Clean Vehicle Technology Fund Overview of Retrofit Technologies and Monitoring

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Selective Catalytic Reduction

Authority	Vehicle No	Type	Supplier	Emission Reduction Estimate	Monitoring Method
Bradford	25	E3 buses	Eminox	TBC	Portable Emission Monitoring System
					NOx sensor
Dudley	10	E3/4 coaches	Eminox	TBC	NOx sensor
GLA	401	400 E3 buses 1 fire engine	Eminox/HJS/Provincia	NOx - 80-95%	NOx sensor
Cheshire	8	E3/5 buses	Baumot	NOx - 90%	NOx emission monitor (TBC)
Mersey Travel	7	E3/4 buses	Green Urban	NOx - 98%	TBC
Brighton	30	E3/4/5 minibus (taxi)	Green Urban	80% NOx / 10% CO2	Vehicle Emissions Testing - On Street

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Selective Catalytic Reduction With E Fan

Authority	Vehicle No	Type	Supplier	Emission Reduction Estimate	Monitoring Method
Leicester City	5	E3 buses	TBC	NOx - 70% / PM - 90%	Portable Emission Monitoring System
					Ambient AQM
Colchester	10	E3 buses	Eminox	TBC	NOx sensor
					Ambient AQM
Mersey Travel	11	E3/4 buses	Green Urban	NOx - 98%	TBC

Useful to have fuel consumption saving of E fan technology and to monitor CO_2 emissions via fuel consumption data

Selective Catalytic Reduction With Driver Management

Authority	Vehicle No	Type	Supplier	Emission Reduction Estimate	Monitoring Method
West Yorkshire	46	E4 buses (school)	Eminox	NOx - 75% / PM - 90%	Vehicle Emission Testing Laboratory
					NOx sensor

Useful to have fuel consumption saving of driver management technology and to monitor CO_2 *emissions via fuel consumption data*

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Thermal Management Technology

Authority	Vehicle No	Type	Supplier	Emission Reduction Estimate	Monitoring Method
South Yorkshire	41	E4 buses	HJS	NOx - 40%	Vehicle Emission Testing Laboratory
					NOx sensor
Mersey Travel	19	E3/4 buses	TBC	TBC	TBC

TMT with micro hybrid

Authority	Vehicle No	Type	Supplier	Emission Reduction Estimate	Monitoring Method
Southampton	9	E5 Buses	HJS + AVID	NOx - 51%	Vehicle Emission Monitoring - Bespoke
Bristol	42	E5 buses	HJS (+ AVID)	NOx - 51%	NOx sensor

Useful to have fuel consumption saving of micro-hybrid technology & monitor CO_2 emissions via fuel consumption data

Flywheel Hybrid

<table>
<tr><th>Authority</th><th>Vehicle No</th><th>Type</th><th>Supplier</th><th>Emission Reduction Estimate</th><th>Monitoring Method</th></tr>
<tr><td>Newcastle</td><td>58</td><td>E5</td><td>GKN</td><td>NOx - 25% / PM - 63%
CO2 -30%</td><td>Ambient AQM</td></tr>
<tr><td rowspan="2">Southampton</td><td rowspan="2">9</td><td rowspan="2">E5</td><td rowspan="2">GKN</td><td rowspan="2">NOx - 7.5% / PM -15%
CO2 - 25%</td><td>Vehicle Emission Testing Laboratory</td></tr>
<tr><td>Vehicle Emission Monitoring - Bespoke</td></tr>
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Useful to monitor CO_2 emissions via fuel consumption data

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Other Conversion Technologies

Authority	Vehicle No	Type	Technology	Supplier	Emission Reduction Estimate	Monitoring Method
Birmingham City Council	80	Euro 2/3 Taxis	LPG	Smiles Engineering	NOx - 90% / PM - 99%	Portable Emission Monitoring System
Reading	100	E4 Taxi	Duel fuel CNG or dedicated CNG	CRD Technology	NOx - 28-52% / PM 36-48%	Vehicle Emission Testing Laboratory
Portsmouth	18	E4/5 Vans	Hybrid Assist + Driver Management System	Ashwoods	NOx - 20%	Vehicle Emission Monitoring - Bespoke
Yorkshire Ambulence	1	E5 Car	Solar panels to reduce fuel consumption	TBC	TBC	Fuel consumption TBC

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What are the overall objectives of the CVTF?

