NW Bicester

An application for the exemplar phase of the
NW Bicester Eco Development proposals submitted by
P3Eco (Bicester) Limited **and the** A2Dominion Group

Sustainable Energy Strategy

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NW Bicester Eco Development

Sustainable Energy Strategy

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1 SUMMARY

Hyder Consulting (UK) Ltd. has been instructed by A2Dominion Group Ltd. (A2Dominion) and P3Eco (Bicester) Ltd. (P3Eco) to provide engineering and infrastructure design in support of the masterplanning and planning for the proposed new eco development on the north-western periphery of the town of Bicester, Oxfordshire. The proposed eco development site will comprise approximately 5,000 homes with supporting employment and education infrastructure.

The NW Bicester eco development is one of four eco-towns identified in the Planning Policy Statement PPS 1 supplement which has received support from central government. The scheme is also supported locally by Cherwell District Council and Oxfordshire County Council, and is identified as a strategic allocation within CDC draft Core Strategy

The development is proposed to comprise some 5000 homes, secondary school, a number of primary schools, retail and commercial space along with health care and other community facilities. Approximately 40% of the site will be green space, including sports playing fields, semi private and public open space. The development will meet the requirements of the PPS 1 supplement on eco-towns; which sets out several key sustainability principles. The first phase of the Bicester NW eco development is located to the north east of the site and will be an Exemplar for future development.

This preliminary report considers the engineering aspects of the energy requirements associated with the phases of the development and the implications that this has on the capacity, location and nature of the energy centres that may be required for Bicester eco-development.

The Exemplar site requirements are more clearly defined and the first energy centre is to be constructed within this phase. Subject to final confirmation, it is understood that this will occupy approximately 21.1 hectares of land lying to the west of the B4100 Banbury Road, Caversfield, Bicester will comprise:

- 394 residential units, of which 30% will be affordable
- primary school site measuring up to 1.34 hectares – the exact dimensions of the building to be defined
- nursery of up to 350 square metres (use class D1),
- community centre of up to 350 square metres (sui generis),
- 3 retail units of up to 770 square metres (including but not exclusively a convenience store, a post office and a pharmacy (use class A1)),
- Eco-Business Centre of up to 1,800 square metres (use class B1),
- office accommodation of up to 1,100 square metres (use class B1),
- Eco-Pub of up to 190 square metres (use class A4),
- Energy centre up to 400 square metres

Of the options that have been considered for the Exemplar site, a combination of energy sources provides the greatest carbon reduction potential and resilience. These include natural gas CHP, Biomass boiler, PV and solar thermal to achieve a carbon reduction of 100% of regulated and unregulated energy

The Exemplar energy centre will comprise;

- The provision of Solar PV (1,984 kW_p);
  - on all residential property (assumed 11,790m^2).
  - on the primary school (2.800 m^2), on the proposed retail unit (385m^2).
  - On the business centre (725m^2) and community centre (175m^2).

- Solar thermal on the energy centre (50 m^2 in association with the thermal store)
- Heat and Power generation;
  - 2 No. 500kWt gas CHP
  - 1 No. 500kWt biomass boiler

During the initial part of Phase 1a construction, mains electricity will be made available to the energy centre to operate in parallel with the CHP and residential Photovoltaic as they become available. A temporary standby gas boiler will be provided to cover CHP plant outages and maintenance. As the thermal load increases, a biomass boiler will be added as part of the final solution, and the temporary standby boiler removed as the Exemplar site is completed. Resilience will be maintained with the final energy solution through the provision of the second gas CHP engine.

Further detailed design work in collaboration with potential energy providers will be required to confirm the strategy and determine with more certainty sizes of plant, engines and boilers. Although elements of the energy centres are specialist items, procurement through a service provider such as MUSCO/ESCO is technically and contractually viable. Detailed process design should therefore be undertaken with the MUSCO/ESCO in respect of

- Confirming energy demand calculation in respect of the final and agreed Master Plan.
- Updating the SAP and SBEM carbon reduction calculations when published.
- Gas connection arrangements.
- Electrical infrastructure connections.
- Guarantees relating generator export and damages associated with none-performance.
- Importing offsite heat supplies.
- Engage with a ‘preferred’ MUSCO/ESCO supplier to develop the MUSCO solution in a format that could be adopted by an alternative MUSCO/ESCO provider should the preferred supplier not be awarded the MUSCO/ESCO concession.

It should also be noted that the definition of “Zero carbon” is currently under review and the incorporation of “allowable solutions” is likely to be clarified early 2011. A full review of the energy strategy is advisable following the publication of the definition to ensure that the energy strategy solution adopted for the development and in particular to achieve “zero carbon” is that which is most cost effective.

2 INTRODUCTION

2.1.1 Background

Hyder Consulting (UK) Ltd. has been instructed by A2Dominion Group Ltd. (A2Dominion) and P3Eco (Bicester) Ltd. (P3Eco) to provide engineering and infrastructure design in support of the masterplanning and planning for the proposed new eco-development on the north-western periphery of the town of Bicester, Oxfordshire. The proposed eco-development site will comprise approximately 5,000 homes with supporting employment and education infrastructure.

The NW Bicester eco development is one of four eco-towns identified in the Planning Policy Statement PPS 1 supplement which has received support from central government. The scheme is also supported locally by Cherwell District Council (CDC) and Oxfordshire County Council (OCC), and is identified as a strategic allocation within CDC draft Core Strategy

The development is proposed to comprise some 5000 homes, secondary school, a number of primary schools, retail and commercial space along with health care and other community facilities. Approximately 40% of the site will be green space, including sports playing fields, semi private and public open space. The development will meet the requirements of the PPS 1 supplement on eco-towns; which sets out several key sustainability principles. The first phase of the Bicester NW eco-development is located to the north east of the site and will be an Exemplar for future development.

This preliminary report considers the engineering aspects of the energy requirements associated with the phases of the development and the implications that this has on the capacity, location and nature of the energy centres that may be required for Bicester eco-development. In addition, the report considers the particular requirement for the initial Exemplar phase of the development. The report considers providing power and heat via the traditional utility procurement routes as well sustainable energy sources which could contribute to a ‘sustainable infrastructure’.

The main national driver for stimulating the uptake of zero carbon energy is the recognition that climate change, which is exacerbated by the impact of man’s activities on the global atmosphere, is leading to rapid global warming.

The Renewable Energy Directive sets out how the EU will increase the use of renewable energy sources in order to meet the overall target of 20% renewables by 2020. Under this Directive, the UK will be required to ensure that at least 15% of its final energy consumption comes from renewable sources by 2020. The Directive sets the UK’s interim targets at 4% for 2011/2012, 5.4% for 2013/2014, 7.5% for 2015/2016 and 10.2% for 2017/2018.

The Climate Change Act 2008 sets targets for green house gas emission reductions of at least 80% compared to 1992 levels by 2050, and reductions in CO_2 emissions of at least 26% by 2020 against a 1990 baseline. As part of the package of measures to achieve this, Government has set a target to generate 20% of the UK’s energy demand from renewable sources by 2020. The Climate Change Act, November 2008, and PPS 22 set out the Government's policies and targets on carbon emissions and renewable energy.

The UK Renewable Energy Strategy aims to tackle Climate Change by reducing carbon dioxide emissions and setting guidelines and targets to increase the renewable energy supply in the UK. It sets out the path for the UK to meet its legally-binding target to ensure 15% of its energy comes from renewable sources by 2020: almost a sevenfold increase in the share of renewables in scarcely more than a decade. The document provides strategies for meeting the following targets for energy; more than 30% of electricity generated from renewable and 12% of heat generated from renewables.

The Town and Country Planners guidance for the development of energy efficient and zero carbon strategies for eco-towns, December 2009, encourage eco-towns to follow best practice to achieve zero carbon as Exemplar developments. The Exemplar eco-towns should be energy efficient, promote renewable energy and minimize energy consumption throughout the year.

For the implementation at Bicester, the developers have committed to achieving Code for Sustainable Homes (CSH) level 5 relative to energy efficiency requirements; delivering significant improvement to the current Part L Building Regulation standards, with 100% of the emissions associated with regulated energy use being required to be reduced. However, PPS1, eco-town supplement, requires the development to reduce 100% of CO_2 emissions attributable to both regulated and unregulated energy uses.

Energy efficiency measures which will be adopted to facilitate the achievement ofd zero carbon status for the development include the following:-

- High U values in materials used for insulation
- Reduce thermal bridging
- Increase air tightness coupled with mechanical ventilation with heat recovery
- Low energy appliances and lighting

In addition, the overarching objective will aim to utilise both Low and Zero Carbon (LZC) energy technologies for the Exemplar site, and will comprise;

- Exemplar Energy Centre – utilising the most efficient and lowest carbon contribution plant such as Biomass Boiler, Gas CHP together with supplementary renewable energy sources such as Solar Thermal to deliver the heat demand associated with the site. All plant will operate in parallel and therefore differing combinations will be possible to enable operational efficiencies to be developed.
- Solar Photovoltaic – comprising the use of integrated PV, utilising roof space on buildings to generate renewable electricity.
- District Heat System – a DHS which allows for future technologies and development phases and/or the potential for future off-site waste heat sources to be connected to the network.

The strategy will be aimed at providing flexibility and robustness and include one or more technologies and take the opportunity to utilise appropriate allowable solutions in the future, to achieve the carbon reduction target. The revised definition and approach to achieving zero carbon compliance has not yet been formally released by the Government; including how allowable solutions may be used. However, SAP2009 carbon contribution table remains available and will be used until the information is updated.

2.1.2 Location

The town of Bicester lies approximately 24km to the north east of Oxford and 28km to the south east of Banbury. The M40 motorway lies 2km to the south west, with ready access to the town from Junction 9. The eco development will be situated on the north-western periphery of Bicester, adjacent to the A4095, approximately 1.5km from the town centre.

The site is predominantly Greenfield land used for agriculture and comprises an area of some 345 ha. There are several ecological habitats across the site, including well established hedgerows, woodlands and rivers. The majority of the site is actively used for both arable and livestock farming and is classified as Grade 3 agricultural land. There are several farm houses and other building located within the site as well as a small area of employment along Howes Lane. A railway line bisects the site, running in a north west to south east direction. The nearest other settlements are Bucknell, to the north, and Caversfield, to the south. Figure 2.1 below presents the location of the site.

Figure 2.1 Image of NW Bicester site

2.1.3 Preliminary Phasing Plan

The preliminary phasing plan (Table 2.1) has been adopted for the development of the energy strategy options. However, it should be recognised that this may be subject to change through the pre-planning, planning and implementation stages.

Table 2.1 – Phasing Plan

Phase	No of Units	Av Build out per yr	Start yr	End yr	Notes
1a	394	100	2011	2014/15	Home Farm Village Exemplar site
1b	276	150	2014	2015/16	
1c	702	200	2016	2020/21	
2a	700	150	2012	2017/18	Himley Village
2b	732	200	2018	2022/23	
3a	437	200	2017	2020	Hawkwell Village
3b	625	200	2022	2025/26	
4	1092	200	2026	2031/32	Aldershot Village

Figure 2.2 shows the preliminary phasing plan.

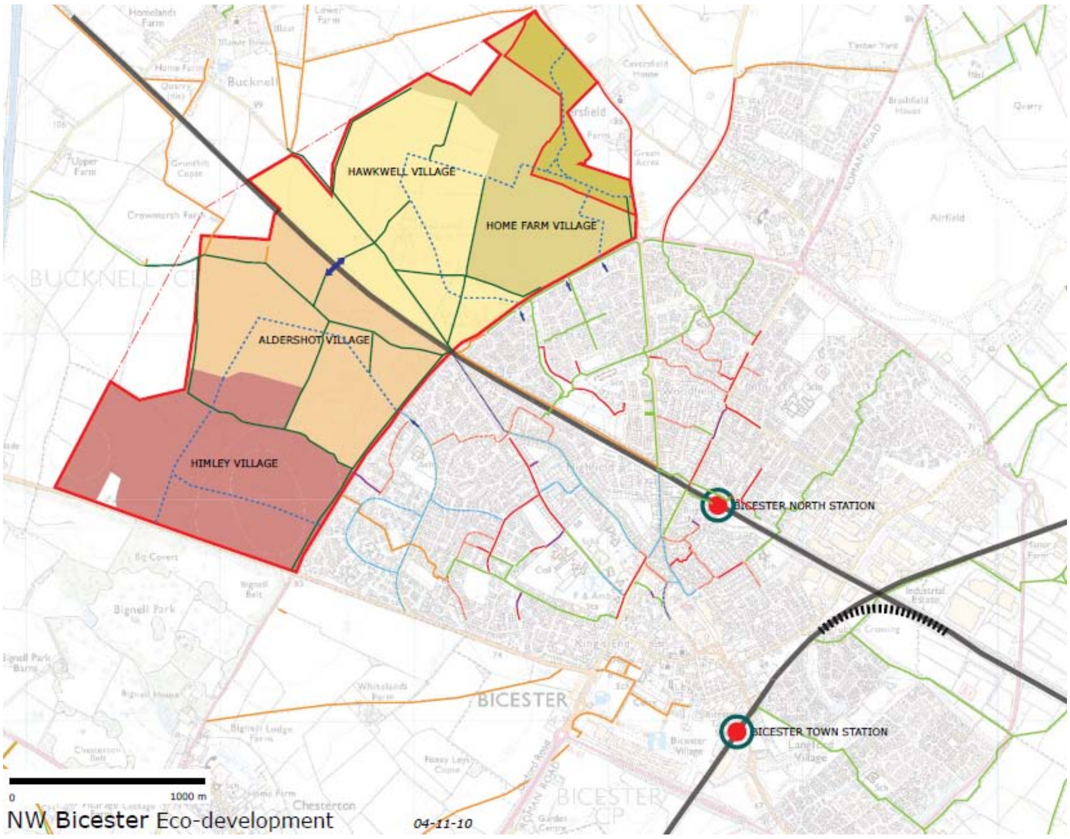


Figure 2.2 Bicester Eco-town Preliminary Phasing Plan

The first phase (Phase 1a) of development is referred to as the Exemplar site and comprises circa 394 homes. It is due to commence on site in 2011, building out approximately 100 residential units per year through to 2014/15.

