Royal Borough of Kingston

Royal Borough of Kingston Detailed District Heating Network Feasibility Study

Kingston DE Network Supply Options Note

RBK/239585/DHSN

Issue | 24 November 2014

Job number 239585-00

Ove Arup & Partners Ltd
13 Fitzroy Street
London
W1T 4BQ
United Kingdom
www.arup.com

ARUP

Document Verification

ARUP

Job title	Royal Borough of Kingston Detailed District Heating Network Feasibility Study			Job number 239585-00
Document title	Kingston DE Network Supply Options Note			File reference
Document ref	RBK/239585/DHSN			

Revision	Date	Filename	Kingston Energy Supply Options Study 2014-11-24-Issue.docx		
Issue	24 Nov 2014	Description	First draft		
			Prepared by	Checked by	Approved by
		Name	Alexandre Moor	Thomas Hurst, Oliver Pitchers	Stephen Cook
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			

Issue Document Verification with Document ✓

Contents

1 Summary

This note gives an overview of initial considerations regarding energy, specifically heat, provision for a potential Decentralised Energy (DE) network in the Kingston town centre area. Every supply technology that has been considered is outlined with a brief description of its particulars, as well as commentary on its greenhouse gas emissions reduction potential, system resilience implications, and notable risks.

All options are able to provide heat to the area via a district heating network. As such, the focus is on analysing potential sources of supply for the energy centre.

The table below provides a brief summary of the options, their key features and whether they are suitable or unsuitable for consideration as a supply source for a DE network at Kingston.

A number of options have been rejected from the analysis due to their low likelihood of receiving planning permission and/or their technical unsuitability for Kingston. There are a number of options which are assessed at this stage to be technically feasible and, although unable to supply a district heating network from a single point, are able to contribute to a district heating network in conjunction with other systems. While some are prioritised for analysis as below, the carbon, cost, and risk performance of each will be used to further prioritise options in later stages of this assessment.

Table 1. Summary of supply options considered

Option	Comments	Shortlisted in previous study?	Preliminary Conclusion
Gas			
Gas boilers	Ubiquitous, reliable, flexible, cheap, no carbon savings	Not shortlisted as a primary option however included for back up	Secondary / top-up option
Gas CHP	Ubiquitous, reliable, cheap, modest carbon savings	Shortlisted option	Shortlisted option
Gas CCHP	More complex but reliable, suitable where large cooling loads are present, modest carbon savings	Not shortlisted	Option to keep in mind
Solid fuels including biomass and waste			
Biomass boilers	Reliable, requires storage and supply chain, low carbon. Supply chain and transport issues dependant on energy centre locations.	Not shortlisted	Shortlisted option
Biomass CHP	Less common, requires storage and supply chain, air quality and transport concerns, less flexible, low carbon	Not shortlisted	Rejected
Energy from Waste	Suitable where residual waste supply is secure, low carbon in CHP mode, may be strongly opposed locally. Existing plant in Sutton was estimated to be too expensive to connect to Kingston town centre DH network in Energy Masterplan.	Not shortlisted	Rejected

Option	Comments	Shortlisted in previous study?	Preliminary Conclusion
Heat pumps			
Air source heat pumps	Reliable, flexible, low COP, low power density, lower output temperature, can be used for heat and cooling, modestly low carbon	Not considered previously	Option to keep in mind
Water source heat pumps	Similar to ASHP but with better COP, some challenges with installation	Shortlisted	Shortlisted option
Ground source heat pumps	Similar to ASHP but with better COP, groundworks can be challenging and unlikely to find sufficient area for groundworks to serve an entire district heating network	Not shortlisted	Option to keep in mind
Deep geothermal	Very good COP, very high capital costs, reliable	Not considered previously	Option to keep in mind
Energy piles	Special form of GSHP, suitable where piled foundations are required although likely will not be able to contribute a significant supply to the sitewide district heating network	Not shortlisted	Option to keep in mind
Other options			
Anaerobic digestion	Low carbon, requires supply chain, requires significant space for operation, risks from odour and traffic	Not shortlisted	Rejected
Gas let-down station	Novel technology however no suitable sites within Kingston	Not shortlisted	Rejected
Solar thermal	Very low carbon, reliable, low yield	Not considered	Secondary option

2 Review of Previous Work

The July 2013 Energy Masterplan report commissioned by the Royal Borough of Kingston included a comprehensive energy supply technology options analysis as well as a review of potential energy centre locations for the Kingston town centre district heating scheme.

