



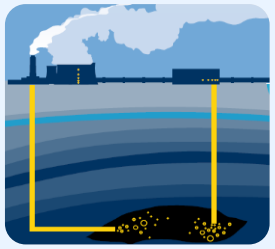



MAKING BIRMINGHAM GREENER

Birmingham NO_x reduction Champions project

LowCVP Gas Vehicle Workshop

May 2016

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Birmingham City Council

eit Climate-KIC

A new solution for cleaner taxis: conversion of older diesel Hackney Carriages to the use of LPG

Background

- TX1, TX2 and TX4 taxis operate with diesel (compression-ignition) engines and typically belong to Euro 2 to 5 classes, i.e. they emit high levels of NOx and Particulate Matter.
- In September 2014, Birmingham City Council received £500,000 from the Department of Transport to convert c.80 taxis to the use of LPG, a much cleaner burning fuel than diesel.
- There was no established and reliable supply chain for the conversion of taxis to LPG (which requires a spark-ignition engine) in Birmingham, nor local skills for the installation of such a system
- Over the period of October 2014 to December 2015, a technical solution has been developed (with emission reduction achievement proven through lab testing) and a local garage has been trained.
- Contract with garage converting taxis signed off in April 2016

A taxi converted to LPG

The spark-ignition engine running on LPG

Source pictures: Autogas Limited

Overview summary of expected versus realised outcomes

Topic	Original target (as per CVTF application)	Achieved/planned
Technology	Replacing the diesel engine by spark-ignition engine to run on LPG	Achieved - Established a new supply chain for TX taxis conversion to LPG
Taxis conversion - volume	80 taxis (LTI TX1 and TX2, Euro 2 and 3 respectively)	63 taxis (LTI TX1 and TX2) [5 done as of early May 2016]
Taxis conversion - cost	£5,500 per taxi [£440,000 in total]	c. £7,700 per taxi [£477,700 in total]
Emission reduction of converted vehicles on NEDC basis	95% for NOx 99% for PM	**TX4: Euro 6 level achieved** -95% for NOx -97% for PM
Emission testing	• PEM testing with purchased equipment • Testing 20 cabs x 3 sets of testing (before, after, after +6months)	• Testing to be tendered • 1 TX1 and 1 TX2 taxis to be tested pre-conversion, post conversion and post+3months (PCO-Cenex cycle)
Local opportunities	• Conversions to be done locally and local skills to be developed	• Conversions done in a local garage • 8 staff trained to the conversion of TX taxis (and accredited LPG converters by UKLPG)

The *Birmingham NO_X reduction Champions* project: description of the main elements of the project

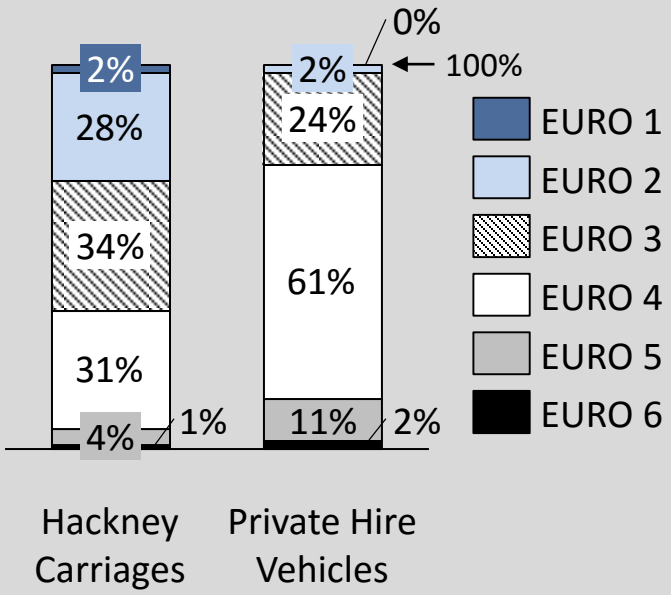
- The following slides describes the main stages of the project and highlight the key learning points, for the following themes:

  A. NOx reduction – choice of vehicle segment
  B. NOx reduction – cost effectiveness
  C. User engagement and considerations
  D. Procurement process
  E. The implemented technology
  F. Emissions testing

A - NOx reduction – choice of vehicle segment and location

- The major contribution to NOx emissions in specific areas are from taxis standing, with engines on for long periods.
- There are 1,247 hackney carriages and 4,173 private hire vehicles licensed by Birmingham City Council, undertaking 16.69-27.87 million journeys per annum.
- Data shows 80% of taxi rank spaces are within the City Centre, where 53 taxi ranks operate for 24 hours covering 50% of the total spaces; Navigation Street rank serving New Street station is the principal rank and is one of the city's highest hotspots for NOx emissions
- **Addressing emissions from hackney carriages is a way of improving air quality (AQ) in the most polluted areas through the conversion of a limited number of vehicles**
- Among hackney carriages **LTI TX1** (over 12 years old, EURO 2) and **LTI TX2** (over 9 years old, EURO 3) represent 40% of the overall HC licenced fleet and were selected for the conversion program

Birmingham taxi fleet



- Hackney Carriages (HC) on the road are older than Private Hire Vehicles, with an average of 11.5 years versus 7.8 years for PHVs.

