Appendix B

Energy Strategy

Strategic Energy Options Appraisal

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A2DOMINON

NW BICESTER ECO TOWN

STRATEGIC ENERGY OPTIONS APPRAISAL

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1 INTRODUCTION

Hyder Consulting (UK) Ltd. has been instructed by A2Dominon South (A2D) to provide strategic advice to support the master planning and outline planning application of the proposed NW Bicester eco development, Oxfordshire.

The proposed NW Bicester eco development will comprise around 5,607 homes, a secondary school, primary schools, retail and commercial space along with health care and other community facilities. Approximately 40% of the site will be green open space, including sports playing fields, semi private and public open space.

This Strategic Energy Options Appraisal has been undertaken to identify the strategic low and zero carbon technology options to enable the site to achieve the PPS1 Ecotown ET 7 planning requirement; as presented below.

"*ET 7 Zero carbon in eco-towns*

ET 7.1 THE DEFINITION OF ZERO CARBON IN ECO-TOWNS IS THAT OVER A YEAR THE NET CAR
EMISSIONS FROM ALL ENERGY USE WITHIN THE BUILDINGS ON THE ECO-TOWN DEVELOPMENT A
ZERO OR BELOW6. THE INITIAL PLANNING APPLICATION AND ALL SUBSEQUENT PLANNING APPLIC
DEVELOPMENT OF THE ECO-TOWN SHOULD DEMONSTRATE HOW THIS WILL BE ACHIEVED.

ET 7.2 THE HEALTH AND SOCIAL CARE NEEDS OF RESIDENTS, AND THE RESULTING ENERGY DEM
BE TAKEN INTO ACCOUNT WHEN DEMONSTRATING HOW THIS STANDARD WILL BE MET.

ET 7.3 THIS STANDARD WILL TAKE EFFECT IN ACCORDANCE WITH A PHASED PROGRAMME TO B
WITH THE PLANNING APPLICATION. IT EXCLUDES EMBODIED CARBON7 AND EMISSIONS FROM T
INCLUDES ALL BUILDINGS – NOT JUST HOUSES BUT ALSO COMMERCIAL AND PUBLIC SECTOR B
ARE BUILT AS PART OF THE ECO-TOWN DEVELOPMENT. THE CALCULATION OF NET EMISSIONS W
OF:

(A) EMISSIONS ASSOCIATED WITH THE USE OF LOCALLY PRODUCED ENERGY

(B) EMISSIONS ASSOCIATED WITH PRODUCTION OF ENERGY IMPORTED FROM CENTRALISED EN
TAKING ACCOUNT OF THE CARBON INTENSITY OF THOSE IMPORTS AS SET OUT IN THE GOVERNM
ASSESSMENT PROCEDURE, AND

(C) EMISSIONS DISPLACED BY EXPORTS OF LOCALLY PRODUCED ENERGY TO CENTRALISED EN
WHERE THAT ENERGY IS PRODUCED FROM A PLANT (1) WHOSE PRIMARY PURPOSE IS TO SUPP
OF THE ECO TOWN AND (2) HAS A PRODUCTION CAPACITY REASONABLY RELATED TO THE O
REQUIREMENT OF THE ECO TOWN.

ET 7.4 THIS STANDARD ATTEMPTS TO ENSURE THAT ENERGY EMISSIONS RELATED TO THE BUIL
IN ECO-TOWNS ARE ZERO OR BELOW. STANDARDS APPLICABLE TO INDIVIDUAL HOMES ARE SE
ET 9."

This appraisal considered the environmental, social, technical and economic issues linked to the available Low and Zero Carbon technologies that may be applicable to the NW Bicester eco development; and will provide guidance to the design team to enable an appropriate energy option to be adopted for the Masterplan.

2 Baseline Energy Demand

To determine the baseline energy demand for the proposed NW Bicester eco development a series of building performance energy models were undertaken (see Technical Note ref 5020-UA005241-ESD-R-1, presented in Appendix A).

In recognition that the PPS1 requires all dwellings to meet CSH level 5/6 as a minimum; the residential building fabric energy efficiency (FEE) standards have effectively sets the baseline regulated energy demands as compliance standards for the NW Bicester site.

The baseline energy demand based for both residential and commercial units are presented in Table 2.1 below. The number of residential units and types of commercial development are based upon the Masterplan 13016(sk) 110 REV F (V2-11-07-13).

Table 2-1 Energy Demand Summary

Development Type	Electricity Demands (kWh) PA	Fossil Fuel Demands (kWh) PA
Residential *5607 UNITS ENERGY DEMANDS REGULATED/UNREGULATED (ELECTRICAL COOKING, ELECTRICAL APPLIANC*	20,759,351	27,398,887
Commercial *UNITS ENERGY DEMANDS*	10,379,975	16,931,235
Total	**31,139,326**	**44,330,122**

NOTE: THE ABOVE TABLE IS BASED UPON ELECTRICAL COOKING WITHIN RESIDENTIAL PROPERTIES. IF A GAS COOKI CHOSEN THEN THE TOTAL ELECTRICAL DEMAND WOULD REDUCE (FROM 31,139,326KWH) TO 28,802,859KWH BUT THE TOT DEMAND WOULD INCREASE (FROM 44,330,121.58 KWH) TO 48,418,258 KWH.

The following charts show the energy demands of both residential and commercial development and also provide the percentage distribution of total electricity and fossil fuel demands.

Figure 2-1 5607 dwellings total energy demands

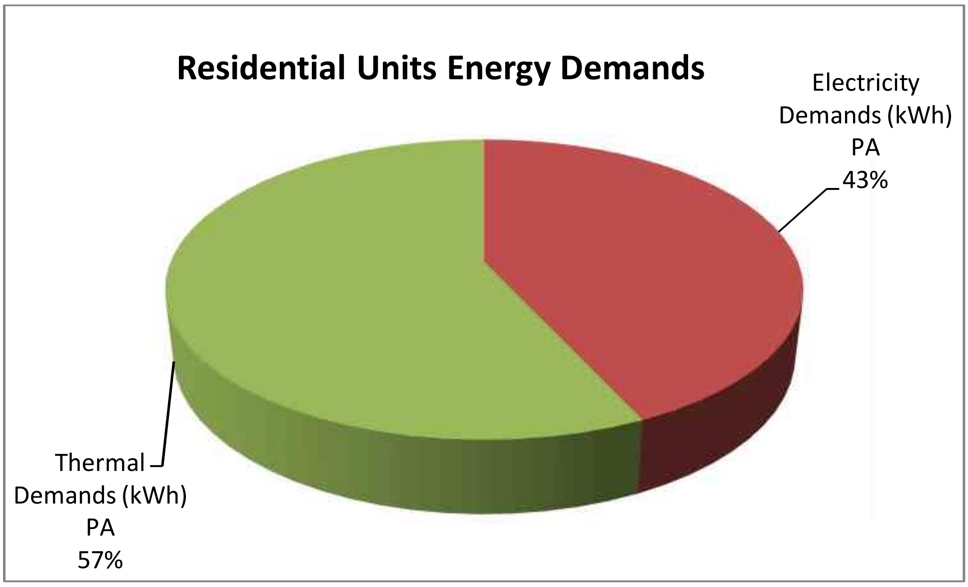
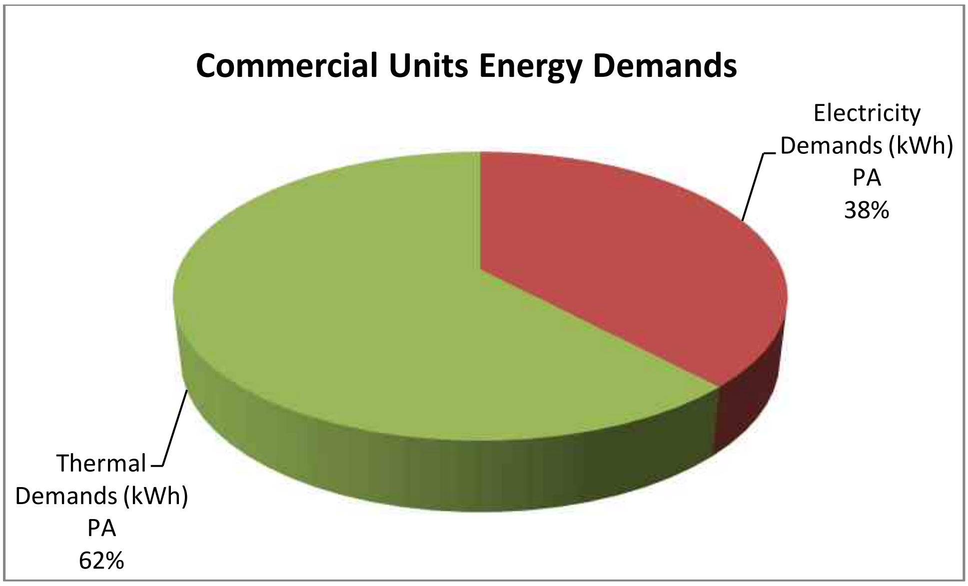


Figure 2-2 Commercial Units total energy demands



The residential demand is further divided into regulated and unregulated energy demands, the term ‘regulated’ energy demand refers to lighting, pumps & fans, space heating and hot water demands whilst the term ‘unregulated’ energy demand refers the appliances and cooking energy demands.

The following table provides a breakdown or regulated and unregulated energy demands, taken from the SAP worksheets which is in compliance with part L 1A, relative to the 5607 residential units.

Table 2-2 Regulated and Unregulated Energy Demands of Dwellings

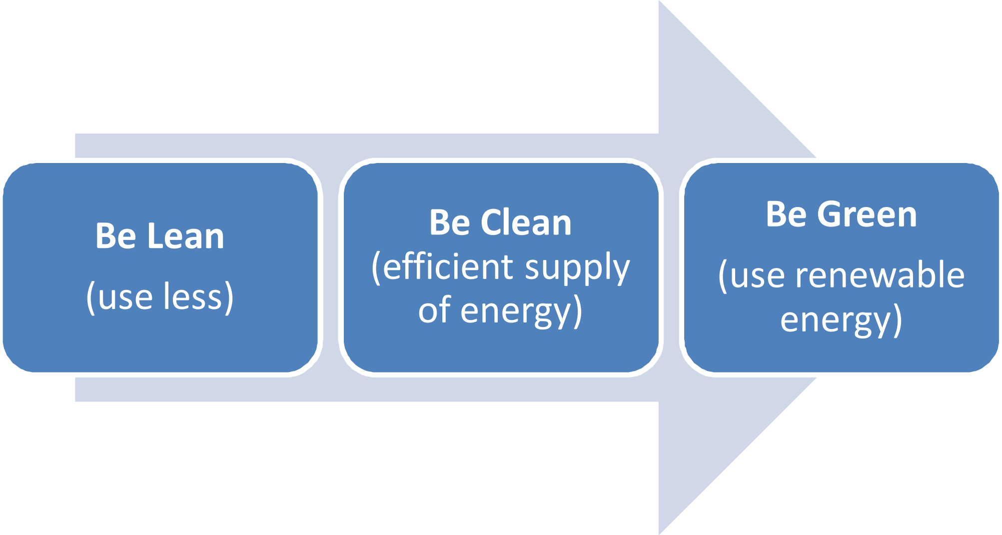
Development Type	Regulated Electricity Demands (kWh) PA	Regulated Fossil Fuel Demands (kWh) PA	Un regulated Electricity Demands (kWh) PA	Un regulated Fossil Fuel Demands (kWh) PA
Residential (Part L1A Compliance) (5607 units of 1 to 5 bedrooms)	1,668,383.04	27,398,886.58	15,227,275.11	4,088,136.60

THE ABOVE UNREGULATED FOSSIL FUEL DEMAND IS BASED UPON GAS OVEN AND GAS HOB SCENARIO

3 APPROACH

This report considers the strategic low and zero carbon energy technologies that may be adopted to meet policy and regulatory requirements as well as client aspiration. The strategies considered follow the energy hierarchy principles; which are:

1. **Be Lean:** Use less energy. Minimise energy demand through efficient design and the incorporation of passive measures;
2. **Be Clean:** Supply energy efficiently. Reduce energy consumption through use of low-carbon technology; and
3. **Be Green:** Use low and zero (renewable) energy systems.



The first principle stresses the primacy of seeking to reduce energy consumption. Within the built environment this comprises adopting energy efficiency measures in both the design and construction of new buildings. The second principle addresses the ‘clean’ supply of energy issue. This will require ‘decarbonising’ and improving efficiency in the generation and distribution of energy. The third principle comprises the use of ‘green’ energy systems. These are renewable sources of energy with low or zero carbon emissions and include, amongst others, solar generated heat and power, wind energy and biomass.

3.1.1 Lean Energy

Part L of the 2010 Building Regulations for domestic dwellings highlights the need to ensure energy efficiency in design. The introduction of the Code for Sustainable Homes in 2007 has moved this agenda further forward and has focused on ensuring buildings are well insulated and airtight (as far as practically possible), to retain warmth and reduce the need for heating.

The NW Bicester development will adopt appropriate Code for Sustainable Homes and BREEAM building standards that will help to ensure that appropriate energy efficiency standards are adopted as the first priority in achieving zero carbon energy.

A range of measures to reduce carbon emissions and increase resilience to climate change can be incorporated into building design; some of these are outlined below.

Design Feature	Adaptation Measure	Technology
Insulation	Green roofs	“A” rated appliances
Air tightness	Grey water recycling	Automatic controls and monitoring
Reduce thermal bridging	Rainwater harvesting	Energy management systems
Passive solar orientation	Water conservation	Energy efficient lighting
Solar shading	Passive cooling	High performance glazing
Use of natural daylight	Colour and material choice	Mechanical ventilation (with heat recovery)
Natural ventilation		

Table 3.1 – Building Energy Efficiency Measures

3.1.2 Clean and Green Energy

Utilising energy generated locally reduces energy lost through transmission and distribution, and can often take advantage of more advanced generating technologies that combine to provide energy more efficiently. Local generation, or decentralised generation, is produced on a smaller scale nearer to the point of consumption and can offer a number of benefits, including:

- Using generated energy more efficiently by reducing distribution losses
- Contributing to security of energy supply by increasing local energy production
- Increasing reliability of supply providing the opportunity to operate ‘on or off grid’
- Reducing carbon emissions through more efficient use of fossil fuels and greater use of locally generated renewable energy
- Provides the opportunity to create stronger links between energy production and consumption.
- Can be linked to fund complementary programmes of work, such as retrofitting microgeneration equipment in existing housing stock.
- Provides a visible message of commitment to sustainable energy

Zero Carbon or renewable energy comes from harnessing natural energy flows from the sun, wind, or water. Many such as solar wind and hydro, directly produce energy and do no emit any carbon dioxide in the process. Others such as biomass, use solar energy to grow renewable plant material that can subsequently be used for energy. Examples here are wood, straw, etc. However, biomass use still generates carbon dioxide when it is burnt; the difference being that this carbon is only that taken from the atmosphere when the plant grew. This is unlike carbon emissions from fossil fuels that are essentially new to the atmosphere, causing increases in atmospheric carbon dioxide levels and climate change. Therefore, when used to replace fossil fuels, biomass leads to a net reduction in carbon emissions; particularly where local supply chains can provide a sustainable supply of biomass.

Energy from waste is considered to be low carbon. While municipal waste combustion contains small elements of things like plastics, the bulk of the material is still organic in nature. Some energy from waste processes can be completely zero carbon, for instance the anaerobic digestion of organic wastes to biogas.

Of the available renewable energy technologies, some are ‘intermittent’ in nature, such as solar and wind. Others such as biomass, ground source heat pumps and energy from waste can service baseload duties.

The table below identifies the low and zero carbon technology options and approaches. These are further discussed in Section 4 and appraised relative to NW Bicester in Section 5.

Macro Solutions **(typically district scale or larger)**	**Micro Solutions** **(typically building related)**
Energy from Waste CHP	Solar Photovoltaic (building mounted)
Anaerobic Digestion CHP	Solar Thermal (building mounted)
Gas CHP	Wind energy (building mounted)
Biomass heat, biomass power (CHP)	Ground source heat pumps
Large scale PV array	Air source heat pumps
Large scale wind energy	

Table 3.2 – Low and Zero Carbon Technologies

This work is designed to advise on the identifying suitable headline technology options and approaches as part of strategic masterplan and outline application work. Further work to appraise these in detail and develop a detailed energy strategy will be required prior to reserved matter / detail applications.

It is recognised, however, that irrespective of whichever strategic approach and technology options are recommended, the implementation strategy must be flexible and enable adaptation to the development, shifting economic incentives and models, and evolving technologies.

3.2 Underlying Assumptions

The following underlying assumptions have been considered during the analysis:

- Energy prices continue to rise in line with current predictions driven by world oil markets, increasingly stringent environmental controls on the combustion of coal in power stations, the increasing need to import gas, etc. These prices will remain volatile.
- Building Regulations continue to tighten as government drives the ‘zero carbon’ agenda, through the Code of Sustainable Homes.
- Climate Change Agreements (CCA) persists, with government continuing to press for compliance.
- The Carbon Reduction Commitment (CRC) will create significant downward pressure on carbon emissions and that a majority of commercial tenants on the site will be impacted by the scheme.
- The Renewables Obligation continues to be a driving force to achieve uptake of electricity generating renewable technologies. The rate of construction of new renewable energy projects continues to lag behind projections, whilst the obligation on electricity distributors continues to rise, keeping the market value of ROCs high.

- Feed in Tariffs continue to make the economic attractiveness of smaller scale renewable electricity generation options more attractive by providing a payment for all the ‘green’ electricity produced and bonus for exports to the grid.

- A ‘Heat Obligation’ similar to the Renewables obligation on electricity suppliers is due to be implemented next year. Renewable heat becomes more cost competitive against fossil fuels as gas, oil and LPG prices rise.

- The current pressures on businesses to have lower carbon footprints continue, creating the prospect of commercial tenants paying a premium for premises with low carbon emissions.

- The current trend towards investors expecting higher levels of Corporate and Social Responsibility from major companies continues.

4 METHODOLOGY

This document discusses the strategic energy options for the masterplan site to provide guidance to the design team to select the best option for the NW Bicester Eco development. Various technical, environmental, social and economic constraints have been considered associated with each technology to explore the options available for the masterplan site.

This section provides a description of each of the constraints / issues that the energy options

4.1 ENVIRONMENT APPRAISAL

Carbon reduction potential: This considers with the carbon reduction potential of each technology; based upon the amount of energy a particular technology can generate and the calculated carbon savings that can be attain from it. The main purpose of this is to identify those technologies that have the potential to generate maximum energy to meet the predicted energy demand but at the same time capable of minimising the carbon emissions

Landscape: This considered the implications of a proposed technology to the landscape character, i.e. whether this technology will impose a negative impact towards the overall landscape character or it will enhance the landscape features of the development. This also includes the visual impact of a particular technology to the surrounded landscape.

Biodiversity: This section considers the impacts of a proposed technology on the local biodiversity; i.e. disruption to local wild life from a particular technology etc.

Environmental Quality: This considers the impacts of a proposed technology on the local environmental quality; i.e. noise disturbance, air quality issues etc. Due to the sensitivity of each of these issues, environmental quality can play a vital role towards to adoption or refusal of any technology.

4.2 SOCIAL APPRAISAL

Governance: This considers how the likely governance of any proposed technology; i.e. whether local / community governance is possible.

Equity: This considers how a proposed technology can be implemented to deliver a fair and equitable outcome to all; and whether a particular technology can generate enough energy, at low cost, to reduce energy bills.

Health / Wellbeing: This considers how a proposed technology can be implemented to enhance the health and wellbeing of the future residents and existing local community. Issues that may be considered range from shadow flickers from wind turbine to the air pollutions from waste plants. Hence, this section considers any health and wellbeing issues linked with a proposed solution.

4.3 ECOMONIC APPRAISAL

Typical Cost: This considers the impacts of capital expenditure (Capex) and operating expenditure (Opex) of the proposed technology. The typical Capex has been determined for each technology on the basis of cost of energy generation including any fuel cost etc. The Opex also includes the maintenance cost has been appraised for each technology to identify the high/low impact (recognising the fact that for some technologies the impact of this is quite minimal and for some it has quite significant).

Typical Payback: This considers the typical payback of each technology; however as the paybacks various significantly from the amount of technology support available i.e. technology advancement and also depends upon the technology cost at the time of purchase.

Incentives/ Grants: This identifies the incentives / grants available such as Feed In Tariff (FIT), Renewable Heat Incentive (RHI) and Renewables Obligation Certificate (ROC). Due to the impact of available incentives the overall generation costs and the paybacks can be reduced and therefore these can have a significant impact on overall costs.

Phasing (cash flow): Due to large development it is important to identify the phasing options of each technology, this is also important for the cash flow requirement to install a technology. The inclusion of this within the appraisal is important as the Eco Town development will be in phases and therefore the phasing possibilities of each technology has been appraised in this section of the appraisal.

Connecting Infrastructure: This is linked to the above phasing issue and import to identify whether the connection infrastructure is capable to deal with the proposed technology. This considers the grid intermittency issues as most of the technologies are produce intermittent energy at the time of production and no storage capacity is available. Hence, these issues have been considered within this connecting infrastructure sector.

Land Values: The land value impact is varying from technology to technology however the significance of this could be higher for some technologies. We have evaluated this issue within this appraisal as the visual impacts on the land values and also the local land restrictions due to the planning etc.

4.4 TECHNICAL APPRAISAL

Physical Factors: This considers factors which can cause constraints to the particular technology; such as wind speed; land use and area (in case of wind turbines), the connection restrictions due to the existing infrastructure such as telecommunication masts or aviation radars etc.

