

## *Birmingham NO<sub>x</sub> reduction Champions project*

Presentation of main results

**LowCVP Taxi Workshop**

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# Agenda

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- **Background to the Birmingham project**
  - Vehicle and technology choice
  - Partners involved
  - Challenges and lessons learnt
- **Emission reduction achievements**
  - Before and after test results
  - Challenges and lessons learnt
- **Consumer angle**
  - Drivers survey results
  - Challenges and lessons learnt
- **Concluding remarks and next steps with the Clean Air Zone**

## RECAP

- 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.
- By May 2017, 65 taxis have been converted in a local garage (8 staff trained) and a new supply chain established



## **Background to the Birmingham project**

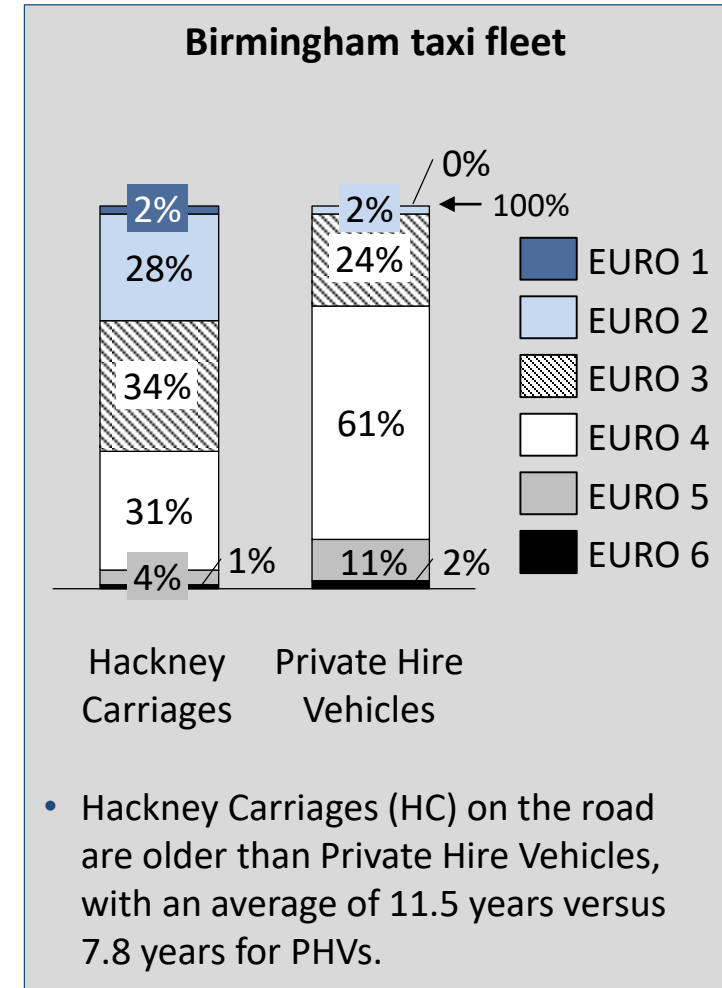
Emission reduction achievements

Consumer's angle

Recap and next steps

# Choice of vehicle segment and location: EURO 2 and EURO 3 Hackney Carriages operating in the centre of the city

- The major contribution to NOx emissions in specific areas are from taxis standing, with engines on for long periods.
- There are over 1,200 hackney carriages and over 4,100 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 14 years old, EURO 2) and **LTI TX2** (over 11 years old, EURO 3) represented 40% of the overall HC licenced fleet and were selected for the conversion program



- 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.

# Selected technology: replacement of the diesel engine by petrol engine and LPG system

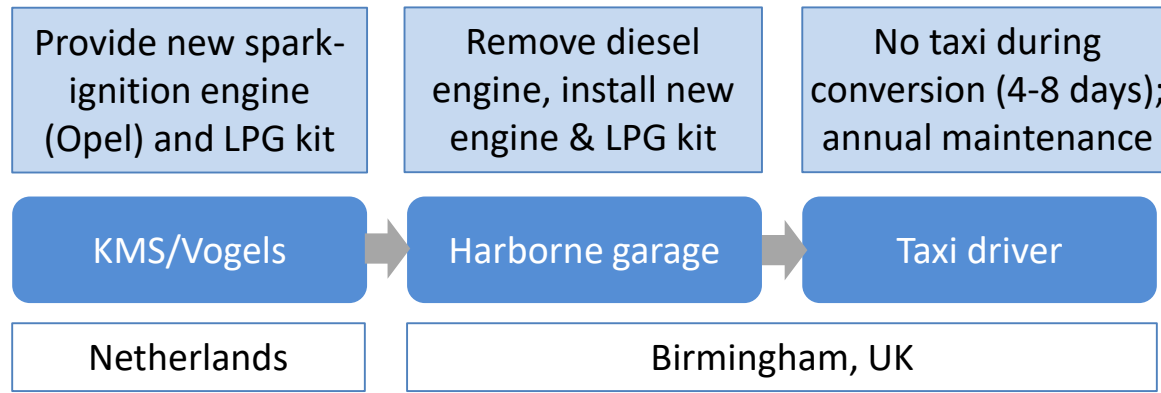
- In 2014, two solutions were identified as compatible with TX1 & TX2:
  - LPG conversion (at a cost of around £6k per vehicle – *final cost ended up being £7.7k*)
  - Electric conversion (at a cost of £27k per vehicle).
- Taking into account the **cost effectiveness** as well as the **taxi drivers/representatives unanimous feedback**, the LPG conversion was selected.