The Energy Masterplan identified three potential energy sources to serve a district heating network; Gas-fired CHP, biogas-fired CHP and water source heat pumps. There a wide range of potential energy sources and secondary heat sources studied although only two secondary heat sources were identified; the River Thames and the Hogsmill Sewage Works Outlet water.

Potential locations for energy centres were evaluated in the Energy Masterplan which identified Kingston University, the redevelopment of the Eden Quarter, the Kingfisher Leisure Centre redevelopment and sources of secondary heat for example Hogsmill Sewage works as potential locations. The location of one or multiple energy centres will be typically guided by the following key principles;

- Located close to the district heating networks transmission core (or the “centre of heat demand”) to reduce pipework costs;
- Situated within “Phase 1” of the network to avoid requiring the installation of additional pipe routes to connect the initial heat loads;
- The distance from neighbouring buildings is important since it will determine the required flue stack heights and have impacts on air quality which may in turn restrict the fuel source
- The energy centre should facilitate fuel delivery where required to prevent disruption to residents and minimise transport
- Potential sites with interest in hosting an energy centre will far more likely result in ultimate scheme commercialisation.

Further detailed investigation into energy centre locations will be undertaken following the final design of the district heating network and connected loads of the Kingston district heating network.

1.1 Supply Options Evaluation

The following pages present an evaluation of the various supply options that show potential for a heat network at the Kingston site. They have been colour coded according to their appropriateness for further investigation in this study, as shown in the key below.

Gas: delivered by pipeline, fossil fuel, flexible, ubiquitous, reliable, cheap

- Gas boilers
- Gas CHP
- Gas CCHP

Solid fuels including biomass and waste: requires surface transport and on-site storage, partially or wholly renewable, supply chains and provenance must be investigated and secured

- Biomass boilers
- Biomass CHP
- EfW

Heat pumps: use refrigerants, performance expressed in terms of COP, work better with low temp systems, can provide heat and coolth, lower power density (can be space hungry but depends on the heat source or sink), goes with the grain of grid decarbonisation.

Other: a mix of unusual options.

- AD
- Gas let-down
- Solar

Colour Code:

