



Slough Borough Council Refuse Collection Vehicles (RCV) Options Appraisal

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Low Emission Strategies Ltd (with Mint Green Sustainability Ltd & JouleVert Ltd)

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1 Background

This appraisal of RCV options forms part of an innovative approach to the review of Slough BC fleet vehicle procurement, taking into account whole life costs and alternatives to diesel vehicles.

This approach stems from the development of the Slough Low Emission Strategy (LES) 2016.

1.1 Slough waste collection fleet

Figure 1 below illustrates the importance of the waste service vehicles in the context of Slough's overall fleet.

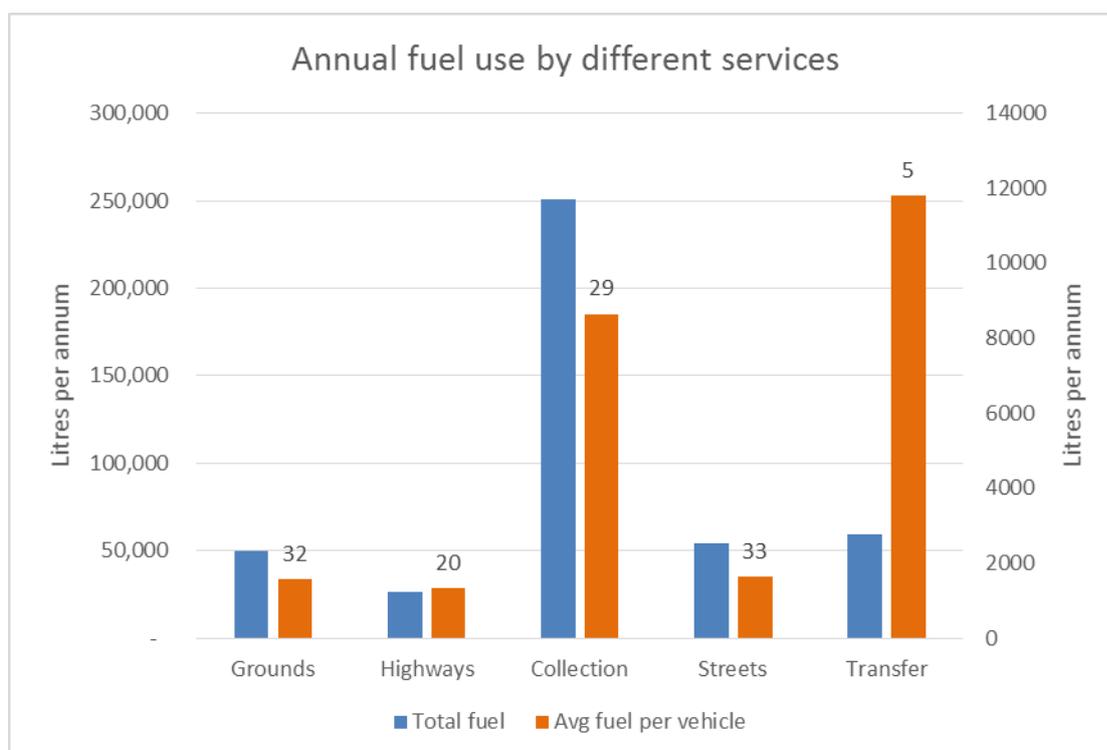


Figure 1: Annual fuel use by different services - data labels indicate number of vehicles

Waste collection has a similar number of vehicles to the other services (apart from the transfer station), but the average fuel consumption of each vehicle is much higher. Grounds, highways and streets operate mostly 3.5t tippers, vans and a few cars and pick-ups, plus some street-sweepers. Most of the vehicles within the waste collection fleet are 26t refuse collection vehicles, operating on stop-start drive cycles. As a result, waste collection uses five times as much fuel as any other service.

1.2 Waste collection fleet emissions

Figure 2 below shows the age profile of the Slough RCV fleet. All but one of the vehicles is of Euro V emissions standard, but it can be seen that much of the fleet is due for replacement – 10 of the 25 vehicles are 7 years old, and a further 9 are 5 years old.

The emissions of the main three pollutants are shown in Table 1 below, as are the estimated 'damage costs' associated with these emissions.

Pollutant	Total mass emitted pa	Total damage cost ¹
CO ₂ e	792 (tonnes)	£27,926
NO _x	5,665 (kg)	£25,127
PM	63 (kg)	£5,547

Table 1: Emissions of Slough RCV fleet, by mass and damage cost

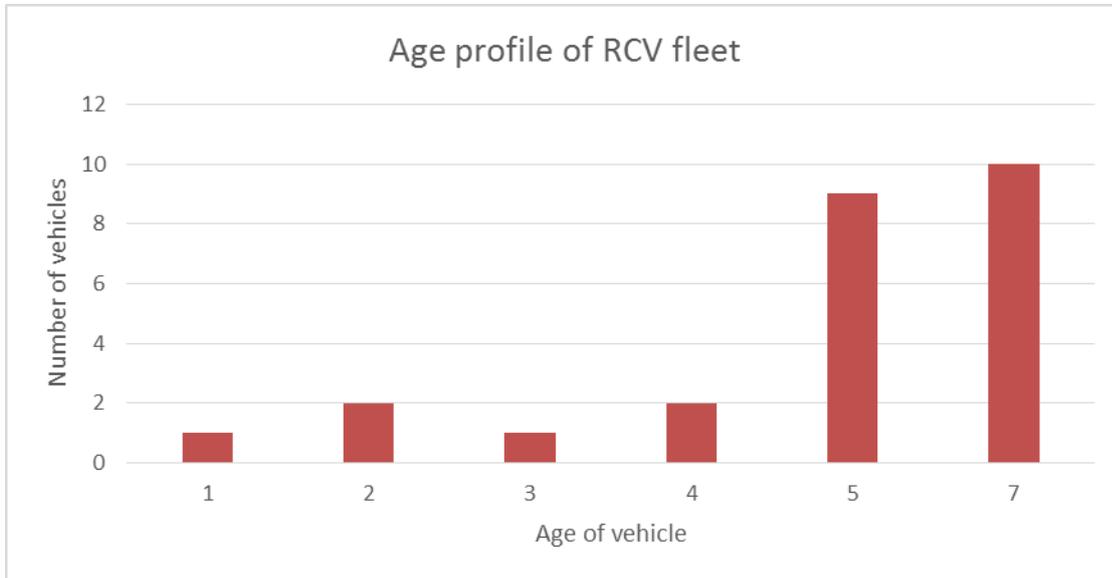


Figure 2: Age profile of Slough RCV fleet

¹ Damage costs calculated according to methodology in EU Cleaner Vehicle Directive

2 Vehicle options for reducing emissions

Within a refuse collection fleet, some fuel saving is possible by optimising routes and driving style, but this is limited. RCVs inherently use a lot of energy because they are heavy, they must operate on a stop-start cycle, and because the bin-lift and compactor use a lot of energy in addition to that required to move the vehicle.

Given the constraints described above, large emissions reductions from RCVs can only be achieved with the adoption of best available technology. Three such options are considered here:

- Use of Euro VI vehicles, possibly also using biofuels
- Use of 'hybrid bodies'
- Use of gas or biomethane

One option that is not considered is a pure electric drivetrain. While electric buses are in production, these rely on shorter routes and opportunity charging. For trucks the upper limit for a battery electric drivetrain is currently 7.5t, and vehicles with very high energy demands, such as 44t artic trucks and refuse collection vehicles, are unlikely ever to use an electric drivetrain unless fuel cell vehicle technology advances significantly.

2.1 Euro VI diesel and biofuels

Not only are the Euro VI emissions standards much tighter than Euro IV and V, there are also controls in place to make sure that vehicles achieve the standards in real world driving. Air quality was expected to increase with the introduction of previous standards, but in practice they achieved little.

Figure 3 below shows the results of 210 tests of various heavy duty vehicles on a range of test cycles. Tests were carried out on Euro IV, V and VI vehicles, and each dot on the figure represents one result. The 'conformity factor' shows how low the NO_x emissions were relative to the official standard – so a factor of 2 means the vehicle emitted twice as much NO_x as a vehicle of its Euro standard should have done on that particular test. Looking at the dots, it can be seen that Euro IV and V vehicles typically emitted two, three or four times as much NO_x as they should have done. The Euro VI vehicles, however, generally emitted well below their target even in realistic driving conditions, despite the fact that the Euro VI NO_x limit is much lower than that for Euro V.