Connecting Infrastructure: This relates to whether enabling or connecting infrastructure is present and /or capable of managing the proposed technology; such as the intermittent energy generation technology impacting grid supply and capacity.

Integration with other technologies: Considers whether and how the technology integrates with other potential energy solutions / different technologies.

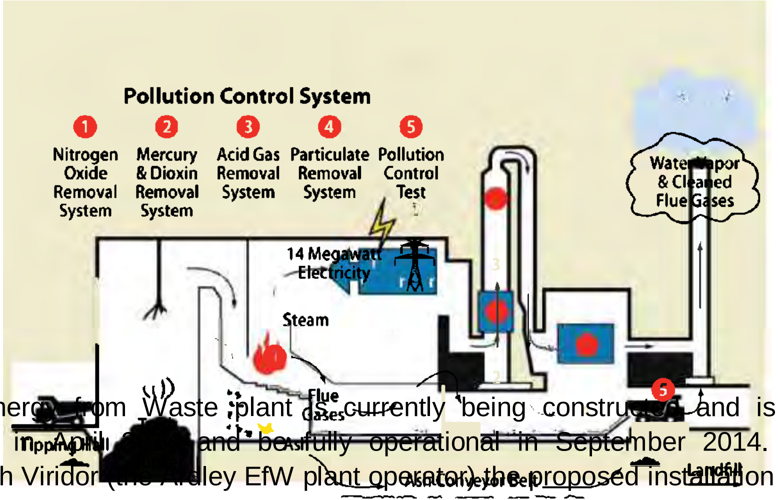
5 ENERGY GENERATION AND CARBON REDUCTION OPTIONS

The following provides a brief overview of the low and zero carbon technologies that have been appraised.

5.1 Energy from Waste

All developments and activities produce waste. Utilising this waste to produce energy is part of the sustainable hierarchy of waste use and diverts waste from landfill. Energy from Waste plants are now commonplace and can provide an acceptable and commercially viable solution to both waste disposal and low carbon energy generation. Even adopting waste reduction targets there will still be substantial amounts of waste generated on site. The collection of this waste and utilisation in a sustainable manner will have environmental and economic benefits. Energy from Waste is most commonly attained through incineration. The waste generally refers to that portion of waste that is left over following reuse and recycling; i.e. the residual waste.

Energy from Waste is a more sustainable approach than landfill, providing the residual waste being used has the right organic / combustible content and is matched with a plant that is efficient enough at turning the waste to energy. Most of the energy from waste is currently produce in the form of electricity. However, the technology can also be applied utilising CHP plants and thus also produce heat. More innovative technologies also have the potential to transform the waste into other energy products such as transport fuels or substitute natural gas.



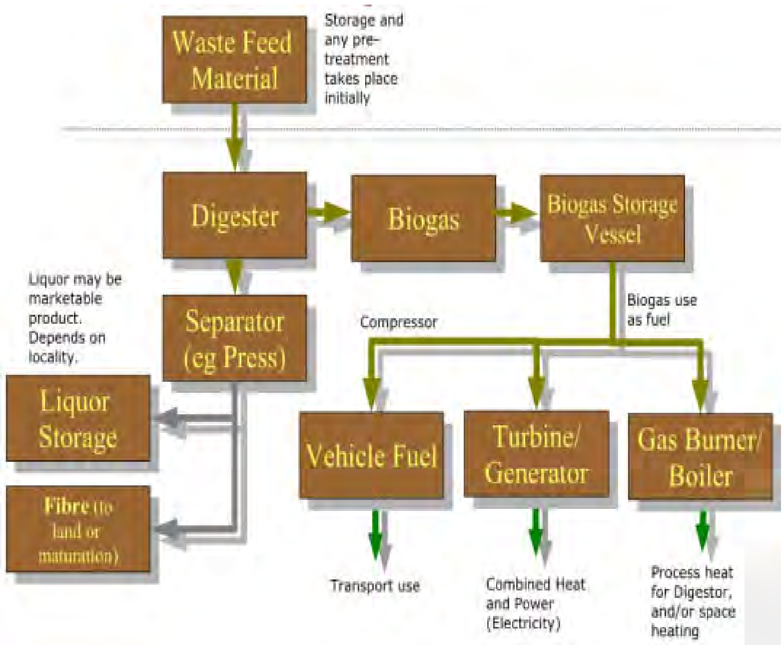
The Ardley Energy from Waste plant is currently being constructed and is due to begin commissioning in April [illegible] and be fully operational in September 2014. During recent discussions with Viridor (the Ardley EfW plant operator) the proposed installation was confirmed to have a generation capacity of 26MWe. This is equates to approximately 17MW$_{th}$ of heat which comfortably enables 150,000 MWh of waste heat to be generated. This waste heat would be sufficient to meet the space heating and hot water demands of eco town development. This option could meet the developments residential and commercial heating and hot water demands of 31,487MWh, which will equates to the total carbon savings of 6,234 tonnes

However, to enable this option to be taken forward, a connecting pipe is required to distribute the waste heat from the Ardley site to the eco town, which typically incur a cost of between £1000 to £1500 per meter based upon soft and hard areas of trenching respectively and have to pass through third party land. This cost and potential ransoms to enable this connecting pipe are significant, however, this options would meet the thermal demands in a carbon neutral way. The distribution pipe network connection, its ownership and the financial implications of this connection are the critical decisions to be made prior to this technology connection. The further cost assessment would determine the cost implications for this option and would require early planning for correct infrastructure

5.2 Anaerobic Digestion (AD) CHP

Anaerobic Digestion is a biological process where a biodegradable waste stream is combined with certain types of bacteria to generate biogas. It is a natural treatment process and as in composting bacteria breaks down organic matter and reduces its bulk or mass. AD utilise series of process in which micro-organisms break down biodegradable material in the absence of oxygen, used for industrial or domestic purposes to manage waste and/or to release energy. AD can play an important role as a means of dealing with organic waste and avoiding, by more efficient capture and treatment, the greenhouse gas (GHG) emissions that are associated with its disposal to landfill.

AD also offers other benefits, such as recovering energy and producing Biogas, which can be used to generate heat and electricity or also can be converted into biofuels or cleaned and injected into the gas grid.



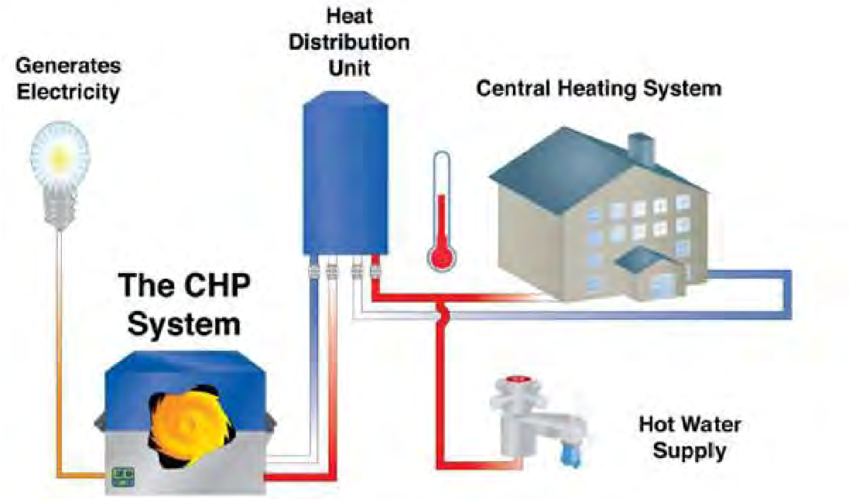
AD system requires large plant and storage space for successfully running the digestion process. Due to the odour, waste storage and fuel combustion emissions issues associated with this technology, the AD plants are normally located away from residential properties. Operationally there would be a requirement to capture additional organic waste from outside the development to generate sufficient biogas to power a CHP.

Also, currently all organic waste is collected co-mingled with garden waste and diverted to composting centre. Therefore the AD plant would needs to import the fuel which will minimise the feasibility of this option.

5.3 Gas fired CHP

Traditional coal and gas fired power stations simply waste vast amounts of heat which is produced during the generation process. Combined Heat and Power (CHP) integrates the production of usable heat and power (electricity), in one single, highly efficient process. CHP generates electricity and produce usable heat at the same time. It is an energy generation technology that is fuel neutral, which means that a CHP process can be applied to both renewables (biogas / EfW) and fossil fuels (gas). The specific technologies employed, and the efficiency they achieve will vary but in every situation the CHP system offers the capability to make more efficient and effective use of valuable primary fuel resources. The CHP system helps to avoid significant energy losses and reduces CO2 emissions; hence CHP units can be up to 95% efficient. There are many types of CHP systems currently available however in this discussion we only refer to gas turbine based CHP systems.

Gas turbines generate power by means of the Brayton cycle and a working gas (typically ambient air) is compressed in the compressor, then fed with fuel and ignited. The high temperature high pressure combustion products are then expanded through turbines to generate shaft power for the compressor and the electrical generator. The action generates power and at the same time waste heat also leaves the gas turbine in the form of hot exhaust gases (≈ 500 °C). There are generally two types of gas turbines are available, those who derived from aeronautical engines and those originally design for industrial and power generation plant. The conventional gas turbines are available from 500kWe to over 100 MWe.



Gas fired CHP systems could be sized to provide sufficient heat to meet the space heating and hot water demands of the development. This solution would also contribute to meeting the electrical needs of the development at the same time and therefore benefit the development in both ways.

However, as the gas fired systems utilises natural gas to generate power and heat, this technology has a relatively high carbon emissions factor when compared to other LZC strategies.

5.4 Biomass CHP

Biomass is any organic matter, typically plant-based matters that is available on a renewable or recurring basis. Biomass resources include forest and mill residues, agricultural crops and wastes, wood and wood wastes, animal wastes, livestock operation residues, aquatic plants, fast growing trees and plants, and municipal and industrial waste. Biomass can be used in solid form or gasified for heating applications or electricity generation, or it can be converted into liquid or gaseous fuels. The use of biomass to produce heat and power can be environmentally beneficial because biomass is a renewable resource and its combustion does not contribute additional greenhouse gases to the atmosphere.

There are two established processes for delivering biomass CHP in small - medium size applications in the 200KWe – 2.5MWe range: the Organic Rankine Cycle (ORC) and Gasification technology.

Biomass CHP plant is a viable option for the development and could be sized to provide sufficient heat to meet the space heating and hot water demands of the development. However, this technology requires biomass fuel such as wood chips/ pellets which should to be sourced, in sufficient quantities, as locally as possible to maintain its sustainability credentials and improve feasibility.

As with other CHP based solutions, this would also contribute to meeting the electrical needs of the development at the same time and therefore benefit the development in both ways. However, due to the renewable nature of the fuel source it would have an improved carbon factor over alternative gas fuelled CHP solutions.

5.5 District Heat Network

A District Heat Network (DHN) is a network of insulated pipes used to deliver heat, in the form of hot water or steam, from the point of generation to the end user. They provide the means to transport heat efficiently provided distances do not become too far. A DHN enables valuable energy, which currently is all too often wasted in power generation or industrial processes, to be harnessed and delivered to point of use and remove the need for additional generation of heat energy. The heat network can transport the heat from a diverse range of sources, including Energy from Waste (EfW), Industrial processes, Biomass CHP plant, Gas fired CHP plants, heat pumps and other geothermal sources.

DHN has been deployed in the UK since 1950's, however, it has only been in the recent past that they have started to become more popular; particularly in cities. Currently DHN provides less than 2% of UK heat demand.

DHN consists of two pre-insulated pipes or a duel/twin pipe (where both flow and return are contained in a single insulating casing. One pipe is the supply pipe with water around 85 to 95°C and the other is the return pipe with water around at circa 50 to 60°C. The maintenance of flow and return temperatures during transmissions through the pipe network is one of the most important aspects of the distribution network and can, if not managed correctly, have a direct impact on the overall operational cost. The DHN works more efficiently if the return temperature is as low as possible.

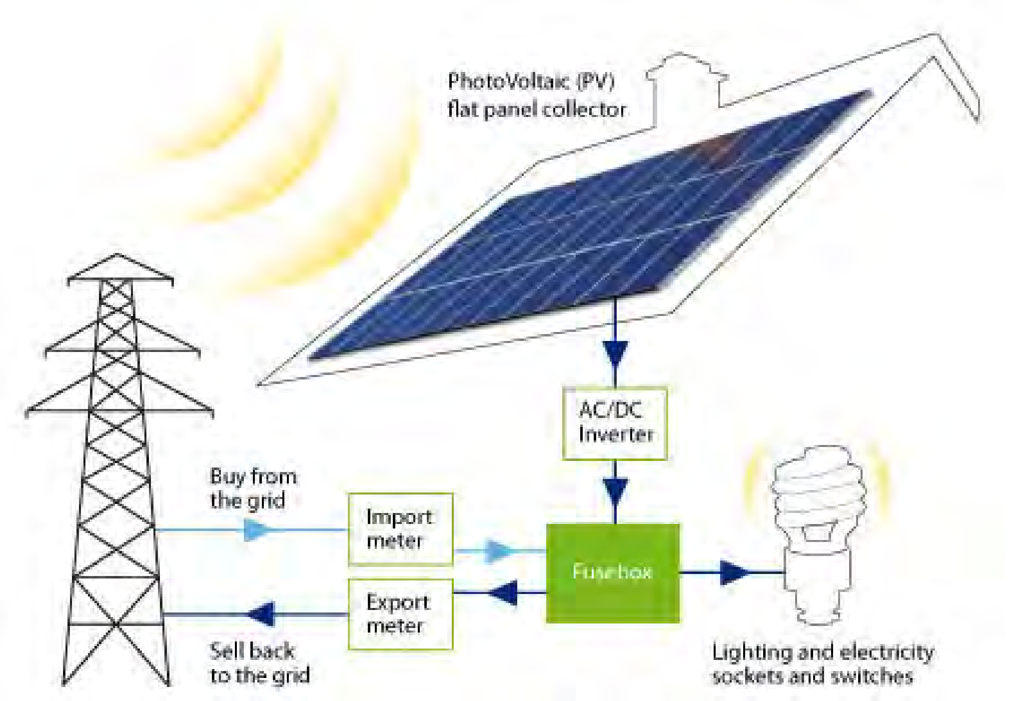
The DHN is a fundamental part of several strategic options already discussed, including Biomass CHP, gas fired CHP and for Energy from Waste, and is therefore an additional cost to these options. The DHN pipework costs vary significantly from approximately £500 - £1100/meter (according to Energy & Climate Change department) and depends upon a range of factors such as ground conditions, other buried services, number of bends and the methods used for joining the pipework (clamped or welded). Hence the capital cost of a DHN could be significant and incur additional cost to the overall connection of any proposed district heating system.

DHN tend to be installed in areas of medium to high density living and work better where there is a constant thermal demand; which is often achieved in mixed use developments where there is both day time and night time heat demand. This demand can be regulated through the use of thermal stores, which enable the hot water generated to be stored and released into the distribution network as needed.

5.6 Building Mounted Solar PV

Solar- Photovoltaic (PV) systems convert energy from the photons within sunlight into electricity through the aid of photocells; made of semi-conductor material, usually Germanium or Silicon. PV systems are suitable for any type of building but they require significant unshaded south facing space as even a small shadow may significantly reduce output. PV systems can be incorporated on buildings in various ways: on sloped roofs and flat roofs, or in facades, atria and shading devices.

Currently, there are four types of solar cells available: mono-crystalline, poly-crystalline, thin film and hybrid. Mono-crystalline and hybrid cells are the most expensive to produce but are the most efficient (12-20%), poly-crystalline cells are cheaper but their efficiency is lower (9-15%) and thin film cells are only 5-8% efficient but can be produced as thin flexible sheets. As the electrical output is DC, they are used in conjunction with inverters to convert this to a useable AC output.



The maximum total annual solar radiation is usually at an orientation due south and at a tilt from the horizontal equal to the latitude of the site minus approximately 20 degrees. The latitude of Bicester is 51.9 degrees. Therefore 32 degrees is the optimal tilt in Bicester, south facing. However, PV's can operate at significant efficiency within a range of deviation from this optimum; e.g. a south east roof, at optimum inclination can achieve 96% efficiency; or a south west roof at +10 degree inclination can provide between 95% and 92% efficiency.

Roof mounted solar PV would be beneficial for development; helping to meet the electricity demands of individual dwellings. If half the available roof area of all dwellings were fitted with PV then a significant portion of dwelling's electricity demands could be fulfilled from this technology.

Based upon 1.41kWp Solar PV production; a total of 13,858.46MWh of electricity could be generated using half of the roof space of each dwelling

5.7 Large Scale Solar Farms

Solar farms, solar parks or land base PV array are large scale Solar Photovoltaic (PV) installation used to generate electricity. They often cover large areas of land, generally between 5 to 60 hectares and are usually developed in rural locations. Solar farms generally go through a rigorous planning procedure to get the planning approval. This takes in to account the suitability of the site, any potential impact on the locality and relevant renewable energy targets.

As with any type of large scale development, the potential impacts of solar parks must be assessed. Large scale arrays have the potential to affect the landscape, natural habitats, soils and geological and archaeological features. Damage may be caused during operation or when panels are being erected or decommissioned. Cumulative impacts might also occur when parks are sited close to one another.

The key barriers of solar farms projects in the UK are grid generation capacity constraints, planning requirements, landscape issues and general public perception of the technology. The grid connection is an increasing constraint of this technology, the usual DNO’s connection delivery quotation for medium to large scale projects connecting at 33kV is 12 to 24 months connection timeline. The potential visual impact of fields of PV can sometimes be difficult to mitigate and are best suited to areas that are not significantly overlooked.

Rapidly changing fiscal incentives can also influence the viability of large scale PV installations, such as the Renewables Obligations (ROCs) banding changes for Solar PV projects (annually) versus the typical development timeline of 12 to 24 months. Given the recent (April 2013) rates of 1.4ROCs/MWh, it is likely that only sunniest locations in the UK will be able to take full advantage of ROC.

A solar farm could contribute to or meet the electricity demands of Bicester eco town; provided sufficient land space and appropriate grid capacity (to manage the intermittence) were available. This option would require significant investment (as it would not be developed in a piecemeal fashion) and therefore the approaches to fund this option may constrain how it may be ‘part’ of the eco town.

However, if a suitable approach to funding was found then the electricity generated (and carbon saved) may be able to be ‘linked’ to the eco town

5.8 Solar Thermal

Solar thermal technology converts the solar energy into heat which can be used to mitigate hot water demands. Solar water heating systems use solar panels, called collectors, fitted to the roof. To gain better savings and most benefits from this technology, the system is integrated with a thermal store system which has the capability to store the heat for longer period of time, i.e. during the day to be utilised at peak time, and also act as a heater (e.g. immersion heater) to further reach the hot water temperatures that may be required.

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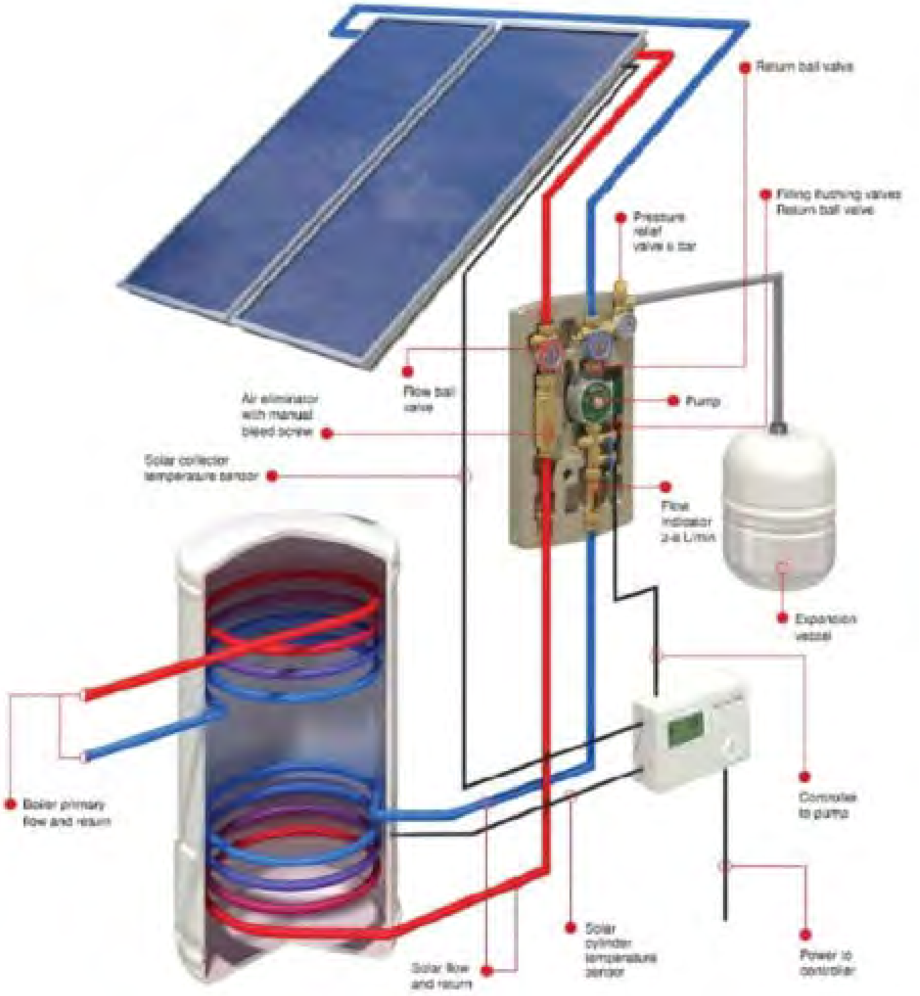


Solar thermal collectors need to be positioned to receive maximum sunlight; and therefore should face south at approximately 32 degrees (for Bicester) to attain maximum proportion of sunlight hours. Easterly facing collectors capture more energy at the start of the day, whilst westerly facing collectors capture more energy in the later afternoon / early evening.