Investigate
Neutral
Do not proceed

Technology	Technology Description	Greenhouse Gas Reduction	Resilience Implications	Risk Review
Gas				
Gas CHP	Combined heat and power (CHP) systems capture the heat released during the power generation process, resulting in higher system efficiencies. The heat to power ratio normally determines the size of the gas CHP unit that is viable for a given building or site load. The typical target for CHP engines are to ensure at least 5,000 running hours per annum (out of a total of 8,760 hours in a year). The economics of gas CHPs are most favourable in mixed land-use and high density developments. On a micro-generation level, gas CHP systems are more expensive than gas boilers, while the installed cost for CHP engines per kW of capacity falls as the engines increase in size. Gas CHP systems are easy to install, use, and maintain. They use the same natural gas supplied by any gas provider although for larger units may require a gas booster to achieve the minimum input pressures required.. In cases where there is a significant cooling baseload such as a data centre, combined cooling, heat, and power (CCHP) systems can become feasible as well. The total gas consumption from a CHP will be higher than if gas is used locally in a gas fired boiler for heat only production. As well as an increase in gas consumption, CHP units are typically reciprocating gas engines which results in higher local emissions of NOx and other pollutants compared with a base case of a building by building solution of gas boilers.	A well-designed gas CHP can reduce carbon emissions due to its higher efficiency compared to the alternative case of conventional gas boiler and grid electricity produced mostly by large distant "power only" power stations. As in the case of all other embedded generation options presented here, gas CHPs located close to the point of consumption eliminate electricity distribution losses and therefore reduce carbon emissions. It is important to consider, however, that in line with UK Climate Change Act targets (for an 80% reduction in national GHGs by 2050 vs. 1990 levels) grid electricity will need to almost completely decarbonise. In a decarbonised, or rapidly decarbonising, grid scenario, gas-fired CHP does not offer CO_2 savings over a boiler-only + grid electricity solution, resulting in lock-in of excess emissions until the end of the system's lifetime or its premature retirement (which would be financially unattractive).	Gas CHPs and most of the other micro generators described here are usually designed for grid-parallel connection, contributing to the baseload of a building or site and thereby offering resilience to systemic failures. The systems can also be sized and designed to provide a full islanded operation with a mini-grid serving a defined network of electric loads. This can provide benefits where there are significant limitations on the capacity of the distribution network but will add considerably to the complexity of the energy system. A mini-grid may also introduce new vulnerabilities if the system is not connected to the main grid. Overall, a hybrid approach where boilers are used to provide top-up heat yields better resilience for the heat network (and better economics).	Local air quality restrictions may lead to objections to deployment of large scale CHP. However this risk can be mitigated through appropriate siting and stack height. Typically a CHP system provides the best economics when all electricity is consumed locally, i.e. to offset electricity imported from the grid due to the low export price normally obtainable by a small electricity producer. Over-sizing CHPs (e.g. to meet peak load) will erode the marginal viability of the additional plant. This situation can be improved by selling electricity privately through a private wire connection or by retailing electricity (possibly through the Licence Lite programme). Although CHP engines would be installed in modular units, the viability of the CHP investment will be poor until the heat network builds up to a sufficient load to ensure steady operations of the engines. It may be appropriate to run a network initially on a boiler-only basis in the early phases of the scheme. The high temperature heat delivered by CHP systems may be incompatible with low-carbon heating solutions which might wish to use a DH network at Kingston in the future, as most favour relatively low temperature heat provision. The choice of temperature regime of the network is also crucial for developers, who will need to specify internal systems appropriately.

Technology	Technology Description	Greenhouse Gas Reduction	Resilience Implications	Risk Review
Gas Boiler	Gas boilers provide top up and back up when deployed in conjunction with any other technology option discussed here. They are likely to offer the cheapest solution even with the subsidies available to the renewable alternatives discussed here.	Gas boilers are the most conventional solution for heating in the UK. They have higher carbon emissions compared to all other options discussed here.	Being a well-developed technology, gas boilers can offer resilience at low costs. They can be used in conjunction with a variety of primary heat supplies to provide top up and back up heat.	No significant risks.
Solid Fuels Including Biomass and Waste				
Biomass Boiler	Biomass resources include wood and wood wastes, agricultural crops and their waste by-products, municipal solid waste, animal wastes, waste from food processing and aquatic plants and algae. Biomass boilers are a proven technology that is able to provide reliable base-load capacity. In many applications, they can be relatively capital-light (although always more expensive than equivalently sized gas boilers). The heat they produce isare eligible for Renewable Heat Incentive (RHI) payments.	The sustainability of biomass can differ greatly by how it is harvested, and can lead to air quality issues (due to particulate matter and NOx emissions) if inadequate abatement measures are in place. The actual net emissions also depend significantly on the distance of the biomass supply and the means of transport to deliver it to site.	Biomass boilers are a well-developed and resilient technology. They can provide a reliable baseload or back up / top up renewable sources such as solar thermal to improve overall reliability. Dependence on fuel deliveries can be a resilience issue, though readily mitigated by building in appropriate redundancy in storage capacity.	Compared to gas fired boilers, biomass boilers are generally less capable of load modulating due to start and stop lags of the heat source, with the exception of biodiesels. Modulation can, however be managed by using appropriately sized and dispatched thermal storage. A biomass solution would require (planning) consideration of transport/traffic implications, as regular pellet / chip / fuel deliveries by truck would be necessary. Noise impacts can be minimised by sizing long-term storage capacity to reduce the frequency of deliveries necessary; gasholder superstructures could make an appropriate storage solution. Biomass energy generally suffers from poor air quality perceptions, due to relatively high NOx and particulate emissions. However, NOx emissions for well-commissioned boilers and good feedstock are generally equivalent to those from gas CHP. Particulates, meanwhile, can be reduced to sub 2.5 microns with inexpensive catalytic filters. Further investigation and detail into the suitability of biomass boilers will depend on the final route and connected customers to the district heating network to evaluate transport and air quality restrictions surrounding the Kingston town centre area.

