Compressed Natural Gas Refuelling feasibility study

(Prepared by JouleVert Limited)

May 2015
## Contents

1) Executive Summary

2) Google Maps of Islington Gas grid

3) Islington Council Fleet Analysis

4) Potential Emissions Savings

5) Other Local Fleet options

6) Real Life Performance of Diesel Vehicles

7) CNG Station outline costings
1) Executive Summary

The London Borough of Islington is a London borough in Inner London.

It is bordered by Haringey to the North, Hackney to the East, City to the South, and Camden to the West.

As part of an ongoing programme to improve Air Quality and reduce Carbon emissions the Council wishes to investigate the potential to have a Natural Gas/Biomethane refuelling facility within the Borough and if possible on the Council fleet site. In addition the ability to understand which vehicles in both the Council Fleet and private fleets could utilise the fuel and the potential resulting AQ and CO₂ benefits will help formulate a roll out plan that can bring about the desired outcomes.

The results of this report show that despite an initial feeling that a station location would be difficult to find there are in fact two locations that, with suitable support, could provide the facility for a grid CNG station. The support of National Grid (the local
Gas Network provider) will be needed to identify the suitability of the sites and the cost of grid connection and pipework to the proposed Gas Station location.

There are enough Council vehicles to justify a station on their own but the ability to allow for local delivery vans to use it as well would be a benefit to the community etc. If Metroline could be persuaded to be involved then some single deck gas buses could be converted to Biomethane providing some significant NOx and PM reductions to the wider streets of London. Further investigation as to the single deck / double deck split at the Upper Holloway depot could show the gas demand and savings attainable.

This report shows the potential savings from Council vehicles could present NOx savings in the order of 3.2 tonnes (though in real life the NOx levels will be significantly higher from the current diesel fleet – see section 6) and PM reductions of 116kg.

In terms of CO₂ savings using grid gas alone should save some 23% of Carbon emissions (approx. 500 Te) or using Biomethane some 3064Te.
2) **Google Maps of Islington Gas grid**

Analysis of the Gas grid network for the Borough of Islington has produced the following ‘maps’. There is nothing beyond medium pressure gas mains within the Borough. However there are some locations which offer the potential to install CNG refuelling connected to the Gas main that will allow for a progressive change over for certain Council vehicles and private sector fleets that operate in the Borough.

The red dots signify potential users, the top one is the Metroline Bus Garage, and the three on Bush Industrial Estate are BT Fleet, London Underground and Royal Mail.
No options in this area
No options in this area
There are no gas mains above low pressure in this area.
Option to site a gas station within the Council depot if suitable space can be identified
No options in this area
No options in this area
No options in this area
3) Islington Council Fleet Analysis

The current split of council commercial vehicles is as follows:

<table>
<thead>
<tr>
<th>Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCVs</td>
<td>31</td>
</tr>
<tr>
<td>Vans &lt;3.5te (incl Tippers)</td>
<td>218</td>
</tr>
<tr>
<td>Vans &gt;3.5te</td>
<td>9</td>
</tr>
<tr>
<td>Minibus</td>
<td>32</td>
</tr>
<tr>
<td>Small Vans</td>
<td>46</td>
</tr>
<tr>
<td>Other HGVs</td>
<td>16</td>
</tr>
</tbody>
</table>

Within the Islington Council fleet the Refuse Collection Vehicles (RCVs) clearly will emit the most Air Quality pollution and Carbon emissions due to the high fuel usage and low/slow speeds.

Natural Gas versions are available for the RCVs, Vans (<3.5te), Vans (>3.5te) and Minibuses. The VW Caddy CNG which fits the small van size of the fleet was withdrawn from UK sale last year (but could be re-introduced if demand is sufficient).

The following vehicles are available in dedicated natural Gas configuration.

a) Volvo

Volvo have just launched a dedicated CNG engined Rigid vehicle up to 26te GVW. This is suitable for RCV work however it should be noted that this is not a low entry cab.
Uses a 9 litre gas engine, Euro 6 with spark plug technology rated at 320 hp / 1356 Nm. Fully automatic transmission with Day cab. Tank system for up to 160 m³ methane gas configured as either 2x4 or 2x3 tanks for compressed natural gas fitted on both sides of the chassis.

b) Scania

Scania also have a rigid running a dedicated Spark ignition CNG engines that can be specified as either CNG or LNG. It uses a same 9 litre engine and they are Euro 6 compliant.