- To determine the efficacy of retrofit technology at reducing NOx, and if possible, NO2 emission concentrations.
- To determine if the retrofit technology has reduced real world NOx concentrations in line with supplier's performance estimation.
- To monitor durability (continued efficacy) of the technology in operation
- Challenging – demonstrate the NOx retrofit technology has improved ambient NO2 concentrations
- Where possible determine the impact of retrofit technology at lowering other pollutant concentrations eg particulate matter and carbon dioxide

- To build knowledge and information to inform future government air quality support initiatives.

What good practice measures should be considered

Overall monitoring strategy

1. Before retrofit installation (control)
2. Post retrofit installation (impact)

→ Demonstrates the impact of retrofit techno on reduction NOx emissions(g/km) (Compare 1&2)

3. 6 and/or 12 months after installation

→ Demonstrates on-going performance of the retrofit technology (NOx g/km) (Compare 1 & 2 & 3)

Key Parameters

- Vehicles: test vehicles of different Euro standards, use the same vehicles for 1,2 and 3 above
- Route: vehicles should be tested on the same or similar route, typical for that vehicle, time of day and year
- Important, vehicle must be tested in motion on a representative duty cycle (real world or in a lab/track environment)
- Testing instrumentation: this will influence if NOx and NO2 emissions concentrations can be measured, degree of accuracy, measurement of mass or just concentration.
- Monitoring equipment should undergo appropriate QA/QC – eg calibration
- Metrics: to determine NOx emissions concentration (g/km), mass air flow should be monitored
- Fuel consumption: useful to determine impact of retrofit on fuel consumption, and CO2 emissions, also could be used as a proxy for determining mass air flow.
- Data reporting: provide full details of monitoring instrumentation, duration, route and results

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What good practice measures should be considered

Identifying a signal in ambient air quality monitoring data of the effectiveness of NOx retrofit technology is challenging, requires a high level of data analysis and great care with interpreting data.