Technology	Technology Description	Greenhouse Gas Reduction	Resilience Implications	Risk Review
Biomass CHP	Biomass CHP is a mature technology that is based on either (i) Organic Rankine Cycle (ORC) or (ii) gasification processes. Anaerobic digestion is not considered here. As in gas CHPs, the heat to power ratio determines the size of the biomass CHP unit. Heat from biomass CHP is eligible for Renewable Heat Incentive (RHI) payments. In both cases biomass system will require considerably more space than a gas CHP engine. The generation plant itself is larger and the biomass will need to be stored on site in a silo or bunker sufficient for a few days' supply. As a general rule, NOx performance is similar or better than gas CHP but PM_{10} is generally worse, though this can be significantly mitigated with the use of filters. Large scale combustion would normally be accompanied by active stack emissions control technologies such as regenerative thermal oxidation (RTO).	Biomass CHPs significantly reduce net carbon emissions. However the actual net emissions depend significantly on the distance of the biomass supply and the means of transport to deliver it to site.	The resilience implications for biomass CHO are similar to those for gas CHP. A further resilience consideration relates to the supply chain. Resilience of biomass is potentially higher due to the on-site storage of fuel (gas would be piped on site to meet demand as it occurs). However the reliability of the fuel source would be more uncertain than for the gas network.	Fuel storage and delivery capacity can be the main risks related to the operation of biomass CHP. In case of a district heating scheme that is based on biomass CHP, the security of biomass fuel supply becomes even more critical.
Energy from Waste (EfW)	Incineration at high temperatures (above 850°C) to generate electricity and heat is the most well-known process for EfW, with the heat able to be exported to the Kingston network. Different EfW thermal processes for different commercial technologies include: - incineration (fluidised bed or moving grate) - gasification (draft, draft down, entrained flow, fluidised bed) - pyrolysis (not commercially developed in the UK) - plasma gasification (emerging technology; limited new facilities under construction in the UK such as Tees Valley). Non-thermal processes include anaerobic	There is active debate about the overall emissions associated with EfW systems. In general it is better to reuse and recycle waste materials rather than recover energy from them. For residual waste which cannot be recycled, EfW offers a significant carbon performance compared with other disposal options such as landfill. Typically around half of municipal solid waste (MSW) is from organic sources (i.e. biomass) and is therefore residual MSW considered a partially renewable fuel. Where a heat offtake can be secured for the EfW facility then the carbon performance is even better. This would of course be the scenario contemplated for this study	Conventional incineration is a tried and tested technology which offered very high reliability for a well-designed and maintained system. Other EfW technologies are more novel and therefore their reliability and longevity remains to be proven. As with biomass, fuel supply chains can represent a risk to the long term operation of a facility. Municipal facilities have a secure supply through the collection of household waste, although arisings are closely correlated with the performance of the local economy, therefore a recession will reduce waste arisings. Commercial	Stringent European and national environmental regulatory requirements make larger plants more cost effective through economies of scale. Local opposition can delay or frustrate EfW development proposals.