Whilst large solar thermal collector systems can also provide some contribution to space heating, this would be limited and require further heating to via a boiler, and is often not considered worthwhile. Similarly, during winter months the system typically requires a heating boost from a boiler/immersion heater to achieve desired hot water temperatures.

5.9 Small Scale Wind

This technology utilises wind (a form of kinetic energy) and transforms this to useable electricity. The annual energy produced by a wind turbine installation is typically dependent on wind speed around the turbine and varies through different weather conditions. Wind turbines can be deployed individually or in a form of multiple turbines. They can be of horizontal or vertical construction.

The key constraint associated with this technology is the wind speed; typically small scale wind turbines required a minimum of 6 meters per second (m/s) to operate effectively. The Department of Climate Change (DECC) wind database identifies that the average wind speed at 10 meters above ground level (agl) is approximately 4.8m/s which will not capable to generate usable electricity. Similarly, the average wind speeds at 25m agl are 5.73 m/s. Therefore based upon the likely wind speed this technology would not be suitable; however, further investigations could be carried out to confirm this if this option was considered favourable.

Other constraint factors include land take and potential restriction of land use around the turbine, proximity to other structures which may cause turbulence and reduce efficiency, potential noise issues and visual impact.

Small scale wind turbines generate modest amounts of electricity and therefore numerous turbines would be required to reach anywhere near the predicted electricity demand of the development.

5.10 Medium to Large Scale Wind Turbine

Medium (40 to 80m hub height) average 500kW to 1MW to large (90 to 150m hub height (and taller)) average 1.5MW to 3MW scale turbines are free standing wind turbines that may be installed singly or in groups.

These wind turbines commonly require a buffer zone or separation zone where other land uses may be affected; for example in Wales there is a Technical Advice Note (TAN 8) that states: "500m is currently considered a typical separation distance between a wind turbine and residential property to avoid unacceptable noise impacts…" In addition, landscape visual issues are likely to require any turbines to be located suitable distances away from the residential dwellings. These constraints would likely mean that any medium to large scale wind turbine would not be able to be sited within the masterplan area without significant redesign to accommodate.

Wind speed is critical to the success of wind turbines; and medium to large scale turbines require a minimum of 6 meters per second (m/s) to operate; and commonly require wind speeds over 9m/s to generate electricity efficiency. The DECC wind database only provides wind speed data up to 45m height, which in this location is estimated as 6.23m/s. Information on wind speeds at various locations have been included within the Appendix C for reference purposes. A nearby wind energy planning application indicates that wind speeds of approximately 6.8 m/s may be reached at 60m height and therefore may be suitable to support medium scale wind turbines. If this option were to be progressed then further investigations would need to be carried out relative to actual wind speed.

Medium to large scale wind turbines can generate significant quantities of electricity which would have a major contribution to the electricity demands of the eco town.

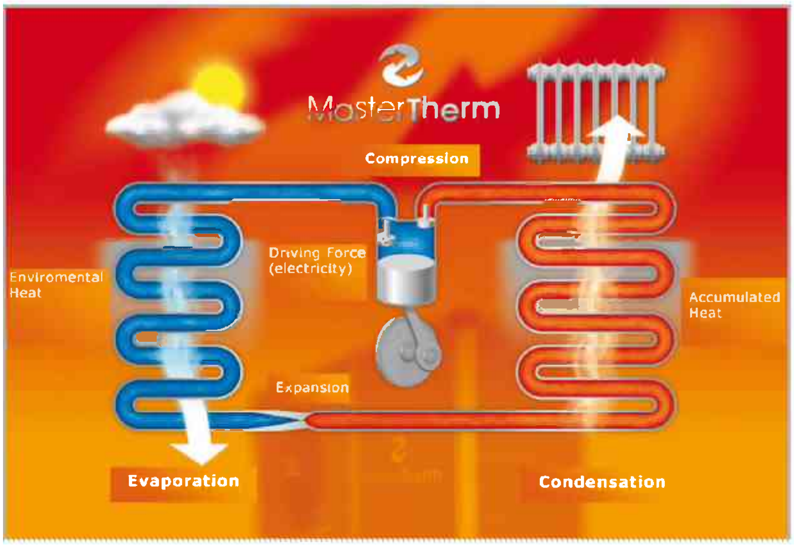
5.11 Ground & Air Source Heat Pumps

Heat pump technology is designed to provide heating and cooling demands. There are two principle type: Ground Source and Air Source.

Ground Source Heat Pump (GSHP) technology can meet heating /cooling demands all year around, as the earth temperature is virtually constant at depth. This technology offers energy savings on meeting heating/cooling demands relatively efficiently. A kW of energy intake will produce up to 4 kW of output which makes this technology more efficient in comparison with traditional Gas boilers. This technology can be used for heating and cooling applications.

The Air Source Heat Pump (ASHP) extracts heat from the outside air in the same way that a fridge extracts heat from its inside. It can get heat from the air even when the temperature is as low as -15° C. This heat can then be used to heat radiators, underfloor heating systems, or warm air convectors and hot water.

ASHP are typically less effective than GSHP but do not have any land requirements as GSHP do. All heat pumps need electricity to run, but the heat they extract from the ground or air is constantly being renewed naturally.



The significant barriers of GSHP technology is the land requirement for ground loop or borehole construction; which also have ground trench or borehole installation costs. ASHP can have external noise constraints (although generally minimal) and the positioning of the external unit needs careful consideration.

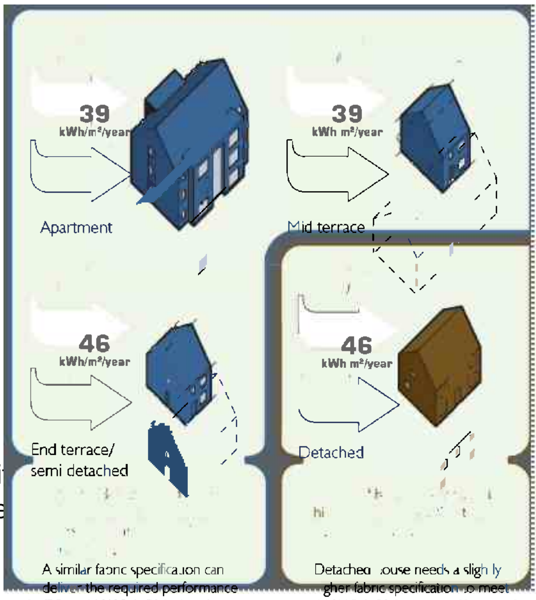
5.12 Enhanced Fabric Energy Efficiency (FEE)

Enhanced Fabric Energy Efficiency (FEE) Standard have been developed specifically in response to developing a strategy for the 2016 zero carbon homes requirement by the Zero Carbon Hub in 2009. The FEE methodology was then adopted within the Code for Sustainable Homes (November 2010 version) under Energy section Ene2, with up to 9 credits available for achievement of a range of specific fabric performance levels.

The FEE methodology considers minimising the space heating and cooling (if any) demands of a dwelling through the improvement in building fabric efficiency. This includes enhanced improvements in the following construction procedures to achieve the required FEE levels:

- Building fabric U-values
- Thermal bridging
- Air permeability
- Thermal mass
- Features which affect lighting and solar gains

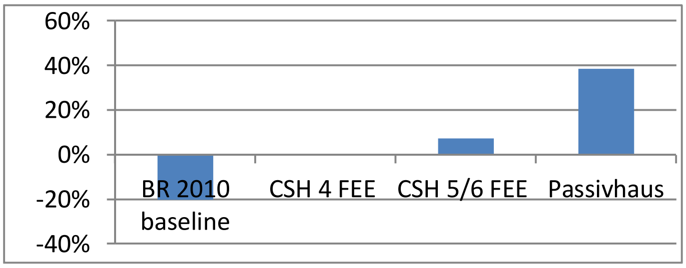
The FEE is measured in kWh/m²/yr, and is not influenced by building services, for example heating system, fixed lighting or ventilation strategy. It is a performance standard, meaning that different combinations of fabric specification can be used to reach a particular level. This allows flexibility when developing a fabric speci ; proposed in building regulations for different type , end terrace and mid terrace dwellings.



The PPS1 Ecotown supplement requires that all homes achieve CSH level 4 including its associated FEE standards. However, with the progressive improvements in Building Regulations planned by 2016, it would be more appropriate to target a higher FEE standard; as planned to be adopted equivalent to the CSH level 5/6 FEE standards.

Designing to Passihaus standards is another, alternative, approach. The Passivehaus FEE standards reduces the space heating energy demand to below 15kWh/m2/yr. On face value this is significantly lower than the shared CSH 5/6 and 2016 Building Regulation standards; which range from 39 to 46 kWh/m2/yr (as the figure above shows); however, there is also a 15kWh/m2/yr standard relative to cooling; which may be required during the summer months.

It is clear that progressive savings in regulated energy demand can be obtained from adopting higher FEE standards over CSH FEE level 4. Savings may be in the order of 7% relative to CSH FEE level 5/6 and 38% relative to Passivhaus FEE standards; as shown:



Build costs will increase to achieve improved FEE standards and as indicated above, additional energy may be required to mechanically ventilate buildings that achieve such standards.

6 APPRAISAL OF OPTIONS

Considering the environmental, social, economic and technical constraints associated with each energy generation and carbon reduction option; the following presents an appraisal of the following available Low or Zero Carbon (LZC) technologies and options:

- Energy from Waste (EfW)
- Anaerobic Digestion (AD)
- Biomass CHP
- Gas fired CHP
- Solar Photovoltaic (PV) (Roof Mounted)
- Solar Photovoltaic (PV) (Land Base Array)
- Solar Thermal
- Wind Turbines
- Land Base Wind Turbine
- Heat Pumps
- Enhance Fabric Energy Efficiency (FEE)

The below appraisal section considers the impact of each technology to this project relative to the following appraisal criteria as discussed in Section 4.

Environmental

- Carbon Reduction Potential & Energy Generation
- Landscape
- Biodiversity
- Environmental Quality

Social

- Governance
- Equity
- Health & Wellbeing

Economic

- Costs
- Payback
- Incentives
- Phasing
- Land Value

Technical

- Connecting Infrastructure
- Physical factors
- Integration with other technology

6.1 Appraisal of Energy from Waste

Key Themes	Comments
ENVIRONMENT	
Carbon reduction and Energy Generation potential	The Ardley Energy from Waste plant is proposed to generate: • Electricity = 26 MW_e • Waste Heat = 17MW_{th} ≈ 150,000 MWh Viridor, the operator, will utilise and sell excess electricity generated to the grid. The waste heat produced, however, is sufficient to meet the eco town's residential and commercial heating and hot water demands of 44,330,122 kWh, which will equate to the total carbon savings of 9,575 tonnes. The below summaries the percentage of energy generated and carbon savings achieved relative to regulated and unregulated energy: Regulated & Unregulated / Regulated only % energy demand met: 59% / 84% % carbon savings: 37% / 69%
Spatial and Landscape	The EfW plant is located near Ardley; has already received planning permission and is in an advanced stage of construction. There are no landscape issues associated with this option relative to the eco town site. However; there would be a requirement to have back-up / resilience heat generation boilers and thermal stores located in energy centres within the masterplan site. It is likely that at least 2 energy centres would be required; sized approximately 25m x15m with additional service yards. It is not considered that these would represent a negative spatial or landscape impact as they would be fully integrated into the masterplan layout and design.
Biodiversity	There are no biodiversity concerns associated with this technology associated with the site.
Environmental Quality	Emissions to air from EfW plants can have negative connotations and potential impact; however the plant has existing planning and environmental permissions to operate which will undoubtedly be safeguarding environmental quality In addition, the EfW plant is not located on the development site and will therefore not have any air, noise, land and water quality issues relative to the site.
SOCIAL	
Governance	As this technology is currently run by a commercial provider there is unlike to be any opportunity for the local community to become involved with the heat generation side of this option. Governance concerns may be raised regarding security of supply, connecting network ownership and how future financial arrangements affect pricing tariffs to residents. There is also a requirement to provide a heat distribution network to serve the development and set appropriate pricing structure. How this heat network could be develop and whether some form of governance model could be used needs further investigation but is possible.
Equity	This technology has the potential to help reduce the heating bills, depending on the pricing strategy adopted; as low cost waste heat could be used to meet the sites thermal demand.
Health / Wellbeing	Emissions to air from EfW plants can have negative connotations and potential impact; however the plant has existing planning and environmental permissions to operate which will undoubtedly be safeguarding air quality. In addition, the EfW plant is not located on the development site and will therefore it is not considered that there will be any negative health and wellbeing issues associated with this technology.

ECOMONIC

Typical Cost	The main cost associated with this option is relative to the heat pipe connection cost from the Ardley EfW plant to the proposed development. Flow and return insulated hot water pipes will need to be installed. Typically these costs are in the order of: £1000/meter for soft land & £1500/meter for hard land. The route to the development would have to cross the M40 motorway and possibly the railway line. These will be significant obstacles to cross; and a average route of 3.5km would be required which would equate to a capital cost in the region of £4.3M; possibly more. Strictly speaking there are no fuel costs associated with this option as the waste collected and used at the plant is part of an alternative waste management contract. However, a negotiated heat tariff would form part of the agreement to obtain the waste heat from the Ardley plant. As a comparable cost, this technology equates to £0.045 / kWh (based on 25 year life time cost). This is based upon meeting the thermal demand of the site; and includes the pipe connection at an average cost of £1,250 per meter from the Ardley EfW plant to the site boundary, the heat tariff cost at the rate of £12/MWh, and a provisional sum relative to provision of district heat network across the development site. The cost per kWh includes 4% RPI average per year for maintenance and fuel cost and 5% interest rate on the capital cost.
Typical Payback	Likely to be at least 10 to 15 years to enable a sufficient customer base to be established.
Incentives/Grants	Waste Infrastructure Grant (WIG) can be explored through local authorities seeking to develop the infrastructure require to meet landfill diversion targets.
Phasing	The major costs are associated with installing the connecting pipe infrastructure which needs to be undertaken at the beginning of the development. There is no opportunity to roll this option out on a phased basis (other than the on-site heat network).
Land Values	Land values will not be materially altered as a result of application of this technology.

TECHNICAL

Connecting Infrastructure	The heat connection infrastructure is a significant issue as, to connect the Ardley EfW plant to the development site, the route will need to cross the M40 motorway and possibly the railway line. These will be significant obstacles to cross, over a distance of at least 2.8km; and would require various easements to be negotiated. In addition, this option requires a site wide heat network to distribute the hot water across the site to each building.
Physical factors	The connecting infrastructure has to cross significant physical barriers; namely the M40 and possibly the railway. These will be significant obstacles to cross, over a distance of at least 2.8km; and would require various easements to be negotiated.
Integration with other technologies	It would not make sense to utilise this technology alongside other thermal generating technologies (such as solar thermal and heat pumps); however, it will be necessary to create resilience and back-up to the heat network through the integration with other boiler and or CHP units and thermal stores located at the site. Electrical generating technologies will be complementary.

SUMMARY

THIS TECHNOLOGY CAN MEET THE THERMAL ENERGY DEMANDS OF THE ECO TOWN. TO ACHIEVE THIS IT REQUIRES CO WATER PIPEWORK FROM THE EFW PLANT TO THE SITE, CROSSING THE M40 MOTORWAY AND POSSIBLY THE RAILWAY LI OF WHICH SHOULD NOT BE UNDERESTIMATED. IN ADDITION, RELIANCE ON THIS TECHNOLOGY WOULD REQUIRE THE CO PIPE TO BE IN PLACE AT AN EARLY STAGE; NECESSITATING SIGNIFICANT UP-FRONT FUNDING AND INFRASTRUCTURE W CONSIDERATION OF THIS OPTION REQUIRES DETAIL INVESTIGATION OF POTENTIAL CONNECTION PIPE ROUTE AND DET ADDITIONAL FINANCIAL REQUIREMENTS TO FACILITATE.

6.2 Appraisal of Anaerobic Digestion

<table>
<tr><th>Key Themes</th><th>Comments</th></tr>
<tr><td colspan="2">ENVIRONMENT</td></tr>
<tr><td>Carbon reduction and Energy Generation potential</td><td>
<p>An AD CHP plant would generate heat and electricity; which would contribute the energy generation and carbon reduction. The relatively limited organic waste generated by the development may limit the heat and power generating ability of this technology. However, alternative organic wastes streams may be identified in the local area, although these are not necessarily guaranteed (as existing contracts are likely to be in place). Therefore, the likely generation capacity of an AD plant utilising kerbside food waste and catering waste from the masterplan development would be:</p>

Electricity Generation = 1,589,844 kWh
Heat Generation = 2,649,740 kWh

<p>The below summaries the percentage of energy generated and carbon savings achieved relative to regulated and unregulated energy:</p>
<table>
<tr><th></th><th><u>Regulated & Unregulated</u></th><th><u>Regulated only</u></th></tr>
<tr><td>% energy demand met</td><td>6%</td><td>8%</td></tr>
<tr><td>% carbon savings</td><td>5%</td><td>10%</td></tr>
</table>
<p>As this technology is not predicted to generate sufficient energy to meet the developments demand; it may be possible integrate this technology alongside other energy generation plants that collectively contribute to a DHN</p>
</td></tr>
<tr><td>Spatial and Landscape</td><td>
<p>AD plants have a slightly larger overall building footprint than some other CHP fed systems; as the AD digestion vessel needs to be accommodated. However, they are not particularly unsightly and are in keeping with the agricultural nature of the existing land use.</p>
<p>As this technology would be unlike to meet the sites total thermal demand; there would likely be a requirement to have additional complementary heat generation boilers and thermal stores located in energy centres within the masterplan site.</p>
<p>It is likely that at least 2 energy centres would be required; sized approximately; the one housing the AD plant and would be in the region of 50m x 25m, and the other around 25m x 15m, both with additional service yards. It is not considered that these would represent a negative spatial or landscape impact as they would be fully integrated into the masterplan layout and design. Each will have exhaust flues extending some 15m from the CHP plant; which would have limited local landscape impact.</p>
</td></tr>
<tr><td>Biodiversity</td><td>There are no biodiversity concerns regarding this technology at the site.</td></tr>
<tr><td>Environmental Quality</td><td>
<p>Odour issues are generally the cause of concern with AD plants; and they are generally located in rural areas often associated with farms and waste water treatment works where sludge is used as the AD feed. Special precautions would need to be taken to reduce any potential odour related issue; such as negative air pressure unloading halls. Preventing odour issues would be possible but would add to building footprint and overall cost of construction and operation.</p>
<p>Noise will be generated by the CHP engines; however, this would be mitigated by acoustic enclosures to acceptable levels.</p>
</td></tr>
<tr><td colspan="2">SOCIAL</td></tr>
<tr><td>Governance</td><td>This type of technology could be linked to local governance structure, if deemed appropriate, and facilitate the community buy-in. In addition, this technology would require a heat distribution network which again could be linked to local governance.</td></tr>
</table>

Equity	This technology has the potential to help reduce the heating bills, depending on the pricing strategy adopted; as low cost waste heat could be used to meet the sites thermal demand. However, due to the relatively small amount of thermal energy generated, this would not be a significant proportion of the heating bills and so limited impact.
Health / Wellbeing	There are no significant health and wellbeing concerns regarding this technology. As mentioned above, there is the potential that odour issues may be present which may negatively impact the immediately local environment.
ECOMONIC	
Typical Cost	Capital costs can be large, however, incentives available for this technology mean that payback are generally lower. As a comparable cost, this technology equates to £0.196 / kWh (based on 25 year life time cost). However, this cost only relates to meeting 8% of energy (thermal and electrical) demands on site from food and catering waste. The fuel tariff cost of waste collection to an AD plant is unknown, however the above cost includes provision of district heat network across the development site, maintenance and capital. The above cost includes the 4% RPI average per year for maintenance and 5% interest rate for the capital cost.
Typical Payback	Typical Payback – 10 years
Incentives/Grants	Grants & Funding – Current available grants/ funding are as follows: RHI= 6.5pence/kWh; FIT= 9.9pence/kWh; ROC = 2/MWH and Export Tariff = 3.2 pence/kWh
Phasing	This technology would need to be implemented early on; if it were to be a main contribution to the thermal demand; necessitating connection to the DHN. Therefore this technology is not usually associated with small phases but can be implemented in development batches; incorporating at least a few hundred homes. As mentioned above; because this technology is not predicted to generate sufficient energy to meet the developments demand; it may be possible integrate this technology alongside other energy generation plants that collectively contribute to a DHN at a later phase.
Land Values	Residential land value immediately adjacent to an AD plant may be reduced due to the potential odour issues as discussed above.
TECHNICAL	
Connecting Infrastructure	This option requires a site wide heat network to distribute the hot water across the site to each building. In addition; it would require grid connection relative to electricity generated.
Physical factors	The availability of feedstock is one of the major issues and if the sufficient organic waste is not available then this technology will not be work optimally. Existing waste contracts are likely to mean that sufficient organic waste to generate significant energy is unlikely.
Integration with other technologies	This technology can integrate with other CHP technologies as part of site wide network; if all units are designed to facilitate this. It will also integrate with other power generating technologies such as wind and solar PV. It would not integrate well with micro heat technologies such as solar thermal; unless specific areas of the site were not to be connected to the DHN.