Figure 2.3 – NW Bicester Phase 1a (Exemplar)

The application for the Exemplar phase of NW Bicester eco-development will comprise 394 residential units and an energy centre (up to 400 square metres), means of access, car parking, landscape, amenity space and service infrastructure and outline permission for a nursery of up to 350 square metres (use class D1), a community centre of up to 350 square metres (sui generis), 3 retail units of up to 770 square metres (including but not exclusively a convenience store, a post office and a pharmacy (use class A1)), an Eco-Business Centre of up to 1,800 square metres (use class B1), office accommodation of up to 1,100 square metres (use class B1), an Eco-Pub of up to 190 square metres (use class A4), and a primary school site measuring up to 1.34 hectares with access and layout to be determined

2.2 The Code for Sustainable Homes (CSH)

To strengthen the sustainability requirements of new dwellings, the Government launched the Code for Sustainable Homes (CSH or 'the Code') in 2006 to operate in parallel to the Building Regulations for energy use for new residential development (Approved Document Part L1A). CSH sets out the national standard for sustainable design and construction of new homes. .

The Code is currently being revised following consultation as a result of recent revisions to Part L of the Building Regulations (conservation of fuel and power requiring higher levels of energy efficiency. The Code includes sections under a number of different sustainability issues which includes; energy use in a home, materials used in the construction and the effect on biodiversity. The Code also addresses issues such as water use within each dwelling, surface water and flooding issues, health and wellbeing issues and pollution issues.

Part L of the Building Regulations (Conservation of fuel and power) will be progressively become more stringent and will eventually require all new dwellings built from 2016 onwards to achieve ”zero carbon” status.

The Code for Sustainable Homes (CSH) was introduced in April 2007 as a voluntary measure to provide a comprehensive assessment of the sustainability of a new home and replaces the Eco-Homes methodology. In terms of carbon emissions Level 3 equals a 25% carbon improvement relative to Building Regulations, 2006. New housing developments are required to achieve CSH Level 4 from 2013 (44% carbon improvement) and ”Zero carbon” from 2016). The Code Level relates to; compliance with mandatory minimum standards for waste, material, and surface water run-off as well as energy and potable water consumption.

The energy targets above are based on improvements to Part L of the Building Regulations and ”zero carbon” is be achieved by offsetting all of the CO_2 emissions associated with both Part L regulated energy uses and non-regulated energy sources (household appliances and cooking). Unregulated energy can account for approximately up to 33% of a household’s energy consumption and will therefore require a reduction on the Target Emission Rate (TER) of approximately 150% to achieve “zero carbon”. The Credits awarded for the Dwelling Emission Rate category are based on the percentage reduction of carbon dioxide emissions. The Carbon reductions in respect of the energy production for the eco development must therefore equate to 100% of the demand of regulated and unregulated energy.

The Bicester eco-development has to achieve zero carbon, therefore as part of the energy strategy the homes and commercial building will be built to high CSH and BREEAM levels. Energy efficiency measures will include;

- Low U values in materials used for insulation
- Reduce thermal bridging
- Increase air tightness coupled with mechanical ventilation with heat recovery
- Low energy appliances and lighting

The definition of “Zero carbon” is currently being reviewed and clarification on “allowable measures” is expected with the revised definition expected to be published early 2011. Following the publication of the revised definition it is recommended that a review of the energy strategy for the Exemplar site is undertaken to ensure that the methodology implemented is the most appropriate and cost-effective for the site.

2.3 Statutory Utilities

The existing Utilities energy infrastructure and services are provided by; Scottish & Southern Energy and Southern Gas Networks.

2.3.1 Scottish and Southern Energy

Scottish and Southern Energy (SSE) has indicated that there are high voltage and low voltage electrical services in the area that are likely to be affected by the proposals.

SSE plans indicate that existing 33kV overhead cables cross the site from the south eastern corner running in a north westerly direction from the B4030. There is a junction in the overhead line approximately 300m west of Himley Farm, the 33kV.

At this location the 33kV line running from the B4030 continues in a north westerly direction. Further to this, a branch from the junction crosses the site in a north easterly direction exiting the northern boundary of the site, approximately 230m east of Bicester Road / Bucknell Road.

11kV overhead cables cross the site, running in a north easterly direction from Lovelynch House, passing near to Himley Farm, and terminating approximately 100m north east of Gowell Farm.

Approximately 150m west of Gowell Farm, an 11kV branch from the overhead cable runs in a northern direction to Aldershot Farm. From here it continues underground, following the route of the track towards Howes Lane, with a branch off serving the police depot.

On reaching Howes Lane the underground 11kV cable enters Bucknell Road. Within Bucknell Road there is a further junction. The underground cable runs along Lords Lane in a north easterly direction, while overhead cables run parallel with the railway line in a north westerly direction.

An 11kV overhead cable runs within the B4100, east of the site. This cable appears to run from Lords Lane / Southwold Lane, terminating at Caversfield House at the eastern most corner of the site.

Low voltage cables are generally located in the vicinity of existing properties within the site. It is likely that the power rating has been reduced from high to low voltage via pole mounted transformers.

2.3.2 Scotia (Southern) Gas Networks

Scotia Gas Networks (SGN) have provided plans of their existing network in the vicinity of the site. These plans confirm that the only SGN apparatus in the vicinity of the site is a Medium Pressure main, running within Howes Lane from the B4030 / Middleton Stoney Road and terminating at the Avonbury Business Park.

A Low Pressure main serves the Avonbury Business Park, and a Medium Pressure main serves the adjacent Police Depot.

SGN have further advised that networks under the ownership of Independent Gas Transporters may be present in the vicinity of the site. Further investigation is required to determine the extent of these

2.3.3 Energy Demand

The development will be required to meet Planning Policy Statement PPS 1 supplement on Eco Towns; which sets out the key sustainability principles. The Eco-Town Standards set out in PPS1 relevant to utility demand include ET7 (Zero Carbon)

ET 7 contains a requirement for the development to achieve zero carbon, and states *"The definition of zero carbon on eco-towns is that over a year the net carbon dioxide emissions from all energy use within the buildings on the eco-town as a whole are zero or below."*

Preliminary calculations to estimate the utility requirement to serve the proposed development have been undertaken. It is understood that both P3Eco and A2Dominion have expressed a joint commitment to achieve at least Level 5 of the Code for Sustainable Homes in relation to the Exemplar site.

The initial demands and assumed reductions which are to be confirmed through discussions with utility or energy providers and the particular client requirements are summarised in Table 2.2. This indicates the level of energy reduction that will be anticipated. This technical report will review the energy requirements in respect of the current Masterplan, the technologies, their impact on carbon reduction and evaluate establish the preliminary options for the energy centre or centres required by Bicester eco development.

Table 2.2 Summary of Annual Demands for the Whole of the Development

Utility	Conventional Development	Mid Level Sustainable Development	High Level Sustainable Development
Electricity	166,160 kVA	116,310 kVA	66,460 kVA
Gas (annual)	406,064,000 kWh	284,245,000 kWh	162,425,500 kWh

2.4 Summary

The strategic approach to low and zero carbon energy provision to the development will consider the selection, application and operation of differing technologies and approaches to meet the energy demand and phasing.

3 ENERGY OPTIONS

3.1 Energy Demand Profile

3.1.1 Eco Development Demand Profile

Whilst the detailed sequence and phasing of the development is yet to be finalised, however the Exemplar Site will be developed first, with Phase 2 following in the South West with the construction sequence then working towards the railway line to complete the development in 2031/2. For each phase the loading will follow the particular construction profile which will further refine the specific criteria for the energy centre design. From the preliminary phasing schedule (Table 2.1), the build profile and the consequent growth in the electricity and heat demands for the development are shown in Figure 3.1.

Although the information is preliminary and will be subject to further definition, the profile enables the impact of the energy outputs from the energy sources to be estimated and profiled with the development requirements.

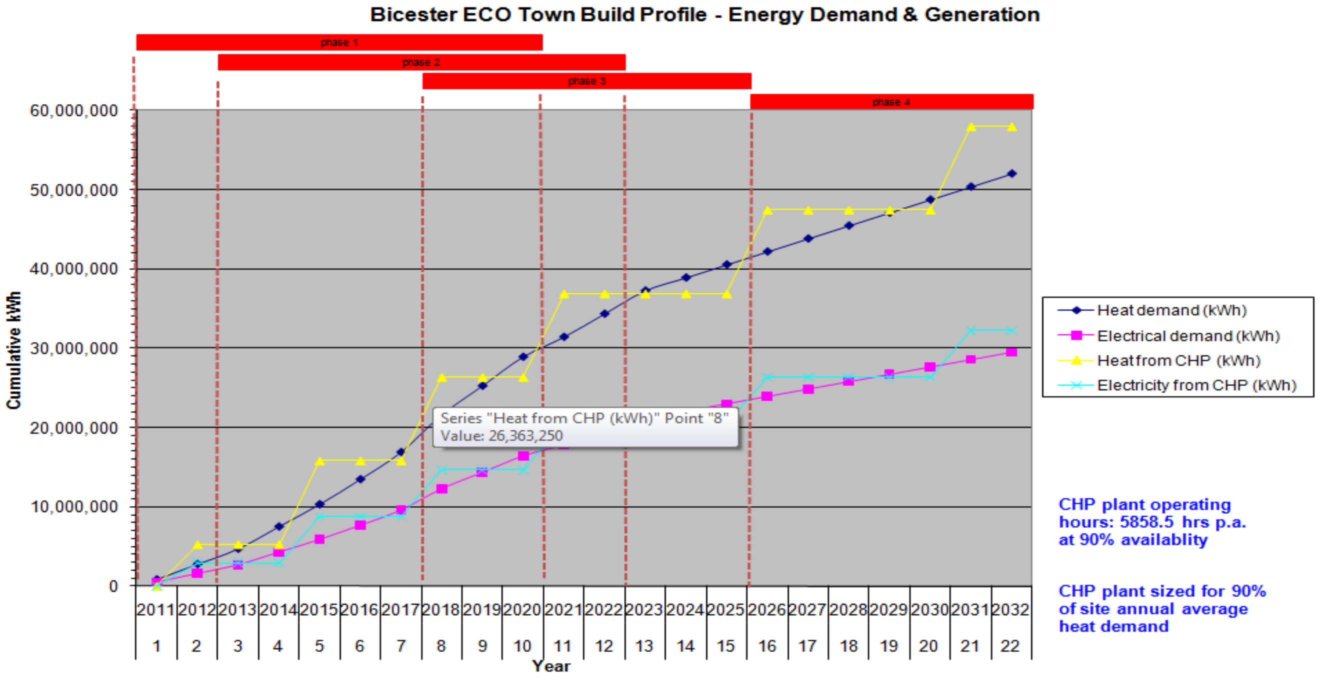


Figure 3.1 - Phase Energy Growth

3.1.2 Exemplar Demand Profile

The Exemplar site, Phase 1a, is currently forecast to commence in 2011 and run through to 2015 at a build rate of 100 units per year. The site comprises approximately 30% of the first phase of residential property and includes the village centre and an energy centre for the Exemplar in isolation which will be required to supply approximately 6,000MWh per annum of energy comprising 2,000MWh of electrical and 4,000MWh of heat respectively.

3.2 Energy Centre Design Capacity

Based on the preliminary Masterplan, the cumulative energy demands calculations for the eco development indicate that the electricity demand will increase by approximately 50,000MWh per annum during each Phase rising and to approximately 29,445MWh per annum on completion of Phase 4.

To allow for the gradual build up of consumers and also include flexibility in the energy centre design, a number of energy centres will be required. The location and capacity of the energy centres will depend on the strategy selected and development phasing. For example, the eco development is divided by an existing railway line and it would be logical for two energy centres to be provided, one to the north and one to the south. From a commercial perspective, plant and equipment located at a single energy centre offers the potential for economy in maintenance and operation costs whilst allowing for standby capacity and plant redundancy. No matter what the strategy, flexibility and adaptability at the energy centre(s) is essential to allow for plant and equipment to be added, supplemented and/or upgraded as the demand increases and the incorporation of advances in technology as they become available.

With the initial phases of construction, phases 1 & 2, at the opposite ends of the development and later built out advancing towards the centre, the logic behind 2 No. energy centres is reinforced. The projected accommodation of in the region of $6MW_e$ of plant and equipment in the design at each energy centre could be accommodated by either phased/modular construction of the building and progressive installing of plant and equipment in $2MW_e$ /$4MW_t$ increments as the demand increases.

A $2MW_e$/$4MW_t$ energy centre will need to be established for the Exemplar site and further development of the facility will require it to be strategically located. As construction must be in a timely manner, the availability of accommodation land for the centre may limit development for further phases. Construction of the energy centre(s) at the boundary of the Exemplar site should therefore be given priority to allow for future expansion.