Technology	Technology Description	Greenhouse Gas Reduction	Resilience Implications	Risk Review
Energy from Waste (EfW)	digestion (AD) (see below). As discussed in the Energy Masterplan, there is an existing EfW plant located in Sutton however it is likely that it will not be economic to connect it to a district heating network located in Kingston town centre.		waste is contracted on relatively short terms and can therefore be more variable.	
Heat Pumps				
Air Source Heat Pump (ASHP)	ASHPs operate using the vapour-compression cycle similar to that of a domestic refrigerator turning a unit of high-grade electrical energy into multiple units of low-grade heat energy This ratio of input electric power to output thermal power is called the coefficient of performance (COP). The COP varies through the year with the air temperature (warmer air gives a higher COP). Average – or seasonal – COPs for ASHPs are typically around 2 to 3. ASHPs have a relatively low power density and offer limited economies of scale. They are therefore more typically suitable for individual building solutions rather than for a centralised energy centre powering a heat network. Their heat output eligible for Renewable Heat Incentive (RHI) payments that vary according to scale.	Electrification of heating and cooling can bring significant carbon emissions reductions if given that electricity comes from on-site renewable sources or as the national grid is being decarbonised. Nevertheless, ASHPs typically represent the poorest heat pump option, with ground source, water source and other secondary heat source heat pumps offering higher COPs and therefore better carbon performance. Heat pumps often use refrigerant fluids (Hydroflourocarbons, or HFCs) which are themselves potent greenhouse gases.	In the non-extreme weather conditions of London, ASHP can provide a resilient solution in tandem with other technologies such as boilers.	When external temperatures are very low (e.g. below 3-4°C), ASHPs may produce almost the same amount of heat as electricity consumed, leading to low efficiencies and carbon benefits. ASHPs are best suited for low temperature heat networks, generally requiring boiler top-up if they are to be used on high temperature networks (and to cope with winter peak demand).
Water Source Heat Pumps (WSHP)	WSHPs function identically to GSHPs, but use water as the heat source. They may work via direct abstraction or indirectly with coolant pipes. The location of the River Thames and the precedence of the Kingston Heights development's use of WSHPs are noted.	WSHPs generally achieve better efficiencies than GSHPs or ASHPs. The COP depends on the temperature profile of the water source, with a typical range of 4 to 6 being achievable.	These systems have low maintenance costs and can be expected to provide safe, reliable and low carbon heating.	The nature of the water source and its frequent use by vessels navigating the river may prove problematic installing a large scale water or heat extraction system from the river without introducing a hazard for the vessels. Discussions will be required with the Environment Agency to secure an appropriate abstraction licence. Aquatic ecology impacts from WSHPs for heating are less of a concern, since the removal of heat from the water source will cool the water and

Technology	Technology Description	Greenhouse Gas Reduction	Resilience Implications	Risk Review
Water Source Heat Pumps (WSHP)				thereby help to raise dissolved oxygen. Using water sources for cooling (i.e. to dump heat) is typically much more at risk of ecological impacts.
Deep Geothermal Energy	Heat from the earth or geothermal energy, can be access by drilling water or steam wells in a process similar to drilling for oil. It is widely accepted that geothermal energy is an enormous underused heat and power resource that is clean and reliable (95% average system reliability). It has 2 key applications: 1. Power generation – Where suitable geology exists, wells of over 2,000m depth can be drilled into underground reservoirs to tap steam and very hot water to propel turbines that drive electricity generators. London geology does not lend itself to this application, and in Kingston a straightforward grid connection is far more suitable for electricity provision. 2. Heating – wells if up to 2,000m depth can be drilled into underground reservoirs to tap hot water that can be brought to the surface for use in a variety of applications. The brownfield nature of the Gasworks site, in particular, means that drilling rigs could readily be used pre-development to produce hot water boreholes.	Despite their high capital costs, geothermal energy systems have very low maintenance costs and provide low carbon energy over long lifetimes, given the availability of adequate geothermal sources at the site. The COP of heat-only geothermal systems can be 20 or higher, depending on how the heat is used.	As stated, this is an extremely reliable means of renewable energy with 95% average system availability. This means a robust and resilient installation. Ground storage of building heat energy can provide resilience in the form of time-shifting.	The main focus is on the required groundwork to bore to the required depth. Risks include the undermining of building foundations (likely not relevant in the expansive gasworks site), and potential complications that would be caused by the amount of existing services in the ground around that area (utilities, trains, underground). These risks in Kingston are possibly less likely than in some more heavily built-up urban areas in London. In addition to the drilling risks, temperatures and water permeability at the target depth are not certain; therefore the operational performance and cost of a geothermal system cannot be firmly predicted. This risk is higher for CHP systems but is not negligible for heat-only systems. Capital costs are likely to prove a greater barrier to this technology, particularly with the expected build-out profile, but it is noted that geothermal heat does qualify for the non-domestic RHI. Overall London's deep geology is less well suited to geothermal energy than other "hotspots" in the UK such as Cornwall, Cheshire and the North East of England.
Ground Source Heat Pumps (GSHP)	Generally, the upper 3 metres of the Earth's surface maintains a nearly constant temperature between 10 and 16^{o}C. A ground source heat pump system in its most basic form consists of pipes buried in the shallow ground near the building, a pump and a heat exchanger. Deep boreholes	Similar to ASHP, electrification of heating and cooling services though GSHP brings carbon reductions if that electricity is supplied from on-site or near-site renewable sources or as the national grid is being decarbonised. A typical seasonal COP for a well-designed	These systems have low maintenance costs and can be expected to provide safe, reliable and low carbon heating for well over 20 years (typically).	Risk of ground loops freezing when they remove too much heat from the ground. Use of coiled loops to reduce this risk is good engineering practice. Unless the GSHP is assisted with a mechanism for replacing the heat extracted from the ground, it will get increasingly costly to extract heat from the