Source: number of licenced taxis as per Dec 2015, excluding suspended vehicles – Birmingham City Council statistics

B - NOx reduction – cost effectiveness

- Two solutions were identified as compatible with TX1 &2:
  - LPG conversion (at a cost of around £6k per vehicle)
  - Electric conversion (at a cost of £27k per vehicle).
- Taking into account the cost effectiveness as well as the taxi drivers/representatives unanimous feedback, the LPG conversion was selected

Summary slide used during the workshop with taxi drivers in July 2014

LPG and electric conversions are available for Hackney carriages – LTI TX1 and LTI TX2 models are compatible

	LPG conversion	EV conversion
Impact on running costs	• 5-10% savings on fuel cost reported by taxi drivers • + £50/year (filter and calibration)	• 85% cheaper fuel cost • Lower maintenance cost
Impact on operation	• Refill with LPG and petrol instead of diesel • ~6 LPG stations in the City	• Driving range 100 miles (75 in winter) • Recharge in 6-10 hours • Grants available for home charging systems • >80 charging points in the City
Impact on air quality	• Reduced NO_X (>90% reduction or below Euro 6 standards)	• Zero emissions
Existing examples	• High demand for converted taxis in London	• 20 Magtec taxis converted in the Netherlands
Conversion time	**8-9 days**	**3-4 days**

The £500,000 grant would allow for about:
- 80 LPG taxi conversions, or
- 18 EV taxi conversions

- **Do you have any questions about these technologies?**

Source: Element Energy LPG: Liquefied Petroleum Gas elementenergy | 15

Key points/lessons learnt

- There were very limited technologies options for taxis conversion and the ones proposed to drivers were based on fragile or nascent supply chains
- There was only 1 UK converter able to provide the selected solution. This led to difficulties at procurement stage and eventually the collapse of the solution. A new conversion technology and supply chain had to be developed during he project, leading to delays
- This risk is inherent to new technologies and should be taken into consideration, e.g. in budget, communication with taxi drivers

C - User engagement has been crucial to the success of the project

- **Workshop in July 2014** (with taxi operators/associations, RMT Union and individual drivers, c. 10 attendees) ahead of grant application preparation: very positive response and over 80 signatures obtained within a few days
- **Workshops in Dec 2014- Jan 2015** to explain process, technology, selection criteria and answer any questions (120 attendees over 4 workshops)
- Resulted in 82 registered taxi drivers
- **From January 2015 to now**: the 82 registered taxi drivers are regularly informed via a quarterly email

Key points/lessons learnt

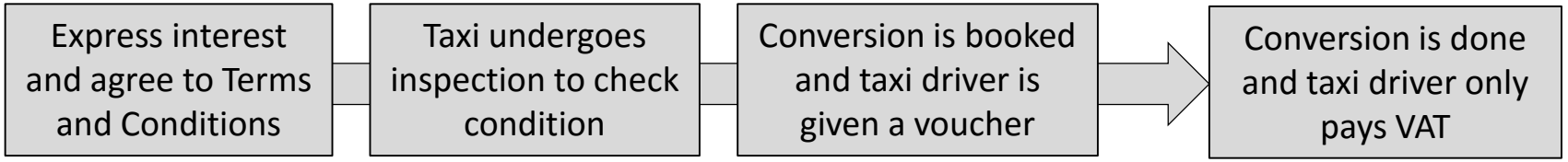
- Early and continued engagement with users underpinned the success of the project – taxi drivers are the ones adopting the change so should be given the opportunity to input in and question the project
- Cost and time should be communicated clearly, differentiating *estimates* from *final values*; VAT accounting rules should also be clearly communicated from the start

A survey of taxi drivers will be conducted in Summer 2016 to cover topics such as:

- **Satisfaction with the conversion process**: communication from Council team, clarity and length of procedure, cost, factors influencing the decision to sign up
- **The converted vehicle:** observed operational differences, ease of use, observed cost impact, level of satisfaction, passenger feedback, refuelling experience

