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Original Proposal from GreenUrban

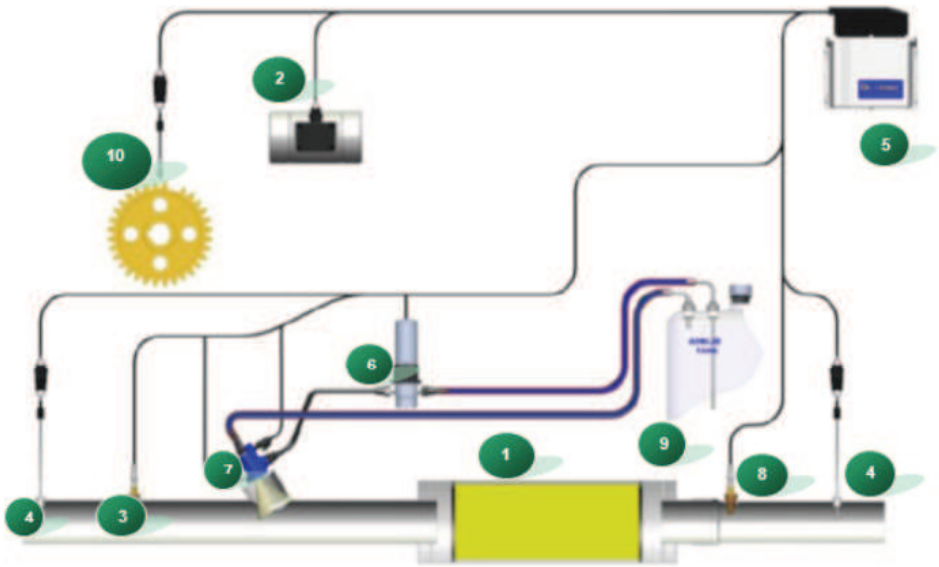
DfT - CLEAN VEHICLE TECHNOLOGY FUNDING – FITTING SCR TECHNOLOGY TO MINIBUS TAXIS

The “Clean Vehicle Technology Funding” program now supports retrofitting of “SCR” Technology for smaller vehicles such as “MiniBus Taxis” to reduce NOx in Air Quality Management Areas

Information on SCR Technology proposed by GreenUrban:

1	SCR catalyst
2	MAP signal
3	NO_x engine out
4	Exhaust temperature
5	ECU
6	AdBlue pressure pump
7	Airless injector module with integrated pressure sensor
8	NO_x out
9	AdBlue tank
10	RPM

Schematic of retrofit SCR System



Proposed vehicles:

Ford Transit MiniBus Taxis

Peugeot E7 MiniBus Taxis

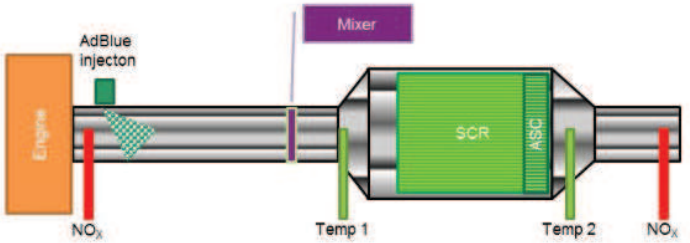
VW Caravelle MiniBus Taxis

INSTALLATION OF THE SCR TECHNOLOGY

1. SCR catalyst located in the exhaust

The SCR catalyst is used for exhaust system configurations when there is no DPF present or where the catalyst is placed downstream of a DPF.

The SCR catalyst features:
- excellent activity at low as well as high temperature operation
- unmatched longevity
- high sulphur tolerance (> to 3000 ppm)
- high thermal and mechanical shock resistance