Technology	Technology Description	Greenhouse Gas Reduction	Resilience Implications	Risk Review
Ground Source Heat Pumps (GSHP)	(typically 100-200m in depth) are an alternative method of extracting heat which results in a more constant temperature as it is less subject to variations in ambient air temperature as well as higher levels of heat extraction. Their essential advantage is that they move the heat that already exists and hence do not require that heat to be generated. The system can be used for a variety of applications including preheating of domestic hot water and space heating. The heat pump can also be reversed in the summer to provide cooling with a separate cooling network. See below for energy piles, a variant of GSHP suitable for new development situations.	GSHP system is around 4. Heat pumps use refrigerant fluids (Hydroflourocarbons, or HFCs) which are themselves potent greenhouse gases.		ground that is getting cooler. Inter-seasonal heat transfer is good engineering practice to avoid this. GSHPs are best suited for low temperature heat networks, generally requiring boiler top-up if they are to be used on high temperature networks (and to cope with winter peak demand).. Ground loops are unlikely to extract sufficient heat to meet the heat demands of large buildings at a building scale or sufficient heat to supply a district heating network. Boreholes would be capable of extracting sufficient heat to meet the heat demands of individual buildings however a large amount of open space and boreholes would be required to serve a district heating system.
Energy Piles	Energy piles are heat exchangers usually formed by incorporating single U-shaped loops of plastic pipes along the length of reinforcement cage for concrete structural piles. These loops are fabricated off-site and filled with heat transfer fluid. They are essentially the same as GSHPs. The advantage of using energy piles instead of conventional GSHP coils is the lower cost of installation. The total output of an energy pile system will be lower than for a conventional coil system due the slower rate of heat transfer from the ground through the concrete walls of the piles. Energy piles are also typically shallower than standard GSHP boreholes.	The COP of energy piles is normally similar to that of other GSHP systems, i.e. around 4.	Typically ground energy systems cost more to install than conventional systems, however they have very low maintenance costs and can be expected to provide reliable and low carbon energy for many years. When combined with a small conventional chiller and boiler, energy piles can offer a very resilient solution.	Energy piles are only suitable for new construction where piling is required for building foundations. Significant ground heave may be caused due to ground reaching sub-zero temperatures at the soil-pile interface. This reduces the shaft capacity of the pile. Depending on the density of the proposed new developments and pile depth, it is unlikely sufficient heat could be extract to supplement a district heating network in addition to the individual building heat demand although energy piles could form part of a wider network with a number of individual sources supply a network at various times.