C - User engagement. With the selected solution, taxi drivers do not have to pay for the conversion

Taxi conversion process from the taxi driver point of view:



- Taxi drivers had to confirm that they operate in City Centre[1]
- Terms and Conditions include agreeing to take part in survey

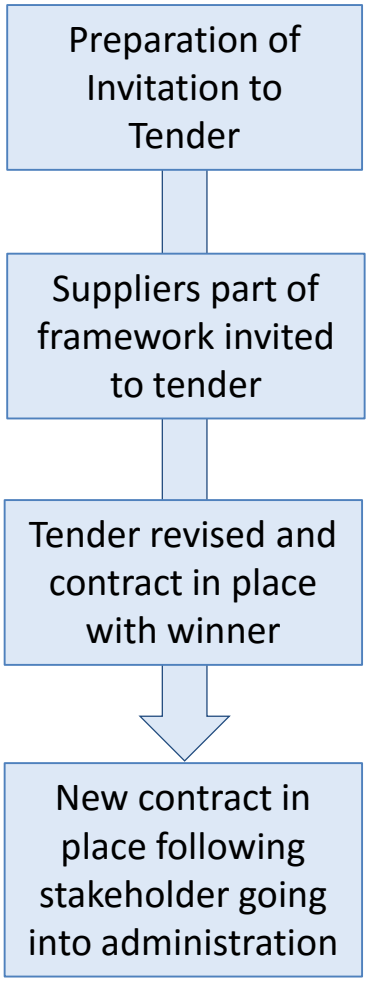
- Some taxis were found to be unfit for conversion and had to undertake repairs or were removed from the conversion list
- ***Oversampling should therefore be considered***

- The garage gets paid by the Council by giving the voucher back, along with signed confirmation of the taxi owner that the conversion has taken place

- Where applicable, taxi drivers can reclaim the VAT (£1,300)
- Some taxi drivers will be surveyed on the conversion process and converted vehicle

1 – The information was cross checked against the Council taxi surveys, as well as MOT records

D - Procurement process



Oct 2014

Nov 2014

Dec 2014-Jan 2015

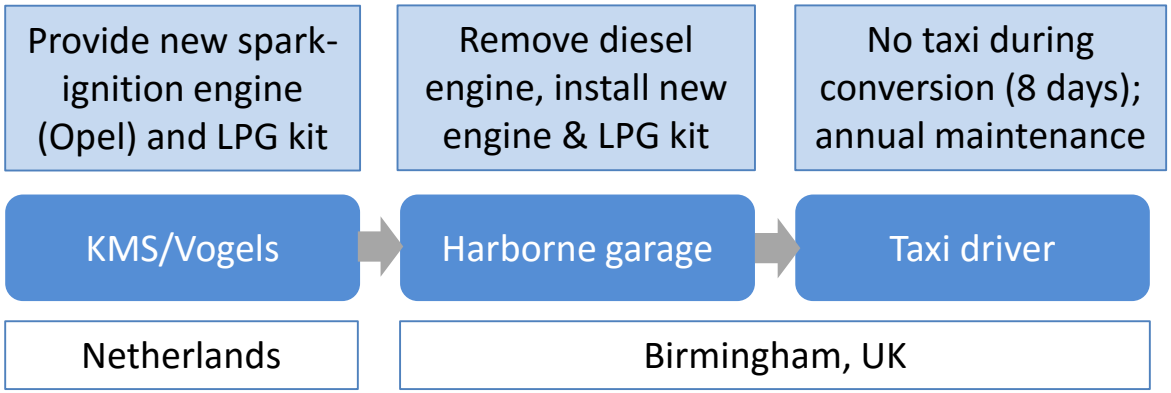
Dec 2015-Feb 2016

Key points/lessons learnt

- Existing Council procurement framework are unlikely to have companies developing new powertrain solutions, or companies interested in small volume projects
- Therefore the approach to procurement should be considered early on to avoid delays

E - The implemented technology: replacement of the diesel engine by a new spark-ignition engine

Current supply chain, established in 2015 for the Birmingham project



- KMS are providing the new Opel engines and the engineering of bespoke parts that are required to convert these engines to LPG into the taxi (TX1 & TX2 models – first tried on TX4).
- Vogels are providing KMS with all the standard LPG parts. Vogels' UK agent is National Autogas.
- Harborne garage removes the engines from the taxis, installs the new engine & LPG system. They calibrate the LPG system and can carry out the yearly maintenance.