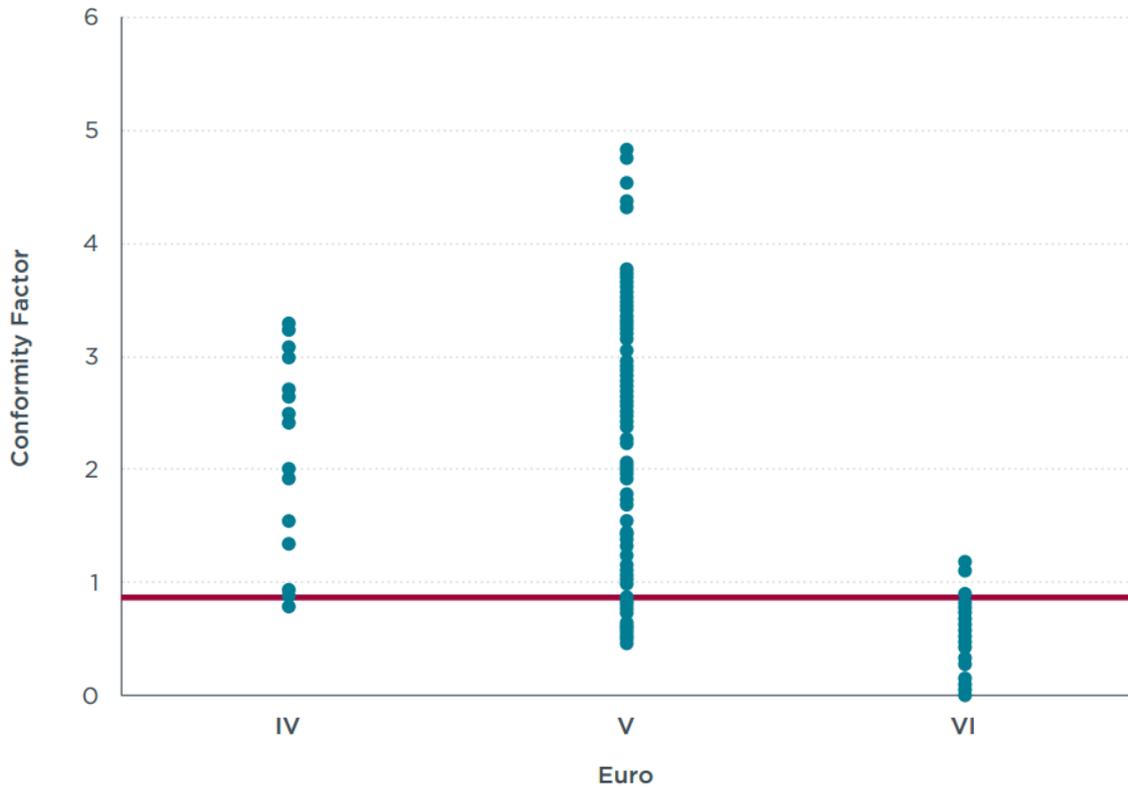


Figure 3: Extent to which heavy duty vehicles achieve Euro standards under real world conditions. Source ICCT briefing March 2015.

Early results therefore suggest that the ‘default’ option of sticking with diesel and upgrading to Euro VI vehicles will produce a large air quality benefit. However, there remain some costs and questions for operators, notably the fact that the vehicles will use increase amounts of AdBlue, and the effect on maintenance costs of having very complex emissions reduction and monitoring systems.

In terms of the damage costs identified in Table 1 above, the largest cost is from CO₂e, and this is not addressed by the use of Euro VI diesel. One option would be to run on some form of biodiesel, however, this is not without its own difficulties.

Growing crops specifically to produce biodiesel is controversial, due to the ‘food vs fuel’ conflict, and the potential to indirectly increase land degradation in other parts of the world. As a result, crop-based biodiesel has been capped in the EU. In the UK, diesel at the pump is already blended with biodiesel, and with the crop-based cap, most of this will be coming from used cooking oil. Since we don’t have enough waste oil in the UK, much of this is already imported from overseas. Therefore, there is little overall benefit to be gained from switching to a higher blend of biofuel at present in the UK.

One other possible issue with biodiesel is its effect on air quality. Some studies suggest that the particulates in biodiesel exhaust are significantly more ‘mutagenic’ (cancer-causing) than those from fossil diesel. Thus the health benefits of reduced emissions from Euro VI could be cancelled out by the increased toxicity of biodiesel emissions, although there is no firm consensus on this as yet.

2.2 Hybrid bodies

The stop-start drive cycle of refuse collection vehicles theoretically makes them ideal candidates for hybridisation. Hybrid vehicles capture the energy usually lost in braking (as heat in the brakes), by instead using the electrical resistance in a generator to slow the vehicle and generate electricity at the same time. In a hybrid car or bus this electrical energy is stored in a battery, and then used with an electric motor to provide extra power to the axles when the vehicle is accelerating.

Unfortunately, ‘full hybridisation’ of a large, heavy vehicle like a truck or refuse collection vehicle is still very expensive. Volvo has produced some hybrid RCVs over the last two years, but their operators have not seen economic payback within the lifetime of the vehicle, and have generally made the investment due to regulation or the need to present a ‘green’ image.

Despite this, another hybridisation approach is attractive for RCVs, due to the fact that the bin-lift and compactors use a lot of the vehicle’s energy. In a conventional RCV, the bin-lift and compactors are driven by hydraulics that take off power from the main diesel engine of the vehicle. Companies such as Faun Zoeller and Terberg make bodies or lifts that are instead electrically operated, using an externally charged battery and in some cases supplementing this with electrical energy collected from braking.



Figure 4: Hybrid body

The hybrid body approach is cheaper than a ‘full’ hybrid, because a second drive-train is not required, and electrical operation of the body is well established. Fuel savings of up to 33% are claimed by the manufacturers but there is no independent test data in the public domain to verify this. Slough’s own fleet has two vehicles with Terberg electric bin lifts (although not electrically operated compactors). Although these units cost £24,000 each, examination of the fleet fuel data shows no apparent fuel saving². Even being generous and allowing a 5% fuel saving, there is no prospect of economic payback – even at high diesel prices of £1.17/lit it would take 35 years for one of these units to pay for itself.

Any fuel saving will translate more or less directly into an equivalent percentage saving on emissions of CO₂e, NO_x and PM. Hybrid bodies can be used on either diesel or gas operated vehicles, and can also be retrofitted.

² A statistical T-test was used to assess whether there was any significant difference between the average fuel consumption of the vehicles with and without the electric bin lifts.

2.3 Natural gas or biomethane

Vehicles running on natural gas, i.e. methane, are inherently 'cleaner' than vehicles running on diesel, although the benefits are not clear cut.



Figure 5: Mercedes Eonic gas powered RCV (source: Leeds City Council)

In terms of air quality, gas as a fuel burns much more cleanly than diesel. Modern gas engines are similar to petrol engines – they use spark plugs and an exact air/fuel mix. The fuel burns completely, so the vehicle has no particulate emissions from the engine (though it will have some from tyres and brakes). And the use of an exact (stoichiometric) air/fuel ratio allows for the use of a three-way catalyst, as on a car, which is a simple way to achieve very low NO_x emissions.

With the advent of Euro VI diesel, gas may offer a limited air quality benefit. However, the emissions control systems required to achieve Euro VI on a gas engine are very simple, whereas those on a diesel engine are highly complex, and it remains to be seen how effective both will be in the long term, and what the difference in maintenance cost will be.

In terms of CO₂e methane emits less CO₂ per unit of energy than diesel, due to it being the shortest possible hydrocarbon molecule. However, diesel uses a more efficient compression-ignition engine, whereas gas requires a spark-ignition engine, and the lower efficiency balances out the fact that gas is a lower carbon fuel. Thus a gas vehicle running on fossil gas has similar CO₂e emissions to a diesel equivalent vehicle.