SUMMARY

ANAEROBIC DIGESTION (AD) CHP IS UNLIKE TO BE ABLE TO GENERATE SIGNIFICANT HEAT OR POWER, RELATIVE TO TH
DEMANDS, DUE TO LIKELY LIMITATIONS ON ORGANIC WASTE FEEDSTOCK; ALTHOUGH ADDITIONAL FEEDSTOCKS MAY BE
NECESSARILY GUARANTEED). THIS WOULD REQUIRE THIS TECHNOLOGY TO BE INTEGRATED WITH OTHER TECHNOLOGI
AND MAY RESULT IN THIS TECHNOLOGY NOT BEING ECONOMICALLY VIABLE (DUE TO SCALE). THERE IS POTENTIAL ODO
ASSOCIATED WITH TECHNOLOGY WHICH WOULD POINT TO IT BEING LOCATED AWAY FROM RESIDENTIAL DEVELOPMEN

6.3 Appraisal of Biomass CHP Technology

<table>
<tr><th>Key Themes</th><th>Comments</th></tr>
<tr><td>ENVIRONMENT</td><td></td></tr>
<tr><td>Carbon reduction and Energy Generation potential</td><td>Biomass CHP utilises renewable wood chips/pellets as a fuel source (or potentially biofuel) to generate heat and power; and therefore reduces carbon emissions further when against traditional gas boiler and gas CHP technologies. However, this technology is only feasible when sufficient sustainable wood chip/pellet fuel is available.
Provided that sufficient biomass fuel is available then this technology can be sized to meet the energy requirements of the development; as follows (based on 2.82MWe system):
• Electricity Generation = 21,109,582 kWh
• Heat Production = 44,330,122 kWh
The net savings after grid displacement of electricity would be 19,922 tonnes. The below summaries the percentage of energy generated and carbon savings achieved relative to regulated and unregulated energy:
<table>
<tr><th></th><th><u>Regulated & Unregulated</u></th><th><u>Regulated only</u></th></tr>
<tr><td>% energy demand met</td><td>87%</td><td>124%</td></tr>
<tr><td>% carbon savings</td><td>77%</td><td>143%</td></tr>
</table></td></tr>
<tr><td>Spatial and Landscape</td><td>No significant landscape issues associated with this option as the biomass plants are enclosed within a building structure; with the exception of the biomass fuel storage which may be a silo type structure; which is in keeping with the existing rural nature of the site and is not considered to represent a landscape impact.
It is likely that at least 2 energy centres would be required; sized approximately 25m x15m with additional service yards. It is not considered that these would represent a negative spatial or landscape impact as they would be fully integrated into the masterplan layout and design. However, each would have exhaust flues extending some 15m from the CHP plant; which would have limited local landscape impact.</td></tr>
<tr><td>Biodiversity</td><td>There are no significant biodiversity concerns with this technology at the site.</td></tr>
<tr><td>Environmental Quality</td><td>Potential air quality can occurs due to the burning of wood fuel, which have a higher nitrogen oxide content than traditional gas boilers; however this would be controlled as part of the plant and flue arrangements and so unlike to cause any actual impact.
Noise will be generated by the CHP engines; however, this would be mitigated by acoustic enclosures to acceptable levels.</td></tr>
<tr><td>SOCIAL</td><td></td></tr>
<tr><td>Governance</td><td>This is district scale technology that requires a site wide DHN to facilitate the transfer of hot water to each building. This type of technology could be linked to local governance structure, if deemed appropriate, and facilitate the community buy-in.</td></tr>
<tr><td>Equity</td><td>This technology has the potential to help reduce the heating bills, depending on the pricing strategy adopted and biomass fuel supply; as low cost waste heat could be used to meet the sites thermal demand.
In addition; it is likely that the Biomass fuel would be purchased locally which would benefit local economy.</td></tr>
<tr><td>Health / Wellbeing</td><td>No significant health and wellbeing issues.</td></tr>
<tr><td>ECOMONIC</td><td></td></tr>
</table>

Typical Cost	As a comparable cost, this technology equates to £0.095 / kWh (based on 25 year life time cost). This is based upon meeting complete thermal demands and approximately 68% of electricity demands. This cost includes, the fuel tariff cost at the rate of £125/tonne of biomass, a provisional sum relative to provision of district heat network across the development site, maintenance and capital cost. The above cost includes 4% RPI average per year for maintenance and fuel cost and 5% interest rate for the capital cost.
Typical Payback	Typical Payback – 10 – 15 Years
Incentives/Grants	Grants & Funding – Current available grants/ funding are as follows: RHI= 2.6pence/kWh, ROC =0.5/MWH
Phasing	This technology would need to be implemented at the start of build out; if it were to be a main contribution to the thermal demand; necessitating installation and connection to a site wide DHN. Therefore this technology is not usually associated with small phases but can be implemented in development batches; incorporating at least a few hundred homes.
Land Values	It is considered that this technology would not have any significant impact on land values.
TECHNICAL	
Connecting Infrastructure	This option requires a site wide heat network to distribute the hot water across the site to each building. In addition; it would require grid connection relative to electricity generated.
Physical factors	The major technical constraint is the availability of biomass fuel and fuel security for long term generation. According to “Nation al Biofuel Supply database” there are few biomass logs, chip and palettes suppliers are available within the close proximity of the site (more information is presented in Appendix D). To generate the energy as mentioned under “Carbon and Energy” section approximately 20,693 tonnes of biomass fuel would be required.
Integration with other technologies	This technology can integrate with other CHP technologies as part of site wide network; if all units are designed to facilitate this. It will also integrate with other power generating technologies such as wind and solar PV. It would not integrate well with micro heat technologies such as solar thermal; unless specific areas of the site were not to be connected to the DHN.
SUMMARY	

BIOMASS CHP COULD MEET THE OVERALL HEATING DEMANDS AND A CONSIDERABLE PROPORTION OF THE ELECTRICA DEVELOPMENT; HOWEVER, CONSISTENT AND AVAILABILITY BIOMASS FUEL WOULD BE REQUIRED TO FACILITATE THIS. T ALSO CREATE SIGNIFICANT CARBON SAVINGS.

6.4 Appraisal of Gas CHP

Key Themes	Comments
ENVIRONMENT	
Carbon reduction and Energy Generation potential	Gas CHP design would be optimised to meet the space heating and hot water demands of development. A 2.79MWe gas CHP unit would be able to meet the space heating/ hot water requirements for the whole site (or smaller units equalling this total); generating: • Total Electricity Generation = 20,428,627 kWh • Total Heat Production = 44,330,122 kWh The net carbon savings after grid displacement of electricity would be 12,045 tonnes. The below summaries the percentage of energy generated and carbon savings achieved relative to regulated and unregulated energy:

	Regulated & Unregulated	Regulated only
% energy demand met	86%	123%
% carbon savings	47%	86%

Key Themes	Comments
Spatial and Landscape	No significant landscape issues associated with this option as the gas CHP plants are enclosed within a building structure. It is likely that at least 2 energy centres would be required; sized approximately 25m x15m with additional service yards. It is not considered that these would represent a negative spatial or landscape impact as they would be fully integrated into the masterplan layout and design. However, each would have exhaust flues extending some 15m from the roof of the CHP plant; which would have limited local landscape.
Biodiversity	There are no biodiversity issues linked to this technology.
Environmental quality	Noise will be generated by the CHP engines; however, this would be mitigated by acoustic enclosures to acceptable levels.
SOCIAL	
Governance	This is district scale technology that requires a site wide DHN to facilitate the transfer of hot water to each building. This type of technology could be linked to local governance structure, if deemed appropriate, and facilitate community buy-in.
Equity	This technology has the potential to help reduce the heating bills, depending on the pricing strategy adopted and biomass fuel supply; as low cost waste heat could be used to meet the sites thermal demand.
Health / Wellbeing	There are no negative health and wellbeing concerns of this technology.
ECOMONIC	
Typical Cost	As a comparable cost, this technology equates to £0.046 / kWh (based on 25 year life time cost). This is based upon meeting complete thermal demands and approximately 66% of electricity demands. This cost includes the capital, maintenance and fuel cost to generate the energy from this option and also the distribution network cost from the energy centre across the development site. The above cost includes the 4% RPI average per year for maintenance and fuel cost and 5% interest rate for the capital cost
Typical Payback	Typical Payback – 10 – 15 Years
Incentive/Grants	There are no FIT's and RHI available for this option, however some export tariff and Climate Change Levy tax relaxations are available for this option

Phasing	This technology would need to be implemented at the start of build out; if it were to be a main contribution to the thermal demand; necessitating installation and connection to a site wide DHN. Therefore this technology is not usually associated with small phases but can be implemented in development batches; incorporating at least a few hundred homes.
Land Values	It is considered that this technology would not have any significant impact on land values.
TECHNICAL	
Connecting Infrastructure	This option requires a site wide heat network to distribute the hot water across the site to each building. In addition; it would require grid connection relative to electricity generated.
Physical factors	There are no specific physical limitations to this option. However, this technology will be dominated by the global supply of natural gas and fossil fuel prices.
Integration with other technologies	This technology can integrate with other CHP technologies as part of site wide network; if all units are designed to facilitate this. It will also integrate with other power generating technologies such as wind and solar PV. It would not integrate well with micro heat technologies such as solar thermal; unless specific areas of the site were not to be connected to the DHN.

SUMMARY

*GAS CHP, IF CORRECTLY SIZED, IS CAPABLE OF PRODUCING ENOUGH HEAT TO MEET THE THERMAL DEMANDS OF SITE,
PORTION OF THE ELECTRICAL DEMAND. HOWEVER, AS WITH THE OTHER DISTRICT HEATING TECHNOLOGY, THIS WILL I
WIDE DHN TO ENSURE EACH BUILDING IS CONNECTED. HOWEVER, THIS TECHNOLOGY IS COMPLETELY DEPENDENT UPON
A GENERATION FUEL AND THEREFORE DOES NOT PROVIDE THE SAME LEVEL OF CARBON SAVINGS AS SOME RENEWA*

6.5 Appraisal of Solar PV (Roof mounted)

<table>
<tr><th>Key Themes</th><th>Comments</th></tr>
<tr><td colspan="2">ENVIRONMENT</td></tr>
<tr><td>Carbon reduction and Energy Generation potential</td><td>Roof mounted solar PV would be limited to south facing roofs. For this appraisal; it has been assumed that 50% of roofs will be orientated southwards; and available for PV generation. The following demonstrate the generation capacity:
• Total Electricity Generation from available Residential roof space = 14,856,351 kWh
The above meets the full regulated electricity demands of the residential development and some of the unregulated demands. In total approximately 72% of the overall residential electricity demand can be met through this option; with a total carbon savings of 7,710 tonnes
• Total Electricity Generation from available Commercial roof space = 3,618,122 kWh
The above meets approximately 35% of the commercial electricity demand of the site; with a carbon saving of 1,877 tonnes
The below summaries the percentage of energy generated and carbon savings achieved relative to regulated and unregulated energy:
<table>
<tr><th></th><th>Regulated & Unregulated</th><th>Regulated only</th></tr>
<tr><td>% energy demand met</td><td>25%</td><td>35%</td></tr>
<tr><td>% carbon savings</td><td>37%</td><td>69%</td></tr>
</table></td></tr>
<tr><td>Spatial and Landscape</td><td>This technology is unlikely to have any impact to landscape character or view. It may however create a distinctive streetscape and design concept relative to the development.</td></tr>
<tr><td>Biodiversity</td><td>There are no biodiversity impacts associated with solar PV option.</td></tr>
<tr><td>Environmental quality</td><td>There are no negative issues with regards to air quality, land quality, noise and water quality as this option.</td></tr>
<tr><td colspan="2">SOCIAL</td></tr>
<tr><td>Governance</td><td>As this technology is installed on each building; it can largely be owned by the home owners / occupiers of the development.</td></tr>
<tr><td>Equity</td><td>Solar PV creates an immediate and direct benefit to the home owners and occupiers of buildings; reducing electricity bills.</td></tr>
<tr><td>Health / Wellbeing</td><td>There are no negative health and wellbeing concerns of this technology</td></tr>
<tr><td colspan="2">ECOMONIC</td></tr>
<tr><td>Typical Cost</td><td>Solar PV is one of the more expensive renewable technologies, but one which has been subject to significant downward price shifting due to relatively rapid take up and technology improvements. For this appraisal the guided solar PV installation cost has been assumed to be £2500/kWp (incl. installation). As downward pricing continues the economics of this option will improve.
As a comparable cost, this technology equates to £0.221 / kWh (based on 25 year life time cost). The above cost contributes towards meeting approximately 59% of total regulated and unregulated electricity demands of the site. This cost includes the capital and maintenance of this option. The above cost includes the 4% RPI average per year for maintenance and fuel cost and 5% interest rate for the capital cost.
The above costs do not include any reinforcement works required to the national grid to enable grid connection.</td></tr>
</table>

Typical Payback	The typical Payback is approximately 10 Years but reducing
Incentives/Grants	Grants & Funding – Current available grants/ funding are as follows: FIT= 6.85pence/kWh ROC = 2/MWH Export Tariff = 4.64 pence/kWh
Phasing	Phasing is easily achievable with roof mounted solar PV; as panels are fitted as each building (or group of buildings) near completion. Therefore operation and cash flow can be phased alongside build out.
Land Values	There are not considered to be any land value issues associated with this technology.
TECHNICAL	
Connecting Infrastructure	Due to the intermittency of electricity generation and balancing generation with demand; there is often a significant grid reinforcement issue associated with solar PV that requires additional infrastructure to be put in place or the incorporation of some balancing / storage technology.
Physical factors	The primary physical constraint is the necessity to have roof orientations facing south to attain the maximum solar harvest for the benefit of the technology. Also the overshadowing needs to be considered for each dwelling/ buildings.
Integration with other technologies	Solar PV is a standalone technology that can integrate with other most other technologies; other than those that may compete for roof space (such as solar thermal). It can contribute to meeting the electricity demands without interfering with heat generating technologies and sit comfortably with other electrical generating options.
SUMMARY	
ROOF MOUNTED SOLAR PV IS ABLE TO GENERATE SIGNIFICANT ELECTRICITY ON SITE. HOWEVER THERE ARE SEVERAL *TECHNOLOGY SUCH AS ROOF AVAILABILITY, ROOF ORIENTATION, SHADING/ SHADOWING AND THE NEED FOR GRID REIN* *THE RESTRICTED AVAILABLE ROOF SPACE THIS OPTION WOULD NOT BE ABLE TO MEET THE TOTAL ELECTRICITY DEMA* *COULD CONTRIBUTE SIGNIFICANTLY. THIS OPTION IS ABLE TO SIT COMFORTABLY ALONGSIDE MANY OTHER TECHNOLO* *COULD BE CONSIDERED AS PART OF A SUITE OF TECHNOLOGIES UTILISED TO ACHIEVE ENERGY DEMAND AND CARBON*	

6.6 Appraisal of Solar PV (Land Base)

<table>
<tr><th>Key Themes</th><th>Comments</th></tr>
<tr><td>ENVIRONMENT</td><td></td></tr>
<tr><td>Carbon reduction and Energy Generation potential</td><td>A large scale land based PV array has the potential to generate significant amounts of electricity resulting in substantial carbon savings. For this appraisal; a 20 ha field has been utilised to demonstrate the generation capacity:

PV array Size = 28,200 kWp
Total Electricity Generation = 23,970 MWh
Net Carbon Savings = 12,440 tonnes

To meet the complete electricity demands of the site approximately 92 hectares would need to be required for PV array. The below summaries the percentage of energy generated and carbon savings achieved relative to regulated and unregulated energy (based on the 20 ha option):
<table>
<tr><th></th><th><u>Regulated & Unregulated</u></th><th><u>Regulated only</u></th></tr>
<tr><td>% energy demand met</td><td>32%</td><td>45%</td></tr>
<tr><td>% carbon savings</td><td>48%</td><td>89%</td></tr>
</table>
</td></tr>
<tr><td>Spatial and Landscape</td><td>Land based PV array would occupy a significant area of land and depending where it is located may be overlooked. However, the site and immediate surrounding area is relatively flat, with numerous hedgerows that define the existing field patterns; which would likely afford significant screening.</td></tr>
<tr><td>Biodiversity</td><td>Installation of land based PV arrays can sit comfortably alongside planting fields with certain species of meadow grass. The need to secure the area around the PV array would likely benefit biodiversity.</td></tr>
<tr><td>Environmental quality</td><td>There are no negative issues with regards to air quality, noise and water quality as this option.</td></tr>
<tr><td>SOCIAL</td><td></td></tr>
<tr><td>Governance</td><td>Local governance is possible but unlikely due to the need to fund the complete array early. However, some sort of ‘share’ type arrangement may be possible as occupiers move into the development; linked to owning properties.</td></tr>
<tr><td>Equity</td><td>This technology has the potential to reduce energy bills; as it requires significant investment cost it will likely managed through private investment.</td></tr>
<tr><td>Health / Wellbeing</td><td>There are no negative health and wellbeing concerns of this technology</td></tr>
<tr><td>ECOMONIC</td><td></td></tr>
<tr><td>Typical Cost</td><td>Solar PV is one of the more expensive renewable technologies, but one which has been subject to significant downward price shifting due to relatively rapid take up and technology improvements. For this appraisal the guided solar PV installation cost has been assumed to be £2500/kWp (incl. installation). As downward pricing continues the economics of this option will improve.
As a comparable cost, this technology equates to £0.288 / kWh (based on 25 year life time cost). The above cost contributes towards meeting approximately 59% of total regulated and unregulated electricity demands of the site. This cost includes the capital and maintenance of this option. The above cost includes the 4% RPI average per year for maintenance and fuel cost and 5% interest rate for the capital cost.
The above costs do not include any reinforcement works required to the national grid.</td></tr>
</table>

Typical Payback	Better payback is achievable due to large energy users are available on site. This is generally between 8 to 10 years.
Incentives/Grants	Grants & Funding – Current available grants/ funding are as follows: FIT= 6.85pence/kWh ROC = 2/MWH Export Tariff = 4.64 pence/kWh FITs are not applicable above 5MW and ROC would only be applicable to 31st March 2017 and then the scheme will be closed for new generations.
Phasing	Theoretically it would be possible to phase installation; as the systems are modular and additional load could be added in stages; however, it is more typical to install larger trenches of arrays at a time; which facilitates other grid connection issues such as sub stations etc.
Land Values	Land based PV arrays take up large areas of land; and therefore directly compete with other land uses. Dependent on screening and security issues; adjoining land values may also be affected by the presence of a PV array.
TECHNICAL	
Connecting Infrastructure	Due to the intermittency of electricity generation and balancing generation with demand; there is often a significant grid reinforcement issue associated with solar PV that requires additional infrastructure to be put in place or the incorporation of some balancing / storage technology.
Physical factors	The major physical constraint is availability of land; that is not overshadowed and overlooked.
Integration with other technologies	Solar PV is a standalone technology and can integrate with most other technologies. It can contribute to meeting the electricity demands without interfering with heat generating technologies and can sit comfortably with other electrical generating options.
SUMMARY	

A SOLAR PV LAND BASED ARRAY WOULD BE ABLE TO GENERATE SIGNIFICANT ELECTRICITY; PROVIDED THAT SUFFICIEN
IT IS ESTIMATED THAT APPROXIMATELY 92HA OF LAND WOULD BE REQUIRED TO MEET 100% OF THE ELECTRICITY DEMA
AND WOULD REQUIRE SIGNIFICANT GRID REINFORCEMENT (WHICH WILL BE NECESSARY AS PART OF THE DEVELOPMEN
ABLE TO SIT COMFORTABLY ALONGSIDE MANY OTHER TECHNOLOGIES AND THEREFORE COULD BE CONSIDERED AS PA
TECHNOLOGIES UTILISED TO ACHIEVE ENERGY DEMAND AND CARBON SAVINGS.