The engine is available in either 280bhp or 340bhp configurations depending on the GVW plated weight requirements. This may be too powerful for RCV work but a low entry cab version is available. No specifically designed RCV though has been produced yet.

c) Iveco

Iveco have been supplying CNG/LNG trucks for the longest time in Europe. They have both articulated and rigid available. These vehicles use the Iveco Cursor 8 Euro 6 spark ignition CNG engine rated at 272/300/330bhp. Can be specified as either LNG or CNG. Transmission is either a 16-gear manual ZF transmission or 6-speed Allison automatic transmission with hydraulic torque converter. CNG models have an overall tank capacity ranging between 400 to 1,300 litres with layouts that can be tailored to suit customer needs. The LNG version has a range of 750km.
2015 also sees Iveco introduce the New Daily (Van) Natural Gas model line-up, designed to operate on compressed natural gas (CNG) or on compressed bio-methane (CBM), these new models build upon Iveco’s extensive experience in the gas powered vehicle market. With its Euro VI certification, New Daily Natural Gas models are ideal for urban operators which have to work within Low Emission Zones, whilst the reduction in operating noise of 5 dB(A) compared with its diesel equivalent gives fleets greater flexibility with night-time and early morning deliveries.

The New Daily Natural Gas Van is able to deliver significant fuel cost savings versus vehicles operating on diesel. As with the previous generation of CNG / CBM-powered
Daily, New Daily Natural Gas models are fitted with a small petrol tank reserve, allowing an additional range of up to 50 miles in a de-rated engine mode, in the event of running out of gas. The vehicle range, whilst operating on natural gas, can vary between models, with extended range tanks available for longer wheelbase vehicles. Operators can select from many Natural Gas models, starting from 3.5 tonne van and chassis cabs with single or twin rear-wheels up the 7 tonne van and 7.2 tonne chassis cab.

d) Mercedes Benz

Mercedes Benz UK offers a dedicated spark ignition engine in the Econic range (a low entry cab design) aimed at the Refuse Collection (Rigid) and smaller urban articulated vehicle market. This is available as either LNG or CNG.

Both variants use the new Euro 6 M 936 G natural-gas engine that is based on the OM 936 turbo diesel engine from the new 7.7 litre BlueEfficiency Power generation. As a mono-fuel engine (gas-powered only), it runs on compressed natural gas (CNG) and has an output of 222 kW (302 hp) while delivering maximum torque of 1200 Nm. The powertrain in the Econic continues to include the Allison six-speed automatic transmission.

In addition the Mercedes Sprinter is available with NGT (Natural Gas Technology) natural gas drive. The monovalent version of the Sprinter NGT is considered a mono-fuel natural-gas vehicle. The mono-fuel Sprinter NGT earns points in particular in the urban environment. The petrol in the downsized fuel tank (< 15 l) only serves for starting off and as an emergency reserve. The switch is automatic and cannot be influenced by the driver.
It too is available as a van, a chassis cab (for tippers), and as a minibus.
4) Potential Emissions Savings

We utilised the Cenex Biomethane Calculation tool in order to give the approximate emissions savings across the Islington Fleet. However in real life (see section 6) the actual real life AQ emissions from the fleet is likely to be significantly higher in terms of NOx due to the slow speeds of the fleet and thus these results shown below will be lower than reality which could be as much as 50% greater. Analysing the annual mileage of the fleet (live data for the RCVs and an annual mileage of 7000 for the rest gave the following results for potential Air Quality emissions savings.

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Ave Mileage</th>
<th>MPG</th>
<th>NOx Saving (kg)</th>
<th>PM Saving (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCV</td>
<td>8,885</td>
<td>4.0</td>
<td>1,446</td>
<td>13.6</td>
</tr>
<tr>
<td>Small Van</td>
<td>7,000</td>
<td>28.0</td>
<td>139</td>
<td>9.8</td>
</tr>
<tr>
<td>Large Van</td>
<td>7,000</td>
<td>20.0</td>
<td>887</td>
<td>116.2</td>
</tr>
<tr>
<td>Van&gt;3.5te</td>
<td>7,000</td>
<td>16.0</td>
<td>37</td>
<td>4.8</td>
</tr>
<tr>
<td>Minibus</td>
<td>7,000</td>
<td>22.0</td>
<td>130</td>
<td>17.1</td>
</tr>
<tr>
<td>Small HGV</td>
<td>7,000</td>
<td>12.0</td>
<td>561</td>
<td>5.2</td>
</tr>
</tbody>
</table>

The fuel used by the fleet would be as follows with associated CNG demand based on a dedicated fleet and the CO₂ savings if Biomethane was used via Green Gas Certificates.