2. Installation Adblue Tank, Pump, Injection Nozzle & Sensors

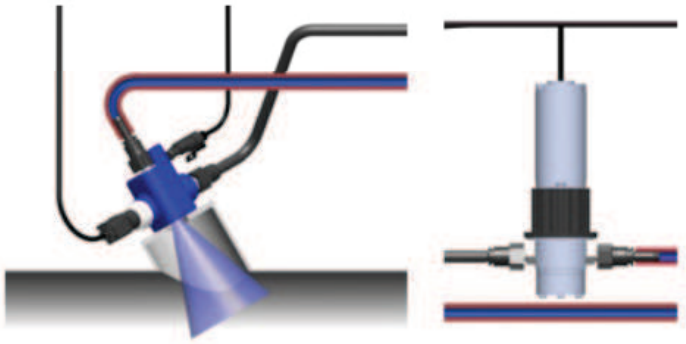
Adblue is stored in an on-board tank which is pumped to the injection nozzle where it is injected into the exhaust upstream of the SCR Catalyst. Adblue is a mixture of 32% urea + 68% water. When injected into the exhaust the water is evaporated and the urea decomposes into a gaseous ammonia at temperatures above 200C. The ammonia gas reacts across the SCR Catalysts to reduce the NOx back to harmless Nitrogen (N2) and water vapour.

When calibrating the SCR Dosing system to achieve higher NOx reductions than 70% an ammonia slip coating (ASC) is used on the rear face of the SCR Catalyst to prevent any ammonia from passing through to the atmosphere

Sensors are used to measure engine speed, load, exhaust gas temperature and engine out / tailpipe NOx levels which is feed back to the Electronic Control Unit (ECU).

The ECU which has an in-built map which adjusts the dosing rate of the adblue according to temperature, exhaust flow rate etc to obtain the optimum levels of NOx reductions possible.

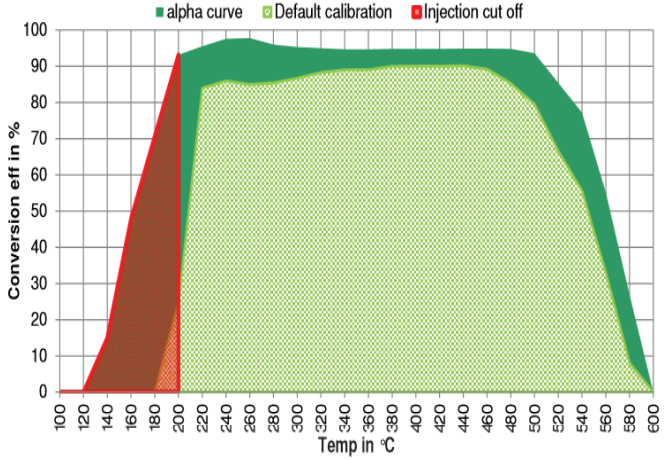
The ECU which comes with a windows friendly interface and dashboard display to alert the driver of adblue levels, continually monitors and logs the SCR performance and any errors and also allows for “Real-Time” reporting of the system performance.



The airless urea injector and urea pump

100 % of the tank full	75 % of the tank full	50 % of the tank full	25 % of the tank full	The urea Injection is switched off due to low level	A major emission risk occurs

SCR System Performance



NOx reductions achievable

The graph left shows:

1. The "Alpha Curve" which represents maximum achievable NOx reductions plotted against temperature (in excess of 90% above 200C)
2. The default calibration in-built into the ECU which will provide -80% to -85% NOx reductions above 220C (can be reset by installer).
3. Injection cut-off point set at 200C to avoid crystallisation of the urea (crystallisation can occur at temperatures below 180C)

Result of reducing NOx -85% when fitted to different Euro Standards of engines

Euro 3 (MY 2000>) 0.50g/km to 0.075g/km (almost Euro 6)
Euro 4 (MY 2005>) 0.25g/km to 0.037g/km (far beyond Euro 6)
Euro 5a (MY 2009>) 0.18g/km to 0.027g/km (far beyond Euro 6)

Stage	Date	CO	HC	HC+NOx	NOx	PM	PN
		g/km					#/km
Compression Ignition (Diesel)							
Euro 1†	1992.07	2.72 (3.16)	-	0.97 (1.13)	-	0.14 (0.18)	-
Euro 2, IDI	1996.01	1.0	-	0.7	-	0.08	-
Euro 2, DI	1996.01[a]	1.0	-	0.9	-	0.10	-
Euro 3	2000.01	0.64	-	0.56	0.50	0.05	-
Euro 4	2005.01	0.50	-	0.30	0.25	0.025	-
Euro 5a	2009.09[b]	0.50	-	0.23	0.18	0.005[f]	-
Euro 5b	2011.09[c]	0.50	-	0.23	0.18	0.005[f]	6.0×10^{11}
Euro 6	2014.09	0.50	-	0.17	0.08	0.005[f]	6.0×10^{11}