6.7 Appraisal of Solar Thermal

<table>
<tr><th>Key Themes</th><th>Comments</th></tr>
<tr><td>ENVIRONMENT</td><td></td></tr>
<tr><td>Carbon reduction and Energy Generation potential</td><td>Solar Thermal technology generally only contributes towards the hot water demands and therefore has small footprint with regards to energy generated and carbon savings. At the NW Bicester site this technology could contribute to meeting the hot water demands of the residential dwellings; requiring approximately 65% of the available roof space. The following calculations has been made for residential properties:

Residential Hot Water Generation = 12,891,619 kWh (from 65% of available Residential roof space); saving 2785 tonnes of carbon
Commercial Hot Water Generation = 747,500 kWh (from 65% of available roof space); saving 161 tonnes of carbon

The below summaries the percentage of energy generated and carbon savings achieved relative to regulated and unregulated energy:
<table>
<tr><th></th><th><u>Regulated & Unregulated</u></th><th><u>Regulated only</u></th></tr>
<tr><td>% energy demand met</td><td>18%</td><td>26%</td></tr>
<tr><td>% carbon savings</td><td>11%</td><td>21%</td></tr>
</table>
</td></tr>
<tr><td>Spatial and Landscape</td><td>This technology is unlikely to have any impact to landscape character or view. It may however create a distinctive streetscape and design concept relative to the development.</td></tr>
<tr><td>Biodiversity</td><td>There are no biodiversity impacts associated with solar Thermal option.</td></tr>
<tr><td>Environmental quality</td><td>There are no negative issues with regards to air quality, land quality, noise and water quality regarding this option</td></tr>
<tr><td>SOCIAL</td><td></td></tr>
<tr><td>Governance</td><td>As this technology is installed on each building; it can largely be owned by the home owners / occupiers of the development.</td></tr>
<tr><td>Equity</td><td>Solar Thermal would create an immediate and direct benefit to the home owners and occupiers of buildings; reducing electricity bills.</td></tr>
<tr><td>Health / Wellbeing</td><td>There are no significant health and safety issues linked with this technology, except the risk of scalding which can if not designed appropriately. Design should be undertaken to maintain the balance between bacteria growth, scald risk, water flow rates and scale reduction.</td></tr>
<tr><td>ECOMONIC</td><td></td></tr>
<tr><td>Typical Cost</td><td>The solar thermal installation cost relatively low but additional plumbing is required in comparison with the traditional boiler which increases the overall cost.
As a comparable cost, this technology equates to £0.423 / kWh (based on 25 year life time cost). The above cost is based upon contribution to the hot water demands only. This cost includes the capital and maintenance of this option. The above cost includes the 4% RPI average per year for maintenance and fuel cost and 5% interest rate for the capital cost.</td></tr>
<tr><td>Typical Payback</td><td>Typical Payback –10 years</td></tr>
<tr><td>Incentives/Grants</td><td>Grants & Funding – Current available grants/ funding are as follows:
RHI = 8.5pence/kWh</td></tr>
</table>

Phasing	Phasing is easily achievable as this technology is building mounted and the solar thermal collectors can be fitted as each building (or group of buildings) near completion. Therefore operation and cash flow can be phased alongside build out.
Land Values	There are not considered to be any land value issues associated with this technology.
TECHNICAL	
Connecting Infrastructure	No grid connection is required and no additional infrastructure required except the additional plumbing and large hot water storage tank. This might be an issue for small 1 to 2 bedrooms unit types.
Physical factors	The technical constraints associated with this option are south roof facings, extra plumbing, and year round hot water demands (which requires a larger than normal hot water storage with immersion heater to boost heat). This technology may be difficult to install in small unit types and flats.
Integration with other technologies	This is a standalone hot water generation technology that can combine with electricity generating technologies; although may conflict with roof mounted solar PV.
SUMMARY	
THIS TECHNOLOGY CAN CONTRIBUTE TO THE HOT WATER DEMANDS AT THE SITE. HOWEVER THERE ARE SEVERAL CHA TECHNOLOGY SUCH AS AMOUNT OF ROOF AVAILABLE FOR INSTALLATION, ROOF ORIENTATION AND SHADING/ SHADOW THERE MAY BE CONFLICTING DEMANDS ON ROOF SPACE BETWEEN SOLAR THERMAL AND SOLAR PV DEPENDENT UPON CARBON SAVINGS ACHIEVED.	

6.8 Appraisal of Wind (Small/Medium Scale)

<table>
<tr><th>Key Themes</th><th>Comments</th></tr>
<tr><td>ENVIRONMENT</td><td></td></tr>
<tr><td>Carbon reduction and Energy Generation potential</td><td>The carbon reduction and energy generation potential of wind turbine technology is dependent upon wind speed.
Small scale wind turbines would not be feasible due to poor wind speed (approximately 4.7m/s) at Bicester at 10m above ground level.
Medium scale wind turbines, with a tower height of 45meters and the average wind speed of 6.1 m/s to 6.4 m/s has the potential to generate electricity; albeit at the lower end of the power scale. Total electricity Generation from a single 800kW wind turbine system at a wind speed of 7m/s and hub height of 60m = 387,472kWh; saving 201 tonnes of carbon per turbine.
To meet the total residential electricity (regulated and unregulated) demands of the site would require around 54 of the above wind turbines and a further 27 to meet the commercial demands. The below summaries the percentage of energy generated and carbon savings per wind turbine to achieved relative to regulated and unregulated energy:
<table>
<tr><th></th><th>Regulated & Unregulated</th><th>Regulated only</th></tr>
<tr><td>% energy demand met</td><td>0.51%</td><td>1%</td></tr>
<tr><td>% carbon savings</td><td>2%</td><td>3%</td></tr>
</table>
</td></tr>
<tr><td>Spatial and Landscape</td><td>Landscape visual impacts will occur as a result of the installation of wind turbines; which would necessitate detailed assessment.
Residential development is typically sited at least 500m away from wind turbines (see below).</td></tr>
<tr><td>Biodiversity</td><td>There are potential biodiversity issues associated with wind turbines i.e. small bird trappings/killing within the turbine wings associated with wind turbines however there are none major issues of concerns occurs for this site.</td></tr>
<tr><td>Environmental quality</td><td>Noise can be an issue associated with this technology; generally requiring turbines to be located at least 500m away from residential areas.</td></tr>
<tr><td>SOCIAL</td><td></td></tr>
<tr><td>Governance</td><td>Local governance is possible but unlikely due to the need to fund the complete array early. However, some sort of ‘share’ type arrangement may be possible as occupiers move into the development; linked to owning properties.</td></tr>
<tr><td>Equity</td><td>This technology has the potential to reduce energy bills; as it requires significant investment cost it will likely managed through private investment.</td></tr>
<tr><td>Health / Wellbeing</td><td>As mentioned above, there may be noise issues associated with this technology that may be regarded as a nuisance.</td></tr>
<tr><td>ECOMONIC</td><td></td></tr>
<tr><td>Typical Cost</td><td>As a comparable cost, this technology equates to £0.142 / kWh (based on 25 year life time cost). This is based on meeting approximately 2% of total regulated and unregulated electricity demands of the site; from a single medium scale (circa 60m hub height) turbine. This cost includes the capital and maintenance of this option. The above cost includes the 4% RPI average per year for maintenance and 5% interest rate for the capital cost.
The above costs do not include any reinforcement works required to the national grid to enable grid connection</td></tr>
<tr><td>Typical Payback</td><td>Typical Payback – 10 to 20 years</td></tr>
</table>

Incentives/Grants	Grants & Funding – Current available grants/ funding are as follows: FIT = 25.40 pence/kWh (15kW to 100kW turbines) Export Tariff = 3.20 pence/kWh
Phasing	Theoretically it would be possible to phase installation; one turbine at a time; however, it is more typical to install several turbine in one go to facilitate planning, grid connection issues and funding.
Land Values	Adjacent and nearby land values may be negatively affected due to perceived visual impact.
TECHNICAL	
Connecting Infrastructure	Due to the intermittency of electricity generation and balancing generation with demand; there is often a significant grid reinforcement issue associated with wind turbines that requires additional infrastructure to be put in place or the incorporation of some balancing / storage technology.
Physical factors	Wind speed is the predominant factor in determining the suitability of this technology. Even at 60m hub height, the predicted wind speed is at the lower end of the power scale; only just making medium scale turbines viable.
Integration with other technologies	Medium scale wind turbine is a standalone technology and can integrate with most other technologies. It can contribute to meeting the electricity demands without interfering with heat generating technologies and can sit comfortably with other electrical generating options.
SUMMARY	
SMALL SCALE WIND TURBINES WOULD NOT BE VIABLE AT BICESTER DUE TO THE LACK OF SUFFICIENT WIND SPEED. ME TURBINES MAY BE VIABLE; WITH AN ESTIMATED AVERAGE SPEED OF 6.8M/S AT A HUB HEIGHT OF 60METERS. EACH MED TURBINE WOULD ONLY CONTRIBUTE A SMALL PORTION OF THE SITES ELECTRICITY DEMAND; REQUIRING AROUND 81 TU TOTAL ELECTRICAL DEMAND. *(NOTE: IF HIGHER WIND SPEEDS WERE RECORDED AT THE SITE IT WOULD SIGNIFICANTLY IMPROVE ELECTRICITY GENE*	

6.9 Appraisal of Wind (Large Scale)

<table>
<tr><th>Key Themes</th><th>Comments</th></tr>
<tr><td>ENVIRONMENT</td><td></td></tr>
<tr><td>Carbon reduction and Energy Generation potential</td><td>The carbon reduction and energy generation potential of wind turbine technology is dependent upon wind speed. Large scale wind turbines generally require a minimum of 6 m/s to operate; and commonly require wind speeds over 9m/s to generate electricity efficiency. Based upon another proposal for large scale wind with Cherwell District Council area we have assumed a wind speed of 6.4m/s may be achievable.
Total Electricity Generation from a 3MW wind turbine at a wind speed of 6.8m/s = 904,102 kWh; saving circa 938 tonnes of carbon (per turbine).
The above meets the portion of the electricity demands of the EcoTown, in total approximately 4% of the overall electricity demands of the residential dwellings and 9% of the commercial buildings. However to meet the residual electricity demand additional 34 similar large scale wind turbines would be required.
The below summaries the percentage of energy generated and carbon savings per wind turbine to achieved relative to regulated and unregulated energy:
<table>
<tr><th></th><th><u>Regulated & Unregulated</u></th><th><u>Regulated only</u></th></tr>
<tr><td>% energy demand met</td><td>1.2%</td><td>2%</td></tr>
<tr><td>% carbon savings</td><td>4%</td><td>7%</td></tr>
</table></td></tr>
<tr><td>Spatial and Landscape</td><td>Landscape visual impact is commonly regarded as one of the major issues associated with this technology and often means that medium to large scale turbines are located away from existing and new developments.</td></tr>
<tr><td>Biodiversity</td><td>There are potential biodiversity issues associated with wind turbines i.e. small bird trappings/killing within the turbine wings associated with wind turbines however there are none major issues of concerns occurs for this site.</td></tr>
<tr><td>Environmental quality</td><td>Noise can be an issue associated with this technology; generally requiring turbines to be located at least 500m away from residential areas.</td></tr>
<tr><td>SOCIAL</td><td></td></tr>
<tr><td>Governance</td><td>Local governance is possible but unlikely due to the need to fund the complete array early. However, some sort of ‘share’ type arrangement may be possible as occupiers move into the development; linked to owning properties.</td></tr>
<tr><td>Equity</td><td>This technology has the potential to reduce energy bills; as it requires significant investment cost it will likely managed through private investment.</td></tr>
<tr><td>Health / Wellbeing</td><td>As mentioned above, there may be noise issues associated with this technology that may be regarded as a nuisance.</td></tr>
<tr><td>ECOMONIC</td><td></td></tr>
<tr><td>Typical Cost</td><td>As a comparable cost, this technology equates to £0.130 / kWh (based on 25 year life time cost). This is based on meeting approximately 2.9% of total regulated and unregulated electricity demands of the site; from a single large scale turbine. This cost includes the capital and maintenance of this option but does not include the grid connection cost to distribute the electricity. The above cost includes the 4% RPI average per year for maintenance cost and 5% interest rate for the capital cost</td></tr>
<tr><td>Typical Payback</td><td>Typical Payback – 4 – 8 years</td></tr>
</table>

Incentives/Grants	Grants & Funding – Current available grants/ funding are as follows: FIT = 4.9 pence/kWh (greater than 1.5MW turbines) Export Tariff = 3.20 pence/kWh
Phasing	Theoretically it would be possible to phase installation; one turbine at a time; however, it is more typical to install several turbines in one go to facilitate planning, grid connection issues and funding.
Land Values	Adjacent and nearby land values may be negatively affected due to perceived visual impact.
TECHNICAL	
Connecting Infrastructure	Due to the intermittency of electricity generation and balancing generation with demand; there is often a significant grid reinforcement issue associated with wind turbines that requires additional infrastructure to be put in place or the incorporation of some balancing / storage technology.
Physical factors	Wind speed is the predominant factor in determining the suitability of this technology. Available information suggests that average wind speeds are relatively low to moderate; at the lower end of the power scale; only just making wind turbines viable. Another physical constraint is spacing distance between turbines and usual separation zone to any residential land use (due to noise impacts).
Integration with other technologies	Wind turbine is a standalone technology and can integrate with most other technologies. It can contribute to meeting the electricity demands without interfering with heat generating technologies and can sit comfortably with other electrical generating options.
SUMMARY	

USING A WIND SPEED OF 6.4 M/S AND 100 M HUB HEIGHT A SINGLE LARGE SCALE TURBINE WOULD GENERATE ELECTRI
OF TOTAL RESIDENTIAL DEMANDS AND 9% OF COMMERCIAL DEMANDS. THIS WOULD REQUIRE AROUND 34 LARGE SCAL
MEET THE TOTAL ELECTRICITY DEMANDS OF THE SITE. HENCE, THE WIND SPEED INVESTIGATIONS SHOULD BE CARRIE
CONSIDERATION OF THIS OPTION. THE ECONOMIC APPRAISAL OF THIS OPTION HAS BEEN DISCUSSED UNDER SECTION

(NOTE: IF HIGHER WIND SPEEDS WERE RECORDED AT THE SITE IT WOULD SIGNIFICANTLY IMPROVE ELECTRICITY GENE

6.10 Appraisal of Heat Pump Technology

Key Themes	Comments
ENVIRONMENT	
Carbon reduction and Energy Generation potential	This low carbon technology requires electricity to leverage the generation of high efficient heat, and therefore has a reduced carbon reduction potential relative to some renewable options. For this appraisal; we have sized this technology to meet the total thermal demand of the site; however, it is often associated with only providing space heating demand. The below details the energy generation and carbon savings associated with this option: • Residential thermal demand = 27,398,887 kWh (Net Carbon Savings in comparison with traditional (85% efficient) boiler = 1178tonnes) • Commercial thermal demand = 16,931,235 kWh (Net Carbon Savings in comparison with traditional (85% efficient) boiler = 728tonnes) The below summaries the percentage of energy generated and carbon savings achieved relative to regulated and unregulated energy: (see table below) Whilst this technology can be sized to meet thermal demand; the corresponding carbon saving is relatively limited because of the electricity used to leverage this heat generation.
Spatial and Landscape	The heat pump does not have any visual impact within the landscape and would not influence streetscape.
Biodiversity	There are no biodiversity concerns of this technology at Bicester site.
Environmental quality	Noise issues can occur with air source heat pumps and therefore careful selection of low noise machines and siting external units in locations to avoid nuisance would be essential. Open loop ground source heat pumps have the potential to impact underlying groundwater characteristics; and would need approval from the Environment Agency. Close loop systems would be more typical and would not have the same potential risk.
SOCIAL	
Governance	This technology is typically installed on a building by building basis; and therefore it can largely be owned by the home owners / occupiers of the development.
Equity	This option would create an immediate and direct benefit to the home owners and occupiers of buildings; reducing electricity bills.
Health / Wellbeing	There are no significant health and wellbeing issues associated with heat pump technology. As mentioned above, there is the potential for air source heat pumps to cause noise issues; which requires careful selection of low noise machines and siting of external units in locations to avoid nuisance.
ECOMONIC	
Typical Cost	As a comparable cost, this technology equates to £0.082 / kWh (based on 25 year life time cost). This cost includes the capital, maintenance and fuel cost of this option. The above cost includes the 4% RPI average per year for maintenance and fuel cost and 5% interest rate for the capital cost.
Typical Payback	Typical Payback – 8 years

	Regulated & Unregulated	Regulated only
% energy demand met	59%	84%
% carbon savings	7%	14%

Incentives/Grants	Grants & Funding – Current available grants/ funding are as follows: RHI = 3 pence/kWh
Phasing	Installation is typically on a building by building basis and therefore operation and cash flow can be phased alongside build out.
Land Values	There are not considered to be any land value issues associated with this technology.
TECHNICAL	
Connecting Infrastructure	There are no additional infrastructure issues directly linked with this technology however for ground source heat pump the bore hole system would cause some additional infrastructure cost for ground works.
Physical factors	Ground source heat pumps require access to land where the borehole system can be installed (underneath buildings if needed). Air source heat pumps require careful siting of the external heat exchanger to prevent nuisance. This technology generally works better with under floor heating system rather than wet radiator heating systems.
Integration with other technologies	This is a standalone hot water/space heating generation technology that can combine with electricity generating technologies. It would not integrate with other heat generating technologies.
SUMMARY	

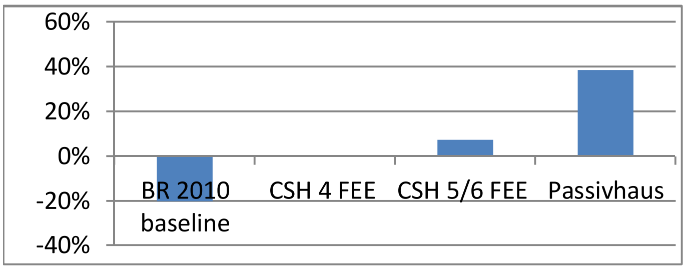
HEAT PUMP TECHNOLOGY COULD MEET THE THERMAL DEMANDS OF THE SITE; HOWEVER IT REQUIRES ELECTRICITY TO
THEREFORE DOES NOT CREATE THE SAME CARBON SAVINGS AS SOME OTHER OPTIONS. GROUND SOURCE HEAT PUM
GROUND SPACE FOR BOREHOLE INSTALLATION OR TRENCHES AND AIR SOURCE HEAT PUMPS REQUIRE CAREFUL SITIN
EXCHANGER TO AVOID NOISE NUISANCE.

6.11 Appraisal of Biomass Boiler Technology

Key Themes	Comments
ENVIRONMENT	
Carbon reduction and Energy Generation potential	Biomass boiler utilises renewable wood chips/pellets as a fuel source (or potentially biofuel) to generate heat; and therefore reduces carbon emissions further when against traditional gas boiler technology. However, this technology is only feasible when sufficient sustainable wood chip/pellet fuel is available. Provided that sufficient biomass fuel is available then this technology can be sized to meet the thermal energy requirements of the development; as follows (based on 2000kW Unit): • Heat Production = 44,330,122 kWh The net carbon savings would be 8,741 tonnes. The below summaries the percentage of energy generated and carbon savings achieved relative to regulated and unregulated energy: The below summaries the percentage of energy generated and carbon savings achieved relative to regulated and unregulated energy: Regulated & Unregulated / Regulated only % energy demand met: 59% / 84% % carbon savings: 34% / 63% This technology option can be sized to meet the thermal demands on site and also reduces the carbon footprint due to non-reliance on fossil fuel. .
Spatial and Landscape	No significant landscape issues associated with this option as the biomass plants are enclosed within a building structure; with the exception of the biomass fuel storage which may be a silo type structure; which is in keeping with the existing rural nature of the site and is not considered to represent a landscape impact. It is likely that at least 2 energy centres would be required; sized approximately 25m x15m with additional service yards. It is not considered that these would represent a negative spatial or landscape impact as they would be fully integrated into the masterplan layout and design. However, each would have exhaust flues extending some 15m from the CHP plant; which would have limited local landscape impact.
Biodiversity	There are no significant biodiversity concerns with this technology at the site.
Environmental Quality	Potential air quality can occurs due to the burning of wood fuel, which have a higher nitrogen oxide content than traditional gas boilers; however this would be controlled as part of the plant and flue arrangements and so unlike to cause any actual impact.
SOCIAL	
Governance	As this technology is installed on each building; it can largely be owned by the home owners / occupiers of the development
Equity	Biomass Boiler would create an immediate and direct benefit to the home owners and occupiers of buildings; reducing the heating bills.
Health / Wellbeing	No significant health and wellbeing issues.
ECOMONIC	
Typical Cost	
Typical Payback	

Incentives/Grants	
Phasing	Phasing is easily achievable with this option; as biomass boilers are fitted as each building (or group of buildings) near completion. Therefore operation and cash flow can be phased alongside build out.
Land Values	There are not considered to be any land value issues associated with this technology.
TECHNICAL	
Connecting Infrastructure	No grid connection is required and no additional infrastructure required except the additional plumbing and large biomass fuel storage space. This might be an issue for small 1 to 2 bedrooms unit types.
Physical factors	The technical constraints associated with this option are mainly the availability, secure and consistent delivery of Biomass fuel and also at the cost effective manner.
Integration with other technologies	This is a standalone technology that can combine with any other electricity generating technologies without interruption.
SUMMARY	
BIOMASS BOILER COULD MEET THE OVERALL HEATING DEMANDS OF THE DEVELOPMENT; HOWEVER, CONSISTENT AND BIOMASS FUEL WOULD BE REQUIRED TO FACILITATE THIS. THIS OPTION WOULD ALSO CREATE SIGNIFICANT CARBON SA	

6.12 Appraisal of Enhance FEE standards

Key Themes	Comments
ENVIRONMENT	
Carbon reduction and Energy Generation potential	Adoption of enhanced FEE standards can result in carbon savings due to reduction in heating demand. The savings in regulated energy demand shown in the graph below are through improvements in the fabric efficiency, ventilation, thermal bridging and air tightness proposed. The chart below shows the impact of changing FEE standard with regards to the % improvement in overall energy demands relative to CSH level 4 FEE standards; which is the PPS1 baseline for the eco-development. 
Spatial and Landscape	This option would not impact landscape character or views.
Biodiversity	There are no biodiversity concerns from enhance FEE as it does not alters the construction process.
Environmental quality	There are no negative issues with regards to air quality, noise and water quality regarding this option
SOCIAL	
Governance	There are no governance issues associated with this option. As each unit would be built to the FEE standards all residents would have equal benefit.
Equity	This option would minimise the overall heating demand of the building and therefore reduce energy bills for every occupant.
Health / Wellbeing	Potential indoor air quality issues may occur due to air tightness; which would require mechanical ventilation and education of occupiers. Improved insulation and build quality would potentially improve noise penetration.
ECOMONIC	
Typical Cost	Adopting higher FEE standards increases the overall construction costs. However by its very nature reduces heating requirements.
Incentives:	No monetary incentives available for higher fabric efficiency
Paybacks:	No data available
Phasing	There are no phasing restrictions as each unit is built to FEE standard.
Land Values	There are no land values issues.
TECHNICAL	
Connecting Infrastructure	No additional infrastructure has been required for this option

Physical factors	There are certain limitations imposed to this option and it is difficult to achieve higher level of fabric efficiency due to building structure and available technology.
Integration with other technologies	If very high FEE standards are adopted; which result in very low heating demand, then the selection of which heating and hot water technology may be influenced.