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Diesel Litres</th>
<th>CNG (kg)</th>
<th>CO₂ Savings (Te)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCV</td>
<td>309,639</td>
<td>256,176</td>
<td>1,446</td>
</tr>
<tr>
<td>Small Van</td>
<td>52,280</td>
<td>42,253</td>
<td>167</td>
</tr>
<tr>
<td>Large Van</td>
<td>346,867</td>
<td>286,976</td>
<td>1,110</td>
</tr>
<tr>
<td>Van&gt;3.5te</td>
<td>17,900</td>
<td>14,810</td>
<td>57</td>
</tr>
<tr>
<td>Minibus</td>
<td>46,287</td>
<td>38,295</td>
<td>148</td>
</tr>
<tr>
<td>Small HGV</td>
<td>42,430</td>
<td>34,104</td>
<td>136</td>
</tr>
</tbody>
</table>

The offtake of CNG shown here is designed to give an indication of station sizing for any prospective station investor. A throughput for such a ‘local’ depot of 400,000kg per annum would make it economic for the investment (estimated to be in the order of £800k to £1m). Therefore focussing on the stock 3.5te van and RCV vehicles could easily bring this about. They could be changed over a three year period and the investment would still be a sound one (see section 7).

The key factors in considering this are:-

a) The sizing the station is the refuelling time and period of refuelling window that is available.

b) The pressure and amount of gas that can be extracted from the grid at any selected point without affecting users around that point.
5) **Other Local Fleet options**

Whilst large industry does not feature within the Borough of Islington, there are a number of smaller distributor type businesses that run vans that could participate in the development of a CNG refuelling facility. Formal engagement with these operators would need to be conducted but reviewing the types of vehicles being used would suggest the potential exists.

The key locations to focus on are:-

1) **Bush Industrial Estate:**

Vans operate from here for London Underground  
A Large Royal Mail sorting and delivery depot is located here  
BT Fleet have a location here  

The Metroline Bus Depot is the other side of the Railway line.

2) **Brewery Road/Brandon Road/Blundell Street/Tileyard Road**

If a CNG station were located at the Council Depot at Hornsey Street then a number of Van users are located on these roads such as the Metropolitan Police, Matt Snowball, Euphorium Bakery, Belloni Pronto Provisions (Food), Carnevale Foods, Russell Hume Foods etc.

Outside of these two locations there is little in the way of concentrated ‘industry/commerce’ or suitable land for a refuelling station.

The Recycling Centre (Cottage Road/Hornsey St) location could also be used by council vehicles parked at the Laycock Building (Highbury Station Road), 222 Upper Street, and Fieldway Crescent.
6) Real Life Performance of Diesel Vehicles

A second factor which is occurring is the underperformance of Air Quality (NOx and PM) emissions equipment that is fitted as standard on Euro IV, V and VI diesel vehicles. The testing regime at a manufacturer (EU) level is for the engines to be tested on their own (without gearboxes and axles etc.) and no ‘real life’ road type testing is carried out to validate the engine out emissions levels in actual use. Recent roadside testing in Sheffield\(^1\) has determined that in real life congested stop start operations the Selective Catalytic Reduction (de-NOx) equipment is severely underperforming. Result on buses for instance showed that a Euro V single deck bus was emitting higher NOx than existing Euro III buses and that Double Deck Euro V buses were on a par for NOx emissions from a Euro II double deck bus. Whilst no specific work was done on RCVs it is clearly evident that the reasons for the shortcomings will apply equally if not to a great extent to RCVs.

Why is this occurring? SCRT is an advanced active emissions control technology system that injects urea into the exhaust stream of a diesel engine which then passes through a special catalyst in the exhaust. The catalyst sets off a chemical reaction between the exhaust gases and the urea that converts nitrogen oxides into nitrogen, water, and tiny amounts of carbon dioxide (CO\(_2\)), natural components of the air we breathe, which is then expelled through the vehicle tailpipe.

SCR technology is designed to permit nitrogen oxide (NOx) reduction reactions to take place in an oxidizing atmosphere. It is called "selective" because it reduces levels of NOx using ammonia as a reductant within a catalyst system. The urea can be rapidly broken down to produce the oxidizing ammonia in the exhaust stream. SCR technology alone should achieve NOx reductions up to 90 percent.

However for the above to occur there needs to be a minimum exhaust temperature to allow this reaction to take place. The typical temperature required is over 250 deg C and this occurs when a diesel engine is under load and ‘pulling’ hard over a period. Therefore in stop start scenarios the temperature quickly drops off resulting in the shutting off of the Urea injection (to prevent urea slip out of the exhaust) and thus an ineffective de-NOx system.