A gas vehicle can also be run on biomethane – this is still methane, identical to fossil gas from the gas grid, but is created from renewable sources, such as anaerobic digestion. This is a very low carbon fuel, offering a 60-95% CO₂e saving vs diesel (depending on the source of the gas).

Both gas and biomethane are cheaper than diesel and attract lower fuel duty, so running costs are lower for gas vehicles. However, this is offset by the need to install refuelling infrastructure, consisting of a connection to the gas grid, plus compressors to put gas into the pressurised fuel tanks. Some biomethane suppliers will provide this infrastructure without any up-front fee, instead spreading the cost and adding it to the cost of each unit of gas supplied.

3 Emissions comparison for options identified

Table 2 and Figure 6 below illustrate the effect of different technologies on overall emissions.

Pollutant	Diesel (current)		Diesel (all Euro VI)		Hybrid bodies (5% saving)		Biomethane	
	Mass	Cost	Mass	Cost	Mass	Cost	Mass	Cost
CO ₂ e	792 (t)	£27,926	792	£27,926	752	£26,529	99	£3,477
NOx	5,665 (kg)	£25,127	1,167	£5,175	5,382	£23,870	1,167	£5,175
PM	63 (kg)	£5,547	32	£2,821	60	£5,270	0	-

Table 2: Mass and cost of emissions using different technologies

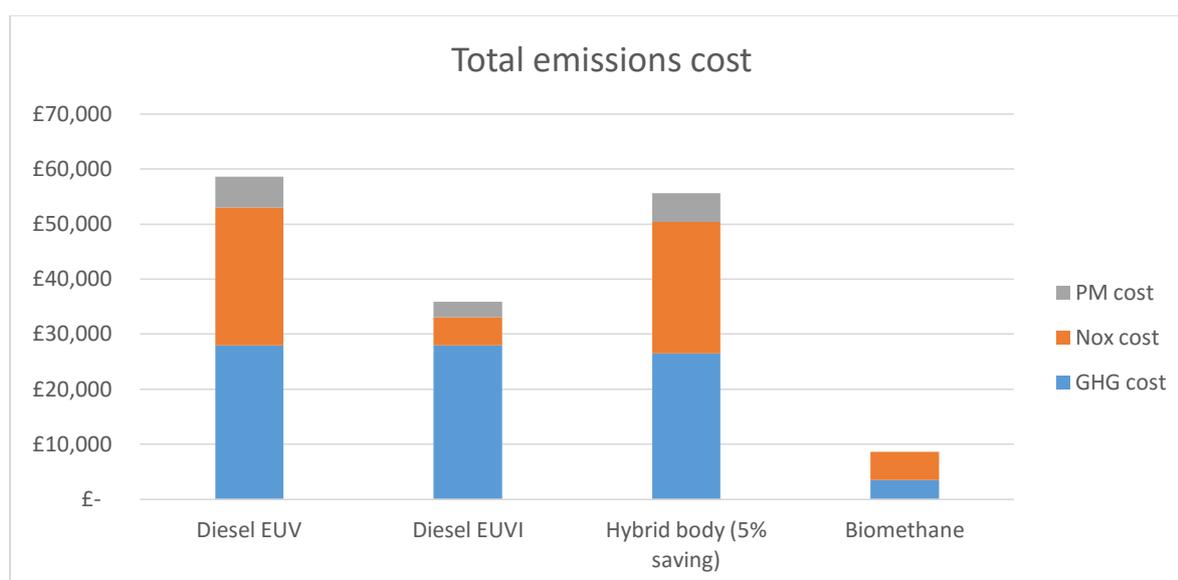


Figure 6: Emissions costs using different technologies

The figures are slightly artificial, as it is assumed that all 25 vehicles are switched to the relevant technology in each case, which would be unlikely in practice. Also, in the case of hybrid bodies, the hybrid system would probably be added to a Euro VI chassis, so the benefits of Euro VI and the hybrid should be added – however, a hybrid body could equally be added to a gas chassis.

For the hybrid, a fuel saving of 5% has been used for the above calculations, in line with section 2.2. Also, NOx emissions are assumed to be the same for Euro VI diesel and Euro VI gas – Euro VI is still too new to the market to test whether this will be the case in the medium to long term.

4 Running Slough RCVs on gas or biomethane – feasibility

Sections 4.1 to 4.3 below consider the purchase costs of gas vehicles, the potential savings in operating costs, and the possible locations and costs for gas refuelling infrastructure in Slough.

4.1 Vehicle purchase costs

Currently the cost of a (spark ignition) dedicated Natural gas fuelled RCV chassis is higher than its Euro VI diesel equivalent. This is primarily due to the current low volumes of production, as gas engines are not inherently any more expensive than engines running on diesel³. There may be some differences between different technologies, depending on the pressure of the fuel and other factors, but these are relatively minor. The vast majority of components and processes are the same whether the fuel is liquid or gaseous.

The cost differential per chassis is currently £27,000 for the low Cab entry Mercedes-Benz Econic, and this is the value which has been used for this analysis. This vehicle is the only such low entry cab gas-fuelled RCV chassis currently running in the UK, with for example 10 of these running in Sheffield (by Veolia) on behalf of Sheffield City Council since 2011. It may be possible to reduce this on-cost by specifying some of the vehicles with fewer gas tanks (the main part of the extra cost of gas vehicles). This is discussed further in sections 4.4 and 5.



Figure 7: Mercedes Benz Econic RCV

Another vehicle option is likely to be available in the UK market very soon. Scania have a rigid chassis with a 9 litre engine Euro 6 compliant dedicated Spark ignition CNG engine. The engine is available in either 280bhp or 340bhp configurations depending on the GVW plated weight requirements. A low entry cab version is available. No specifically designed RCV though has been produced yet using this chassis and on cost details compared to Euro VI diesel have not yet been released.

³ Fuel tanks for gas vehicles are inherently more expensive than diesel fuel tanks. However, this is offset by the fact that emissions control for diesel engines is inherently more expensive than for gas. In other regards, the two types of engine share largely common components.



Figure 8: Scania CNG Rigid

4.2 Vehicle operating costs, and potential savings vs diesel

Overall, gas is a significantly cheaper source of energy than diesel. As a transport fuel, gas also benefits from a lower level of fuel duty, just 17.78 pence for the equivalent energy found in a litre of diesel for which the duty is 57.95 pence⁴. Furthermore, the price of oil and the price of gas are linked, as on wholesale markets much of the world's gas is traded via contracts that are indexed to the price of Brent crude.

However, engines burning 100% gas are less efficient than diesel engines – gas engines are spark ignition like petrol engines, and the efficiency difference is similar to that between diesel and petrol. The exact extent of this efficiency difference is currently difficult to define, as gas engines are undergoing rapid development at the present time, compared to diesel engines which have seen around 100 years of R&D.

For the purpose of this analysis we have referenced two other local authority fleets that use gas fuelled RCVs, Sheffield and Leeds. Sheffield has 10 Mercedes-Benz Econics on gas, operated by Veolia, while Leeds has 5 of the same vehicle in its own fleet.

In Sheffield the diesel equivalent RCVs have high fuel consumption, getting only 2.5mpg, due to the hilly terrain. The gas RCVs consume around 0.73 kg of gas for every litre of diesel consumed by the conventional vehicles. In Leeds the overall fuel consumption is lower, with the diesels getting 3.3mpg. The gas RCVs consume around 0.93 kg of gas for every litre of diesel used by their conventional counterparts on comparable routes.

Clearly there can be quite a wide variation in the relative efficiency of gas vehicles as compared to diesel. This reflects the ongoing rapid development of the technology and probably the different operating 'sweet spots' of the gas vs the diesel engine. In this analysis, we have used an intermediate efficiency, and have assumed that each gas RCV uses 0.83 kg of gas for every litre of diesel consumed by the current fleet. In Table 3 below, showing annual fuel cost savings, the main figure is based on this assumption, but the range of results from the Sheffield/Leeds data is given in parentheses.

⁴ Duty on gas is usually quoted at 24.7 pence, but this is per kg. A kg of gas has 50 MJ of energy, whereas a litre of diesel has only 36 MJ of energy.