SUMMARY

ADOPTING VERY HIGH FEE LEVELS INCREASES BUILD COSTS WHILST REDUCING HEATING DEMANDS. INCREASING FEE
BEYOND A CERTAIN LEVEL MAY INFLUENCE WHETHER SOME HEATING AND HOT WATER TECHNOLOGIES REMAIN VALID.
DECISION IS REQUIRED WHETHER TO CONTINUE TO REDUCE DEMAND AT HIGHER BUILD COST OR CONNEC
THIS REPORT HAS CONSIDERED THAT ALL RESIDENTIAL UNITS WOULD BE BUILT TO CODE LEVEL 5 FEE STANDARDS.

7 TECHNOLOGY INTEGRATION

The appraisal sections discuss the limitations of each technology and how they may complement (C) or pair (P) well together; and conversely where they do not typically work well together (X). The following table provides a summary of technology integration and combination.

	EfW	AD CHP	Gas CHP	Biomass CHP	PV array	Wind	Roof PV	Solar Thermal	Heat pumps
EfW	-	X	X	X	C	C	C	X	X
AD CHP	X	-	X[1]	X[1]	C	C	C	X	X
Gas CHP	X	X[1]	-	X[1]	C	C	C	X	X
Biomass CHP	X	X[1]	X[1]	-	C	C	C	X	X
PV array	C	C	C	C	-	P	P	C	C
Wind	C	C	C	C	P	-	P	C	C
Roof PV	C	C	C	C	P	P	-	C[2]	C
Solar Thermal	X	X	X	X	C	C	C[2]	-	X
Heat pumps	X	X	X	X	C	C	C	X	-

Table 7-1 Technology Integration

As always, there are never hard and fast rules; and exceptions exist where technologies that do not typically complement each other; such as biomass CHP and gas CHP, comes when there is a significant heat demand and opportunity exists to have more than one technology combining to service that demand. For example several energy centre with differing CHP technologies all linked via a site wide DHN; sized to share the heat demand – these opportunities are identified in the above table as X[1]. Such a situation may exist at the NW Bicester site due to the size of heat demand and may provide benefit relative to resilience and security of supply.

Where one technology generates heat and another power; then these technologies would typically complement each other. There can, however, be certain situations where physical limitations can create conflict; for example roof mounted solar PV and solar thermal complement each other relative to their respective electrical and thermal generation but compete on roof space to achieve this – such aspects are identified in the above table as C[2].

In other circumstances; technologies may be able to be paired together to meet a specific demand; such as roof mounted PV and wind turbines. Each generate electricity but do not necessarily compete against each other.

8 SUMMARY OF ENERGY GENERATION, CARBON SAVINGS AND COSTS

This section summarises the energy generation and carbon savings of each option in the following tables. These enable comparison of each technology and, together with the previous section, help identify which options may work well together as a collective solution.

Table 8-1 below provides a summary of each technology options energy generation capability relative to regulated and regulated/unregulated energy demand.

Table 8 – 1 – Energy Generation Potential of Various Options

Technology Options	Total Generation Capacity	% of Total Demand met (Regulated and Unregulated)	% of Regulated Demand
Ardley (EfW)	T: 44,330,122 kWh	59%	84%
AD (only food and catering waste)	E: 1,589,844 kWh T: 2,649,740 kWh	6%	8%
Biomass CHP (sized to meet thermal demands)	E: 21,109,582 kWh T: 44,330,122 kWh	87%	124%
Gas CHP (sized to meet thermal demands)	E: 20,428,627 kWh T: 44,330,122 kWh	86%	123%
Large Scale PV (20ha - land space)	E: 23,970,000 kWh	32%	45%
Large Scale Wind (3MW turbine)	E: 904,102 kWh	1.20%	2%
Building Scale PV (50% of Roof space)	E: 18,474,473 kWh	25%	35%
Biomass Boiler (2000 kW_{th} Unit)	T: 44,330,122 kWh	59%	84%
Medium Scale Wind (800kW turbine)	E: 387,472 kWh	0.51%	1%
Solar Thermal (to meet the hot water demands)	T: 13,639,119 kWh	18%	26%
Heat Pump (to meet the thermal demands)	T: 44,330,122 kWh	59%	84%

WHERE E REFLECTS TO ELECTRICAL DEMAND AND T REFLECTS TO THERMAL GENERATION

Notes:

Site Total Thermal Demand = 44,330,122 kWh and Site Total Electrical Demand = 31,139,326 kWh

The above options do not provide any connection hierarchy and have been appraised as individual options relative to their potential to meet the energy demands of the proposed development. Some of the district level options are optimised to meet the complete thermal demand and therefore the above generation capacity depends upon the size of the proposed technology option. The Biomass CHP and Gas CHP options have the potential to meet significant portions of the developments total energy demands; however individual option cannot satisfy the total regulated and unregulated energy demands and a suitable options mix is inevitable.

Table 8-2 below provides a summary of carbon savings of each option; relative to the energy generation identified in table 8-1 above.

Table 8 – 2 – Total Carbon Emissions Savings

Technology Options	Total Carbon Savings	Zero Carbon (Regulated and Unregulated)	Zero Carbon (Regulated Energy Only)
Ardley (EfW) (meeting thermal demand)	9,575 tonnes CO2	37%	69%
AD CHP (only food and catering waste)	1,387 tonnes CO2	5%	10%
Biomass CHP (sized to meet thermal demands)	19,922 tonnes CO2	77%	143%
Gas CHP (sized to meet thermal demands)	12,045 tonnes CO2	47%	86%
Large Scale PV (20ha - land space)	12,440 tonnes CO2	48%	89%
Large Scale Wind (single 3MW turbine)	938 tonnes CO2	4%	7%
Biomass Boiler (2000kW Unit)	8,741 tonnes CO2	34%	63%
Building Scale PV (50% of Roof space)	9,588 tonnes CO2	37%	69%
Medium Scale Wind (single 800kW turbine)	402 tonnes CO2	2%	3%
Solar Thermal (to meet the hot water demands)	2,946 tonnes CO2	11%	21%
Heat Pump (to meet the thermal demands)	1,906 tonnes CO2	7%	14%

THE CARBON FACTORS UTILISED ABOVE ARE AS FOLLOWS: NATURAL GAS=0.216KGCO2/KWH, ELECTRICITY = 0.519KGCO2/KWH AND BIOMASS = 0.016

The above table shows the carbon savings from each option and also the percentage of overall carbon saving relative to meeting regulated and regulated/unregulated energy carbon emissions. As can be seen from the above; no one single option is capable of generating the total carbon saving needed; however some options provide significantly more carbon saving than others; therefore a combination of options is inevitable.

It should be noted that the above tables (8-1 and 8-2) quote the wind turbine options as a single turbine. It is obvious from the above that a significant number of turbines would be required generate the required electrical demand and create sizeable carbon savings.

Table 8-3 below presents a summary of the cost analysis for each option relative to the energy each option generates (as presented in Table 8-1 above). The cost summary table (8-3) presents a comparable £ / kWh cost for each option. Costs have been calculated on the based on capital costs; and a 5% interest rate on capital cost; average RPI (Retail Price Index) of 4% for maintenance and fuel cost over the period of 25 years.

Following is the indicative costs evaluation table for residential development and lists the capital, maintenance and fuel costs for all the options.

Table 8 – 3 – Technology Options Cost Appraisal

Technology Option	District Heat Network (DHN) Cost[1] (£)	Capital Cost[1] (£)	Maintenance Cost[2] (£)/yr	Fuel Cost[2] (£,000)/yr	Cost Comparison[3] (£/kWh)
Ardley Energy from Waste - 26MWe	£23,880,000	£4,375,000	£43,750	£532	0.045
Anaerobic Digestion - 185kWe	£23,880,000	£925,000	£27,750	Unknown	0.196
Biomass CHP - 2.82MWe	£23,880,000	£9,850,000	£395,000	£2,500	0.095
Gas CHP - 2.79 MWe	£23,880,000	£9,470,000	£300,000	£660	0.046
Land base PV Array - 36,635kWp	Not Applicable	£91,580,000	£200,000	Not Applicable	0.288
Large Scale Wind - 1064 kWe	Not Applicable	£1,330,000	£13,300	Not Applicable	0.130
Building mounted Solar PV - 21,735 kWp	Not Applicable	£54,330,000	£110,000	Not Applicable	0.221
Solar Thermal - 85,244m2	Not Applicable	£72,455,000	£350,000	Not Applicable	0.423
Medium Scale Wind Turbine - 456kWe	Not Applicable	£684,000	£3,500	Not Applicable	0.142
Heat Pumps - 1,687kWth	Not Applicable	£4,635,000	£23,000	£1,950	0.082

THE CAPITAL COSTS ARE TAKEN FROM TABLE 2.11, CYRILL SWETT RESEARCH AND SURVEY OF SUPPLIERS AND INSTALLERS, IN RESEARCH TO ASSESS THE COST AND BENEFITS OF THE GOVERNMENT'S PROPOSALS TO R
DEVELOPMENT CLG, SEPTEMBER 2008, THE AD CAPITAL COST IS TAKEN FROM CARBON TRUST CTG011, MAKING SENSE OF RENEWABLE ENERGY TECHNOLOGIES, MARCH 2012.. THE ARDLEY COST IS BASED UPON THE PIPE N
AVERAGE COST BASED UPON THE COST OF £1000 FOR SOFT LAND AND £1500 FOR HARD LAND AND AVERAGE COST OF £1250 HAS BEEN USED TO DRIVER ARDLEY CAPITAL COST. THE 3.5KM PIPE RUN IS THE INDICATIVE DISTA
TRACK FROM ARDLEY PLANT TO THE ECOTOWN, HOWEVER THERE WILL BE ADDITIONAL EXTRA COST TO CROSS MOTORWAYS AND RAILWAY LINE. FUEL COST WOULD BE WOOD PELLETS = £125/TONNE AND GAS = 3.48 PENCE/
ENERGY SAVINGS TRUST, DOMESTIC LOW AND ZERO CARBON TECHNOLOGIES DOCUMENT, REF CE317, SEPTEMBER 2010.. THE ABOVE COST DOES NOT INCLUDE THE COST TO BUILD AND OPERATE THE ENERGY CENTRE AND T
TO BUILD THE ENERGY CENTRE UPON THE ENERGY CENTRE.

Notes:

1: Total Cost – this would be subject to 5% interest over 25 years period

2: Maintenance & Fuel Cost – this would be subject to annual Retail Price Index (RPI) of 4% over 25 years period

3: The cost comparison is based upon the annual cost over 25 years period with the reflection of 5% interest and 4% RPI.

9 CONCLUSION

This report reviews available Low or Zero Carbon technology options that may be utilised at NW Bicester and also investigates their environmental, economic, social and technical impacts of each of the option. This has been undertaken on the basis of energy demands of both residential and commercial units.

The energy demands for the residential units are taken from the SAP 2009 calculations and for commercial units the CIBSE TM46 has been consulted. The details of these calculations and our approach can be found under “Energy Demand Technical note” (presented in Appendix A) and the copies of SAP worksheets can also be found within the report.

Following are the energy demands in terms of fossil fuel and electricity for NW Bicester site.

Table 9 – 1 Energy Demands Summary

Development Type	Electricity Demands (kWh) PA	Fossil Fuel Demands (kWh) PA
Residential *5607 UNITS ENERGY DEMANDS REGULATED/UNREGULATED (ELECTRICAL COOKING, ELECTRICAL APPLIANC*	20,759,351	27,398,887
Commercial *UNITS ENERGY DEMANDS*	10,379,975	16,931,235
Total	**31,139,326**	**44,330,122**

NOTES: THE ABOVE TABLE IS BASED UPON ELECTRICAL COOKING WITHIN RESIDENTIAL PROPERTIES. IF AN GAS COOKING THEN THE TOTAL ELECTRICAL DEMAND WILL CHANGE (FROM 31,139,326KWH) TO 28,802,859KWH AND THE TOTAL THERMA INCREASE (FROM 44,330,121.58 KWH) TO 48,418,258 KWH.

The above demands are based on adopting an improved building fabric efficiency level (CSH level 5). Therefore to meet the above demands we would require a technology/ mix of technology options which can fulfils the electricity demands of 28,803MWh/yr. and the thermal demands of 48,418MWh/yr.

According to the recent discussions with Ardley EfW developer, we have established that the Ardley EfW plant will produce enough waste heat to meet the site space heating and hot water demands, without the need of any additional technology but will require a considerable connecting pipe (alongside a site wide additional district heating network). However this option would require further investigations with regards to the connection from Ardley plant to the Bicester EcoTown, the typical possible routes have been provided within Appedix C of this report.

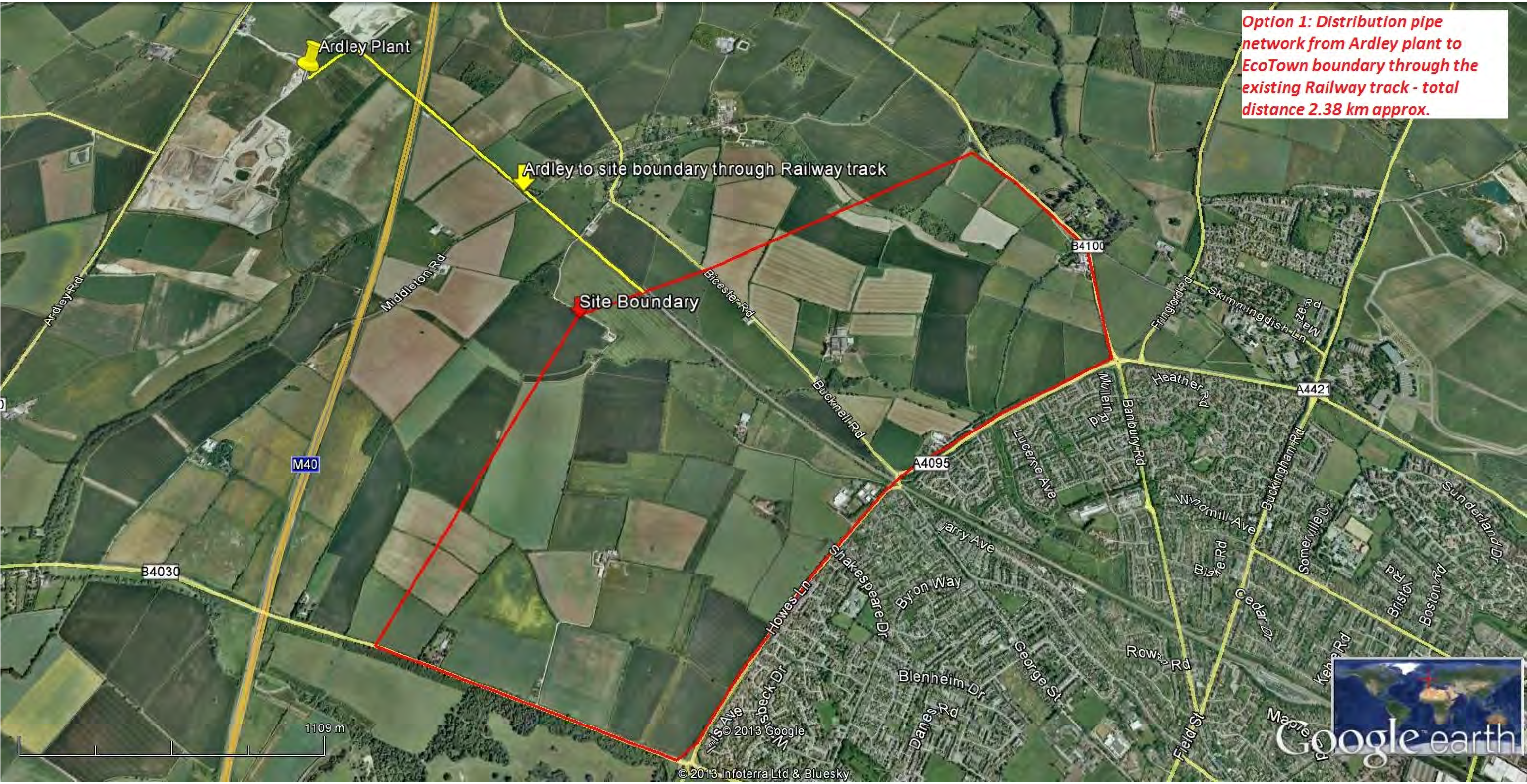
The appraisal has demonstrated that whilst certain technologies may go a considerable way to meeting demands and creating carbon savings; no one technology can fulfil the site’s total energy demand and carbon reduction target. A combined technology solution will be inevitable.

Appendix A

Baseline Energy Demand – Technical Note – 5020-UA005241-ESD-R-1

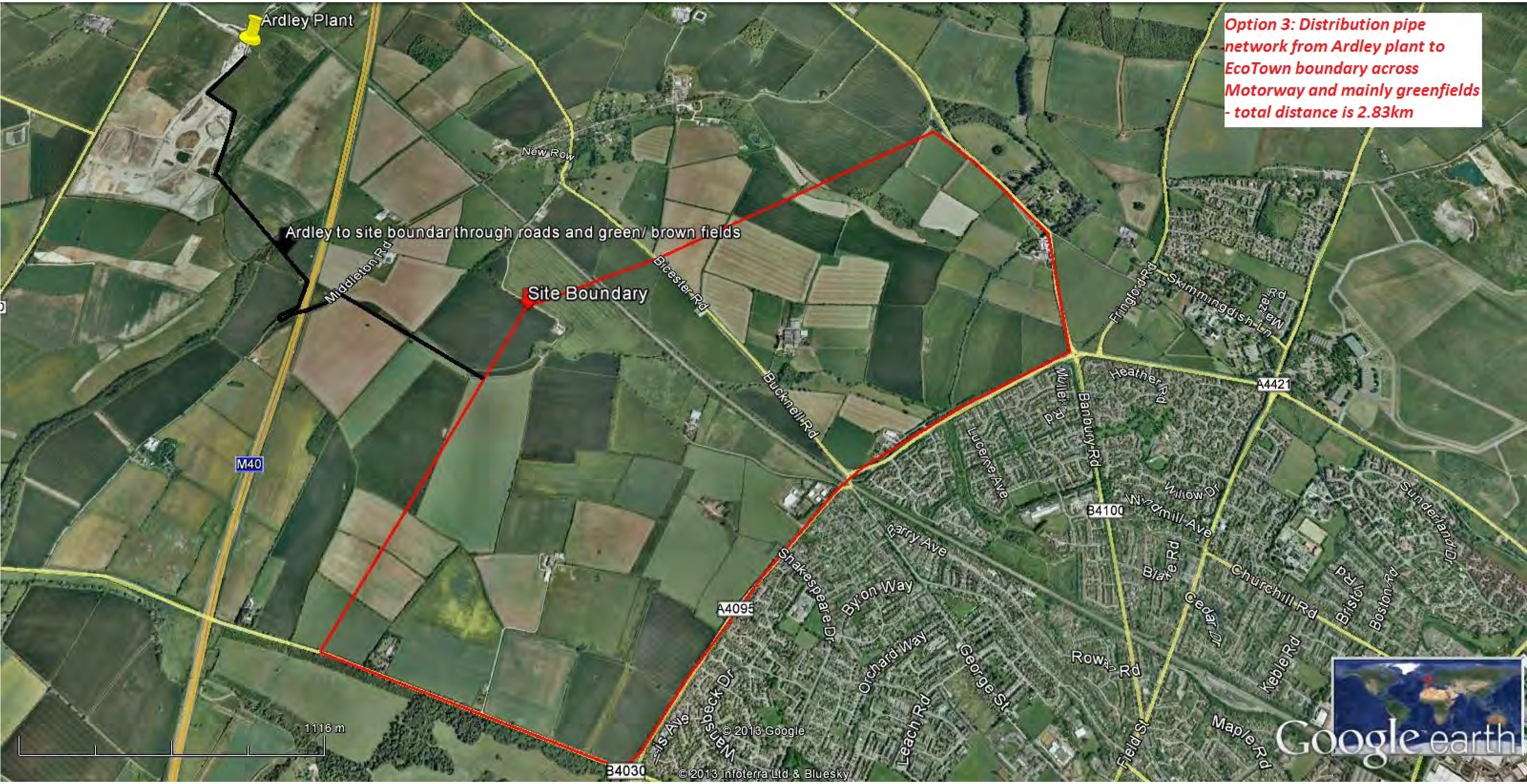
Appendix B

Ardley Road Routes options



Option 1: Distribution pipe network from Ardley plant to EcoTown boundary through the existing Railway track - total distance 2.38 km approx.