Technology	Technology Description	Greenhouse Gas Reduction	Resilience Implications	Risk Review
Other Options				
Anaerobic Digestion	Anaerobic digestion (AD) is a commercially developed biomass conversion technology that can be used to recover both the nutrients and the energy contained in organic wastes. This process generates gases with a high content of methane which can be used in an engine or boiler or (with additional treatment) fed into the gas grid. Feedstock for AD can include food waste, farm waste or other wet organic material. Woody waste can also be used but is less suitable. The dry residue is called digestate and can be used as a soil conditioner. An AD plant could either be sited at the Gasworks development, or located offsite, with certificates for low carbon gas grid injection purchased by the development to qualify as low carbon generation.	AD plants use organic material as a feedstock and are therefore a renewable energy technology providing a low carbon fuel with similar properties to fossil fuel gas. As with other solid fuel options, the overall carbon performance depends greatly on the distance the material travels between source and AD plant.	Coupling an AD plant with a CHP engine reduces the need to additional requirement for gas pipeline infrastructure to provide gas to the CHP engine, AD can offer a sustainable heat (and electricity if coupled with a CHP) supply to end-users. The main issues are: - the dependence on feedstock, - the (costly) need to inject propane to meet the grid standard, - the current lack of long-term contracts.	In gas-to-grid schemes, required compliance with the quality bands for national gas pipelines makes the business case very sensitive to the chemical processes at the plant. Storage of feedstock and / or digestate near to the site may not be particularly popular with residents or developers, meaning this is a solution more suitable as an off-site measure. The Energy Masterplan identified that to serve a large biogas scheme (of 1MWe), an amount of waste equivalent to the average arising's of three times the number of households in the Royal Borough of Kingston are required. It is noted that the "ownership" of residual municipal waste in is with the South London Waste Partnership as Waste Disposal Authority.
Gas Let-Down Generators	The gas infrastructure network is made of transmission and distribution pipes at different pressures. Gas let-down stations are located at the points of connection between high pressure transmission pipes and lower pressure distribution pipes. The process of reducing gas pressure can be harnessed to generate electricity. However, it also causes the gas to cool significantly (well below 0°C) which, in turn, may damage distribution pipes. Normally, additional gas is burned to increase its temperature to safely inject it into the local distribution grid. There is already a proposal in the West Kingston Masterplan Energy Strategy (2008) to consider a gas turbo expander scheme linked to the gas let-down facility located on	Capture and use of the energy released through the pressure reduction process would provide lower carbon heat and power compared with a conventional system which uses gas. One particularly attractive option would be to locate computer data centres – which typically require significant and continuous cooling – near the gas let-down facility to use the temperature drop to replace their refrigeration and air conditioning units.	The steady flow of gas through the critical gas infrastructure at the heart of this system would make this a highly resilient solution in relation to fuel supply.	This is a relatively novel approach entailing technological and commercial risks such as high capital costs and limitations in handling fluctuations in gas flow rates and pressure. Likely to be a more costly way of generating electricity than centralised power station generation BAU. The previously proposed "Blue NG" low-carbon solution (turboexpanders + biofuel CHP) was previously refused on air quality and traffic safety grounds, and there is no reason to assume that the technology has now overcome these limitations. Currently there are no identified significant Gas Let-Down generators in the area surrounding Kingston which may be suitable for investigation.

Technology	Technology Description	Greenhouse Gas Reduction	Resilience Implications	Risk Review
Gas Let-Down Generators	Gas Works site, which would be supplemented with a biofuel CHP engine to reheat the gas and provide heat for the district heating network.			
Solar Thermal	Solar thermal technologies are well-suited for use in urban areas and widely used in many cities. It is a mature and commercially available system. Solar thermal technologies continue to evolve in terms of improved performance, lower costs, greater flexibility and lower deployment costs. The main applications in the UK are for heating domestic hot water (DHW). Other uses are possible but the limited yield normally makes it more suitable to focus on a single specific use. The heat from solar thermal is also eligible for RHI payments.	Solar thermal is perhaps the lowest carbon heat technology available.	Roof-top solar thermal can rarely provide 100% of the heat requirements for buildings in the UK, but is a good complementary supply solution, providing resilience benefits.	Commercial solar water heating technologies are mature and there are no fundamental technical issues remaining- however since each installation is unique, technical competence in system design, specification, construction and support is essential. In the UK, winter performance can be significantly reduced versus summer levels. As identified in the Energy Masterplan, large scale solar thermal installations were not considered any further due to the value of land in Kingston. Solar thermal installations on suitable buildings (e.g. residential) are not likely to exceed the heat demand of the building sufficiently to export to a district heating network. Solar thermal installations on individual buildings to meet building heat demand is a viable solution and should be considered for individual buildings.