The other key determinant of running costs, besides vehicle fuel consumption, is the relative price of diesel and gas. The gas market typically lags behind the oil market, since gas is often traded on contracts with prices fixed for months or even years ahead. For this reason, at times of falling oil prices (such as now in 2016) the price differential between diesel and gas tends to be squeezed, whereas when oil prices rise, gas will lag behind and fuel cost savings will be greater.

Additional discussion of the relative prices of gas and diesel can be found in Appendix A. However, for the purposes of this feasibility appraisal we have used two scenarios, one based on recent prices when the differential was about as low as it is ever likely to get, and one based on prices two years ago when the differential was considerably higher. This higher differential is closer to the long term average.

Table 3: Annual fuel cost comparison, gas vs diesel

Fuel price scenario	High fuel cost difference	Low fuel cost difference
Assumptions: Diesel price includes AdBlue, 4%, 35ppl Gas price is includes electricity @ 5ppkg and biomethane certificate @ 2.8p	Diesel price: £1.17 Gas price: £0.74 Difference: £0.42	Diesel price: £0.93 Gas price: £0.67 Difference: £0.26
Annual per vehicle saving: (range due to fuel efficiency in brackets)	£6,503 (£5,626 - £7,380)	£4,435 (£3,648 - £5,222)
Total annual fleet saving⁵: (range due to fuel efficiency in brackets)	£130,055 (£112,514 - £147,596)	£88,703 (£72,959 - £104,448)

Table 3 above shows the annual fuel cost comparisons under the different fuel scenarios. The total annual fuel saving can clearly vary considerably depending on what assumptions are made about fuel prices and vehicle efficiency. However, overall the fuel cost saving is most likely to be close to the £130,000 figure.

Several assumptions should be noted. Diesel price comes from average UK pump price data, and includes 1.4p/l for AdBlue, which is assumed to be used at 4% of diesel consumption and cost £0.35/l. The low diesel price is based on the last quarter of 2015, as this is also the last quarter for which gas price data is also available from the Department of Energy and Climate Change (DECC). The high diesel price is from the last quarter of 2013.

The base gas price has been calculated from DECC statistics for users of different volumes of gas. The calculation assumes the fleet requires around 250 tonnes of gas per year, and interpolates the likely contract price from the UK average price statistics. To the base price is added fuel duty, at 24.7p/kg, the electricity used by the station, at 5p/kg, and the cost of a green gas certificate to ensure that the gas purchased is biomethane (renewable gas), at 2.8p/kg.

⁵ In order to complete this analysis, we have been supplied with two sets of data on the RCV fleet. The first set of data included 25 vehicles, of which 20 consumed most fuel and 5 were apparently only lightly used. The second set of data included only 20 vehicles. Since payback will be better for vehicles that are used more intensively, we have included only 20 vehicles in the analysis, disregarding the 5 most lightly used vehicles.

4.3 Infrastructure locations and estimated costs

4.3.1 Gas station locations examined

Extensive analysis was conducted to determine potential locations for Gas Grid connected Compressed Natural Gas (CNG) stations within the Borough of Slough. The google map, Figure 9 below, shows the routes of the High Pressure (orange) Local Transmission System (LTS) mains, the Intermediate Pressure (IP) (green) mains and the Medium Pressure (MP) (blue) mains. The LTS or IP are the ideal mains to connect to for large volume through-puts with associated minimum energy and environmental impacts. We also assessed the Slough Trading Estate for suitable refuelling station locations but this appears to have been extensively redeveloped and therefore does not allow for such a station to be built there.

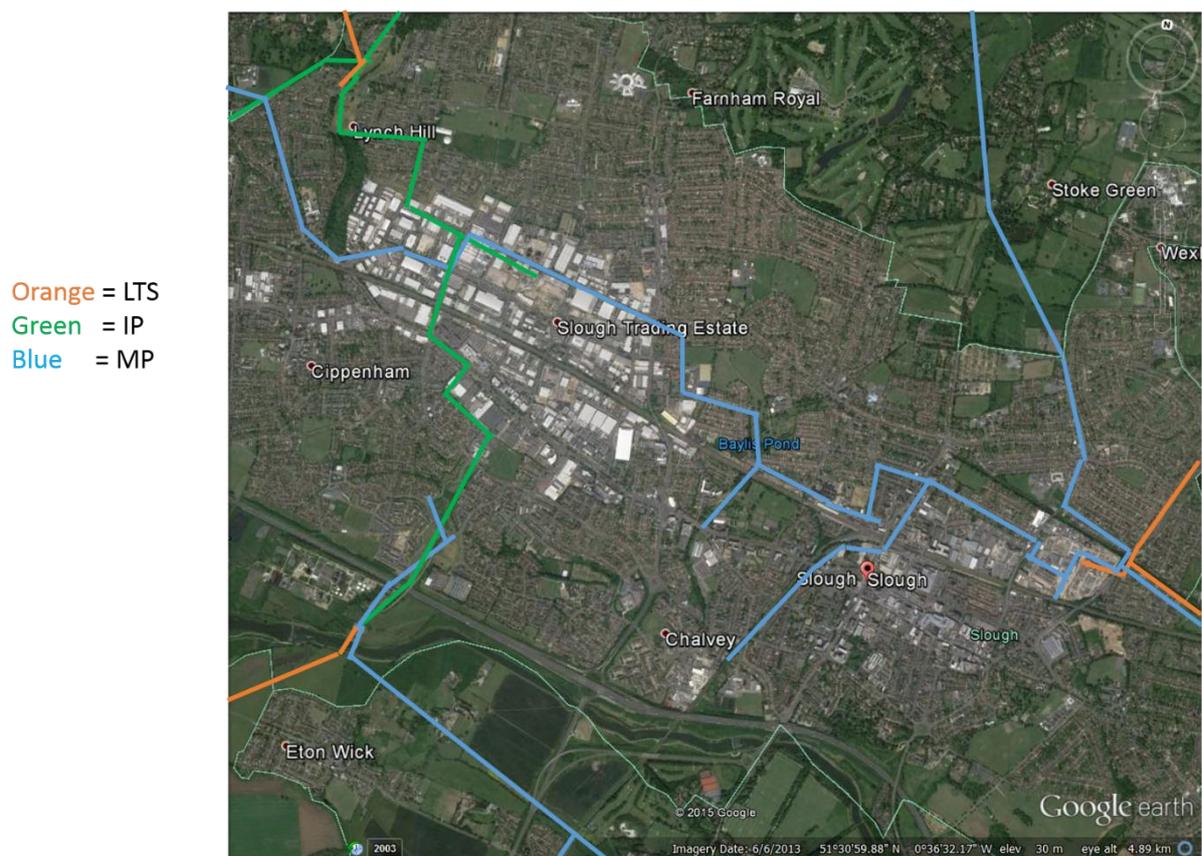


Figure 9: Google map of Slough showing position of gas mains

We then assessed the Chalvey waste transfer site, shown in Figure 10 below. There is only a low pressure (red) main on site which would not be able to provide sufficient volume throughput for a fleet of RCVs. Also LP mains tend to have damp gas and therefore the additional cost of a drier would need to be added to any station costs.

There could be an option of extending the Medium pressure main down alongside the embankment of the railway and then bringing it into the site on the eastern side but the cost and feasibility would need to be assessed for this. This would though give the capability of a station to fuel the RCVs and potentially other vehicles (such as the SSE vans located alongside the Chalvey site).



Figure 10: Position of gas mains in and around Chalvey waste transfer site

There is a further option that would be worth considering. In the Slough BC development plans are to develop the Akzo Noble (formerly the ICI Paints) site in Wexham Road. Shown in Figure 11 and Figure 12 below, this is an interesting site in that the LTS high pressure main comes to this location and National Grid occupy part of the site. If a suitable development could be considered that would relocate the Slough RCV and van fleets to this location and, in addition, relocate the First Bus depot (shown in Figure 13) from opposite the Rail station to here, then a large and very lucrative CNG refuelling station could be built on the site.

This in turn would release the land opposite the train station for more prosperous use. It would also potentially allow for redevelopment of the Chalvey site into a better recycling centre or redeployment for housing.