## 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 the 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

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

## Current supply chain, established for the Birmingham project



Spark ignition engine part of the 'LPG kit'



Spark ignition engine fitted in the taxi

## 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

# Actors involved in the conversion programme

## Directly contracted

- **Harborne garage**
  - Conversion of vehicles (including pre-check and selection)
  - Support emission testing: liaise with drivers, transport to testing centre
- **Element Energy**
  - Funding application support
  - Drivers' engagement support and drivers' survey
  - Emission testing coordination and management
  - Reporting and dissemination

## Broader supply chain / support

- **KMS/Vogels** (Netherlands): supplier of the LPG kit
- **Autogas Ltd**: helped liaising with local partners to set up the supply chain, and with technical expertise, commissioned emission testing as part of the new solution development
- **VRS**: new company created in the course of the project (founders are ex-Autogas), developed the new LPG kit with KMS/Vogels, now UK provider of the technology
- **Millbrook and MIRA**: emission testing centres
- **LowCVP**: advice on emission testing choice/procedure

Background to the Birmingham project

**Emission reduction achievements**

Consumer's angle

Recap and next steps



# Several testing procedures exist, with different level of relevance to the Clean Air Zone (CAZ) requirements and real world taxi operations

NEDC	WLTP	PCO-Cenex test
<ul style="list-style-type: none"><li>• The New European Driving Cycle is the official testing procedure for Euro levels, until September 2017</li><li>• The upcoming CAZ in UK cities will have the following thresholds:<ul style="list-style-type: none"><li>– Euro 4 for petrol (and LPG) vehicles</li><li>– Euro 6 for diesel vehicles</li></ul></li></ul>	<ul style="list-style-type: none"><li>• The Worldwide harmonized Light vehicles Test Procedure is the official testing procedure for Euro levels, <b>since September 2017</b></li><li>• There is very limited data on taxi WLTP results (either diesel or LPG) but evidence is needed to design the CAZ retrofit requirement (led by JAQU/LowCVP).</li><li>• <b>The Birmingham project is filling this gap, and provides the first TX1 WLTP results on retrofit solutions</b></li></ul>	<ul style="list-style-type: none"><li>• Test cycle developed for taxis so <b>most representative of taxi ‘real-world emissions’</b></li><li>• Produce higher emissions per km results than the official tests as it is a much harsher test</li><li>• <b>The significant difference between PCO and WLTP results called for the BCC programme to use the PCO-Cenex, to evidence emission reduction in conditions close to real-world taxi operations</b></li></ul>
<b>Targets set for the taxi conversion programme:</b>	Meet CAZ requirements: Euro 4 petrol limits for NOx, PM, CO	<ul style="list-style-type: none"><li>• 80% reduction in NOx</li><li>• &gt;90% reduction in PM</li><li>• CO emissions not going over Euro 6 petrol limits</li></ul>

# Results: the LPG conversion technology has been tested under various driving cycles and has proven its ability to reduce harmful emissions

## NEDC

- Converted **TX2 and TX4 taxis are CAZ compliant** (and go beyond the Euro 4 threshold of petrol engines, by meeting Euro 6 limits)

## WLTP

- The tested **TX1 taxi meets the CAZ conditions**, and even meet Euro 6 petrol limits for NOx – once the pilot ECU was replaced with the production version
- The tested **TX2 taxi meets the CAZ conditions** (Euro 4 petrol for NOx, and even Euro 6 for CO and PM) – this was found in the only other TX2 taxi WLTP test too

## PCO-Cenex test

- Tests show that the LPG conversion **reduced NOx and PM emissions by 80% and 99%** respectively, compared to the diesel version
- No increase in CO<sub>2</sub> emissions** (some decrease even observed)
- CO emissions well under the Euro limits**

