial programs:disseminate findings on local network management solutions to DNOs and related stakeholders
- R&D bodies & DNOs: Investigate network related topics: charging/demand management technologies, Vehicle-2-Grid, impact on battery life, co-locating energy storage devices with rapid charge points to alleviate strain on weak grid

In summary

- Increasing numbers of CVs, particularly LCVs, increasing source of GHG and impact on air quality.
- Range of technologies which are capable of reducing GHG and improving air quality.
- Electrification of powertrain focused on light and medium duty applications, opportunities for electrification of ancillaries and energy recovery.
- Accreditation scheme for vehicles and components can provide marketing opportunity for manufacturers, confidence for fleet operators and metric for Govt to set incentives against.
- Electrification of CVs will increase pressure on electricity distribution network and need for reinforcement or demand side management.
- Electric vehicles offer opportunities for demand levelling and V2G.
- To make most of electrification of vehicles will require a level of information flow between vehicles, recharging infrastructure and networks which is unprecedented.

Thank you!

Jonathan Murray
Low Carbon Vehicle Partnership
www.lowcvp.org.uk

Links to key studies on LowCVP website

- Market background study
- Technology Roadmap
- Technology Testing study
- Technology accreditation
- HGV Simulation tool
- LowCVP report on recommendations to accelerate the market for Low Carbon HGVs
- Auto Council Commercial and Off-highway Technology Roadmap
- Opportunities for low emission HGVs Report
- Infrastructure Roadmap Final Report
- Infrastructure Roadmap - Electricity
- Infrastructure Roadmap – Hydrogen
- Accreditation Scheme for Aftermarket Technologies - Sample Certificate (Updated 29.06.16)
- Development of test cycles and measurement protocols for a low carbon truck technology accreditation scheme. (Updated 29.06.16)
- Test Procedure for Measuring Fuel Economy and Emissions of Trucks Equipped with Aftermarket Devices. (Updated 29.06.16)