Therefore the results seen in real life should be no surprise but do make life very difficult for fleet operators in urban areas.

\(^1\) Vehicle Emission Measurement and Analysis - Sheffield City Council, Dr James Tate, University of Leeds
As a result of this realisation, the retrofit SCR suppliers have added a small fuel injection (of diesel) prior to the SCR unit to ignite and raise the exhaust temperature artificially to enable operation but this adds to fuel use and CO₂ emissions.

Gas fuelled vehicles on the other hand are not affected by stop start and congestion scenarios as they do not need exhaust after treatments. Dedicated gas engines being spark ignition based (like petrol) produce extremely low levels of NOx and Particulates. They are also half the noise level of a diesel engine.
7) **CNG Station outline costings**

This section will break down the costs associated with building a CNG refuelling station without the cost of land or civils.

a) **Station Hardware**

With regards to Health & Safety requirements, the current ISO working group for natural gas vehicle refuelling stations has developed ISO/PC 252- WG1 to cover CNG stations and WG2 to cover LNG & LCNG stations. The standard also covers various types of methane gas fuel such as bio gas/biomethane (of various sources), coal bed methane, and fossil gas.

Gas inlet pressure is critical – Best is LTS (Local Transmission System) at 15-38 bar pressure followed by Intermediate Pressure (IP) mains at 4-7bar and finally Medium pressure (MP) mains is 0.5-2 bar. MP requires extra compression to reach a 300bar pressure (5 stage compression compared to 3 for the other two) and hence higher (+20%) electricity costs to compress. LTS mains allow for high throughput without affecting the rest of the grid users.

Most CNG stations made up of:
Compressor(s) + Staged Storage Cylinders (150/200/300 bar) + Dispenser(s) + Filter/Dryer (optional)

Most stations are specified with one compressor only that either fills the vehicle directly or recharges the on-site storage. Storage would be typically able to fill 4 to 6 vehicles before re-pressurisation by the compressor. Compressor are sized according to station throughput and associated storage capacity. They are either 3 or 5 stage compressors that build up the pressure to 300 bar.

When refuelling a vehicle the station starts with the lower pressure 150 bar storage then as the back pressure builds the software switches to each of the high pressures (200 bar and 300 bar) until the vehicle tanks are full. (Think like pumping up a bicycle tyre).

Compressor availability (reliability) can be ensured by well planned maintenance of the unit when the station is not in primary use. Some compressors need a service at 500hours (2-3 hours work) others 6-8000 hours (major service – up to 8 hours work). Major services could be staggered over a number of days to ensure station operation.
Vehicle refuelling capacities

A Dual fuel truck will have about 100kg of CNG stored on board, a dedicated truck will have nearer 200kg to enable around 300 miles per day. A dedicated Bus typically has 80-100kg as they cover up to 180 miles per day. A van will have in the order of 50kg CNG to cover around 200 mile per day.

CNG Station Costings

If station payback is over 10 years then the following table gives today’s ‘through the nozzle’ cost

<table>
<thead>
<tr>
<th>Station Size (kg/day)</th>
<th>Annual Throughput Capacity (Te)</th>
<th>Total Station Cost</th>
<th>Base NG delivered2 Price/kg</th>
<th>Capital payback5 (p/kg)</th>
<th>Fixed Opex1 (p/kg)</th>
<th>Operators profit (p/kg)</th>
<th>Fuel Duty (p/kg)</th>
<th>Fuel Price (p/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>125</td>
<td>£300,000</td>
<td>28</td>
<td>35</td>
<td>24</td>
<td>10</td>
<td>24.70</td>
<td>121.70</td>
</tr>
<tr>
<td>1000</td>
<td>250</td>
<td>£450,000</td>
<td>28</td>
<td>27</td>
<td>14</td>
<td>10</td>
<td>24.70</td>
<td>103.70</td>
</tr>
<tr>
<td>2000</td>
<td>500</td>
<td>£600,000</td>
<td>28</td>
<td>22</td>
<td>10</td>
<td>10</td>
<td>24.70</td>
<td>94.70</td>
</tr>
<tr>
<td>50003</td>
<td>1000</td>
<td>£750,000</td>
<td>28</td>
<td>16</td>
<td>8</td>
<td>10</td>
<td>24.70</td>
<td>86.70</td>
</tr>
<tr>
<td>100004</td>
<td>2000</td>
<td>£1,200,000</td>
<td>28</td>
<td>12</td>
<td>7</td>
<td>10</td>
<td>24.70</td>
<td>81.70</td>
</tr>
</tbody>
</table>

1 – Includes electricity usage, compressor and ancillary equipment servicing, emergency breakdown cover, cylinder re-evaluation (every 10 years)
2 – NG price based on 55p/therm divided by 2.217 to get to kg plus 3p/kg grid transmission fees.
3 – Contains extra storage to cater for faster refuelling times
4 – Contains extra storage and extra compressor to cater for faster refuelling times and redundancy
5 – includes capital costs for Grid and electrical connections and is over 5 years.
b) Infrastructure Costs

There are two infrastructure costs to take into account – the connection to the Gas Grid and the connection to the electricity supply (Three phase).