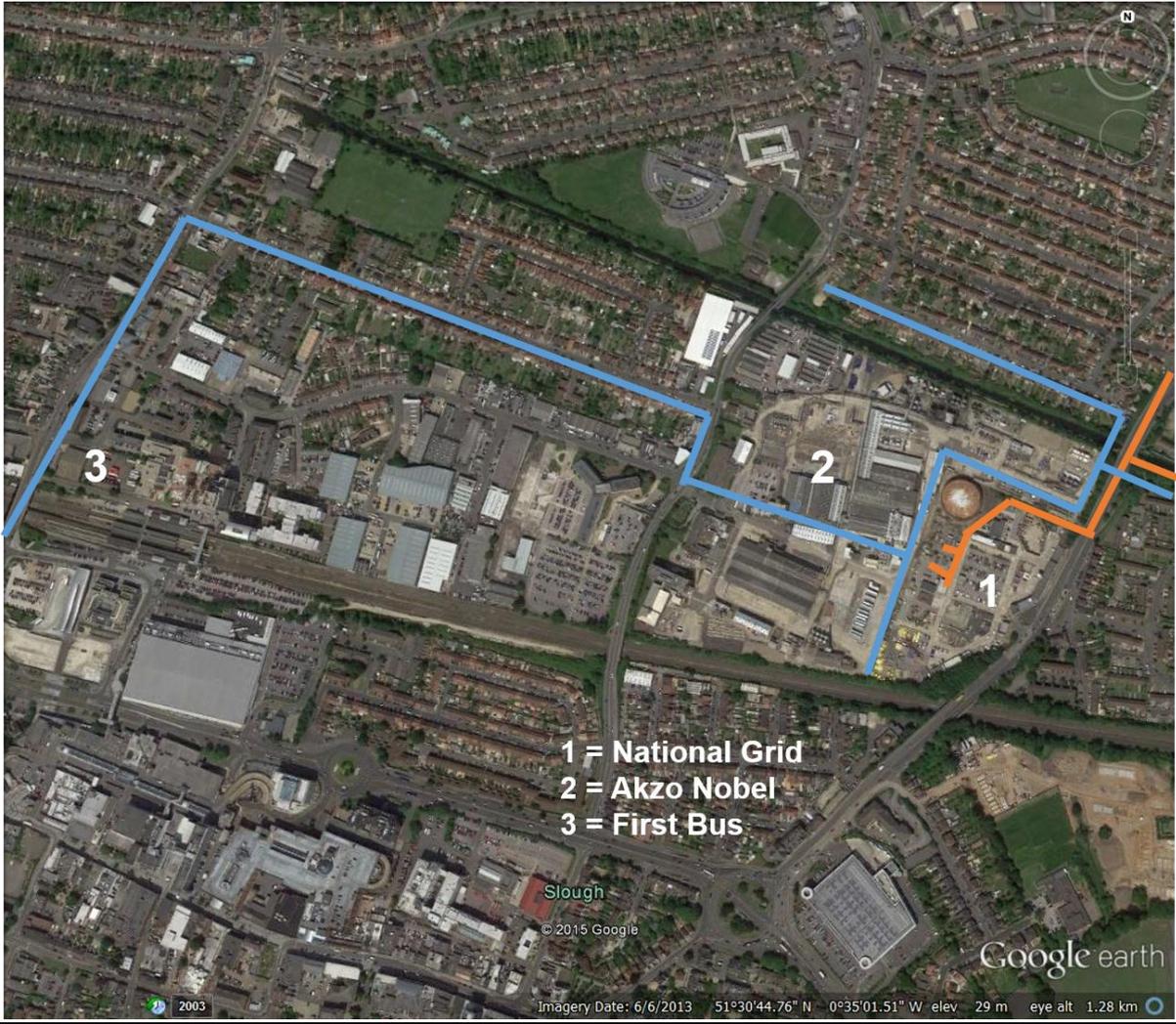


Figure 11: Position of gas mains in and around the Akzo Nobel site



Figure 12: Close up of Akzo Nobel site and associated gas mains

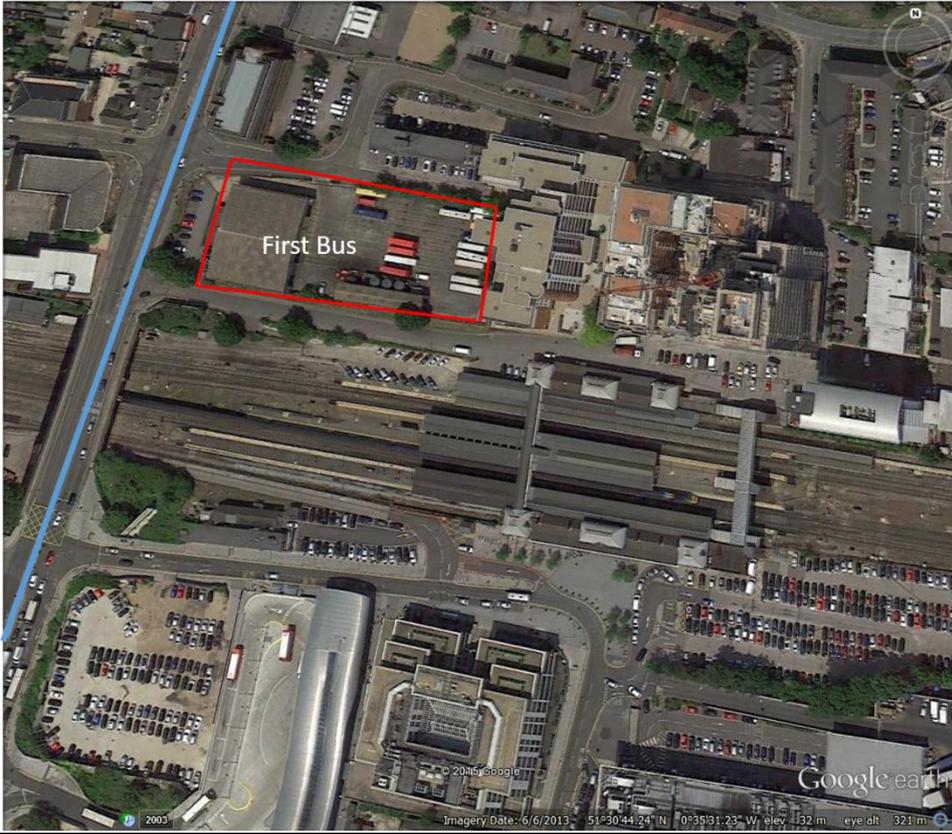
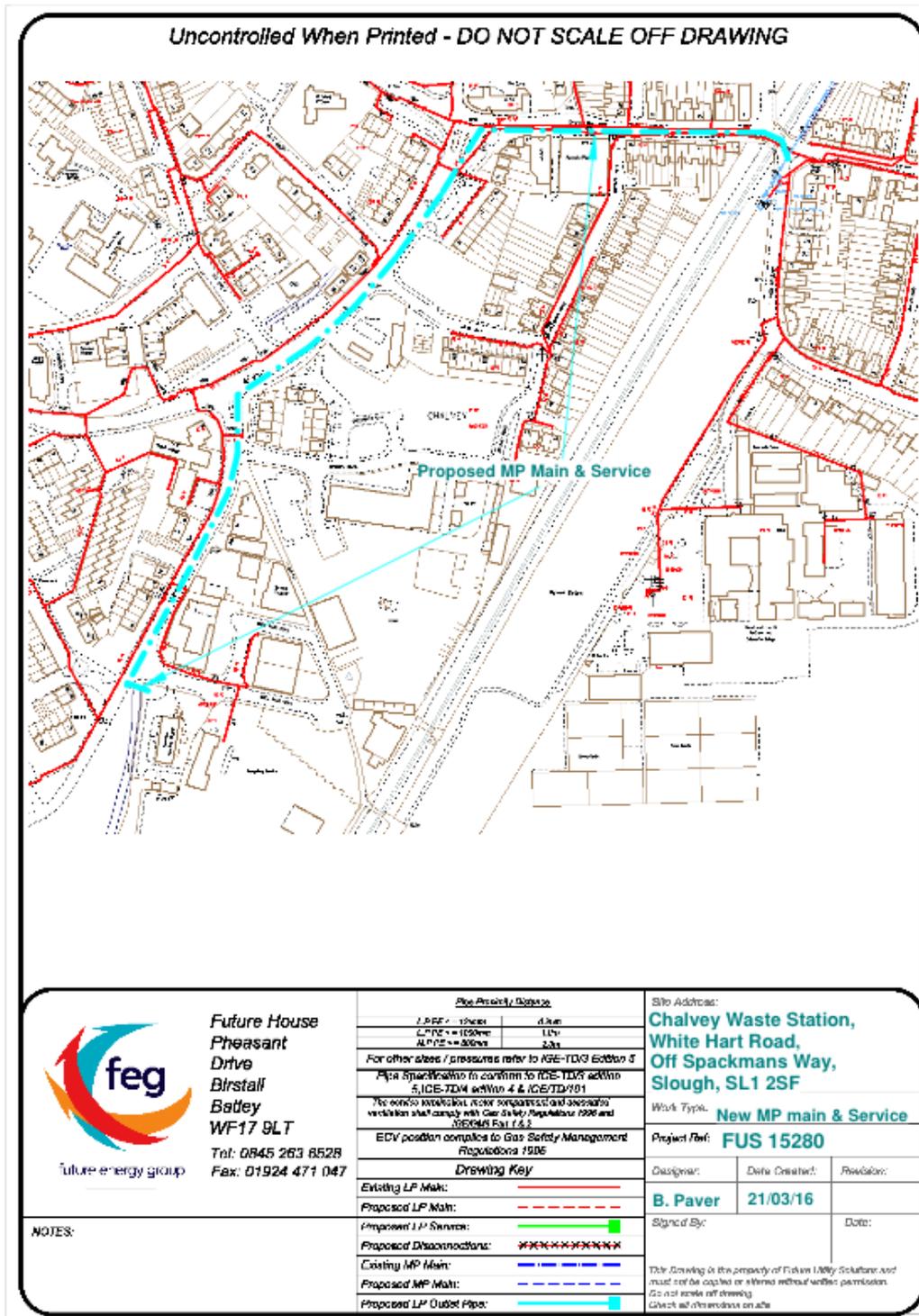