Considerations

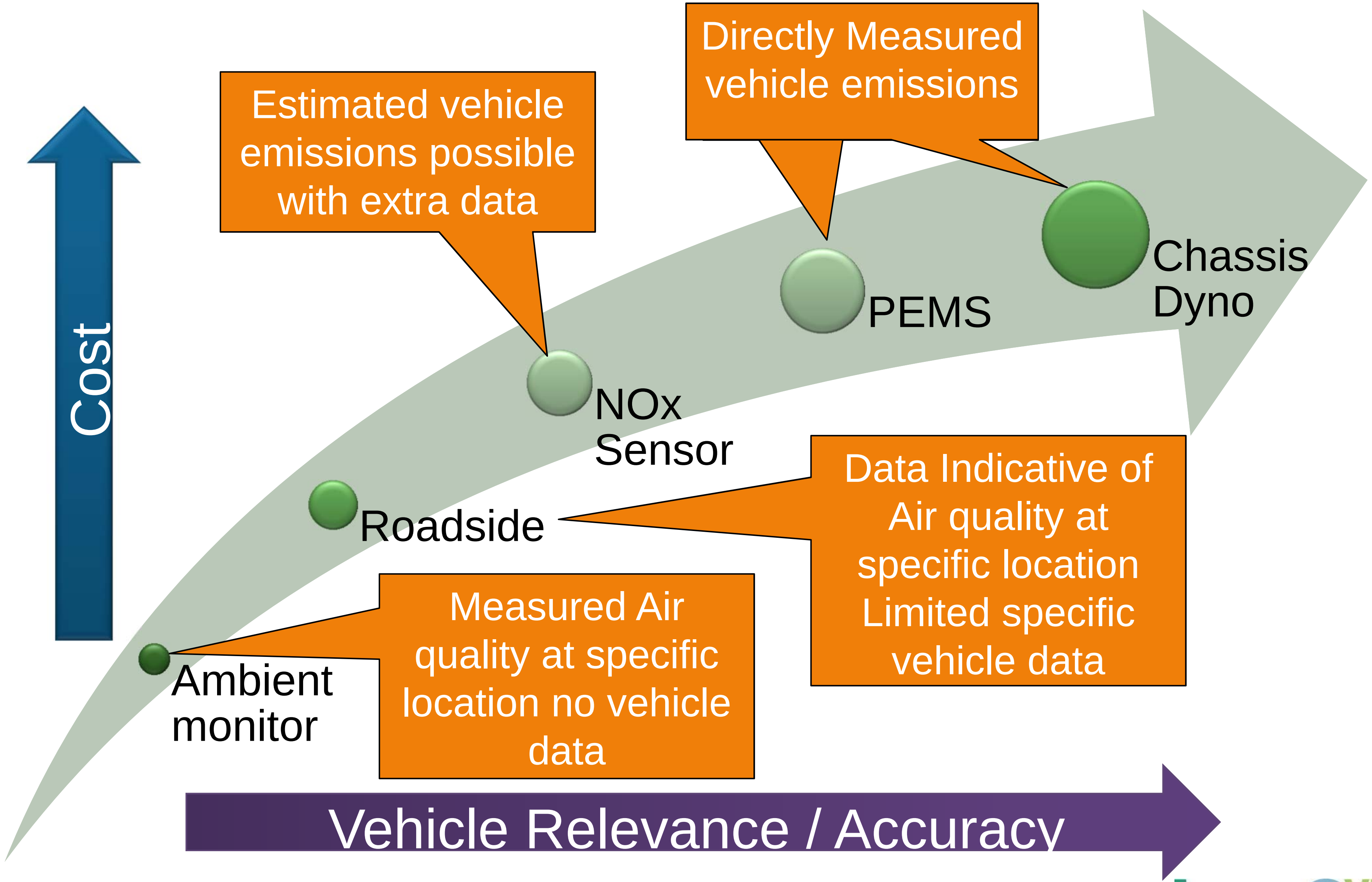
- Adequate control: 12 – 24 months roadside monitoring data post retrofit installation, background monitoring data useful for comparison (ie reduction is not experienced elsewhere)
- Require 12 months post retrofitting (consider LAQM guidance)
- Use of continuous NO2 monitoring data with robust QA/QC rather than diffusion tubes
- Location of NOx monitor(s) important
- Effective of local emissions sources in particular change in traffic over time
- Effective use of meteorology
- Source apportionment ie what contribution do vehicles retrofitted contribute to NOx emissions (the higher the better) and what number of vehicle retrofitted (eg 5 vehicles likely to have less of an impact than 50)

Progress to Date and Next Steps

- Introductory calls with all Local Authorities
- Introductory calls with technology suppliers planned for Feb
- Engagement with First Group regarding CVTF monitoring
- Review of CVTF Progress Reports – 11 submitted to date

- March – August 2015 arrange visits with LAs to assist with monitoring strategy
- Review monitoring data as sent
- Review report to DfT May/Jun
- Ongoing support and monitor to Sept
- Project evaluation report for DfT Oct/Nov 2015

Options to determine real NOx reduction



To gain maximum benefit from the programme

Working in collaboration between:

- **Technology provider** – robust characterisation of technology, target for performance, assistance in monitoring, in depth understanding of data,
- **Vehicle operator** – knowledge of route/duty cycle, support for monitoring in service, operational experience of technology (maintenance)
- **Vehicle manufacturer** – potential impact of technology on original equipment.
- **Testing partner** – knowledge of best test processes, data processing and reporting
- **Local Authority** – Air quality monitoring
- **LowCVP** – support and advice for monitoring, collaboration across projects to identify common data or significant programme gaps. Collation of programme data.
- **DfT** – Funding! Project report

Key messages – CVTF programme monitoring

- We have a wide range of technologies and providers within the project but there are areas for potential sharing of core data.
- Vehicle emissions vary hugely with engine load/speed conditions along a route
- To determine actual mass emitted needs – Concentration, Volume and Density measured over the cycle
- To estimate mass emitted needs – NOx concentration, fuel consumption in real time (1 Hz minimum)
- To estimate catalyst performance needs – real time temperature,
- Air Quality impact will be extremely difficult to attribute to funded technology due to other "influences" unless the source is highly dominant.

- LowCVP are here to help you gain the maximum benefit from the programme with best value for money through robust data and minimum duplication

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The Low Carbon Vehicle Partnership

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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