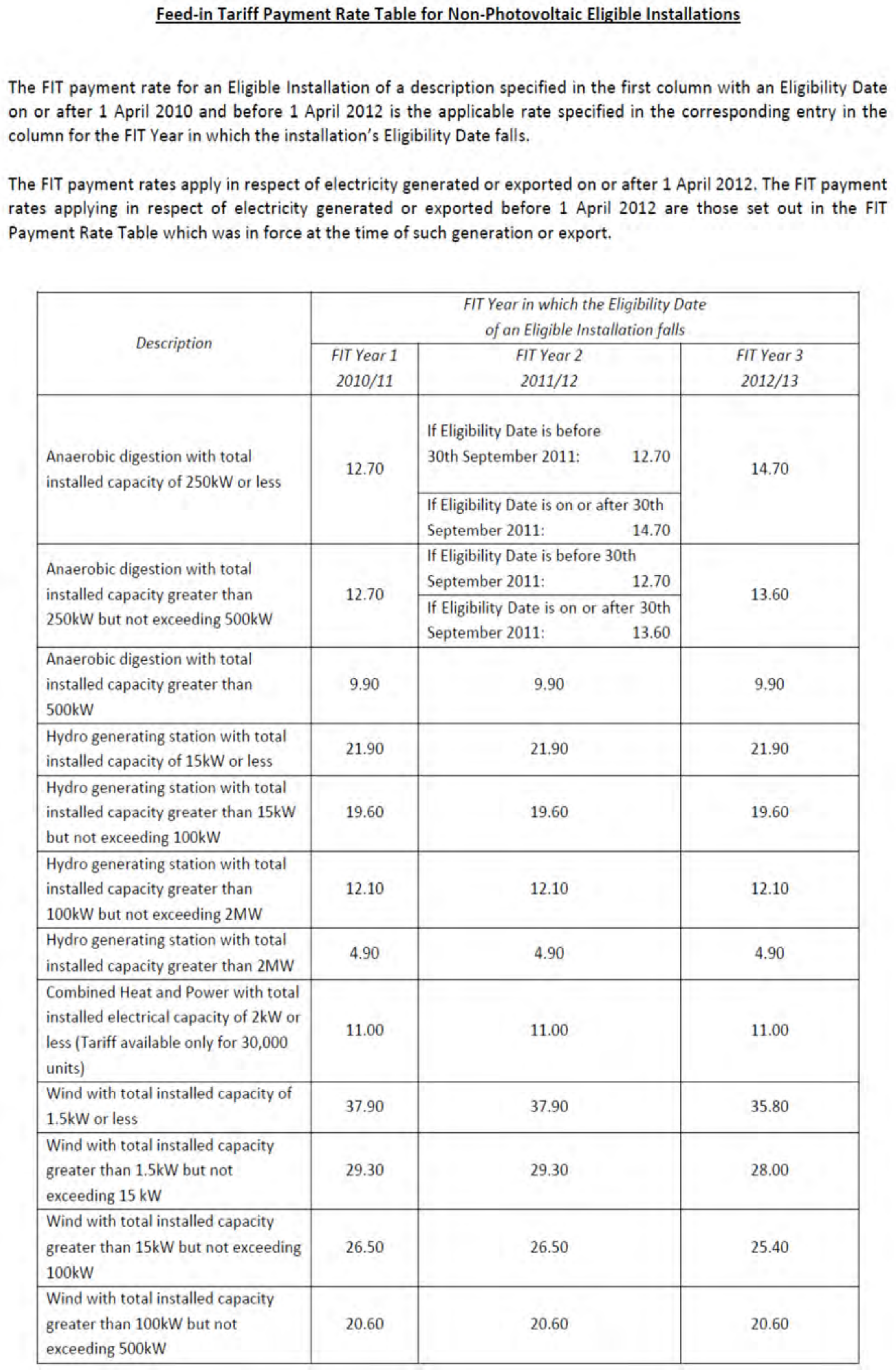
Option 2: Distribution pipe network from Ardley plant to EcoTown boundary across Motorway and link roads - total 4.20km approx.



Option 3: Distribution pipe network from Ardley plant to EcoTown boundary across Motorway and mainly greenfields - total distance is 2.83km

Appendix C

Reference document FIT, RHI tables

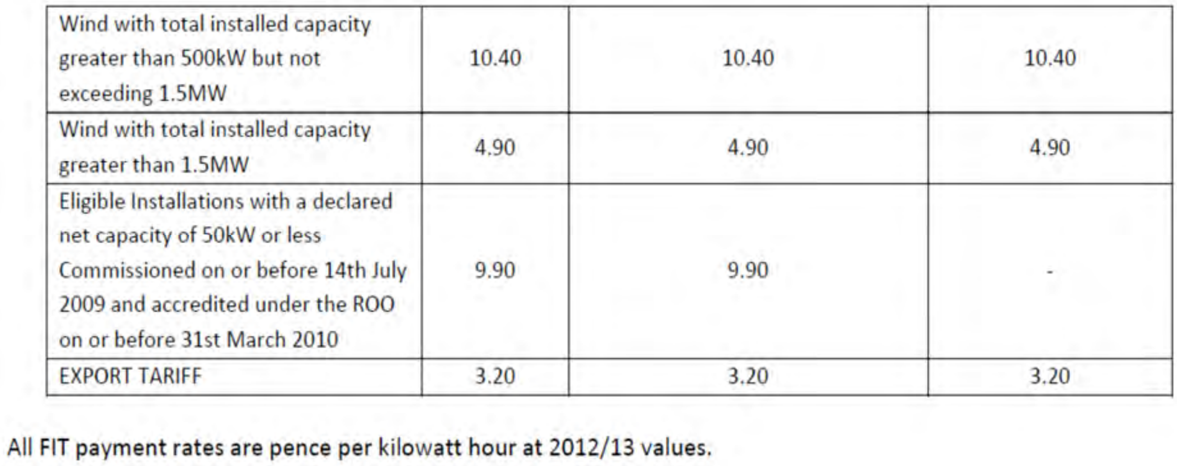


Feed-in Tariff Payment Rate Table for Non-Photovoltaic Eligible Installations

The FIT payment rate for an Eligible Installation of a description specified in the first column with an Eligibility Date on or after 1 April 2010 and before 1 April 2012 is the applicable rate specified in the corresponding entry in the column for the FIT Year in which the installation's Eligibility Date falls.

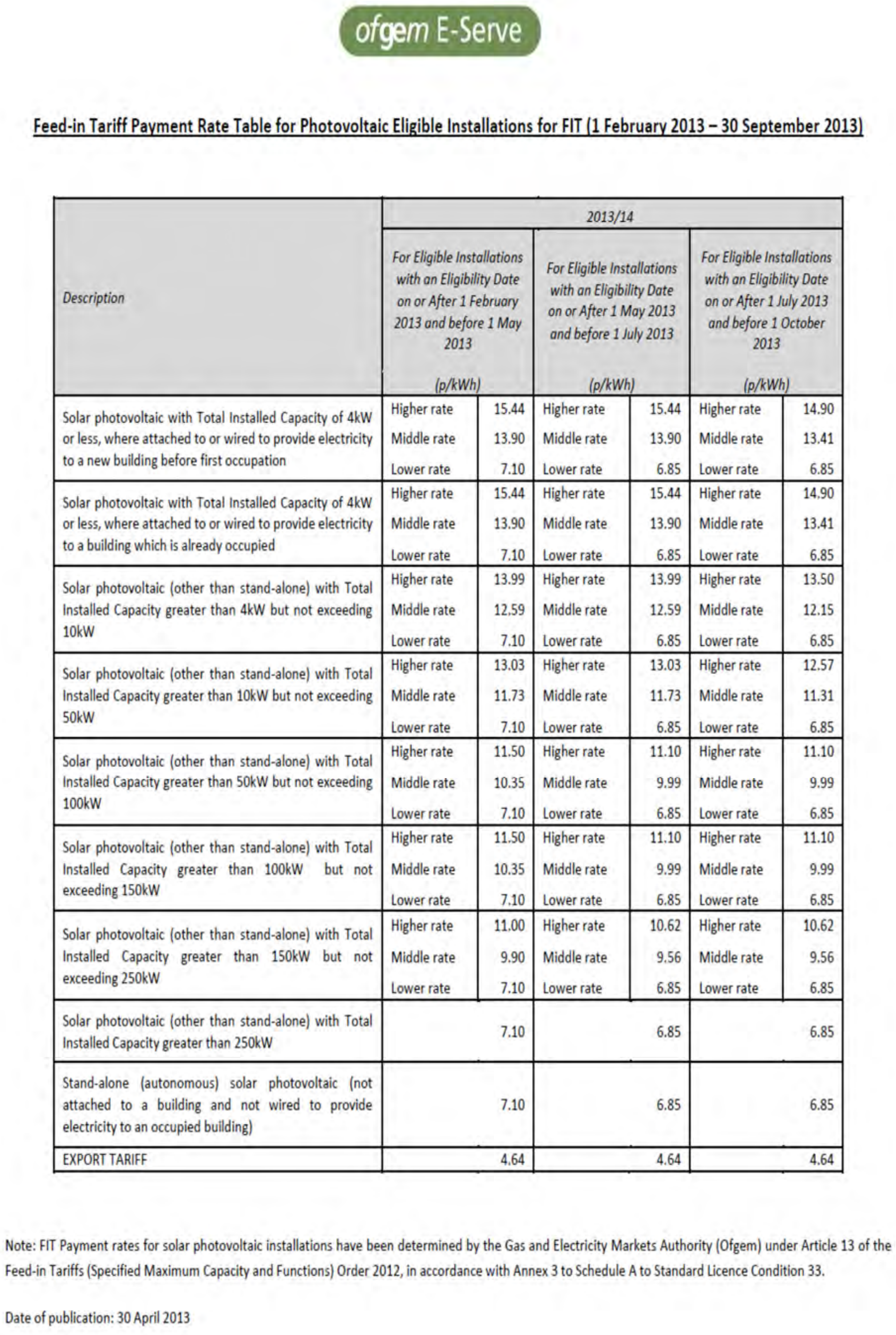
The FIT payment rates apply in respect of electricity generated or exported on or after 1 April 2012. The FIT payment rates applying in respect of electricity generated or exported before 1 April 2012 are those set out in the FIT Payment Rate Table which was in force at the time of such generation or export.

Description	*FIT Year in which the Eligibility Date of an Eligible Installation falls*		
	FIT Year 1 2010/11	*FIT Year 2 2011/12*	*FIT Year 3 2012/13*
Anaerobic digestion with total installed capacity of 250kW or less	12.70	If Eligibility Date is before 30th September 2011: 12.70 If Eligibility Date is on or after 30th September 2011: 14.70	14.70
Anaerobic digestion with total installed capacity greater than 250kW but not exceeding 500kW	12.70	If Eligibility Date is before 30th September 2011: 12.70 If Eligibility Date is on or after 30th September 2011: 13.60	13.60
Anaerobic digestion with total installed capacity greater than 500kW	9.90	9.90	9.90
Hydro generating station with total installed capacity of 15kW or less	21.90	21.90	21.90
Hydro generating station with total installed capacity greater than 15kW but not exceeding 100kW	19.60	19.60	19.60
Hydro generating station with total installed capacity greater than 100kW but not exceeding 2MW	12.10	12.10	12.10
Hydro generating station with total installed capacity greater than 2MW	4.90	4.90	4.90
Combined Heat and Power with total installed electrical capacity of 2kW or less (Tariff available only for 30,000 units)	11.00	11.00	11.00
Wind with total installed capacity of 1.5kW or less	37.90	37.90	35.80
Wind with total installed capacity greater than 1.5kW but not exceeding 15 kW	29.30	29.30	28.00
Wind with total installed capacity greater than 15kW but not exceeding 100kW	26.50	26.50	25.40
Wind with total installed capacity greater than 100kW but not exceeding 500kW	20.60	20.60	20.60



Wind with total installed capacity greater than 500kW but not exceeding 1.5MW	10.40	10.40	10.40
Wind with total installed capacity greater than 1.5MW	4.90	4.90	4.90
Eligible Installations with a declared net capacity of 50kW or less Commissioned on or before 14th July 2009 and accredited under the ROO on or before 31st March 2010	9.90	9.90	-
EXPORT TARIFF	3.20	3.20	3.20

All FIT payment rates are pence per kilowatt hour at 2012/13 values.



ofgem E-Serve

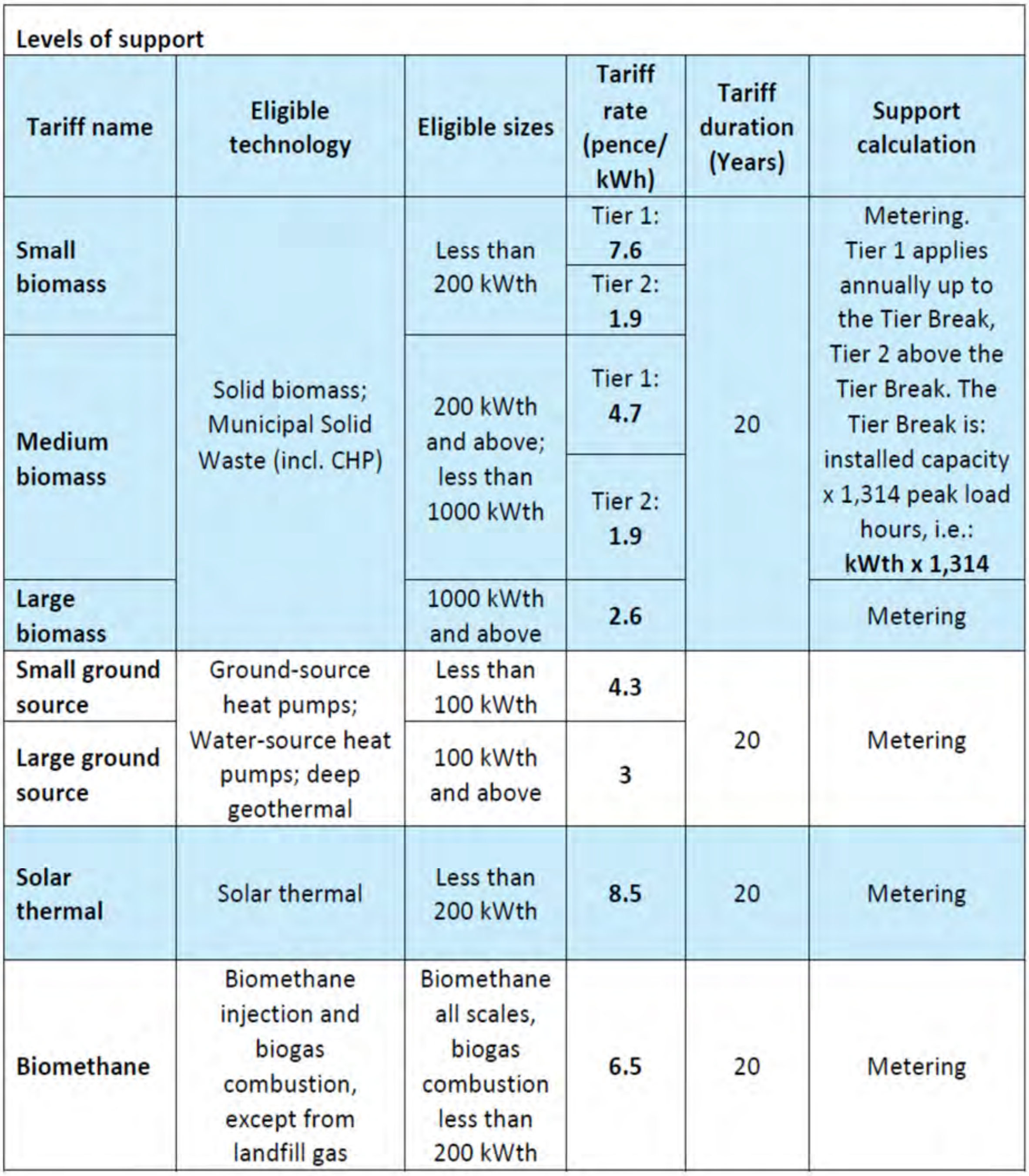
Feed-in Tariff Payment Rate Table for Photovoltaic Eligible Installations for FIT (1 February 2013 – 30 September 2013)

Description	2013/14					
	For Eligible Installations with an Eligibility Date on or After 1 February 2013 and before 1 May 2013 (p/kWh)		For Eligible Installations with an Eligibility Date on or After 1 May 2013 and before 1 July 2013 (p/kWh)		For Eligible Installations with an Eligibility Date on or After 1 July 2013 and before 1 October 2013 (p/kWh)	
Solar photovoltaic with Total Installed Capacity of 4kW or less, where attached to or wired to provide electricity to a new building before first occupation	Higher rate Middle rate Lower rate	15.44 13.90 7.10	Higher rate Middle rate Lower rate	15.44 13.90 6.85	Higher rate Middle rate Lower rate	14.90 13.41 6.85
Solar photovoltaic with Total Installed Capacity of 4kW or less, where attached to or wired to provide electricity to a building which is already occupied	Higher rate Middle rate Lower rate	15.44 13.90 7.10	Higher rate Middle rate Lower rate	15.44 13.90 6.85	Higher rate Middle rate Lower rate	14.90 13.41 6.85
Solar photovoltaic (other than stand-alone) with Total Installed Capacity greater than 4kW but not exceeding 10kW	Higher rate Middle rate Lower rate	13.99 12.59 7.10	Higher rate Middle rate Lower rate	13.99 12.59 6.85	Higher rate Middle rate Lower rate	13.50 12.15 6.85
Solar photovoltaic (other than stand-alone) with Total Installed Capacity greater than 10kW but not exceeding 50kW	Higher rate Middle rate Lower rate	13.03 11.73 7.10	Higher rate Middle rate Lower rate	13.03 11.73 6.85	Higher rate Middle rate Lower rate	12.57 11.31 6.85
Solar photovoltaic (other than stand-alone) with Total Installed Capacity greater than 50kW but not exceeding 100kW	Higher rate Middle rate Lower rate	11.50 10.35 7.10	Higher rate Middle rate Lower rate	11.10 9.99 6.85	Higher rate Middle rate Lower rate	11.10 9.99 6.85
Solar photovoltaic (other than stand-alone) with Total Installed Capacity greater than 100kW but not exceeding 150kW	Higher rate Middle rate Lower rate	11.50 10.35 7.10	Higher rate Middle rate Lower rate	11.10 9.99 6.85	Higher rate Middle rate Lower rate	11.10 9.99 6.85
Solar photovoltaic (other than stand-alone) with Total Installed Capacity greater than 150kW but not exceeding 250kW	Higher rate Middle rate Lower rate	11.00 9.90 7.10	Higher rate Middle rate Lower rate	10.62 9.56 6.85	Higher rate Middle rate Lower rate	10.62 9.56 6.85
Solar photovoltaic (other than stand-alone) with Total Installed Capacity greater than 250kW		7.10		6.85		6.85
Stand-alone (autonomous) solar photovoltaic (not attached to a building and not wired to provide electricity to an occupied building)		7.10		6.85		6.85
EXPORT TARIFF		4.64		4.64		4.64

Note: FIT Payment rates for solar photovoltaic installations have been determined by the Gas and Electricity Markets Authority (Ofgem) under Article 13 of the Feed-in Tariffs (Specified Maximum Capacity and Functions) Order 2012, in accordance with Annex 3 to Schedule A to Standard Licence Condition 33.