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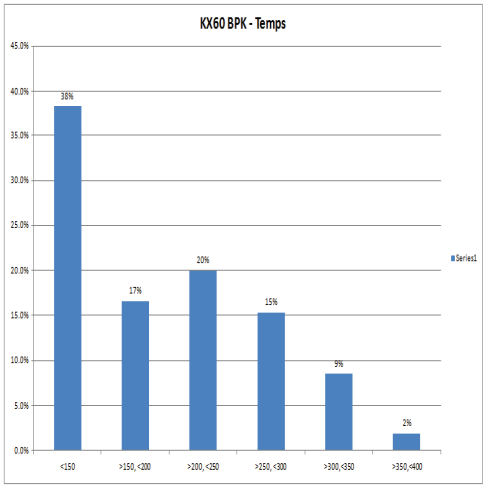
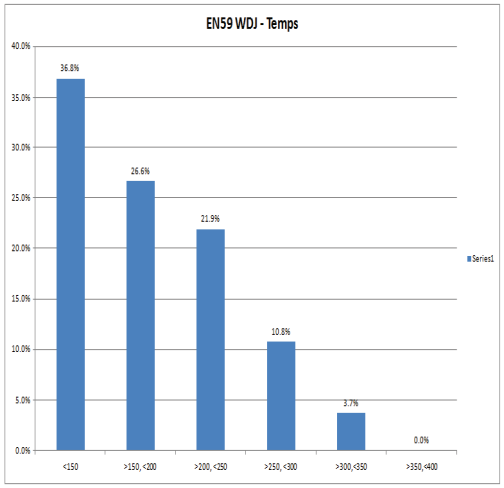
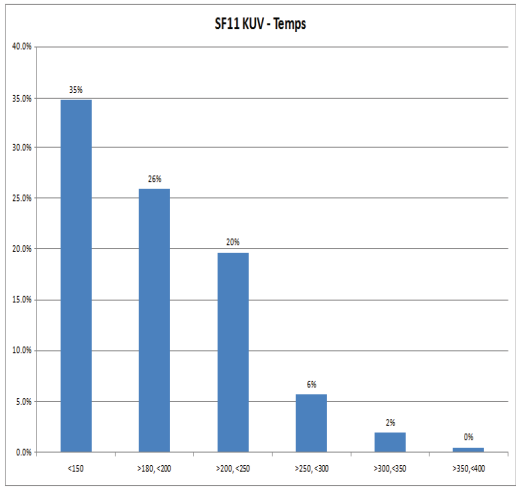
Results of Data-logging by GreenUrban

3 x Mini Buses Datalogged in Brighton over 2 weeks







	Total Duty Cycle		
	<150C	150-200C	>200C
KX60	38%	17%	45%
KX59	37%	27%	36%
SF11	35%	26%	39%

- Across the entire duty cycle over a 10 day period temperatures were only above 200C for 36-45% of the time because of amount of idling
- Reducing "Idling Time" improves fuel consumption but does not improve exhaust temperatures
- Recommendation is to add "Ammonia (NH3) Generator to improve NOx reductions