Gas Grid charges range from £50k (where the station is directly on the Gas main) to £250k where a section of pipe needs laying. Grid connection is a specialist job requiring skilled and certified engineers.

Electricity Grid connections depend on on site voltage/current availability. Costs can range from £10k to £100k depending on location and any equipment upgrades necessary.

c) General Opex Costs

Electricity and maintenance are the two main costs associated with the running of the station and are direct correlations to station throughput.

d) Base Fuel Cost Diesel vs Natural Gas

Base Gas trading is done through the ‘Henry Hub’. The Henry Hub is a distribution hub on the natural gas pipeline system in Erath, Louisiana, owned by Sabine Pipe Line LLC, a subsidiary of Chevron Corporation. Due to its importance, it lends its name to the pricing point for natural gas futures contracts traded on the New York Mercantile Exchange (NYMEX) and the OTC swaps traded on Intercontinental Exchange (ICE).

In late 2011 Natural gas Pricing disassociated itself from Crude Oil pricing due to the increased global availability through LNG shipments and production volume increases. Whilst Gas prices fluctuate between summer (low use) and winter (high use) it is still low compared to crude. In October 2014 gas has risen to 50p/therm and Brent Crude has reduced from $105/bbl to $85/bbl there is still a sizeable end cost differential.

The following graphs illustrate the recent trends.
Through the Nozzle Pricing:

Market prices for CNG is in the band 82-95p/kg before VAT though most current refuelling stations are in private company ownership and therefore difficult to get true costs, throughput is critical in reducing the price to this level. Biomethane (as LBM) is around 10p/kg more. LNG is around 90-100p/kg before VAT.

1kg Natural Gas can displace up to 1.365 litres diesel in a dual fuel truck. Thus on paper running LNG in a dual fuel truck would mean 90p of LNG replaces £1.43 of diesel (@£1.05/litre). An 80,000 mile truck would use 45,400 litres diesel at 8mpg. So at 60% substitution it saves 27,240 litres of diesel or a fuel saving of just over £10,000, before any additional costs.

For dedicated vehicles using CNG using the above consumption then the fuel consumption comparison with its diesel equivalent will yield any savings in the order of £15,000. The savings are not double as the Spark ignition engine has a slight efficiency penalty compared to the diesel engine.

e) Green Gas Certificates / Biomethane Availability

There are three Green Gas Certificate schemes that can provide Biomethane Certificates from Grid injection of Biomethane. These operate in the same way that Green Electricity certificate operate. These Green Gas Certification Schemes track biomethane, or ‘green gas’, through the supply chain to provide certainty for those that buy it. Currently the cost of a GGC for 1 kg of Biomethane is in the region of 4p but depends on supply and demand. This is anticipated to be fairly stable. By mid 2015 it is anticipated that new Biomethane to grid projects currently in build will provide up to 195 million kg of Biomethane certificates.

Green Gas Trading (http://greengastrading.co.uk)

This scheme allows the purchaser to determine the Carbon saving of each ‘stream’ of Biomethane injected and therefore can buy more gas certificates than the gas used in order to claim 100% carbon reduction if that is a criteria.

Barrow Green Gas (www.barrowgreengas.co.uk)

Barrow Green Gas is the trading name of Barrow Shipping Limited (BSL). They hold a UK Gas Shipper Licence and create value for biomethane producers through:

- Purchasing biomethane
- Offering a flexible service – no restriction on volumes
  - Optimising transportation discounts
  - Separating Green Gas Certificates (GGC) from gas production
  - Marketing GGC collectively to maximise their value
  - Membership of our Biomethane Producers Club
Green Gas Certification Scheme (www.greengas.org.uk)

The Green Gas Certification Scheme is managed by Renewable Energy Assurance Ltd. which is owned by the Renewable Energy Association. Each unit of green gas injected into the grid displaces a unit of conventional gas. So the GGCS tracks each unit of green gas from its injection into the distribution grid, to any trades, to its sale to a consumer, or group of consumers. It tracks the contractual rather than physical flows to ensure there is no double-counting from production to end use.