As with the majority of utility infrastructure construction projects, the scale of each installation will have a commercial impact on the development. The drive for energy efficient and sustainable management, as well as the move towards renewable sources rather than the grid network, focuses on the use of autonomous distributed heat and power systems. For commercial advantage and recovery of Feed-in-Tariff's, parallel operation with mains electricity will be essential.

Some renewable technologies including wind turbines and photo voltaic cells are connected in parallel with grid electricity for power export, because they do not generate electricity 24/7.Other renewable energy efficient sources such as ground and air source heat pumps require a net electricity input as part of the energy conversion technology.

A single energy centre for Bicester eco-development could be more economical per kWh but, a central location would result in extended district heating systems for the initial phases and operation and maintenance could also be hindered by the railway line bisecting the site.

Regardless of the strategy, the provision of centralised energy centre, or centres, providing both electricity and heating offer the greatest flexibility, the potential to reduce implementation costs and the opportunity for energy management after the development is complete. In addition, risks to the developer are also reduced. As the infrastructure provider, either option would be attractive to an ESCO or MUSCO although they may favour a centralised modular approach, adding capacity as demand grows, as this offers them greater commercial advantage. For each energy centre, the accommodation of the generator plant, controls and switchgear as well as fuel and material storage have to be taken into account. Section 4 considers these issues for the particular options.

A centralised option also impacts on other aspects of the infrastructure development such as:

- There will be no requirement for a gas distribution system to individual consumers and/or premises.
- The requirement for gas based cooking will only be provided to individual catering facilities such as restaurants, hotels and schools.
- Local energy centres could complement offsite heat sources.
- Local energy centres could also be independent from offsite infrastructure.

Clearly, the energy centre strategy will influence the variety of demands for heat and power by the consumer regardless of whether or not they are domestic or commercial premises.

In the short term, the power infrastructure currently available from the National Grid or Distribution Network Operator (at either 11kV or 33kV), from an extension to the electricity supply network, will be the most convenient method of providing electricity throughout the development under Utilities obligations that currently apply. Similar obligations will also apply to the gas and water supply as well as wastewater or sewer connections.

In order to meet the environmental criteria, some integration and planning of the interfaces will be required if the Development power and heat sources are to be independent.

In addition, with the potential that offsite heat is available in the future, connection to the energy centre(s) could be both commercially advantageous as well as benefiting the energy, carbon and environmental objectives. This would not be readily available if energy provisions were at individual premises.

3.3 Technology Options

The adoption of renewable energy has been driven by climate change and the effect of consumption of fossil fuels on global warming. The use of sustainable energy sources is aimed at reducing greenhouse gas emissions and atmospheric carbon dioxide concentrations in line with Government targets. The adoption of low or zero carbon technologies are therefore considered in association with others available sources which have been traditionally considered as waste or uneconomical for the recovery of energy.

Technology options available for consideration include:

- Gas CHP
- Biomass Boilers
- Biomass CHP
- Solar - thermal
- Solar - Photo Voltaic
- Waste Combustion
- Anaerobic Digestion (AD)
- Ground Source Heat Pumps
- Wind Power

- Offsite Waste Heat
- Offsite Electrical Power

Gas-fired CHP and off-site waste heat are relatively traditional technologies and are regarded as low carbon solutions. All of the others are generally considered zero carbon providing the cost of equipment manufacture is discounted. Where a stand-alone network is considered, there are issues of redundancy which have to be addressed to ensure supply guarantees are met. In addition, where power is generated in parallel with the grid, there are also service level guarantees and obligations which will also have to be assured through the Developer/MUSCO agreements.

The potential energy sources are summarised in Figure 3.4; a summary of each of the technologies is considered below.

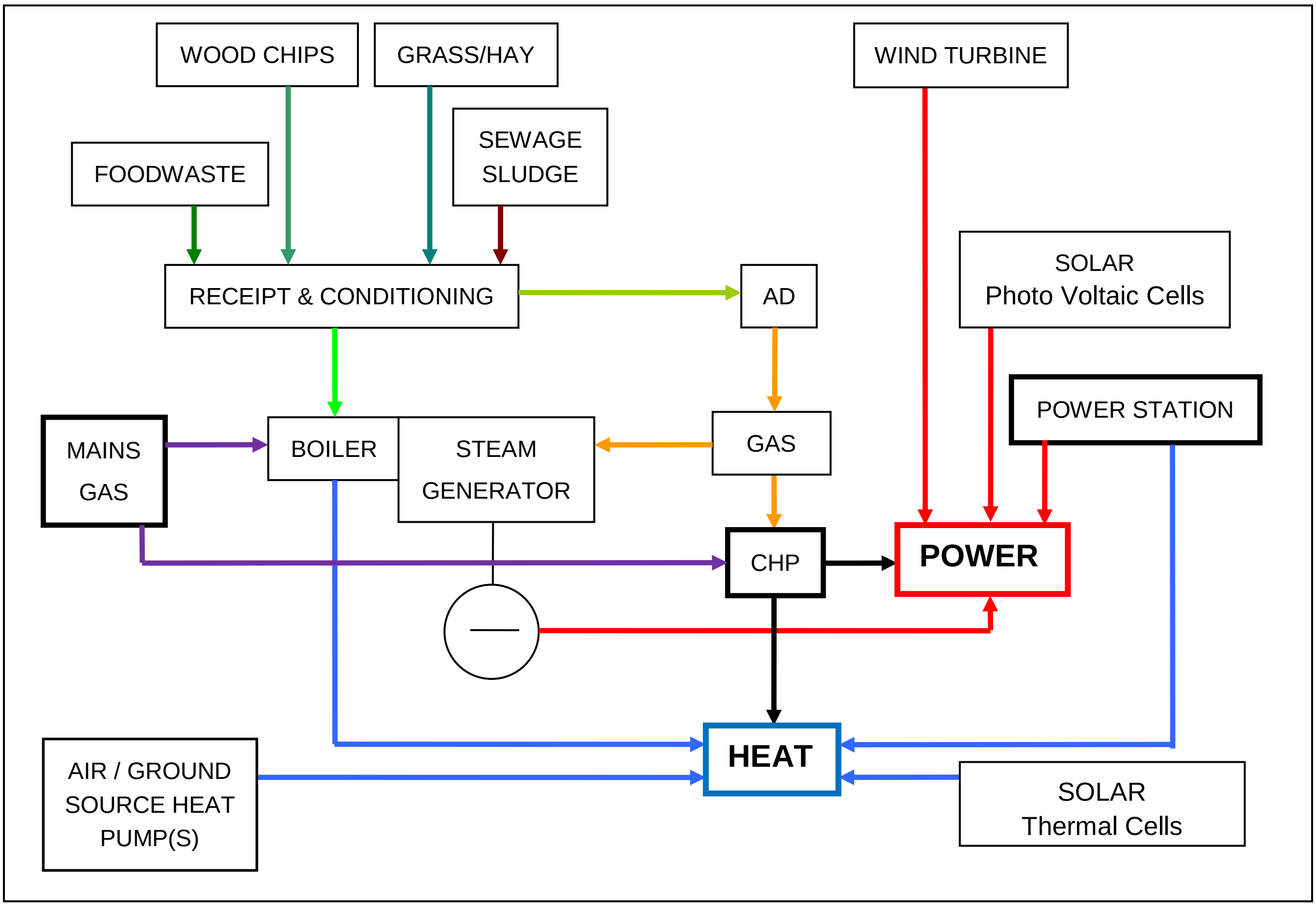


Figure 3.4 Fuel Sources

3.3.1 Gas CHP

Combined Heat and Power (CHP) plant provide both electricity and heat from a single energy process and have the advantage of;

- High energy efficiency,
- Are local and de-centralised from the mains
- Energy export income (RHIs, ROCs and FITs)

Gas CHP generators are low carbon, being energy efficient even though they consume a fossil fuel. They comprise reciprocating engine or gas turbine technology as the prime driver and provide both electrical and thermal energy outputs. They are an established technology in either form and when fuel source is mains gas and they are attached to the national grid, they are a viable means of generating power with reduced carbon emissions to grid electricity.

However, gas CHP will be required to comply with the definition of “high efficiency” and as a result, a voluntary application to the CHP Quality Assurance Scheme will be required.

Gas CHP energy centres for the early phases could be used to provide independent power. However, thermal demand from CHP is a fundamental controlling factor and will affect both operational efficiency and costs. During the early stages of the project, if thermal demand is low, the continuous operation of CHP operation will either require heat to be dumped or the generator being set being turned off with commercial consequences. A sensitivity analysis and economical appraisal will be required to establish the risks and costs which no doubt the energy provider will take a view on.

Gas CHP is also suitable for use in association with sewage sludge, food and animal waste anaerobic digestion (AD) where the treatment process produces Biogas which has a similar calorific value to natural gas. As further phases of the eco development are constructed, the availability of Biogas and Biomass to supplement mains gas as a complementary fuel source for Gas CHP may be possible.

3.3.2 Biomass Boilers

Biomass boilers are a means of providing zero carbon emissions for space and water heating. The technology is becoming established and is available for use with a wide range of fuels. Efficiency is generally best through the use of quality wood pellet fuel rather than wood chips. The moisture content of the raw fuel must be controlled and storage has to be provided under appropriate conditions to maintain feedstock quality to ensure sustained operation. Large scale energy centre(s) rather than individual biomass boilers generally benefit from economy of scale and routine cleaning and maintenance is critical to continued and efficient plant performance. Flue gas emissions are also critical to the application of the technology and must comply with Local Air pollution Prevention and Control, (LAPPC), PG/12.

A major issue for Biomass boiler plant is the requirement for frequent replenishment of fuel and the removal of ash. Consequently, vehicle access and movements for fuel deliveries must be accommodated within the development. In addition, whilst local and secure guaranteed fuel supplies will provide the least carbon emissions, transportation and extended supply chain management may be a key factor in the adoption of the technology.

The adoption of biomass boiler plant for base load heating demand in association with gas CHP or offsite waste heat, where they are able to boost heat input to the distribution main, is also possible.

3.3.3 Biomass CHP

The Biomass CHP proposed for incorporation within the development comprises a wood gasification unit and generator. As biomass CHP can provide heat and electricity, and may therefore be a more flexible option than biomass heating, although the issues around fuel supplies, delivery, storage and emissions are the same. As with gas CHP, biomass CHP can provide base load heat whilst delivering a carbon neutral electricity source, but, the heat/thermal demand dictates the viability of Biomass CHP.

The Biomass CHP system recommended, a wood gasifier, will deliver heat and electricity at an appropriate ratio for the development. Part of the heat output produced by the unit will be used to further remove moisture from the fuel source thereby ensuring the optimal operation of the unit whilst minimising the need for dumping of heat in periods of excess heat production.

3.3.4 Solar – Thermal

Solar thermal systems are generally roof-mounted and use energy from the sun to provide hot water. Providing the orientation is suitable for maximum solar gain, they have the potential to provide up to 1 kW/m^2 and are used in association with alternative heat sources for peak demands. As of result of relatively low flow and return temperatures, solar thermal systems can be used in conjunction with thermal storage facilities to supplement and reduce the alternative heating energy input to the heating / hot water system.

Solar thermal collectors are usually used to displace, in part, other hot water generating systems as opposed to space heating systems.

Care should be taken when selecting and sizing solar thermal collectors systems to ensure that sufficient hot water demand exists, or thermal storage facility is provided to minimise risk of damage to the collector system.

3.3.5 Solar – Photo Voltaic

Solar- Photovoltaic (PV) systems convert energy from the photons within sunlight into electricity. As the electrical output is DC, they are used in conjunction with inverters to convert this to a useable AC output. Providing the orientation of the cells are suitable for maximum solar gain, they have the potential to provide up to 1.25 $kWp/10m^2$ and are usually used in conjunction with traditional electricity supply sources for peak demands and low or no output periods (hours of darkness).

The output of PV system can be used to directly displace imported mains electricity and has the potential to provide an income through the feed-in tariff.

The design of PV systems should allow for a 20% reduction in output over the lifetime (20 years) of the PV as well as a reduction owing to the location and latitude of the site. In the case of Bicester, the optimum performance is considered to be no more than 90%. Consequently, the practical design capacity will be approximately 72% of the maximum output.

For an average dwelling, with electricity demand of 2.45kW, an approximately south-facing PV array of $30m^2$ will be required, with peak demands met via alternative electricity sources, such as imported grid electricity or the electrical output of energy centre CHP plant.

3.3.6 Waste Combustion

Waste combustion technologies are relatively well developed although the nature of the feedstock material influences whether or not that the energy is considered to be renewable and/or sustainable. General waste and sewage sludge are examples where the incineration process is used in conjunction with electricity power generation. Waste incineration is not considered attractive for small population centres due to the logistics and the cost of the plant and equipment. However, when incineration processes are used in conjunction with gasification and anaerobic digestion systems there is the potential for renewable obligation certificates (ROCs) income.

Economy of scale is particularly applicable to this technology and public perception regarding the material being brought to the site, transportation methods, waste combustion processes and their associated emissions may affect local acceptability. Planning approval is also likely to be protracted and although there is the potential to minimise the quantity of waste associated with the development being sent to landfill, whilst also generating power, it is not the technology of choice in the context of the Bicester eco development.