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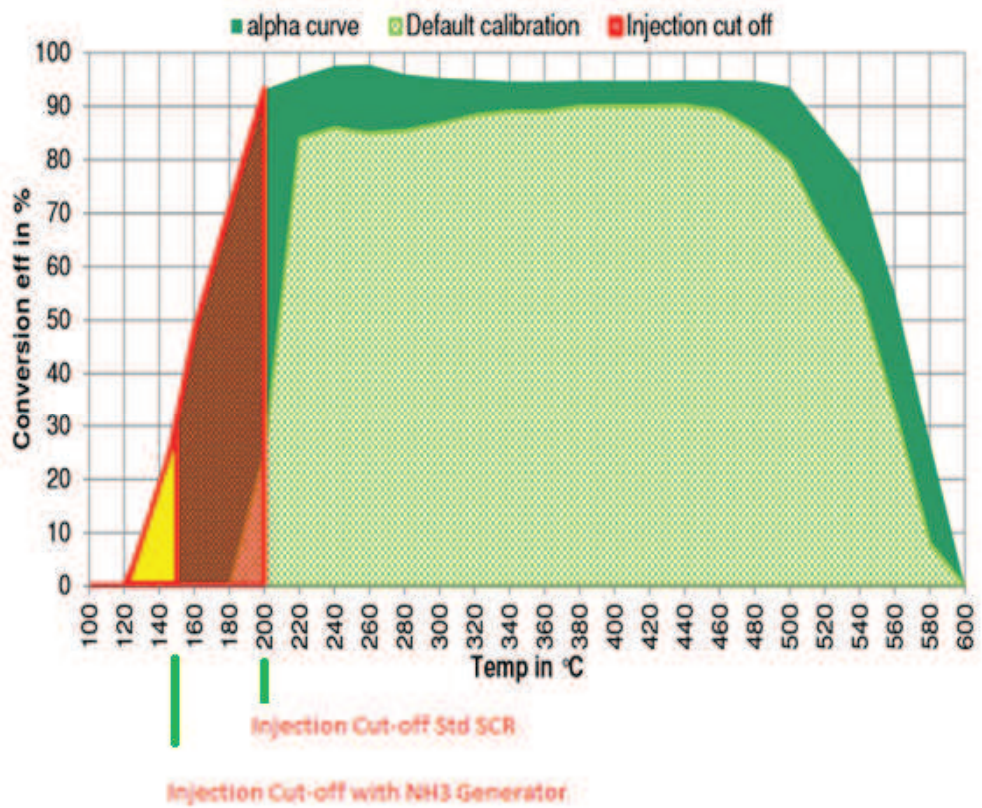
Revised Proposal from GreenUrban as result of Data-logging

Using Ammonia Generator and Anti-Idling to improve SCR System Performance



- Injection "Cut-off" point for Standard SCR System for Injection of Adblue (Urea) = 200C
- Can achieve -85% NOx reductions above 200C

- Using NH3 Generator to turn Adblue (Urea) into an Ammonia Gas prior to injection means Injection Point can be lowered to 150C without any crystallisation taking place
- Can achieve -85% NOx reduction at 150C
- Can achieve -98% NOx reduction at 200C

Result is using the Ammonia Generator will improve NOx reductions across the whole Duty Cycle from 30-38% to around -60% across the whole duty cycle (-98% above 200C) without fitting an anti-idling device

NOx emission can be reduced further by also installing an "Anti-Idling Device" to cut the engine after it has idled for 3-4 minutes .... will means Zero NOx emissions while the engine is off . . . and fuel/CO2 emissions reductions (improving carbon footprint)

	Total Duty Cycle			Std SCR	SCR +NH3 Gen		
				NOx -85%	NOx -85%	NOx -98%	Total Nox Red
	<150C	150-200C	>200C	>200C	150-200C	>200C	>150C
KX60	38%	17%	45%	38.25%	14.45%	44.10%	58.55%
KX59	37%	27%	36%	30.60%	22.95%	35.28%	58.23%
SF11	35%	26%	39%	33.15%	22.10%	38.22%	60.32%