*Tests conducted by industry/TfL – not as part of the Birmingham programme*

- 1 TX1 LPG taxi tested, twice (once at pilot stage, once on final/production version)
- 1 TX2 LPG taxi tested once

- 1 TX1 taxi tested: once before conversion, twice after conversion
- 1 TX2 taxi tested: once before conversion, once after conversion

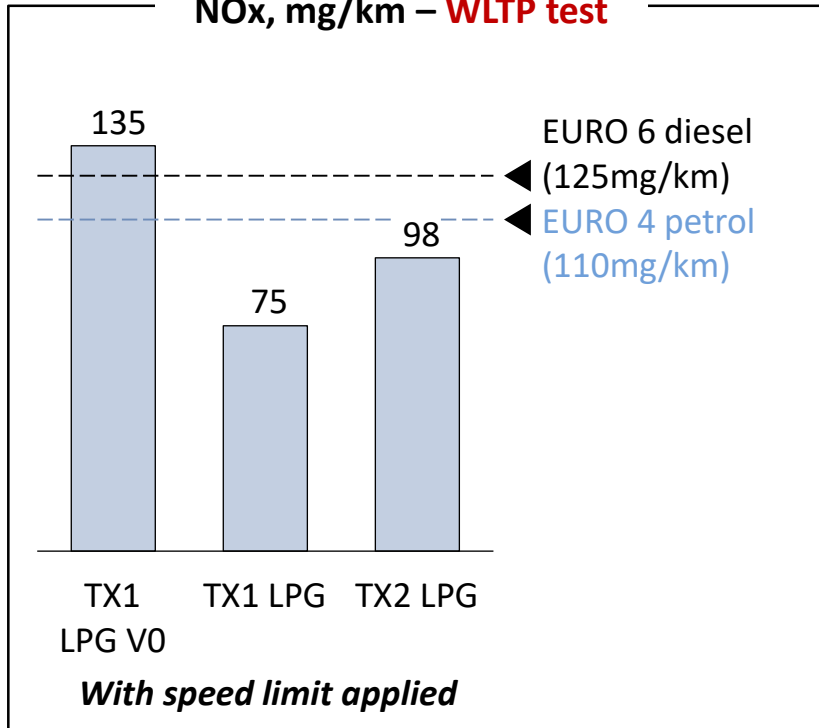
# The emission testing encountered challenges that the CVRT should take into account when setting rules

## Emission testing challenges

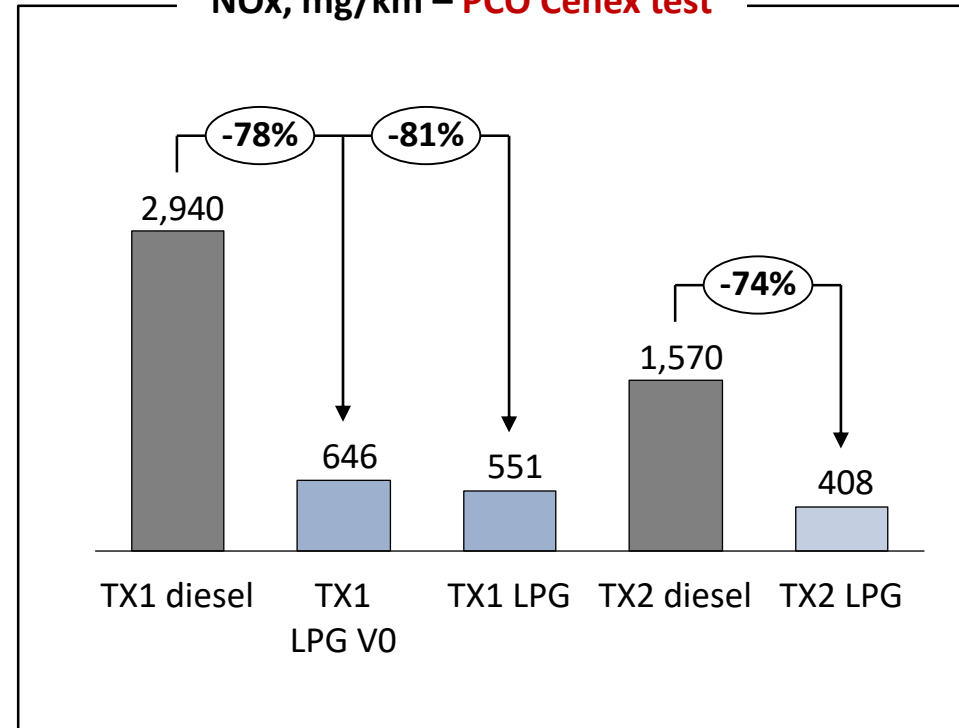
- The taxis are in actual use so the test booking had to work around drivers to minimise the impact on their business, and speed limits had to be introduced to avoid damages
  - WLTP had to be adapted: Extra high speed phase replaced by Low speed phase
- The vehicles are old (over 15 years), which caused issues with a testing centre refusing to undertake testing on one of the taxi – that means the TX1 before/after results are actually done on 2 different vehicles
- Diesel taxi testing is very expensive and sometimes not possible: they are so dirty that testing centres either refuse to test them, or charge an extra £1,500 for the extra cleaning
- The budget limited the testing to 2 taxis, which gives only a limited vision of the technology performance
  - However more taxis could be tested: as part of the conversion programme, all taxi drivers who had their vehicle converted have accepted that their vehicle could be tested.