3.3.7 Anaerobic Digestion (AD)

Anaerobic Digestion (AD) technology is an established process which involves the receipt and conditioning of material and treatment to provide a final product which has potential for use in land reclamation and agriculture. AD produces a gas which can be used as a fuel to sustain the process, for renewable energy conversion and export; and where the gas is ysed to generate electricity is eligible for ROC (Renewable Obligations Certificate) green energy income.

There is the potential for combining treatment of food waste to minimise landfill whilst generating both power and heat. The Biogas produced from organic waste can be used to fuel the embedded CHP generators and supplementary gas boilers or it can be connected directly to the gas distribution system.

The AD process involves a number of treatment stages where, in an oxygen free environment, the material is broken down to produce the Biogas. Biogas comprises methane as the primary fuel for combustion either for sustaining the process or for energy conversion. Typically, AD is undertaken in either a single or two phases. Two phase treatment includes a pasteurisation stage of treatment at a temperature exceeding 70^{o}C followed by > 12 days further retention at 35^{o}C and is generally referred to as either “enhanced” or “advanced” digestion. The process is continuous and is stabilised through frequent feeding. The final sludge product is normally suitable for recycling to land or for further conversion.

A variety of materials can be used as feedstock for AD and these include waste from dairies, households (food), breweries and caterers as well as green waste and sewerage sludge. All have the potential for conversion of the volatiles to “Biogas” although some have a greater potential than others. Crucially, the final product is stable, relatively odour-free and is in a form which can further be used as a soil conditioner in the reclamation of waste land or the rejuvenation of forestry. Where the final product is for use in agriculture and crops for human consumption, there are particular quality constraints specified in the DEFRA Quality Protocol Document, 2009 and the PAS 110:2008. The PAS also specifies the need for appropriate critical continuous performance monitoring of the process to ensure the material is of the appropriate standard for re-use.

The Kyoto convention and the UK government’s implementation of the Climatic Change Levy (CCL) has emphasised the need for energy efficiency. Gas sources such as landfill and anaerobic digestion provide the potential for power generation by Combined Heat & Power (CHP) systems in association with their respective processes. The respective interface engineering involves the evaluation of the prospective load requirements for proposed process plant, peripheral services and mains power supplies.

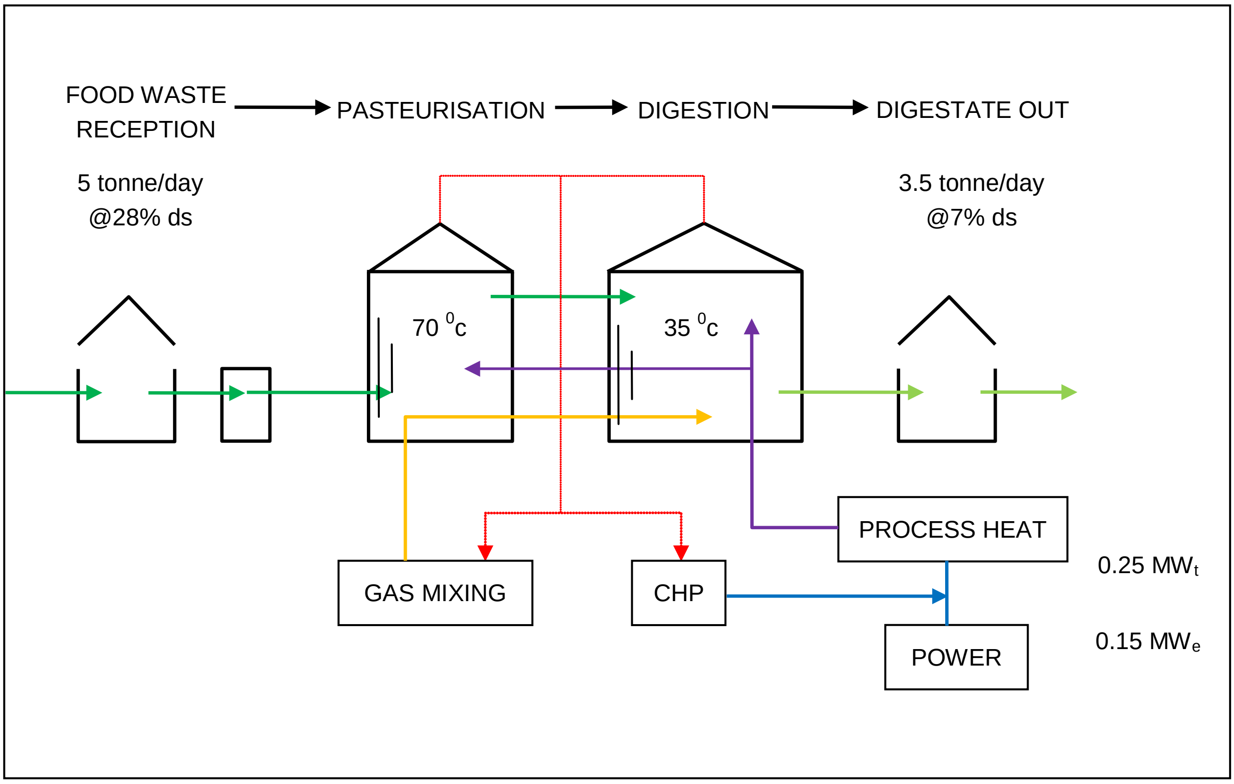


Figure 3.4 – AD Indicative Process Flow Diagram

As an example, for 5 tonnes of food waste per day Figure 3.4 shows the anticipated process for the hub, assuming that the waste feedstock is appropriate for digestion and that there are no inhibitors.

As with waste, there are traffic issues with material import and export. There are also similar issues to those experienced at Waste Water Treatment Works (WwTW) particularly odour and noise. Sewerage and food waste are energy sources and there is a synergy through the local water company and council by the potential of co-digestion. Domestic food waste in the UK amounts to approximately 4kg/house per week and for approximately 5,000 properties will produce, on average, approximately 0.15MW_e of power. Schools and hotels produce a similar quality of food waste per capita with commercial food waste at almost double that for domestic waste, almost three times as much power could be generated. With an average residence rate of 2.8/unit, the organic waste from approximately 5,000 homes produce almost 0.75 MW_e of power could be available when the project is complete.

Clearly, the local sewerage network infrastructure, the treatment of sewage and the sludge product could be undertaken by the local water company and or a facilities company who have greater potential for AD to be viable. In either case, there is the potential, through power export, for Renewable Obligations Certificate Income (ROC income). AD offers multi-benefit, multi-income stream and high levels of market support and could be considered for the supply of renewable energy to the Bicester eco development when the Masterplan, phasing and the respective loading schedule are finalised.

3.3.8 Ground Source Heat Pumps

Ground-source heat pumps are a relatively mature technology and utilise the energy in the ground through a refrigeration cycle. The ground source heat pump is an efficient way of producing economic heat and, due to the efficiency of the operation have the potential to save in excess of 25% carbon. The ground source heat loop can be laid horizontally or can be located in dedicated boreholesof between 50 and 150 metres deep..

Alternatively, where vertical structural piles are required, there is the potential to utilise these to additionally accommodate pipework associated with the GSHP system. These are referred to as “energy piles”. However, structural piles are typically shorter than dedicated boreholes for GSHP systems and therefore more energy piles may be required since the output is reduced.

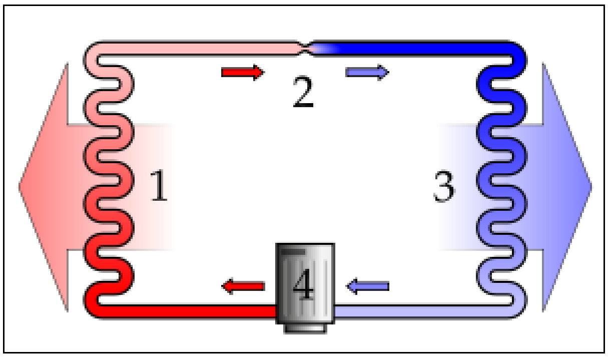


Figure 3.5 – Simple heat pump’s vapour-compression refrigeration cycle (Fundamentals of Engineering Thermodynamics, by Howell and Buckius)

Figure 3.5 shows the principle elements of a Heat Pump (*1) condenser, 2) expansion valve, 3) evaporator, 4) compressor.* The cycle loops may be either horizontal or vertical. The amount of vertical or horizontal loop required is a function of the ground formation thermal conductivity, deep earth temperature, and heating and cooling power needed, and also depends on the balance between the amount of heat rejected to and absorbed from the ground during the course of the year.

Approximately 50% of the solar radiation received by the Earth is absorbed at the surface. As a result, the ground temperature shows seasonal fluctuations to depths of about 15 m where the temperature is approximately equal to the mean annual air temperature (8 - 11° C in the UK). Below this the ground temperature increases at, on average, 2.6°C per 100 m due to heat flowing from the interior of the Earth. Mean temperatures at 100 m depth in the UK vary between about 7 - 15°C.

Providing the associated plant; pumps, compressors, etc are selected correctly, they are relatively efficient and carbon neutral. However, they are a net consumer of electricity and their efficiency depends on the co-efficient of performance (CoP). A CoP of 5% is possible but for design purposes, a CoP of 20% should be adopted.

In addition, A/GSHPs provide an output temperature of 55^{o}C and DHS systems normally operate at between 70 - 85^{o}C which makes them suitable for space heating and cooling of commercial and retail buildings, public community buildings, schools and medical centres. Connection to DHSs would therefore, have to be where lower temperature operating systems are acceptable, they provide heat energy during low demand periods or district cooling is required.

Further, GSHP systems are particularly suited to under floor heating systems, where the area of dissipation of the heat is greater to allow for the lower grade heat produced.

GSHP systems are more advantageous when used to provide cooling to buildings since they displace electricity (which has a higher carbon emission factor than natural gas) as opposed to gas for traditional boiler systems.

3.3.9 Wind Power

Wind turbines are another example of Zero carbon technology and by using wind energy they can displace grid electricity, are a renewable source. The adoption of turbines depends on local wind conditions and geography.

Reliable operation requires wind speed in excess of 6m/s at 45m. At the NW Bicester site, the conditions only just meet the criteria and limit the capability to generate energy. Wind is also intermittent and availability of as little as 20-30% is not unusual and parallel connection to the mains and/or CHP is essential.

Further, large scale wind turbines should, as a rule of thumb, be located at least 400m from residential accommodation to mitigate any associated noise issues.

While the public is generally more accepting of wind energy in principle and a wind turbine would be a highly visible landmark for the eco development, there remains the potential for strong local opposition to any proposed developments, especially for large turbines (primarily due to the visual impact).

To increase cost effectiveness, turbines are becoming larger and mounted on higher towers, which increases negative visual impacts, though issues with noise can be reduced. A 2MW turbine footprint is relatively small at ground level but with the hub at 80m and a 40m diameter rotor the total height will be 120m, In addition, the turbines are relatively noisy which can be unacceptable. They also need to be constructed with an appropriate safety exclusion zone which will be a “topple area” surrounding the device of at least 1.5X the overall height.

The location of wind turbines can be significantly restricted by local conditions, proximity to housing, airport and MoD radar installations, etc. These are all likely to be a key issue at NW Bicester.

3.3.10 Offsite Waste Heat

The use of waste heat from an existing conventional power station in the proximity of Bicester does not appear viable because of the transmission distances involved. However, an existing waste incinerator plant is present at Ardley, which is planned to be extended and this could provide low grade heat. A critical factor in the viability of waste heat relates to the commercial arrangements and guaranteed levels of service. As this is not currently available, this option has not been considered any further as a source of heat for buildings because the carbon reduction would be considered relatively low when compared with the emissions from gas-fired boilers at individual premises.

3.3.11 Offsite Power

As there is an existing distribution network adjacent to the eco development, electricity supplies could be procured conventionally via appropriate, sub-station(s) at 33kV or 11kV with HV circuits and distribution substations throughout the development. Enquiries made to the incumbent DNO, SSE, indicate that supplies through the conventional utility procurement route are possible. In addition, alternative procurement of the distribution system via a MUSCO/ESCO would be an alternative within the new development.

4 ENERGY CENTRE DESIGN

4.1 Carbon Emissions

Selection of the technology for the energy centre or centres is influenced by the prevailing technical and commercial conditions when implementation takes place. Seasonal factors also influence the reliability of renewable technologies such as wind turbines and biomass availability.

In addition, local infrastructure exists for the respective water, gas and electricity utilities and whilst they may not currently comply with the desired emission factors in order for sustainability, future upgrading will result in improvements and could affect the procurement strategy.

The prime objective of the development requires the design of the energy centres to be developed to enable the development to be zero carbon. The anticipated carbon emission factors and primary energy factors that will apply to the development are shown in Table 4.1.

Table 4.1 – Carbon emission factors (all figures are kg CO_2/kWh)

Technology/Fuel Type	SAP2005 / Part L2A 2006	SAP2009
Electricity (Standard tariff)	0.422	0.517
Mains Gas	0.194	0.198
Gas Oil / Heating oil	0.265	0.274
LPG (bulk)	0.234	0.245
Wood chips	0.025	0.009
Wood pellets	0.025	0.038
Domestic Coal	0.291	0.301
Electricity generated by CHP	0.568*	0.529*
Electricity generated by PV	0.568*	0.529*
Waste heat from power stations	0.018	0.058

SAP2009 figures

*deducted from costs, emissions or primary energy

Biofuels are considered to be a sustainable energy options providing there is appropriate resource availability. Whilst the technology is relatively mature, durable and secure supply networks need to be established as a pre-cursor to adoption for the eco development.