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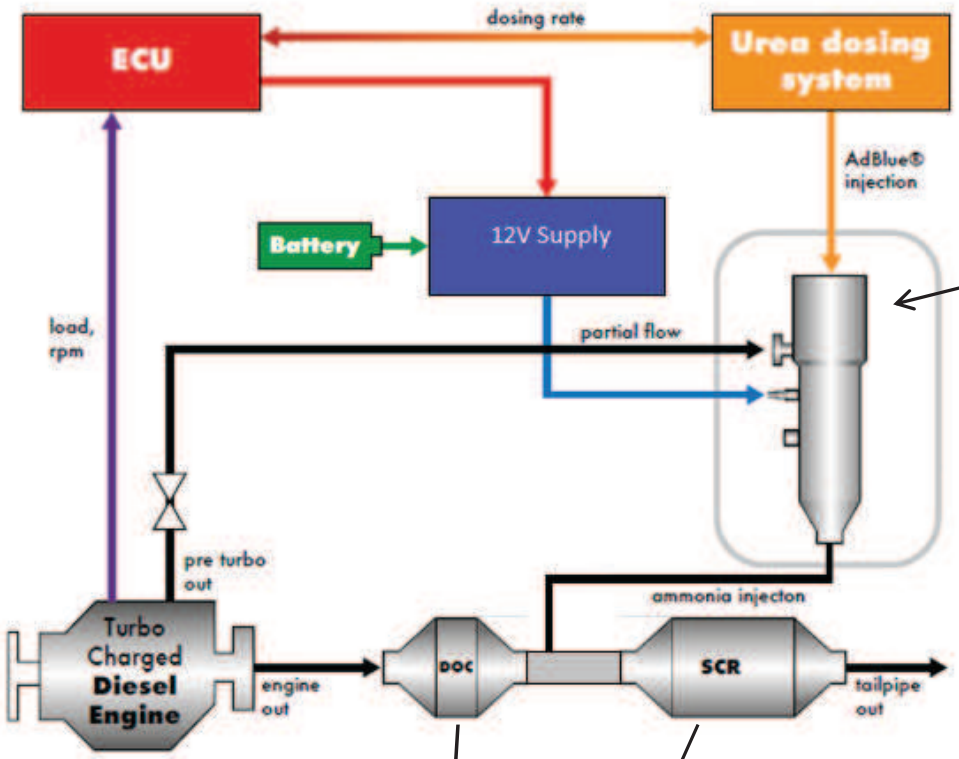
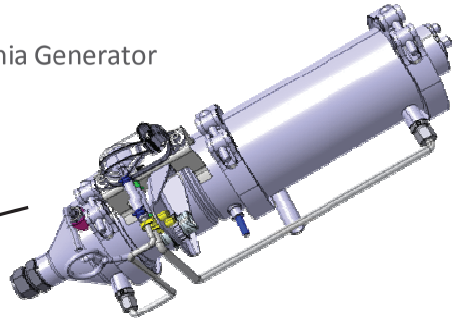
Revised Proposal from GreenUrban as result of Data-logging

How the Ammonia Generator system works



Ammonia Generator

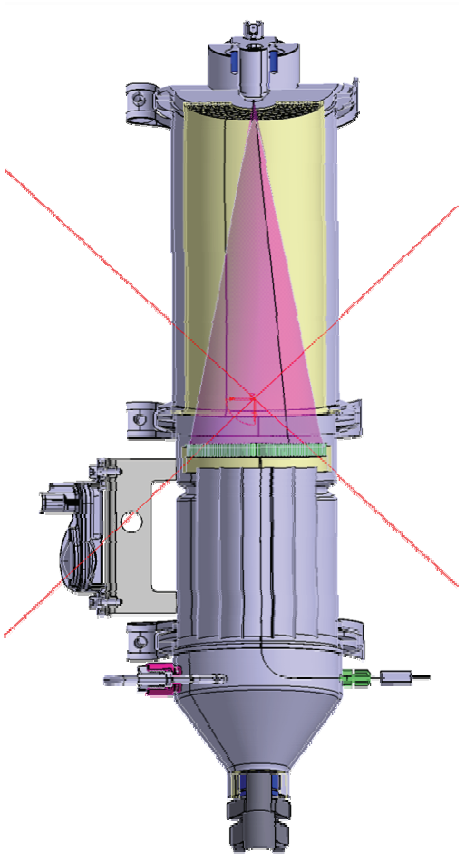


1. CO/HC/PM is reduced by oxidation process within passive DOC System
2. Adblue (68% water-32%urea) is injected into the Ammonia (NH3) Generator rather than directly into the exhaust where it is converted into a gaseous ammonia outside of the exhaust stream for direct dosing of ammonia gas
3. The water content of the Adblue is evaporated in the first part of the ammonia generator using heat from a pre-turbo partial flow pipe leaving just urea which gets converted to ammonia gas when passed across a hydrolysis catalyst in the second part of the generator
4. A small heater is used periodically to maintain the temperature within the ammonia generator
5. The ammonia gas is then injected into the exhaust where it mixes with the exhaust gas
6. The ammonia gas then passes over the SCR Catalysts which reacts to reduce NOx (NO/NO2)