Key points/lessons learnt

- A vehicle screening must be put in place so conversion is done on vehicles that are:
  - In use in areas of high air quality issues
  - In good condition and thus more likely to be able to safely stay on the road for a number of years
- As conversions are by definition applied to in-use/old vehicles, inspections will reveal some cases where the conversion cannot be carried out; this should be taken into account in the sampling of vehicles and project timeline

F - Emissions testing – Overview of testing conducted so far

Emission testing done – as of end of February 2016

Taxi model	Diesel (before conversion)	LPG (after conversion)	LPG + 6months (after conversion)
TX1	1 done	*pending*	*pending*
TX2	1 done	*pending*	*pending*
TX4	1 done	1 done	*pending*

More emission testing will be performed at a later date of the project (TX1 and TX2 taxis to be tested [to be tendered], pre and post conversion [after conversion and after conversion + 3 months])

- The CO_2 emission results: show no significant changes brought by the conversion to LPG
- Pollutant emissions results: significant reductions achieved, shown next

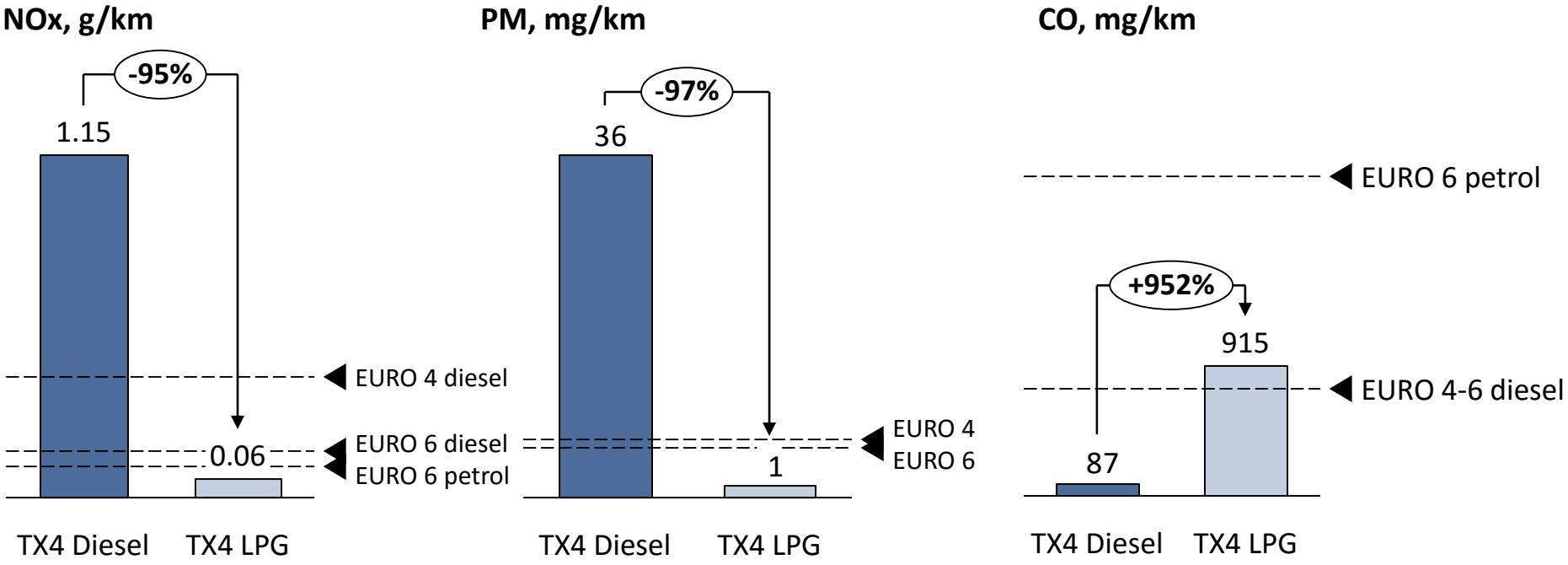
Key points/lessons learnt

- Testing the old diesel taxis proved challenging: they are so dirty that they damage the measuring equipment
- Emission testing, if required, must be budgeted in and the test sample must be proportionate so the budget for emission testing does not compromise the overall number of conversions
- PEM testing proved too costly for this project
- Guidance on the relevant driving cycle for testing can be obtained from DfT or the LowCVP

PEM: Portable Emission Measurement

F - Emission testing – Tests under the NEDC indicates the TX4 converted to LPG meets the Euro 6 limits (category N1, class III)