Wood chips and/or pellets as a fuel source are the most favourable relative to CO_2 emissions. The recovery of waste heat from the adjacent energy from waste operations is also favourable, Power generation and mains power from a coal-fired power station is the least favourable with Biomass and gas-fired CHP more carbon friendly.

For the energy requirements for the eco development, taking into account the full build and the respective determination reduction in CO_2 based upon the proposed emission factors in SAP2009. The key performance requirement for the eco development relates to the achievement of zero carbon, including non-regulated energy, between L2A 2006 and those proposed in the SAP 2009.

The estimated electrical power inputs for the Draft Masterplan, for the whole of the eco development, assume that energy efficiency standards are incorporated into residential buildings and that community and public buildings adopt optimum use of energy. The carbon reduction targets can be achieved through a combination of technologies, and it is anticipated that use of Biomass CHP, gas CHP, Solar PV and Solar Thermal for the energy production for the whole of the eco development should achieve the zero carbon target.

In addition, the impact of off-site waste heat facility may be considered in the future as other local facilities become available.

Whilst the economic implications have not been considered in this technical appraisal, the adoption of a combination of energy sources would also retain operational flexibility and availability whilst achieving the sustainability targets. High efficiency biomass and gas-fired CHP, for the thermal and power energy, is technically sound and when developed as an independent supply, could ensure carbon reduction compliance. However, CHP operation is susceptible to the thermal demand profile and dumping of heat will be necessary, where the heating demand is low and the power demand remains could be counter-productive. The ability to turn-down the CHP whilst retaining efficiency will be essential along with the provision of a thermal store.

Finally, with the expected redefinition of zero carbon expected imminently and likely to include the use of “allowable solutions”; the strategy for the eco development should be allowed to remain flexible to adapt to changing defining, technology advances and economic viability.

4.2 Basis of Design - Exemplar

The Exemplar site requirements are more clearly defined and the first energy centre is to be constructed during Phase 1a. Subject to final confirmation, it is understood that this will occupy approximately 21.1 hectares of land lying to the west of the B4100 Banbury Road, Caversfield, Bicester will comprise:

- 394 residential units, of which 30% will be affordable
- primary school site measuring up to 1.34 hectares – the exact dimensions of the building to be defined
- nursery of up to 350 square metres (use class D1),
- community centre of up to 350 square metres (sui generis),
- 3 retail units of up to 770 square metres (including but not exclusively a convenience store, a post office and a pharmacy (use class A1)),
- Eco-Business Centre of up to 1,800 square metres (use class B1),
- office accommodation of up to 1,100 square metres (use class B1),
- Eco-Pub of up to 190 square metres (use class A4),
- energy centre up to 400 square metres

4.2.1 Design Options

The energy strategy for the Exemplar site has considered the options available and has deduced that the adoption of a combination of energy sources will achieve the carbon emission reduction targets and that operational flexibility and sustainability is required. The options that are available include; offsite electricity (Mains Power), Solar Photovoltaic, Solar Thermal, Gas-fired CHP and Biomass CHP and/or heating.

The energy demand for the Exemplar is shown in See Appendix A-01. The baseline heat load of 4,716,274Mwh and electrical load of 1,883,266MWh are reduced through advanced practice energy efficient (APEE) measures to 3,534,034MWh and 1,429,666MWh respectively.

Energy production relates to the use for heat and electricity, the efficiency of the buildings and the extent to which the electricity can be exported. For the options that have been considered, a combination of energy sources provides the greatest carbon reduction potential which include gas CHP with PV and solar thermal along with biomass heating. This combination is able to provide a zero carbon energy solution.

4.2.2 Offsite Electric Supply

In the short term, the power infrastructure that is currently available from the National Grid and/or Distribution Network Operator (at either 11kV or 33kV) would be the most convenient method of providing electricity throughout the development under Utilities obligations that are currently apply or via a MUSCO. However, this does not contribute to achieving the zero carbon target.

4.2.3 Photovoltaic

Based on the data available from Solar Century and an effectiveness/ efficiency performance of 72%, the roof area available on residential, community and commercial properties will provide 1,9051$MW_{e.}$ This will be sufficient for average energy consumption but requires alternative energy sources for peak demand and during periods of darkness. PV ought to be able to export up to 40% of electricity during periods of low demand.

4.2.4 Gas-Fired and Biomass Engines

The initial requirements for approximately 2MW_e and 4MW_t could be provided by an energy centre comprising gas CHP and biomass boiler in combination with grid connection. See Appendix A. The energy centre would be modular to facilitate expansion as the load profile develops.

4.2.5 Grid Connection

The technical requirements for the connection of embedded generation into the DNO network are proven and well documented and should be technically viable at Bicester eco development irrespective the technology adopted. The primary consideration relating to the income stream from exported electricity will have an impact on the return on investment including the cost of maintenance and overhaul. However, the particular engineering requirements are over-ridden where guarantees are not achieved and tariff penalties apply.

4.2.6 Offsite Heat Supply

The availability of waste heat from the Ardley energy from waste plant and Finmore landfill are not yet definite and have therefore not been considered any further relative to the Exemplar site due to phasing.

4.3 Exemplar Energy Centre Capacity

Based on the estimated electrical power inputs for the masterplan for the Exemplar site, a combination of Gas CHP, Biomass and PV along with APEE are able to achieve a zero carbon energy solution.

The economic implications of each of the alternative energy sources have not been considered in this report; and discussions are currently taking place with contractors and potential Energy Supply Companies (ESCO). However, there will be economies of scale which have implications in terms of £/unit of energy delivered or kg CO_2 saved. In order to assess the capacity of the energy centres, the base load and peak requirements affect the selection of unit ratings, duty and standby requirements. In order to meet the prevailing and seasonal requirements, a combination of different technologies offers the greatest potential for ensuring that the carbon is minimised whilst ensuring energy availability. Detailed modelling of the different options and the required plant capacity for the ranges of heat and electricity demand will be necessary. Heat demand is fundamental to any CHP option and if there are periods of low demand such as during the summer months or during the early phase of the project, natural gas boilers may be required to avoid dumping of heat.

As the discussions with contractors and potential ESCO operators continue, refinements to the energy solution may be identified. In addition, and as previously mentioned, the redefinition of zero carbon is due to be presented shortly; and this may trigger a reappraisal of the energy solution.

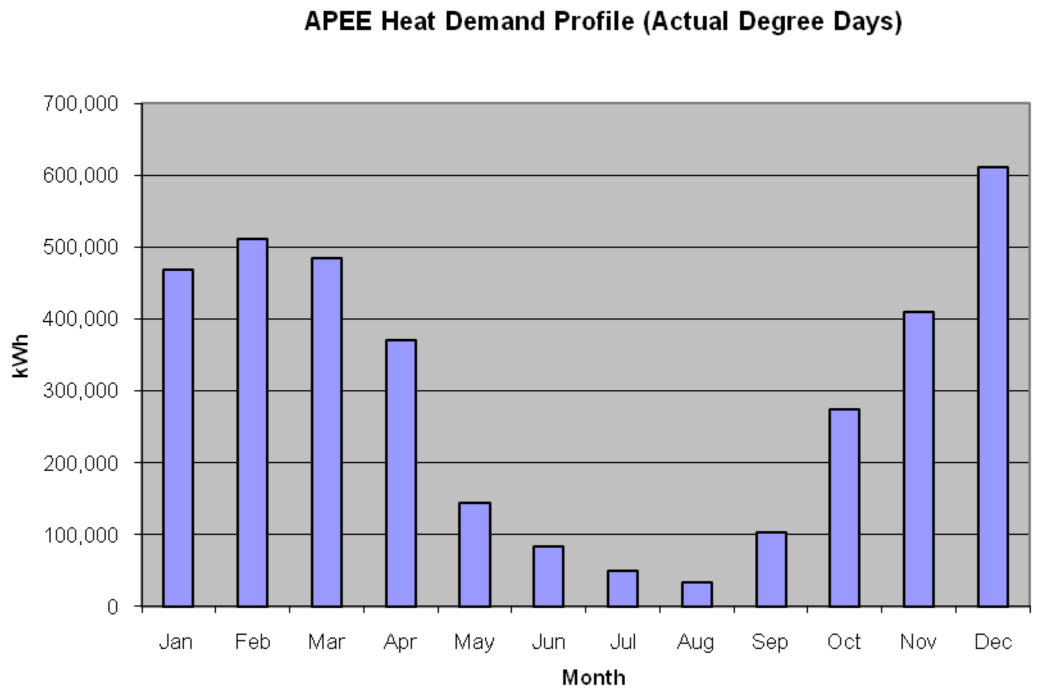


Figure 4.2 – Average annual heat demand profile

Relative to the whole eco development to have independent energy provision and allow for the gradual build up of consumers and the forecast profile (see Section 2, Figure 2.4), the most flexible approach would be for a number of similar sized energy centres be constructed across the site. To meet the forecast demand for the eco development, 2 No. $6MW_e$ energy centres would be needed for the development to provide the electricity and the heat requirements. However, heat demand is the primary control of the energy centre and if there is either a partial or no heat demand (See Figure 4.1), as may be the case during spring, summer and possibly in the autumn, this will affect plant selection and a full CHP station may be inappropriate.

The design of the energy centre must recognise the practical implications of both the demand profile and the relevant technologies. For example, the average demand for a typical home may be 2.47kW_e, the instantaneous peak is likely to be twice that value. The energy provisions must account for this. In addition, whilst a 30m^2 PV array on each property has the potential to generate all of the daily average house demand (based on location, effectiveness and efficiency) during daytime, the energy consumption is likely to be 40% of the average and during that time, power will be exported providing a positive carbon contribution to the development. Electricity consumption during evening and hours of darkness will have the opposite effect and, as long as the design is sufficiently robust, the net effect can be carbon neutral or positive.

The phasing of the development and the construction profile within each phase is influential when considering the source, capacity and location of the energy centres. Assuming “stand alone” energy provision for the eco development, the proposed Masterplan and phase profile tends to support the location of the first energy centre in the Exemplar area of the development. This would need to be constructed to initially accommodate the Exemplar and allow additional plant set(s) to be added at a later date. As phase 2 is at the opposite end of the development, another energy centre within the south western area would also appear logical.

If off-site waste heat and power becomes available, a similar logic would apply although strategic deployment of additional plant and equipment is likely. During the development of each phase and as the demand increases, the hire or purchase of containerised generators and/or boilers could be considered to meet short term demands.

To maximize sustainability and availability whilst optimising carbon efficiency, the proposed energy strategy for the Exemplar site will therefore comprise; the most efficient and lowest carbon contribution plant such as;

- APEE
- Biomass Boiler,
- Gas CHP,
- Solar – Thermal,
- Solar PV for the power demand

A District Heating System (DHS) will be provided to allow for future technologies and development phases and/or the potential for future off-site waste heat sources to be connected to the network. All plant will operate in parallel and therefore differing combinations will be possible to enable operational efficiencies to be developed.

The energy balance for the Exemplar Site is provided in Appendix A-02.

4.4 Eco Development Energy Centre Space Requirements

A 6MW_e station using 4 No. 1.5MW sets will occupy a building approximately 60mx60m and depending on how the heat recovery is designed, each set could produce a similar level of high grade heat (1.5MW) and approximately 60% low grade (600kW).

For Biomass CHP, steam raising boilers of the same capacity (i.e. 6 MW), the boilers will occupy approximately 30mx30m, the turbine room and control room would be approximately 30mx20mand the station footprint would be doubled to account for strategic fuel storage and risk. For example, 1 month consumption of biomass for a 1MW set requires approximately

1,000 tonnes per month of wood pellets. Furthermore, there will be a requirement for ash disposal.

Where biomass is the fuel source, economics are likely to result in either a single energy centre or one in the south western area and one in the north eastern area. Depending on the feedstock, there will be a requirement for a storage yard of approximately 50mx50m. Although not essential, this may need to be covered to minimise moisture drive off in the combustion process.

If advantage is taken of the local utilities obligations including power and sewerage, offsite waste heat would avoid the need for any generation on site. In this instance, the local energy centre would need to accommodate a sub-system DHS pumping station with control and metering for the respective area and each would occupy approximately 7mx5m. The local sub-system pumping stations could also be accommodated within public amenity buildings or as stand-alone structures.

Distribution sub-stations (4mx4m) would be located within either palisade fenced or walled compounds. These too could be accommodated within public amenity buildings and constructed alongside the heating distribution pumping stations.

4.5 District Heating System

For the heating to be provided from strategically located energy centre(s) for approximately 5,000 housing units and other non-domestic facilities the total heat requirements is estimated at 52,110,900MWh per annum.

The outline design proposed concentrates on the infrastructure requirements within the development on the understanding that the proposed architecture is suitable for either independent or off-site heat sources. The district heating system proposed would provide heat energy by means of low temperature heating water (LTHW). The LTHW would be distributed to individual consumers in a district heating pipe network in several discrete hydraulic systems, comprising a primary loop, secondary loops, and tertiary loops.

The primary loop would be directly fed by the originating heat source (e.g., Energy centre). The primary loop would extend throughout the proposed site, and encompass all phases. The heat energy from the primary loop would distribute into the secondary loop networks. The secondary loops distribute heat within the individual development phase areas. Heat energy would then be fed to consumer interface units directly or further tertiary hydraulic loop systems supplying heat energy to clusters of individual consumer interface units.

The geographical location, arrangement, size and number of secondary and tertiary loop networks will be determined at detailed design stage in order to optimise heat transfer efficiency and tie-in with the phased development construction.