Revised Proposal from GreenUrban as result of Data-logging

How the Ammonia Generator system works

Ammonia Generator



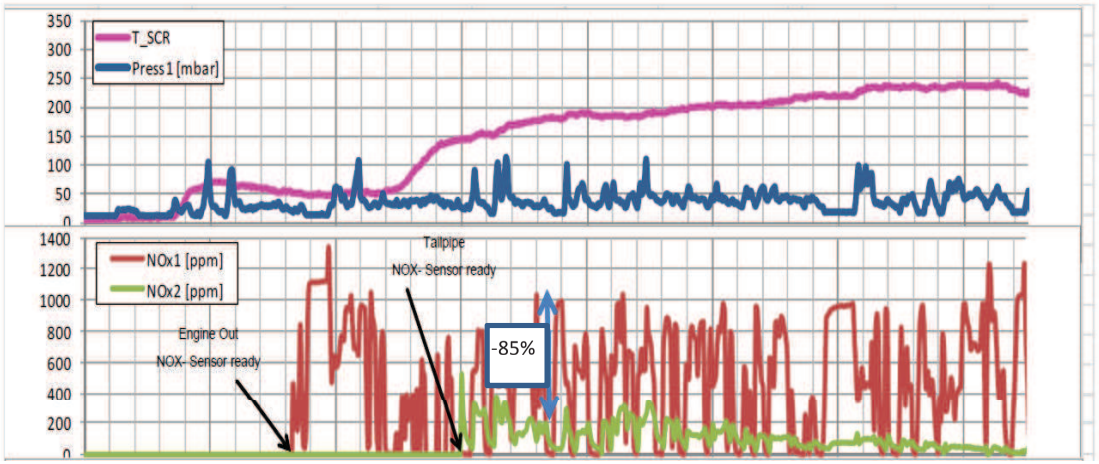
Ammonia Gas injected into exhaust

Adblue Injected into Ammonia Generator

Water content evaporates in Spray zone with Heat from Pre-Turbo leaving Urea

Urea decomposed to Ammonia Gas across Hydrolysis Catalyst

Small 12 v heater used for milliseconds to keep up temperature



In-Field Test results on Buses in Manchester show -85% NOx reductions as low as 150C – ideal for “Cold Start “ conditions

Engine Idle Cut-Out Device

Engine Idle Cut-Out Device

The Idle Cut-Out Device is linked to the engine and is activated automatically under certain conditions.

For example when the vehicle has been idling for more than a minute "If the driver has applied the handbrake" the Cut-Out Device will shut down the engine.

The System has a number of built-in safety functions:

1. Timings can be set from a minute to several minutes
2. If the battery voltage is low or if an attempt to start the engine has failed, the system is deactivated.
3. To avoid cold starts and also overheating, the system only operates at coolant temperatures of between 40°C and 100°C.
4. The comfort of the vehicle's occupants is also taken into account: when the outside temperature is below freezing point, the system is de-activated.