Figure 13: Location of Slough Station and First Bus depot

Budget quotation for full Turn Key delivery as per the above is £195,000 to include the laying of new main, service, meter, kiosk and base. It excludes any out of hours working, any specific highways stipulations i.e. road closures weekend working etc., outlet.

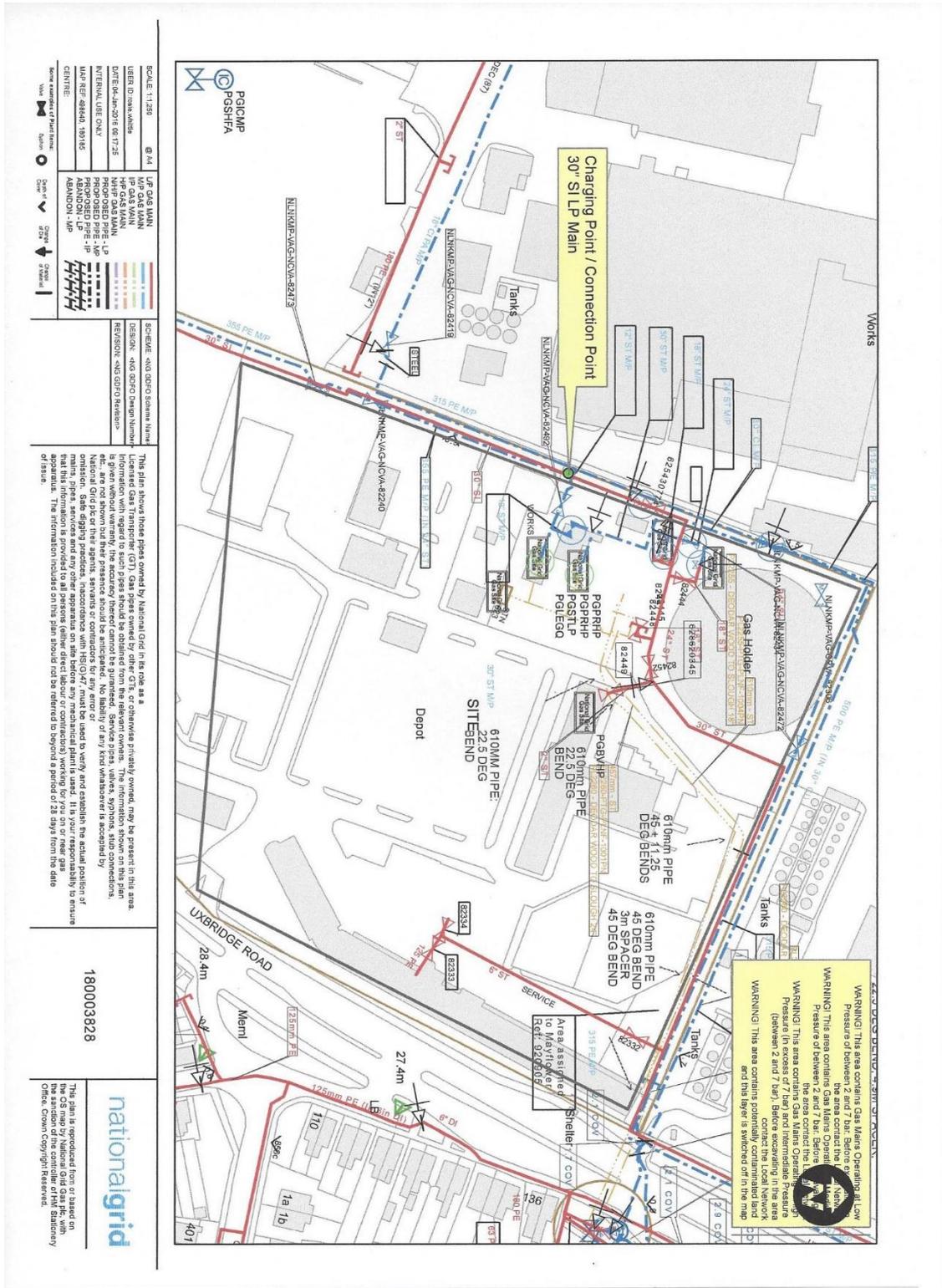
The map below shows the new proposed gas main (Light Blue) to facilitate the gas offtake requirement. This is a medium pressure gas main that will provide dry gas at the required volumes to the facility at a pressure of up to 2 bar.



g:\data\fus 15280 - Approximate Scale 1 in = 250 feet

b) Land Enquiry for Proposed Development Site at NEW SUPPLY, AKZO NOBEL SITE, WEXHAM ROAD, SLOUGH, SL2 5DS.