Figure 4.2 shows a simplified diagrammatic representation.

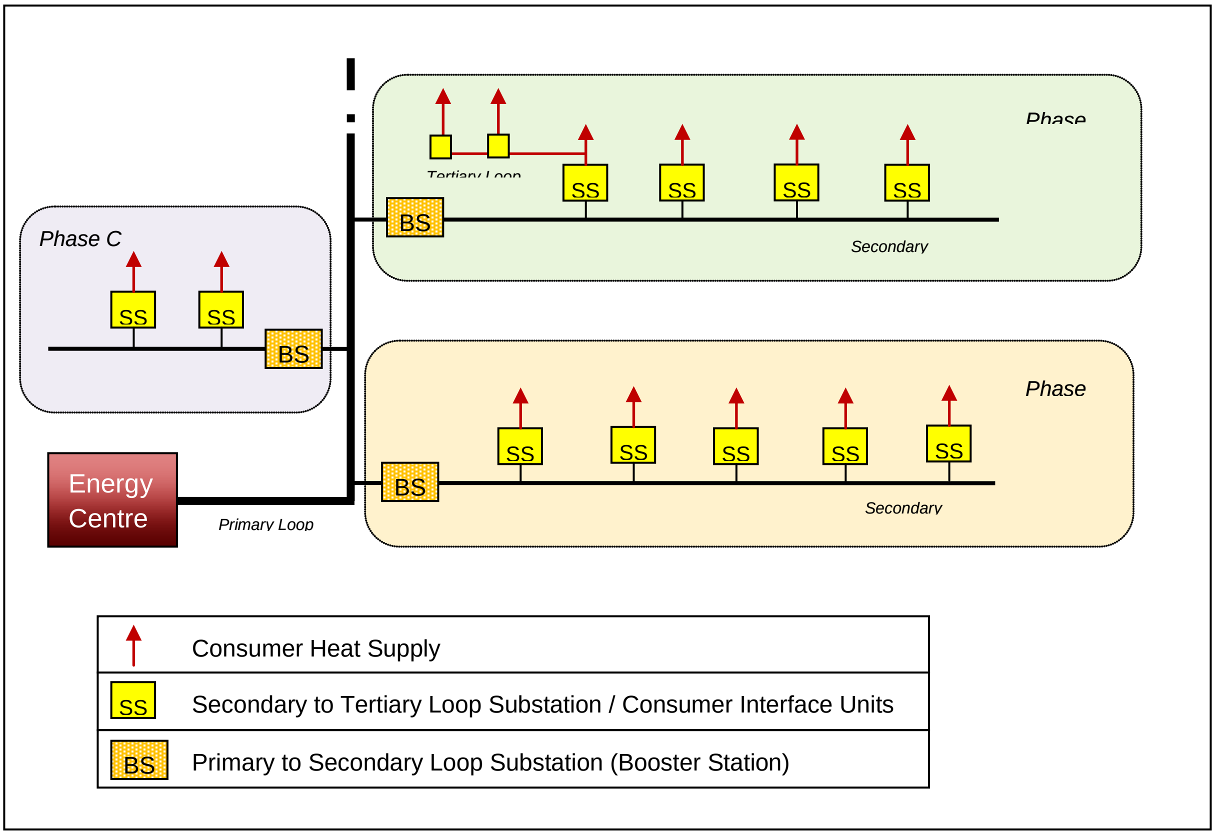


Figure 4.2 - District Heating Network Overview

4.5.1 Pipework

The pipework in the primary and secondary loop systems will be of pre-insulated, bonded carbon steel construction, typically provided in 12m lengths. It is envisaged that the pipework will be directly buried with connections of electrically welded sleeves to minimise leakage. It is envisaged that rigid and flexible plastic pipes will be used for tertiary loops and individual consumer connections.

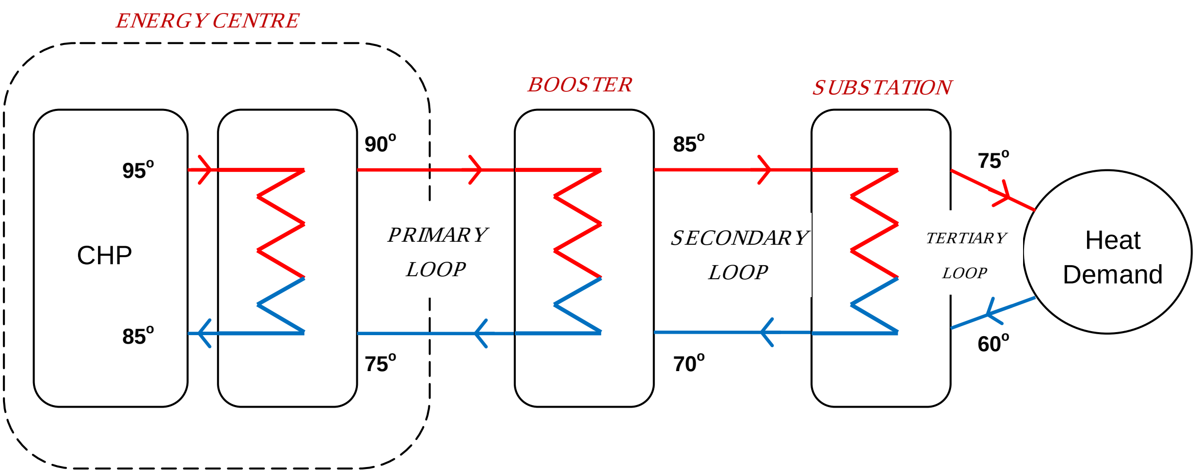


Figure 4.3 - LTHW Temperatures

The pipework will incorporate a polyurethane layer with an approximate thickness of 35mm to 45mm bonded directly to the outside of the pipework. A protective outer shell, manufactured from high density polyethylene (HDPE) would surround the insulation layer. All pipework and joints would be made watertight.

For the primary and secondary systems, the LTHW supply temperature will be in the range of 90ºC to 85ºC and the return temperature will be 70ºC to 75ºC dependent on network loop. However, the steel pipework will be designed for a continuous operating temperature of up to 120ºC and an occasional maximum operating temperature of 140ºC. (Figure 4.3).

The thermal losses in the pipework are considered to be negligible with respect to the potential heat energy. However, a conservative estimate of 8% heat losses have been applied for concept design calculations. The normal operating pressure should not normally exceed 10 bar (TBC), however the pipework will be designed for higher maximum pressures of up to 25 bar in consideration of over pressure and transient pressures.

To minimise construction costs and ease of connections, the supply and return pipework will be installed in a twin arrangement in the same trench where possible. Monitoring systems for the detection of pipe failure and leakage will be incorporated into the steel pipework systems.

During installation, the pipework will be pre-heated in an 'unstressed' state before backfilling the trench in order to allow the thermal forces to be reduced to an acceptable level by the friction between the soil and the pipework during operation. However, the use of compensators (expansion joints / bellows) is still considered to be necessary in places. The compensators will be butt welded, sealed and insulated.

4.5.2 Design Parameters

A schedule of key design parameters and assumptions are set out in Table 4.4 below. All calculations are based on standard industry assumptions and are subject to verification.

Table 4.4: Schedule of Parameters

PRIMARY LOOP	
Pipe Diameter	DN600
Heat Transmission Capacity	52.4MWh (25MW peak)
Supply Flow Rate	764l/s
Supply Water Temperature	90 ºC
Return Water Temperature	75 ºC
Pipe Material	Steel (insulated)
Monitoring System	Leakage & Failure
SECONDARY LOOP	
Pipe Diameter	DN250 to DN350
Heat Transmission Capacity	2 to 6MW
Supply Water Temperature	85ºC
Return Water Temperature	70ºC
Pipe Material	Steel (insulated)
Monitoring System	Leakage & Failure
TERTIARY / CONSUMER LOOP	
Supply Water Temperature	75ºC
Return Water Temperature	65ºC
Pipe Material	Plastic
Monitoring System	None

4.5.3 Booster Stations

The transfer of heat energy between the primary and secondary loop networks will be achieved by plate exchangers located in booster stations.

In order to directly supply consumers, connections from the secondary or tertiary loops will piped directly to consumer properties where a substation or consumer interface unit will transfer metered heat to the consumers individual heating and hot water circuits.

Delivery in the primary and secondary network loops is accomplished by circulation pumps that create a pressure differential between the incoming return and outgoing supply pipes. The pumps will be located at each energy centre and booster station.

The pumps are selected to overcome the flow resistance in the supply and return pipe network, the pressure differential in the booster station and the pressure differential at the consumer interface substations furthest from the delivery point. The design pressures in each loop network system will be selected to ensure appropriate maximum and minimum pressures at all points, and in consideration of the network topography. The use of variable frequency drives will be adopted to optimise power consumption under all demand conditions.

Under the proposed district heating system, each network is hydraulically separate with heat energy transferred indirectly between primary, secondary and tertiary via heat exchangers. This enables each network system to be run at differing temperature and pressures, allowing more design flexibility, but is constrained by the minimum temperature return and heat source temperature since a temperature difference is necessary between each system for optimal heat transfer and appropriate heat exchanger sizing. Consideration at detailed design stage is therefore required for lowering return temperatures or increasing supply temperatures for further pipe network optimisation.

It is anticipated that each booster station will be sized to transfer in the region of 2 to 6 MW of heat energy from the primary network into secondary network. A footprint size 7m by 5m (see Figure 4.4) is envisaged for a typical booster station in order to comprise the following elements:

- Pumps
- Heat Exchanger
- Regulating Valves
- Control Valves
- Flow Control Measurement
- Make Up Water
- Automatic control and monitoring system
- Control Panel/ MCC
- Communications back to main Control centre.

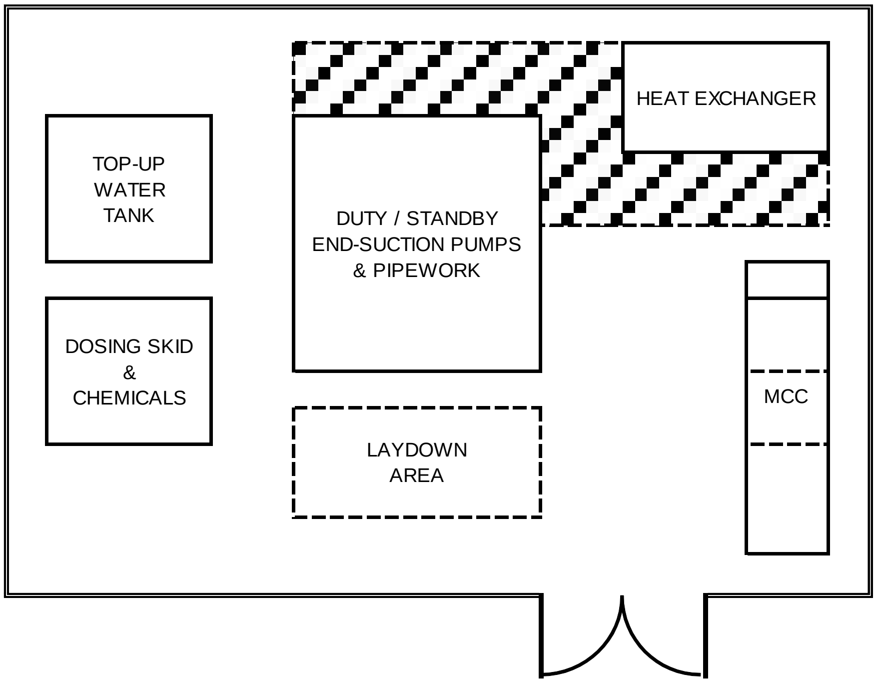


Figure 4.4 - Booster Station Outline Arrangement

The outline concept design of the Exemplar DHS network is provided in Appendix A, 7305-UA01881-01.

4.6 Electricity Supply Network

Based on the estimated energy requirements, the total electrical demand for the eco development is approximately 29,445MWh per annum. The indicative energy profile for the outline of the eco development show the demand trend over the construction period for housing, retail, commercial premises and schools, and is estimated at approximately 12.5 MW_e by the time the development is complete.

4.6.1 Exemplar site (Phase 1a)

The estimated demand for the Exemplar site, will rise to approximately 2 MW_e by 2015. A DNO supply will have to be adopted in order for the Exemplar energy centre to be connected to the mains network and P2/6 compliant CHP will have to be adopted to facilitate energy export and redundancy to be constructed. The P2/6 CHP will need to comprise:

- Gas-fired CHP and Biomass Boiler heating and electricity peak lopping and export.
- PV for daytime electricity and export.
- Load management system to start the generators whenever the site demand exceeds 1MVA.
- If the DNO supply fails or the SEPD transformer fails then both generator LV breakers open
- Part of the site demand restored manually within 3 hours via CHP
- P2/6 compliant provided at least site demand less 1 MW is restored via CHP

4.6.2 Remaining Phases of the eco development

As the eco development progresses, each of the energy centres will include a primary Sub-station and comprise either 33/11 kV or 11 kV/400v transformers and associated switchgear. As the demand increases to approximately 12.5 MW_e it will be necessary to interface the energy centres with each other and the DNO supply. At this time reinforcement of the 11kV network is not clear and connection requirements will need to be developed by the MUSCO/ESCO obligations.

4.6.3 Electrical Infrastructure

For 5,000 residential units, community buildings commercial premises the 11kV distribution network will be required to include up to 10 No. secondary distribution substations associated with each phase of the development. This distribution network is intended to be suitably designed for adoption by the DNO or the preferred MUSCO/ESCO provider.