Date of publication: 30 April 2013

1. Table of Tariffs (RHI for industry, business and large organisations)



Levels of support

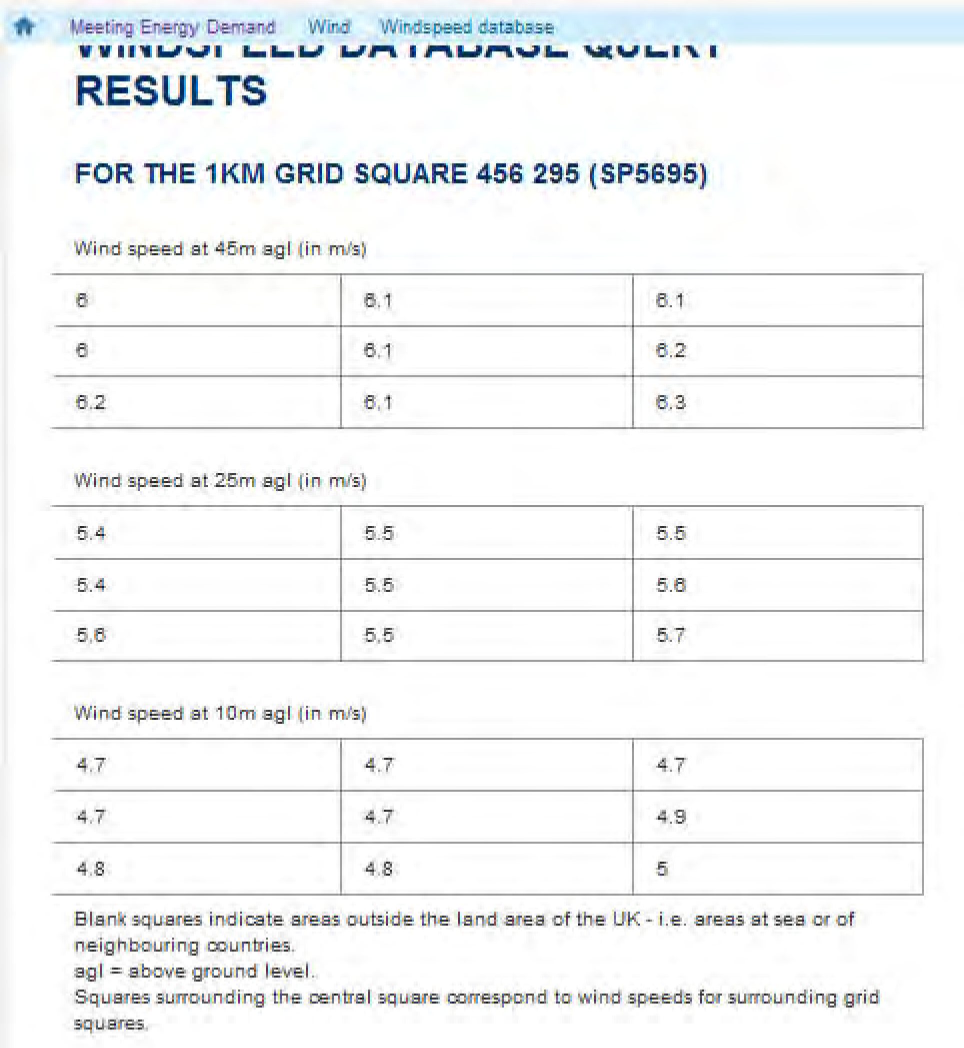
Tariff name	**Eligible technology**	**Eligible sizes**	**Tariff rate (pence/ kWh)**	**Tariff duration (Years)**	**Support calculation**
Small biomass	Solid biomass; Municipal Solid Waste (incl. CHP)	Less than 200 kWth	Tier 1: **7.6** Tier 2: **1.9**	20	Metering. Tier 1 applies annually up to the Tier Break, Tier 2 above the Tier Break. The Tier Break is: installed capacity x 1,314 peak load hours, i.e.: **kWth x 1,314**
Medium biomass		200 kWth and above; less than 1000 kWth	Tier 1: **4.7** Tier 2: **1.9**		
Large biomass		1000 kWth and above	**2.6**		Metering
Small ground source	Ground-source heat pumps; Water-source heat pumps; deep geothermal	Less than 100 kWth	**4.3**	20	Metering
Large ground source		100 kWth and above	**3**		
Solar thermal	Solar thermal	Less than 200 kWth	**8.5**	20	Metering
Biomethane	Biomethane injection and biogas combustion, except from landfill gas	Biomethane all scales, biogas combustion less than 200 kWth	**6.5**	20	Metering

Appendix D

Wind Data, Technical Datasheets

http://tools.decc.gov.uk/cgi-bin/nre/noabl1.pl

At Post Code OX27 7HN and Grid Reference SP56895 or SP570251



RESULTS

FOR THE 1KM GRID SQUARE 456 295 (SP5695)

Wind speed at 45m agl (in m/s)

6	6.1	6.1
6	6.1	6.2
6.2	6.1	6.3

Wind speed at 25m agl (in m/s)

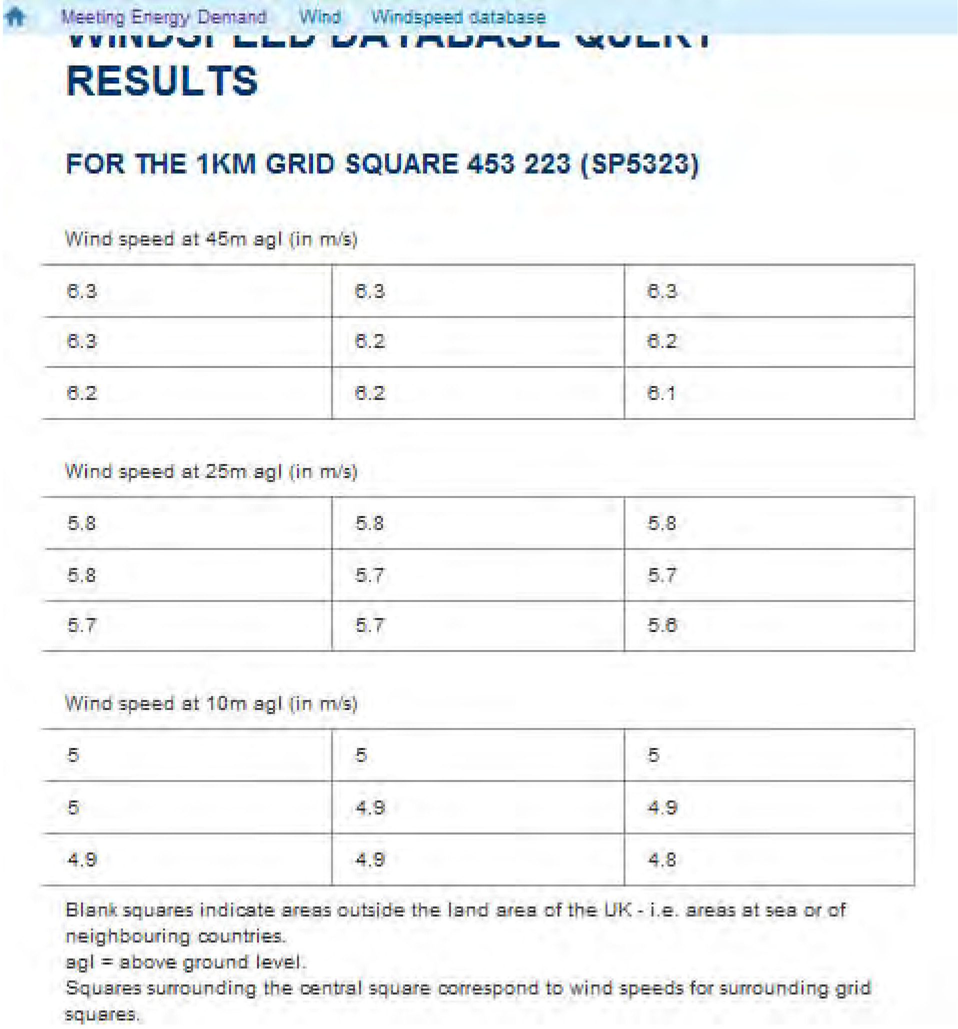
5.4	5.5	5.5
5.4	5.5	5.6
5.6	5.5	5.7

Wind speed at 10m agl (in m/s)

4.7	4.7	4.7
4.7	4.7	4.9
4.8	4.8	5

Blank squares indicate areas outside the land area of the UK - i.e. areas at sea or of neighbouring countries.
agl = above ground level.
Squares surrounding the central square correspond to wind speeds for surrounding grid squares.

Grid Reference SP 535230



WINDSPEED DATABASE QUERY RESULTS

FOR THE 1KM GRID SQUARE 453 223 (SP5323)

Wind speed at 45m agl (in m/s)

6.3	6.3	6.3
6.3	6.2	6.2
6.2	6.2	6.1

Wind speed at 25m agl (in m/s)

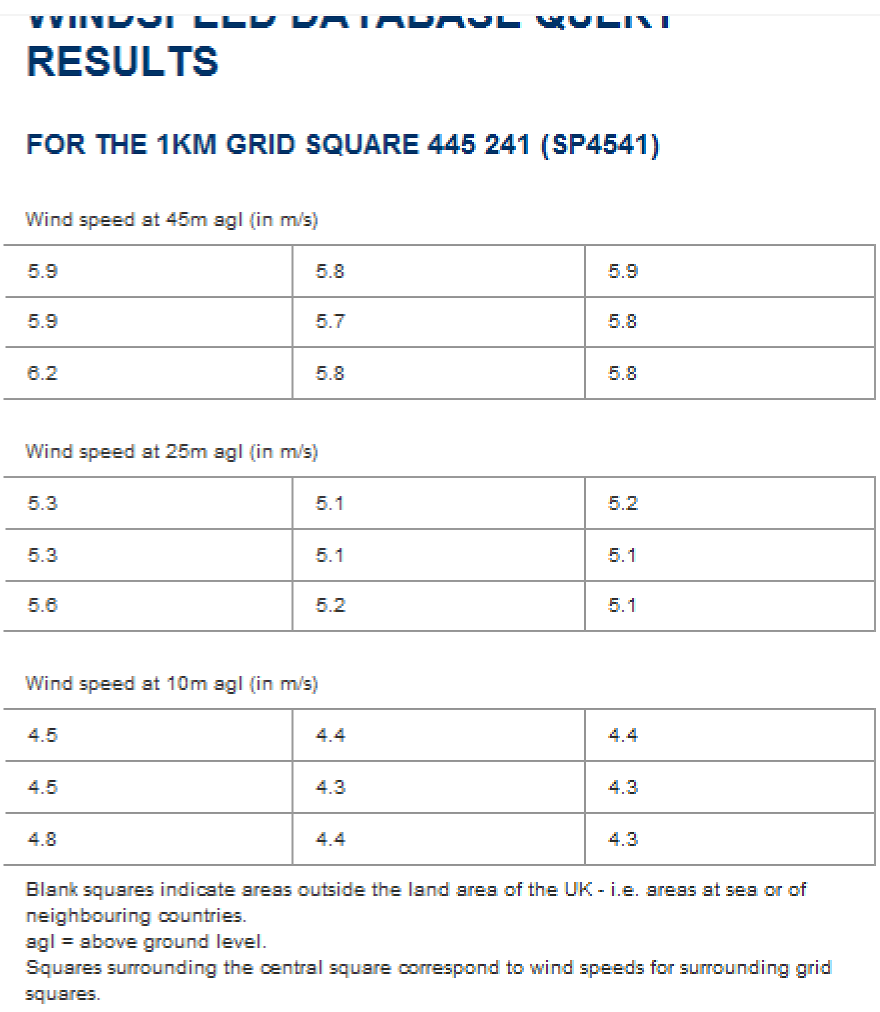
5.8	5.8	5.8
5.8	5.7	5.7
5.7	5.7	5.6

Wind speed at 10m agl (in m/s)

5	5	5
5	4.9	4.9
4.9	4.9	4.8

Blank squares indicate areas outside the land area of the UK - i.e. areas at sea or of neighbouring countries.
agl = above ground level.
Squares surrounding the central square correspond to wind speeds for surrounding grid squares.

Grid Reference SP453410



WINDSPEED DATABASE QUERY RESULTS

FOR THE 1KM GRID SQUARE 445 241 (SP4541)

Wind speed at 45m agl (in m/s)

5.9	5.8	5.9
5.9	5.7	5.8
6.2	5.8	5.8

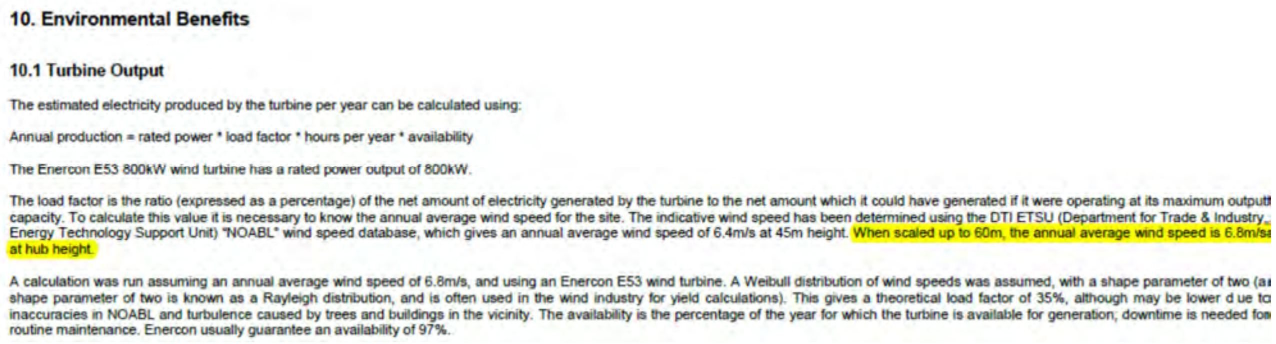
Wind speed at 25m agl (in m/s)

5.3	5.1	5.2
5.3	5.1	5.1
5.6	5.2	5.1

Wind speed at 10m agl (in m/s)

4.5	4.4	4.4
4.5	4.3	4.3
4.8	4.4	4.3

Blank squares indicate areas outside the land area of the UK - i.e. areas at sea or of neighbouring countries.
agl = above ground level.
Squares surrounding the central square correspond to wind speeds for surrounding grid squares.



10. Environmental Benefits

10.1 Turbine Output

The estimated electricity produced by the turbine per year can be calculated using:

Annual production = rated power * load factor * hours per year * availability

The Enercon E53 800kW wind turbine has a rated power output of 800kW.

The load factor is the ratio (expressed as a percentage) of the net amount of electricity generated by the turbine to the net amount which it could have generated if it were operating at its maximum output capacity. To calculate this value it is necessary to know the annual average wind speed for the site. The indicative wind speed has been determined using the DTI ETSU (Department for Trade & Industry, Energy Technology Support Unit) "NOABL" wind speed database, which gives an annual average wind speed of 6.4m/s at 45m height. When scaled up to 60m, the annual average wind speed is 6.8m/s at hub height.

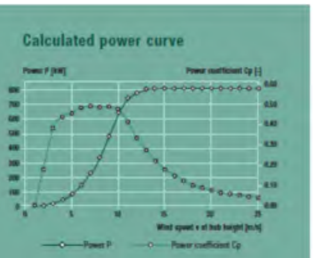
A calculation was run assuming an annual average wind speed of 6.8m/s, and using an Enercon E53 wind turbine. A Weibull distribution of wind speeds was assumed, with a shape parameter of two (a shape parameter of two is known as a Rayleigh distribution, and is often used in the wind industry for yield calculations). This gives a theoretical load factor of 35%, although may be lower d ue to inaccuracies in NOABL and turbulence caused by trees and buildings in the vicinity. The availability is the percentage of the year for which the turbine is available for generation; downtime is needed for routine maintenance. Enercon usually guarantee an availability of 97%.

ENERCON WIND TURBINE DATA

E53

800 kW

Calculated power curve



Wind [m/s]	Power P [kW]	Power coefficient Cp [-]
1	0.0	0.00
2	2.0	0.19
3	14.0	0.39
4	38.0	0.44
5	77.0	0.46
6	141.0	0.48
7	228.0	0.49
8	336.0	0.49
9	480.0	0.49
10	645.0	0.48
11	744.0	0.42
12	780.0	0.34
13	810.0	0.27
14	810.0	0.22
15	810.0	0.18
16	810.0	0.15
17	810.0	0.12
18	810.0	0.10
19	810.0	0.09
20	810.0	0.08
21	810.0	0.06
22	810.0	0.06
23	810.0	0.05
24	810.0	0.04
25	810.0	0.04

$\rho = 1.225$ kg/m^3

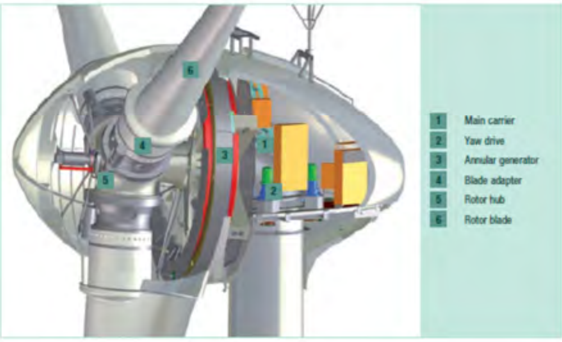
For more information on the ENERCON power curve, please see the last page.

Technical specifications E-53

Rated power:	800 kW
Rotor diameter:	52.9 m
Hub height:	60 m / 73 m / 75 m
Wind zone (DIBt):	WZ II exp
Wind class (IEC):	IEC/NVN Class S (v_{av} = 7.5 m/s, v_{ref} = 57 m/s)
WEC concept:	Gearless, variable speed Single blade adjustment
Rotor	
Type:	Upwind rotor with active pitch control
Rotational direction:	Clockwise
No. of blades:	3
Swept area:	2,198 m^2
Blade material:	GRP (epoxy resin); Built-in lightning protection
Rotational speed:	Variable, 12 – 28.3 rpm
Pitch control:	ENERCON single blade pitch system; one independent pitch system per rotor blade with allocated emergency supply

Drive train with generator	
Hub:	Rigid
Main bearing:	Tapered roller bearing pair
Generator:	ENERCON direct-drive annular generator
Grid feed:	ENERCON inverter
Brake systems:	– 3 independent pitch control systems with emergency power supply – Rotor brake – Rotor lock
Yaw system:	Active via yaw gear, load-dependent damping
Cut-out wind speed:	28 – 34 m/s (with ENERCON storm control*)
Remote monitoring:	ENERCON SCADA

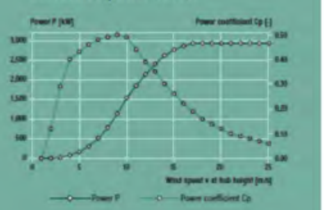
*For more information on the ENERCON storm control feature, please see the last page.



E82

3,000 kW

Calculated power curve



Wind [m/s]	Power P [kW]	Power coefficient Cp [-]
1	0.0	0.00
2	3.0	0.12
3	25.0	0.29
4	82.0	0.40
5	174.0	0.43
6	321.0	0.46
7	532.0	0.48
8	815.0	0.49
9	1,180.0	0.50
10	1,580.0	0.49
11	1,900.0	0.44
12	2,200.0	0.39
13	2,480.0	0.35
14	2,700.0	0.30
15	2,850.0	0.26
16	2,950.0	0.22
17	3,020.0	0.19
18	3,020.0	0.16
19	3,020.0	0.14
20	3,020.0	0.12
21	3,020.0	0.10
22	3,020.0	0.09
23	3,020.0	0.08
24	3,020.0	0.07
25	3,020.0	0.06

$\rho = 1.225$ kg/m^3

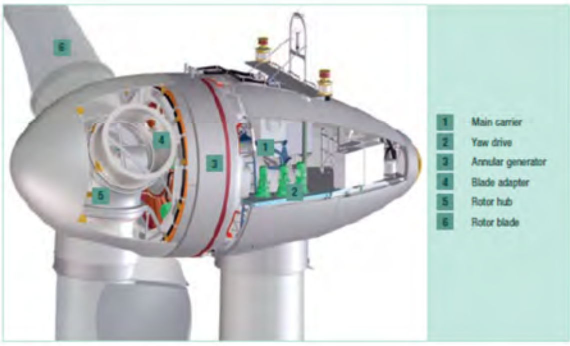
For more information on the ENERCON power curve, please see the last page.

Technical specifications E-82 E3

Rated power:	3,000 kW
Rotor diameter:	82 m
Hub height:	78 m / 85 m / 98 m / 108 m / 138 m
Wind class (IEC):	IEC/NVN IA and IEC/NVN IIA
WEC concept:	Gearless, variable speed Single blade adjustment
Rotor	
Type:	Upwind rotor with active pitch control
Rotational direction:	Clockwise
No. of blades:	3
Swept area:	5,281 m^2
Blade material:	GRP (epoxy resin); Built-in lightning protection
Rotational speed:	Variable, 6 – 18.5 rpm
Pitch control:	ENERCON single blade pitch system; one independent pitch system per rotor blade with allocated emergency supply

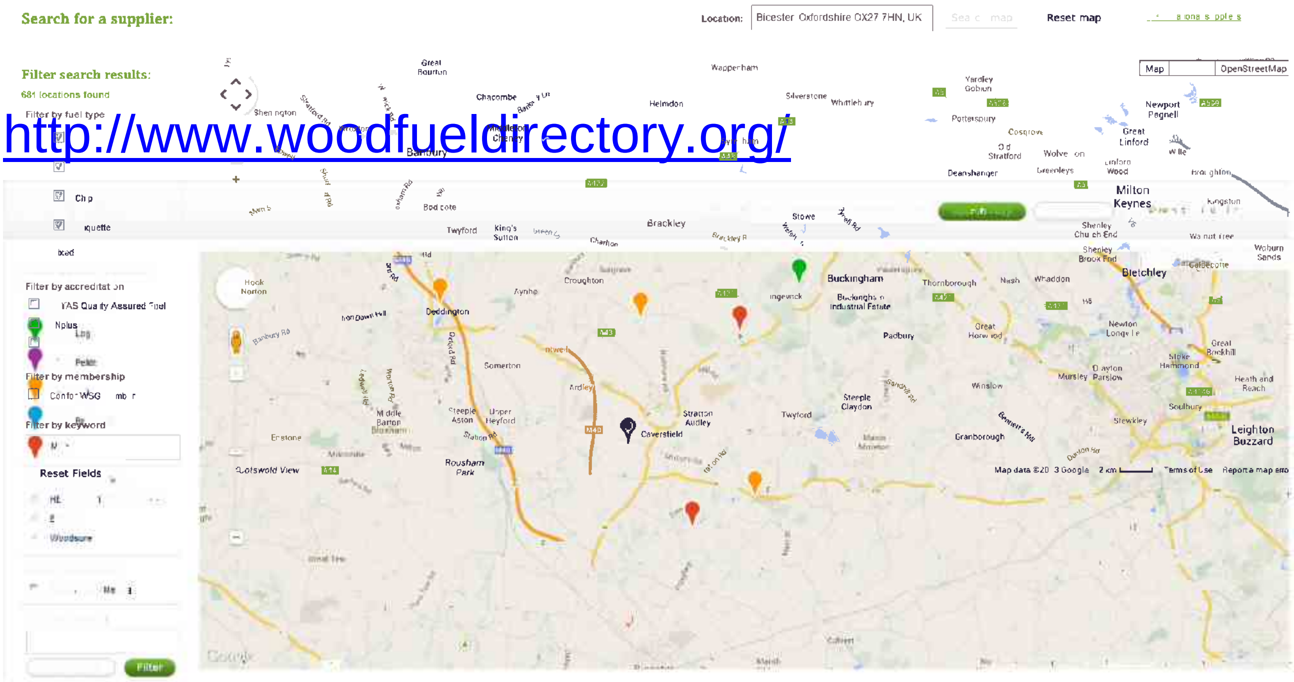
Drive train with generator	
Hub:	Rigid
Main bearing:	Double-row tapered/cylindrical roller bearings
Generator:	ENERCON direct-drive annular generator
Grid feed:	ENERCON inverter
Brake systems:	– 3 independent pitch control systems with emergency power supply – Rotor brake – Rotor lock
Yaw system:	Active via yaw gear, load-dependent damping
Cut-out wind speed:	28 – 34 m/s (with ENERCON storm control*)
Remote monitoring:	ENERCON SCADA

*For more information on the ENERCON storm control feature, please see the last page.



Appendix E

Biomass Fuel Map



http://www.woodfueldirectory.org/

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bicester

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THINKING ABOUT TOMORROW