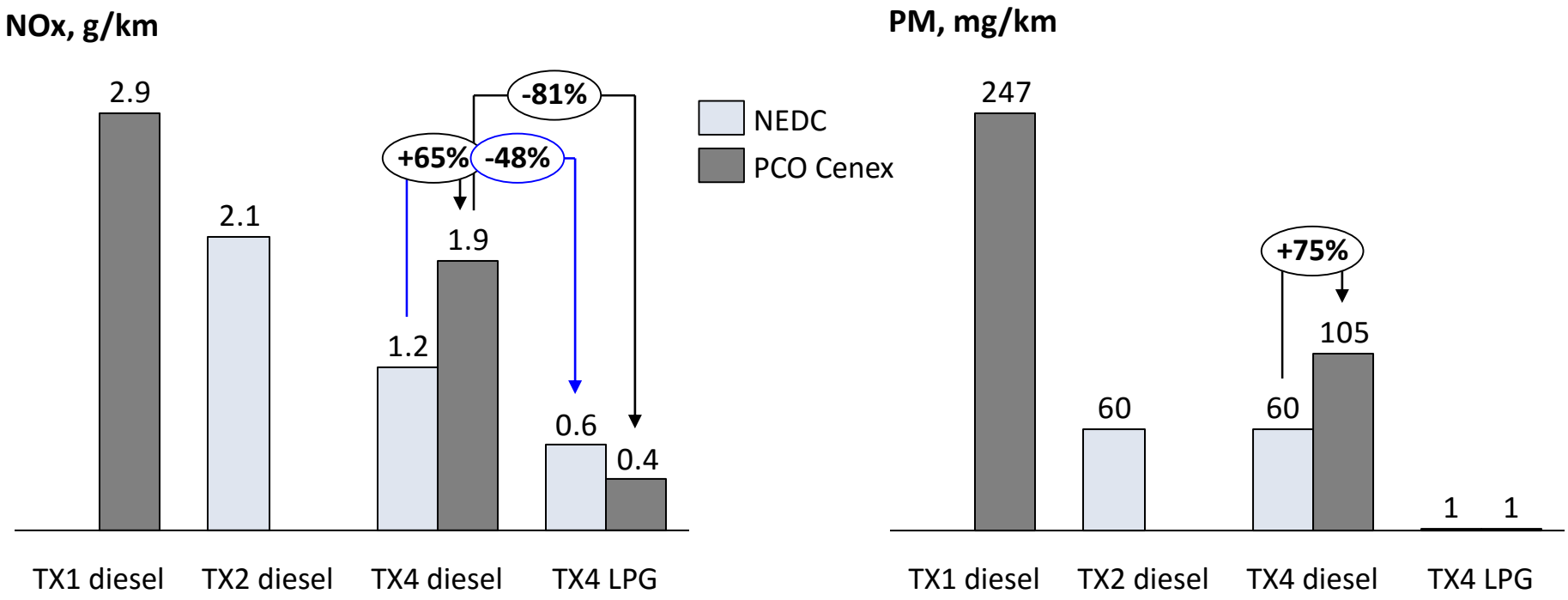
Euro limits shown for N1 Class III vehicles



- These results are based on the New European Driving Cycle (NEDC), the official test for Euro limits.
- Results show a significant decrease in NOx and PM emissions when converted to LPG: 95% for NO_X and 97% for PM. Results also show the diesel TX4 tested does not meet Euro 4 NX and PM limits.
- Emissions of carbon oxide (CO) however increase but meet the Euro 6 limits for spark-ignition engines

Source data: Autogas Ltd, based on tested run at Millbrook and TÜV Pfalz Verkehrswesen in 2015

F - Emission testing – The PCO-Cenex drive cycle is more representative of the real-world emissions of taxis and indicates much higher emissions



- Under the PCO Cenex driving cycle, emissions are much higher than under the NEDC cycle for the diesel engines: +65% for NOX and +75% for PM emissions
- The difference between diesel and LPG taxi emissions are even greater under the PCO driving cycle: -81% vs -48% in the case of NOx

The PCO-Cenex driving cycle is a 48 minute cycle, based on a three phase test plus 3:12 minutes of engine off time between phases 1 and 2. Each phase represents one of the 3 London zones, Central, Inner and Outer. Phase 3 is weighted by a factor of 0.65 to retain correct proportionality of a working day.

Source data: Autogas Ltd, based on tested run at Millbrook and TÜV Pfalz Verkehrswesen in 2015

Final remarks

Reflections on the Clean Vehicle Technology Fund and challenges met during the project

- The Clean Vehicle Technology Fund payment mechanism
- The lack of established solutions for taxi retrofit
- Challenges related to the development of a new solution and supply chain

Reflections on the key factors contributing to the success of the project

- Excellent engagement with taxi drivers and local garage trained
- Support from industry experts
- Perseverance in the face of setbacks

Project over £172,000 in values have to go through the Official Journal of the European Union or framework set in place through the OJEU