It is anticipated that pad-mount style, ground mounted secondary distribution transformers generally designed to BS EN60076 will be adopted. Pad-mount transformers are used to supply small load centres primarily in rural locations and with the approval of the DNO Planning Engineer who may require additional switchgear (ring main unit or air break switch dis-connectors) where required by the network design.

4.6.4 Sub-Station Enclosure

A standard fenced substation comprises a site of approximately 4m x 4m with specific access and cable routes. Alternatively, an enclosed sub-station of either a GRP or brick built structure. Fencing is usually chain link or palisade and whatever the enclosure, it must be suitable for the associated “risk grade” of the substation. Wooden fencing is not permitted. An open construction (no roof) can be provided subject to one side being formed of palisade or expanded panelling (legally required to provide visibility into the substation from outside).

Fencing is not required around a pad mount transformer unless it is situated in a high risk area. The area inside the enclosure will be sand filled and covered with a minimum of 150mm of stone chippings or course gravel once the electrical works have been completed.

Provisions in the legal documentation giving DNO rights of access to all external sides of the enclosure for the purposes of repair, maintenance and replacement of the enclosure will be required.

4.6.5 Brick Built Sub-Station Enclosure

Brick built Sub-stations can be incorporated as part of a range of buildings such as attached to a garage block, bicycle or bin store. (Figures 4.6, 4.7 & 4.8).

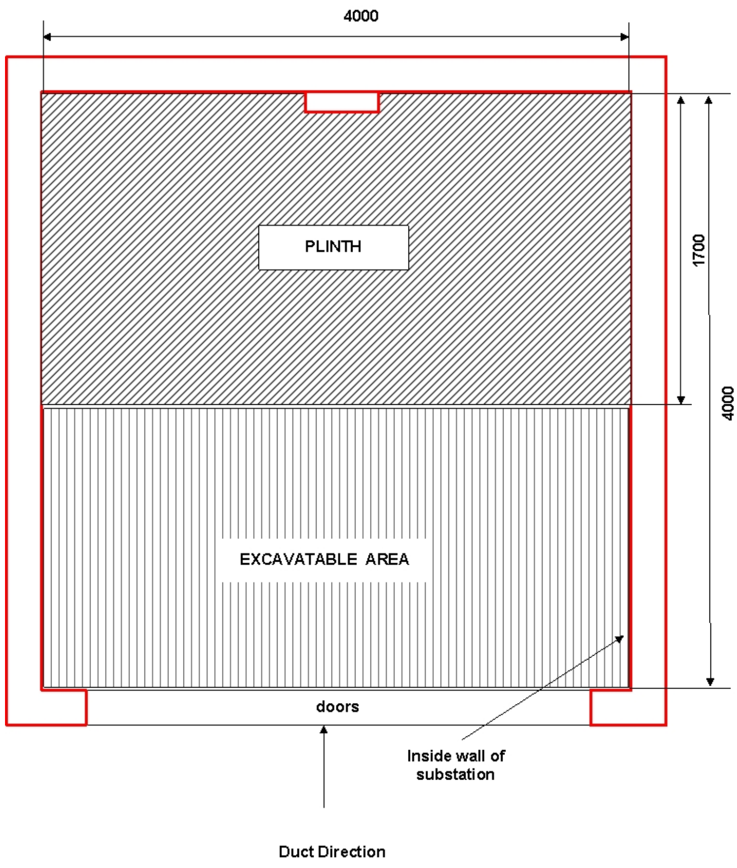


Figure 4.6 Brick Built Sub-Station Enclosure

The external dimensions of the building will be approximately 4m X 4m with an overall site requirement of 6m X 6m with the additional provision for access and cabling. Locations abutting domestic properties shall be avoided. An open type sub-station which is accessible from an adjacent roof is not permitted.

Brick built sub-station enclosures are to include a removable roof which is usually fabricated from GRP in either a flat or simulated ridged tile style and be pitched. This required to allow the installation or removal of equipment using a crane. Where there are specific planning or environmental demands a traditional tiled roof may be accepted although this is not generally preferred.

Double access doors, with an approved locking system, roof and ventilation arrangements are required to be constructed from materials which will attract minimal life -time maintenance costs and be capable of containing a disruptive failure of the switchgear or transformer.

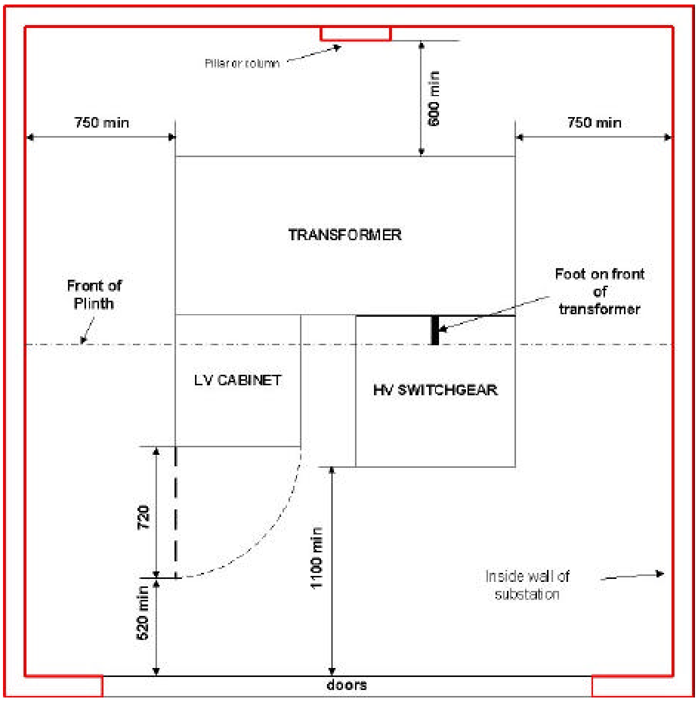


Figure 4.7 Sub-Station Enclosure – Internal Clearances

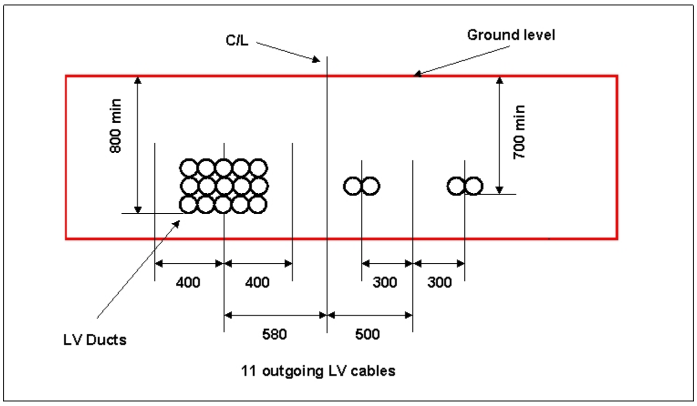


Figure 4.8 Cable Details

4.7 Energy Centre Procurement

Although elements of the energy centres are specialist items, procurement through conventional design, design-build or via a service provider such as from a multi-utility service company (MUSCO) or an Energy Supply Company (ESCO are technically and contractually viable.

As the development will include infrastructure and utility services in addition to the energy centres, procurement directly from a MUSCO/ESCO is considered the most appropriate mechanism providing the contractual terms and aspects of cost benefit are favourable to the P3Eco and A2 Dominion.

4.8 Phasing

Taking a pragmatic view of the current Masterplan and the available technology, there are existing electricity supplies in the Exemplar area which could be adopted and extended. A district heating system could be established either temporarily from boiler plant located in the Exemplar energy centre. The construction of the energy centre would allow for the addition of a thermal store and modular extension of the heating and generation plant for future phases.

The proposals for Phase 2 depend upon the particular scheduling agreed in the Masterplan. The provision of electricity supplies through the current supplier obligations are anticipated to require a two year lead time. If Phase 2 is coincident or in advance of Phase 1, a gas-fired CHP and associated boiler(s) will be required for both electricity and heating demands.

The progressive addition of Phases 3, 4 and 5 towards the centre of the development will require; the energy centres in Phases 1 and 2 to be extended along with the district heating, or a third energy centre to be constructed. For flexibility, resilience and to optimise the use of low and zero carbon technologies, and to ensure availability, all of the energy centres will need to be networked when the eco development is completed. A detailed strategy for the remainder of the site will be established when the phasing and Masterplan is finalised.

4.9 Timescale

Although elements of the energy centres are specialist items, delivery period for mechanical, electrical, control and instrumentation components is generally 6 months from placement of orders. Some items may take approximately 9 months. The system design engineering and integration with the associated civil works to facilitate final ordering of plant and equipment will also take approximately 6-9 months. The civil engineering construction will take approximately 12 months and the equipment installation approximately 6 months. A programme allowance of approximately 24 months is therefore prudent although the adoption of standard components could reduce this period by as much as 25%.

The allowance for procurement of offsite utilities, water, sewerage and electricity also generally require 2 years for completion.

The programme for procurement and availability, whether phased or modular, should be integrated with the Masterplan and developed in association with the other infrastructure and utility services MUSCO/ESCO provider.

4.10 Summary

The adoption of a combination of energy sources has the potential to achieve the carbon emission reduction targets and provide operational flexibility and sustainability.

Relative to the total eco development, it is likely that at least two, possibly three, energy centres offer a strategic advantage and these may be as full energy providers or as boosters and control of the offsite heat sources. A detailed energy strategy will be established when the phasing and Masterplan is finalised

The Exemplar site will be the location of the first energy centre, and will include a primary electricity sub-station and distribution sub-stations will also be required together with booster pumping stations and metering on the heating network. A combination of energy sources provides the greatest carbon reduction potential which include; gas CHP, biomass boiler, Solar photovoltaic and solar thermal to achieve a zero carbon development.

It is proposed that the Exemplar energy centre will comprise;

- The provision of Solar PV (1,984 kW_p);
  - on all residential property (assumed 11,790m^2).
  - on the primary school (2.800 m^2), on the proposed retail unit (385m^2).
  - On the business centre (725m^2) and community centre ([1]75m^2).
- Solar thermal on the energy centre (50m^2 in association with the thermal store)
- During Phase 1a, year 1;
  - 1 No. 500kW_t gas CHP and a 300kW_t standby gas boiler
- At the end of Phase 1a, during year three;
  - 1 No. 500kWt biomass boiler
- At the end of Phase 1a, year three;
  - Remove gas boiler and replace with 1 No, standby 500kWt gas CHP

During the initial part of Phase 1a construction, mains electricity will be made available to the energy centre to operate in parallel with the CHP and residential Photovoltaic as they become available. A temporary standby gas boiler will be provided to cover CHP plant outages and maintenance. As the thermal load increases, a biomass boiler will be added and the temporary standby boiler removed as the Exemplar site is completed.

The initial concept design for the Exemplar energy centre layout, DHS network (7305-UA01881-01) and HV network (7300-UA01881-01) are provided in Appendix A.

5 CONCLUSIONS

The NW Bicester eco development is one of four eco-towns identified in the Planning Policy Statement PPS 1 supplement which has received support from central government. The scheme is also supported locally by Cherwell District Council and Oxfordshire County Council, and is identified as a strategic allocation within CDC draft Core Strategy

The eco development is proposed to comprise some 5000 homes, secondary school, a number of primary schools, retail and commercial space along with health care and other community facilities. The development will meet the requirements of the PPS 1 supplement on eco-towns; which sets out several key sustainability principles; of which is a requirement for the development to be zero carbon (relative to energy use of buildings).

The first phase of the Bicester NW eco development is located to the north east of the site and will be an Exemplar for future development. The Carbon reductions in respect of the energy production for the Exemplar site must therefore equate to 100% of the demand of regulated and unregulated energy.

A variety of renewable technology options have been considered for Bicester eco development as well as the practical aspects of energy centre design. The energy sources considered included:

- Gas CHP
- Biomass Boilers
- Biomass CHP
- Solar - thermal
- Solar - Photo Voltaic
- Waste Combustion
- Anaerobic Digestion (AD)
- Ground Source Heat Pumps
- Wind Power
- Offsite Waste Heat
- Offsite Power

Of the options that have been considered for the Exemplar site, a combination of energy sources provides the greatest carbon reduction potential which include gas CHP, biomass boiler, photovoltaic and solar thermal to achieve a “zero carbon” development.

The phasing and details of the overall eco development have yet to be finalised and the energy requirements have been estimated based on current benchmarks in order to develop both a pragmatic and environmentally sustainable strategy; which includes.

- Mains power procurement through conventional infrastructure providers is viable and achievable and offers traditional advantages. However, the carbon tariff is high.
- Gas-fired CHP is an efficient energy conversion, is a mature technology and is readily available.
- Biomass Boiler plant is an available technology and offers the potential for near zero carbon emissions. However, there are commercial and environmental issues that have to be addressed regarding the reliability and viability of the supply change.

- Renewable energy sources such as GSHP, PV and wind power are readily available technologies and with low carbon emissions.
- Off-site waste heat opportunities have not been evaluated but flexibility to enable future inclusion (through connection to site wide heat network) have been considered.

Continued flexibility around the use technologies, such as GSHP and PV as well as other micro power generation may also be beneficial particularly if government continues to maintain a feed-in tariff. For the purpose of this preliminary report for Bicester eco development, the adoption of a combination of energy sources has the potential to achieve the carbon emission reduction targets and provide operational flexibility and sustainability.