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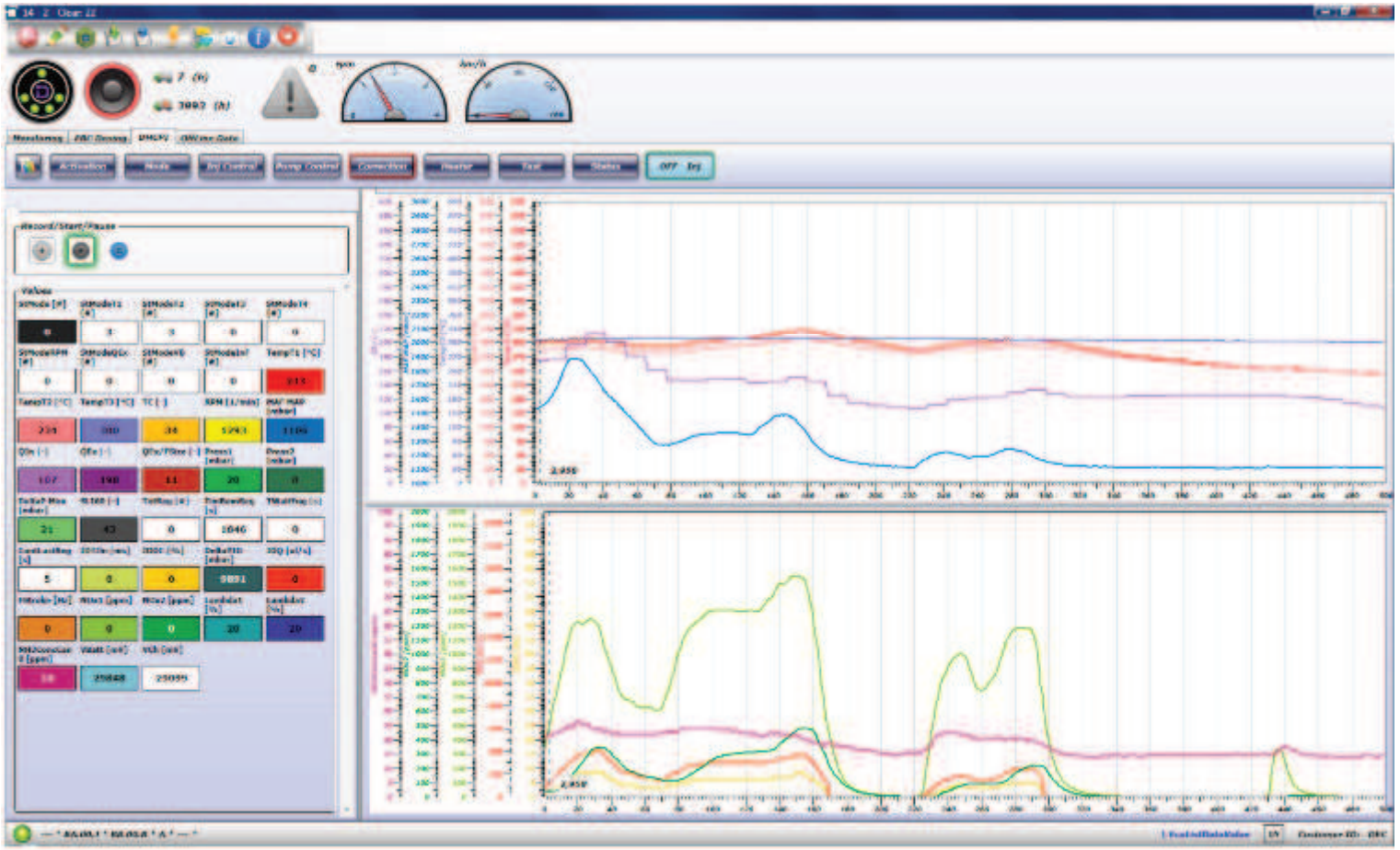
Windows Friendly - Real-Time - Emissions Performance



Pricing and Installation Schedule

Price of Standard SCR System originally ordered: £6500 per system plus vat

For £195k funding from DfT this equates to 30 systems

Price of SCR System with Ammonia Generator plus anti-Idling device: £9750 per system plus vat

For £195K funding from DfT this equates to 20 systems

Fleet Monitoring (Pre-Order – October 2014):

- Analyse Fleet and fit thermocouples and data loggers to representative vehicles - Carry out temperature data logging (2-3 weeks)

Installation if Order Placement by end November 2014:

System Engineering & Sign-Off

Carry out Packaging Study, manufacture first prototypes including NOx data measurement system.
Monitor prototypes and obtain sign off of installation (4-6 weeks) . . End December 2014

Fleet Roll Out

• Locate Garage for installation of the systems
• Install at rate of 3-4 systems per week dependent on vehicle availability (8-10 weeks for all vehicles) Jan/Feb 2015 – latest March 2015

On-going customer support

• Bi-Monthly project status and NOx reduction monitoring will be provided for 6 months

On-going maintenance

• Annual routine checks and cleaning of catalysts if required can be offered at rate of £95 per system
• Full Repair and Maintenance Packages can be offered if required
• System comes with 1 year warranty as standard