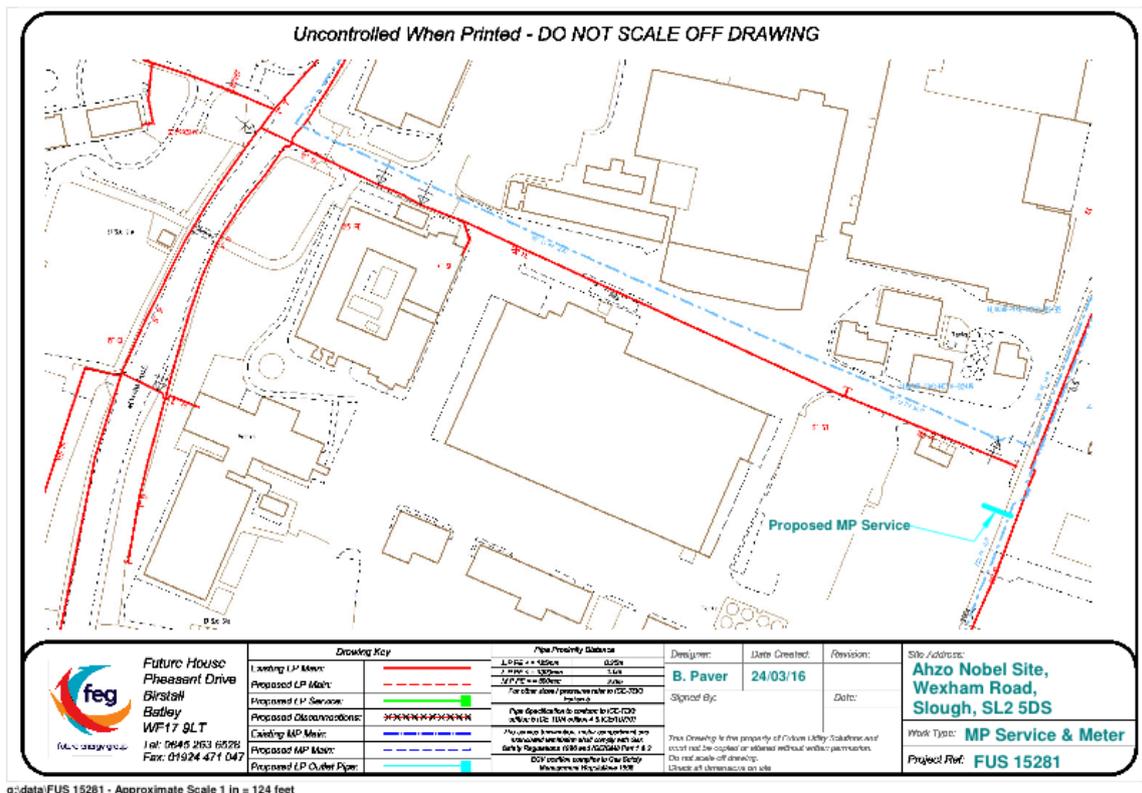
The nearest main with sufficient capacity is 5 metres from the site boundary and it is a Medium Pressure main.



Budget quotation for the above is £74,000 to include Service, meter, kiosk and base. It excludes any out of hours working.

The reason for the lower cost is that according to Section 50's it looks like the existing mains are within the site curtilage.

The map below shows the new proposed gas main (Light Blue) to facilitate the gas offtake requirement. This is a medium pressure gas main that will provide dry gas at the required volumes to the facility at a pressure of up to 2 bar.



4.3.3 Estimated station costs

Station costs are estimated to be in the region of £823,000⁶. This would be for a complete 'turn-key' CNG refuelling station to allow for the refuelling of the entire RCV fleet at Slough (analysed at 25 vehicles). It would include all civils, electrical connections (on the basis of available electric capacity), installation and commissioning. Given the station is drawing from a medium pressure gas main there should be no need for gas dryer before the gas compressor.

The proposed design would include a 5 stage Gas Compressor, 3 x compressed gas storage capacity (at 150bar, 250 bar and 300 bar pressure) along with a refuelling dispenser. The dispenser would have both NGV1 and NGV2 type hoses and nozzles to allow for both truck and van refuelling. The compressor would be sized to allow for between 4-6 truck refills per hour (in line with current diesel refuelling times).

These costs break down as follows:

⁶ This is over and above the cost of connecting to the gas grid as detailed in section 4.3.2.

Compressor	£240,000
Gas Storage (1 day's usage)	£ 82,000
Dispensers (3 off)	£ 75,000
Fuel management system	£ 9,000
Acoustic Cabinets	£ 18,000
Gas Pressure Pipework	£ 37,000
Gas Connection (on site)*	£ 45,000
Electrical Connection**	£ 52,000
Equipment Installation	£ 38,000
Civil Engineering	£ 80,000
Planning/design	£ 25,000
Project Management	£ 42,000
Contingency	£ 80,000

Total	£823,000

* includes metering

** includes metering and HV connections



Figure 14: Typical CNG refuelling station

One alternative to purchasing a station is to buy the gas on a 'wet contract'. Under this arrangement, the fuel supplier provides the station and arranges for it to be installed and

maintained, adding a small amount to the price of each kg of gas to cover the associated costs over the lifetime of the contract.

This arrangement has several advantages. Gas supply companies typically will have creditors suited to lending at good rates against the assets, and they will have the technical experience and capacity to scale the gas station equipment through time to match the required throughput as the fleet expands.

4.4 Estimated payback for gas vehicles and infrastructure

By simply dividing the upfront costs of vehicles and infrastructure by the annual fuel savings achieved, a simple payback time in years can be calculated. This is used here to illustrate the broad feasibility of a switch to gas RCVs. A full business case would also take into account the likely cost of capital and other factors to more accurately characterise the return on investment (ROI).

4.4.1 Payback time – vehicles only

Based on a £27,000 on-cost over Euro VI diesel, the payback for Slough’s RCVs if switched to gas is estimated at around 5 years. In Table 4 below the range of payback times can be seen for the different fuel price scenarios (assuming average vehicle efficiency).

The table also illustrates the effect of one possible strategy to reduce the vehicle cost. As noted in section 4.1, much of the extra cost of a gas vehicle is due to its fuel tanks. According to the data provided, all but three of the Slough RCVs appear to do less than 65 km/day. Provided they are able to refuel every day, these vehicles could be ordered with only a single bank of fuel tanks (as opposed to the normal two), thus saving around £5,000 per vehicle.

Table 4: Simple payback time for gas vehicles under different scenarios

Scenario	High price difference – 42p	Low price difference – 26p
Vehicle on-cost £27,000	4.2 years	6.1 years
Vehicles specified with smaller fuel tanks, on-cost £22,000	3.4 years	5.0 years

4.4.2 Payback time – vehicles and station, Chalvey site

However, the vehicles are not the only capital cost, the station must also be considered. As analysed, the 20 RCVs if converted to gas would consume around 200 tonnes of gas per year. This is a relatively small amount for the installation of grid connected refuelling infrastructure. The total cost of station and grid connection at the Chalvey site would be £1,020,000, which if spread over 10 years would amount to 51p for every kg of gas delivered. On this basis the payback period is impossible to quantify as it is in the order of 30-40 years, during which time costs, taxes and other variables are likely to have changed significantly.

There are two possible ways to reduce the station costs. The first is to make operational changes that extend the ‘filling window’ for the vehicles, thus allowing fewer or smaller compressors to be specified. The second would be to buy the gas on a ‘wet contract’, in which the gas provider also provides, owns and maintains the fuelling station, passing the cost on as part of the per kg price charged for the gas.

The major expense in a CNG filling station is compressors, and the more vehicles need to be filled in a given time, the larger or more numerous the compressors must be. If changes can be made to

operational practices, it can have a big impact on the cost of the station required. If half the vehicles are filled at the start of their shift, and half at the end, this would make a big difference. If the shifts can then be staggered, at say half hour intervals, then this could further extend the window of time in which vehicles can be filled. Individual fills can still be completed in a comparable time to diesel filling⁷, but with more time in between fills. It is difficult to quantify what level of saving could be made through this approach, and while it will be worth investigating it is unlikely on its own to make the project payback in a reasonable time.

Purchasing gas on a ‘wet contract’ would probably have a considerable cost benefit. Based on conversations with potential fuel providers, we have an estimate that a station could be provided at roughly 20p additional cost per kg of gas supplied over a 10 year contract. This would not include the cost of the grid connection, but would still be significantly lower than the 51p per kg of owning the station as calculated above, bringing the overall payback period down to between 8 and 15 years depending on how fuel prices develop. This could again be reduced further if the vehicles were specified with smaller fuel tanks. The wet contract would also include the maintenance on the station, and pass responsibility for the infrastructure to an experienced third party.

Table 5: Simple payback time for gas vehicles and station at Chalvey under different wet contract scenarios

Scenario (Wet contract)	High price difference – 42p	Low price difference – 26p
Vehicle on-cost £27,000	8.1 years	14.9 years
Vehicles specified with smaller fuel tanks, on-cost £22,000	7.0 years	12.8 years

4.4.3 Payback time – vehicles and station, Wexham Road site

The major benefit of developing the Wexham Road site described in section 4.3 would be the potential to sell gas to a third party, specifically the bus company.