# NOx test results: programme targets are met

NOx, mg/km – **WLTP test**



NOx, mg/km – **PCO Cenex test**



----- NEDC Euro limits shown for CAZ compliance, for diesel and **petrol** vehicles

LPG taxis have a spark-ignition engines so relate to **petrol limits**.

Background to the Birmingham project

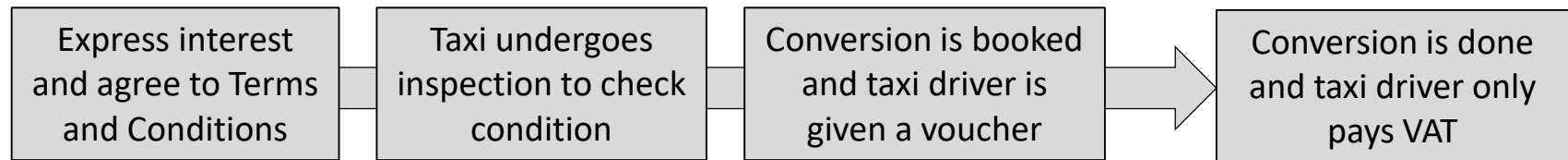
Emission reduction achievements

**Consumer's angle**

Recap and next steps

# 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<sup>1</sup>
- 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 (c. £1,500)
- Some taxi drivers have been surveyed on the conversion process and converted vehicle

# 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 December 2016:** the 82 registered taxi drivers were regularly informed via a quarterly email, and further workshops



## 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 has been conducted in Summer 2017 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

# The Birmingham LPG taxi drivers' survey show high levels of satisfaction with the converted taxis but also a cost challenge

## Results of the survey are summarised below:

- **Overall satisfaction with the taxis and the conversion process is very high** (85% and 94% respectively are very or slightly satisfied)
- **97% of taxi drivers would recommend the conversion** to other drivers but think **most would not convert without grant support** – despite fuel savings indicating a payback period of under 5 years
- Overall very high satisfaction levels with the converted vehicles' main performance characteristics, biggest improvement needed with the number of refuelling stations with only 28% of respondents saying all their needs were met by the current infrastructure.
- Over half of the drivers had problems with their taxis following the conversion but it appears a **large part of the problems were caused by ageing parts** rather than the upgraded equipment.
- **Any feedback received from passengers was positive** with 52% of all feedback being about the reduced engine noise.



Background to the Birmingham project

Emission reduction achievements

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**Recap and next steps**

# Key achievements of the project and next steps for lowering the existing taxi's fleet emissions

## Key achievements

- 65 highly polluting taxis were converted to LPG with demonstrated 80% reduction in NOx emissions and 99% in PM, making taxis CAZ compliant
- A local garage was trained in the retrofit procedure and the first UK supply chain for diesel to LPG conversion for TX vehicles was established
- Taxi drivers are highly satisfied with the project: 97% would recommend the conversion to other taxi drivers
- Emission data was provided for the Clean Vehicle Retrofit Accreditation Scheme design → techno accredited in 2018
- Older taxis have now an alternative to purchasing a new vehicle to comply with the upcoming CAZ

## Next steps – Clean Air Zone

- Over 95% of taxis are not CAZ compliant – taxi licensing conditions request taxis are compliant from Jan 2020 (both Hackney Carriages and Private Hire Vehicles)
- The work has shown that taxi drivers like the technology and would recommend it to others, but they anticipate no/low willingness to pay for it.
- Birmingham is seeking support from government through the Clean Air Fund for
  - Grant toward LPG retrofit for Hackney Carriages
  - Operational support for electric HCs
  - Grant towards HEV or ULEV PHVs

The project received the Local Authority & Public Sector Air Quality Initiative of the Year in 2017