Based on data provided by First Bus in Slough last year, it is understood that the fleet of 55 buses (of which 50 are operational daily) consumes around 1.5 million litres of diesel per year. If First Bus were to agree to operate a significant part of its fleet on gas from a station developed on the Wexham Road site, this could reasonably see sales of 1 million kg of gas per year.

Several bus companies in the UK are now operating buses on biomethane, including in nearby Reading, and in doing so they are able to claim an additional government subsidy of 6p/km, making it financially attractive. If Slough Borough Council were to develop this site on a wet contract basis with a third party gas supplier, as the owner of the site they would expect to negotiate a small margin on those sales of gas.

Table 6 below shows the payback period for vehicles and station at the Wexham Road site, assuming a wet contract and third party sales. The sales margin is assumed to be 3p/kg on 1 million kg of gas, and the lower cost of grid connection to the site is also factored in to the calculation.

Table 6: Simple payback time for gas vehicles and station at Wexham Road, with wet contract and third party sales

Scenario (Wet contract, £30,000	High price difference – 42p	Low price difference – 26p
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⁷ This is achieved by use of a bank of pressurised gas storage, which is ‘charged’ by the compressors and then allows a fast fill. Between fills the bank is then recharged by the compressors running more steadily.

margin on third party sales /yr)		
Vehicle on-cost £27,000	5.1 years	7.7 years
Vehicles specified with smaller fuel tanks, on-cost £22,000	4.3 years	6.5 years

It should be noted that a payback as swift as shown in the table above would be unlikely to be achieved in practice, as the bus company would take a number of years to switch vehicles to gas. However, it illustrates the comparative benefit of this approach compared with the Chalvey site. The station would ultimately need to have a larger capacity to service the extra vehicles, but under a wet contract the gas supplier would bear this cost as their own margin would be increased by the higher volume of gas sold.

5 Summary and conclusions

There are currently few viable options for making significant cuts to the emissions of SBC's RCV fleet over and above what can be achieved by Euro VI diesel. Full electrification is currently not an option, while full hybrids are extremely expensive and at an experimental stage. The market tested options are hybrid or electric bodies, and gas vehicles running on biomethane.

SBC's own experience of partially electric bodies suggests they offer little benefit at quite high cost. The use of biomethane fuelled vehicles is bolder, requiring as it does an investment in both vehicles and infrastructure, but the projected benefits are much higher, and there is precedent from other councils in the UK that have made this choice.

The principle benefits of switching to gas are emissions savings and noise reduction. In the previous report for Slough we highlighted the emissions savings from a range of options, including biomethane. The largest saving vs Euro VI diesel would be in greenhouse gas (GHG) emissions, estimated at 693 tonnes CO₂e per year, with NO_x around the same as Euro VI diesel, and lower particulates. The fact that gas vehicles are noticeably quieter than diesel would be a particular advantage for RCVs although of course this benefit is hard to quantify.

Gas vehicles have the potential to deliver these benefits at no net cost over the lifetime of the vehicles, although this will depend on several factors and cannot be guaranteed. The cost of providing a fuelling station is a significant barrier given the economies of scale required, and the relatively small amount of gas required by the SBC fleet. The cost, and risk, of investing in fuelling infrastructure is likely to be considerably lower if outsourced to a fuel provider on a long term contract, and this would be the recommendation of this report.

It is feasible to convert the SBC RCV fleet to gas operating from the current Chalvey site. However, even with a third party fuel and infrastructure provider, this would only be cost neutral within the lifetime of an RCV (assumed to be 7 years) under a 'best case' scenario. If this option is to be pursued, in order to minimise the financial risk, this report would recommend exploring ways to minimise the cost of vehicles and infrastructure by modifying operating practices – something which we recognise is not always easy in waste operations.

If it is feasible from a development point of view, and if it is possible to gain interest from First Bus, there would be clear advantages to developing a joint bus and RCV fuelling station at Wexham Road. By generating income from sales of gas to the bus fleet, SBC could potentially gain the emissions and noise benefits of a switch to gas in a cost neutral manner, even without changes to operating practice and in more challenging fuel price conditions.

6 Appendix A: Note on gas vs diesel prices

Historically, at a wholesale level, gas prices have broadly tracked oil prices, as illustrated in Figure 15 and Figure 16 below. This is largely because most of the world's gas was traded on contracts index linked to the price of oil, although this is now changing with the emergence of an independent global market in gas.



Figure 15: Spot gas prices at the UK National Balancing Point (NBP) for the last 5 years, p/therm (source Heren report)

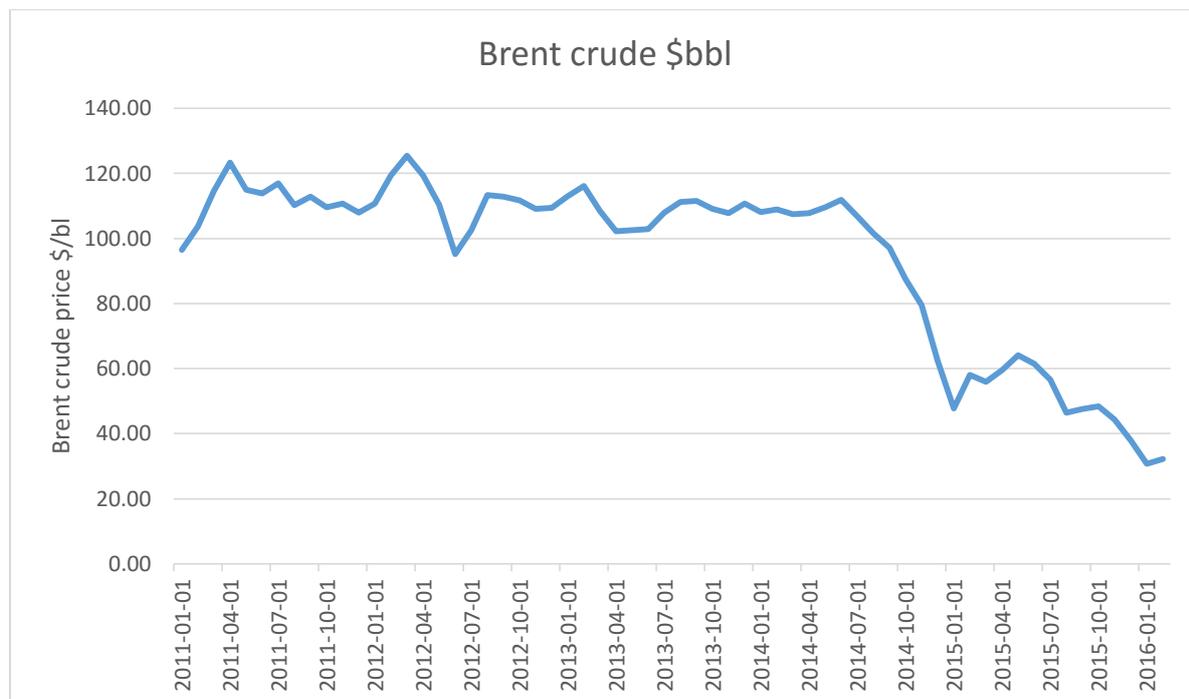


Figure 16: Price of Brent crude in dollars per barrel, last 5 years

Gas prices have also generally lagged behind oil prices as gas is bought on longer term contracts. For this reason, at times of falling oil prices, the differential between oil and gas has fallen, whereas when oil prices rise, the gap gets wider.

Although the current differential between diesel and gas is at an historic low, there are good reasons to expect it to increase in the coming months/years. Firstly, oil price is currently climbing, and although most analysts do not expect it to climb back to \$100 pbbl, it is expected to reach a new equilibrium higher than the \$30 pbbl seen in recent months. Secondly, large amounts of extra gas capacity, particularly in LNG (which is internationally traded) are due to come on-stream in the next two years. The investments in this extra capacity were initiated many years ago with a view to servicing Japan and the rest of East Asia, where demand is less than was predicted, leaving the global gas market oversupplied.

One other key difference between oil and gas prices at the consumer end is that the price paid is much more sensitive to the volume being taken. Although wholesale diesel prices are a little lower than the normal pump price, the spread is quite small. By contrast, industrial users of gas can expect to pay half the price of domestic consumers, with a range of prices in between.