Whether integrated with the offsite waste heat and grid electricity or independently, the eco development will need to include both an HV and a district heating network. In order to provide robustness, availability and service security, the power and heating networks should interface with the energy sources. The preliminary proposed strategy for the overall eco development comprise;

- Two No. 6 MW_e energy centre(s) (North and South of the Railway line) will be required for the eco development.
- HV network with a primary electricity sub-station (including grid connection) at each energy centre and distribution sub-stations throughout the network at load centres.
- District heat network complete with booster pumping stations.

A detailed strategy to achieve the zero carbon target for the Exemplar site is proposed to achieve zero carbon.

The Exemplar site will be the location of the first energy centre, and will include a primary electricity sub-station and distribution sub-stations will also be required together with booster pumping stations and metering on the heating network. A combination of energy sources provides the greatest carbon reduction potential which include; gas CHP, biomass boiler, Solar photovoltaic and solar thermal to achieve a zero carbon development. It is proposed that the The Exemplar site will be the location of the first energy centre, and will include a primary electricity sub-station and distribution sub-stations will also be required together with booster pumping stations and metering on the heating network. A combination of energy sources provides the greatest carbon reduction potential which include; gas CHP, biomass boiler, Solar photovoltaic and solar thermal to achieve a zero carbon development.

It is proposed that the Exemplar energy centre will comprise:

- The provision of Solar PV (1,984 kW_p);
  - on all residential property (assumed 11,790m^2).
  - on the primary school (2.800 m^2), on the proposed retail unit (385m^2).
  - On the business centre (725m^2) and community centre (175m^2).
- Solar thermal on the energy centre (50m^2 in association with the thermal store)
- Heat and Power generation;
  - 2 No. 500kWt gas CHP
  - 1 No. 500kWt biomass boiler

During the initial part of Phase 1a construction, mains electricity will be made available to the energy centre to operate in parallel with the CHP and residential Photovoltaic as they become available. A temporary standby gas boiler will be provided to cover CHP plant outages and maintenance. As the thermal load increases, a biomass boiler will be added as part of the final solution, and the temporary standby boiler removed as the Exemplar site is completed.

Resilience will be maintained with the final energy solution through the provision of the second gas CHP engine.

Further detailed design work in collaboration with potential energy providers will be required to confirm the strategy and determine with more certainty sizes of plant, engines and boilers. In addition, it should also be noted that the definition of “Zero carbon” is currently under review and the incorporation of “allowable solutions” is likely to be clarified early 2011. A full review of the energy strategy is advisable following the publication of the definition to ensure that the energy strategy solution adopted for the development and in particular to achieve “zero carbon” is that which is most cost effective

Although elements of the energy centres are specialist items, procurement through a service provider such as MUSCO/ESCO is technically and contractually viable. Detailed design development should therefore be undertaken with the MUSCO/ESCO in respect of

- Detail calculations on energy demand in respect of the final and agreed Master Plan.
- Specific SAP carbon reduction calculations for individual units.
- The revised definition of “zero carbon” and clarification of allowable solutions when published.
- Gas connection arrangements.
- Electrical infrastructure connections.
- Guarantees relating generator export and damages associated with non-performance.
- Importing offsite heat supplies.
- Engage with a ‘preferred’ MUSCO/ESCO supplier to develop the MUSCO solution in a format that could be adopted by an alternative MUSCO/ESCO provider should the preferred supplier not be awarded the MUSCO/ESCO concession.

Appendix A

Drawings

Bicester Eco Development

1. Exemplar energy demand calculation

2. Exemplar Energy balances

3. Exemplar Site Energy Centre Layout

4. Exemplar HV Network Layout

5. Exemplar District Heating Network Layout

Table 2a
Predicted Baseline Energy Usage (EXEMPLAR Site)

carbon emissions factor (gas) 0.198 **$kgCO_2/kWh$**

carbon emissions factor (electricity) 0.517 **$kgCO_2/kWh$**

Use Class	Sub Use	Description			GIA (m²)	assumed building type	% of GIA	basis of benchmark			good practice energy benchmark ($kWh/m^2/yr$)				good practice energy benchmark ($kWh/m^2/yr$)		total (kWh/yr)		carbon dioxide emission ($kgCO_{2/yr}$)	
										(m²)	space	water	L&A	cooking	Fossil Fuel	Electricity	Fossil Fuel	Electricity	Fossil Fuel	Electricity
		5.1 Retail (Use Class A)			**1,157**															
A1	(a)	Food Store			510	Small food store - Co-operative	52%	CIBSE TM46 (Small food store)	sales floor area	265	-	-	310	-	0	310	0	82212	0	42504
A1	(a)	Convenience Retail			297	Shops/stores: non-food stores (hairdressers)	67%	CIBSE TM46 (General retail	sales floor area	199	-	-	165	-	0	165	0	32833	0	16975
A3		Restaurants & Café's			350	ECO-PUB Restaurants (with bar) and cafe	100%	CIBSE TM46 (Restaurant)	gross floor area	350	40	120	90	210	370	90	129500	31500	25641	16286
																0				
		5.2 Business (Use Class B)			**1,305**					-						0				
B1	(a)	ECO-Business Centre			930	Office, air conditioned (standard)	90%	CIBSE TM46 (General office)	treated floor area	837	70	50	95	-	120	95	100440	79515	19887	41109
B1	(c)	Offices			-	Office, air conditioned (prestige)	85%	CIBSE TM46 (General office)	treated floor area	-	70	50	95	-	120	95	0	0	0	0
B1	(c)	Light Industrial			-	Light manufacturing	100%	BSRIA Rules of Thumb	gross floor area	-	49	-	31	-	49	31	0	0	0	0
B1	(c)	Energy Centre			375	Workshops	100%	CIBSE TM46	treated floor area	375	90	90	35	-	180	35	67500	13125	13365	6786
										-						0				
		5.3 Hotels & Residential Institutions (Use Class C)			**-**											0				
C1		Mid-range Hotel			-	Hotels: small	100%	CIBSE TM46 (Hotel)	treated floor area	-	165	110	105	55	330	105	0	0	0	0
C1		Country Club (Golf) Hotel			-	Hotels: business/holiday	100%	CIBSE TM46 (Hotel)	treated floor area	-	165	110	105	55	330	105	0	0	0	0
C2		Assisted Living			-	Residential and nursing homes	100%	CIBSE TM46 (Long Term Resi)_	treated floor area	-	200	120	65	100	420	65	0	0	0	0
										-						0				
		5.4 Residential Dwellings (Use Class C)		**393**	**37,845**											0				
C3										-						0				
		4 bed, 7person house = 250m GIA	111	9	999		100%	Approved Document L1A 2006	gross floor area	999	43	36	35	13	92	35	92206	34917	18257	18052
		5 bed, 7person house = 250m GIA	130	42	5,460		200%	Approved Document L1A 2007	gross floor area	10,920	43	36	35	13	92	35	1007895	381675	199563	197326
C3					-					-					0	0				
		3 bed, 5 person house = 85m GIA	83	99	8,217	Semi-detached	100%	Approved Document L1A 2006	gross floor area	8,217	39	38	34	15	92	34	754058	282876	149303	146247
		4 bed, 6 person house = 112m GIA	74	58	4,292	Detached Bungalows	100%	Approved Document L1A 2006	gross floor area	4,292	43	36	35	13	92	35	396143	150014	78436	77557
					-					-					0	0				
C3					-					-					0	0				
		1 bed, 2 person flat = 51m GIA	77	7	539	Top floor flat	100%	Approved Document L1A 2006	gross floor area	539	37	46	36	19	102	36	54978	19404	10886	10032
		2 bed, 4 person flat = 74m GIA	88	23	2,024	Top floor flat	100%	Approved Document L1A 2006	gross floor area	2,024	37	46	36	19	102	36	206448	72864	40877	37671
		3 bed, 5 person house = 85m GIA	102	99	10,098	Semi-detached	100%	Approved Document L1A 2006	gross floor area	10,098	39	38	34	15	92	34	926673	347630	183481	179725
		4 bed, 6 person house = 112m GIA	111	56	6,216	Detached	100%	Approved Document L1A 2006	gross floor area	6,216	43	36	35	13	92	35	573725	217261	113598	112324
																0				
		5.5 Non Residential Institutions (Use Class D)			**2,821**											0				
D1	(c)	Primary Schools			1,689	Primary school	100%	CIBSE TM46	gross floor area	1,689	66	45	40	39	150	40	253350	67560	50163	34929
D1	(c)	Secondary School			-		100%	CIBSE TM46	gross floor area	-	66	45	40	39	150	40	0	0	0	0
D1	(c)	Further Education Institution			-	Further & Higher Education - Teaching	100%	BSRIA Rules of Thumb	gross floor area	-	-	-	-	-	0	0	0	0	0	0
D1	(c)	Community Centre			422	Local authority buildings - community centres	100%	CIBSE TM46 (public buildings with light use)	net lettable items	422	60	40	20	5	105	20	44258	8430	8763	4358
D1	(c)	Office			470	Emergency services	100%	CIBSE F	treated floor area	470	70	50	95	10	130	95	61100	44650	12098	23084
D1	(c)	Nursery			240	Primary health care (general practitioners' surgeries and dental practices)	100%	CIBSE TM46 Clinic	gross floor area	240	95	70	70	35	200	70	48000	16800	9504	8686
D1	(c)	Private Hospital			-	Hospitals: acute	100%	CIBSE F	heated floor area	-					0	0	0	0	0	0
D1	(c)	Outdoor Market			-		200%	CIBSE F								0				
D1	(c)															0				
																0				
		5.6 Assembly & Leisure Facilities (Use Class D)			**-**											0				
D2		Equestrian Centre				Sports and recreation: dry sports centre	100%	CIBSE F	treated floor area	-	-	-	-	-	0	0	0	0	0	0
D2		Tennis Academy				Sports and recreation: dry sports centre	100%	CIBSE F	treated floor area	-	-	-	-	-	0	0	0	0	0	0
																0				
						Totals				**48,152**							**4,716,274**	**1,883,266**	**933,822**	**973,649**

Notes

1 good practice benchmarks can be assumed upper limits for new build
2 where no good practice benchmarks available, typical practice benchmarks used
3 fossil fuel taken to be gas (fossil-thermal energy)
4 benchmark figures include cooling, as applicable to building type
5 calculations are for EXEMPLAR build

Table 2b
Predicted Energy Usage (EXEMPLAR Site) CSH6 Energy Efficiency

carbon emissions factor (gas) 0.198 $kgCO_2/kWh$

carbon emissions factor (electricity) 0.517 $kgCO_2/kWh$

Use Class	Sub Use	Description			GIA (m²)	assumed building type	% of GIA	basis of benchmark			good practice energy benchmark ($kWh/m^2/yr$)				Advanced practice energy efficiency energy benchmark ($kWh/m^2/yr$)		total (kWh/yr)		carbon dioxide emission ($kgCO_{2/yr}$)	
										(m²)	space	water	L&A	cooking	Fossil Fuel	Electricity	Fossil Fuel	Electricity	Fossil Fuel	Electricity
		5.1 Retail (Use Class A)			**1,157**															
A1	(a)	Food Store	0	0	510	Small food store - Co-operative	52%		sales floor area	265	-	-	267	-	-	266.6	0	70702	0	36553
A1	(a)	Convenience Retail	0	0	297	Shops/stores: non-food stores (hairdressers)	67%		sales floor area	199	-	-	142	-	-	141.9	0	28237	0	14598
A3		Restaurants & Café's	0	0	350	ECO-PUB Restaurants (with bar) and cafe	100%		gross floor area	350	34	103	77	181	318	77.4	111370	27090	22051	14006
		0	0	0												0				
		5.2 Business (Use Class B)	0	0	**1,305**					-						0				
B1	(a)	ECO-Business Centre	0	0	930	Office, air conditioned (standard)	90%		treated floor area	837	55	40	75	-	95	75.05	79348	62817	15711	32476
B1	(c)	Offices	0	0	-	Office, air conditioned (prestige)	85%		treated floor area	-	55	40	75	-	95	75.05	0	0	0	0
B1	(c)	Light Industrial	0	0	-	Light manufacturing	100%		gross floor area	-					-	0	0	0	0	0
B1	(c)	Energy Centre	0	0	375	Workshops	100%		treated floor area	375	71	71	28		142	27.65	53325	10369	10558	5361
		0	0	0						-						0				
		5.3 Hotels & Residential Institutions (Use Class C)	0	0	**-**											0				
C1		Mid-range Hotel	0	0	-	Hotels: small	100%		treated floor area	-	111	74	70	37	221	70.35	0	0	0	0
C1		Country Club (Golf) Hotel	0	0	-	Hotels: business/holiday	100%		treated floor area	-	111	74	70	37	221	70.35	0	0	0	0
C2		Assisted Living	0	0	-	Residential and nursing homes	100%		treated floor area	-	134	80	44	67	281	43.55	0	0	0	0
		0	0	0						-										
		5.4 Residential Dwellings (Use Class C)		**393**	**37,845**															
C3		0	0	0						-										
		4 bed, 7person house = 250m GIA	111	9	999		100%		gross floor area	999	32	27	26	10	69	26	69154	26188	13693	13539
		5 bed, 7person house = 250m GIA	130	42	5,460		200%		gross floor area	10,920	32	27	26	10	69	26	755921	286256	149672	147994
C3		0	0	0	-					-					-	-				
		3 bed, 5 person house = 85m GIA	83	99	8,217	Semi-detached	100%		gross floor area	8,217	29	29	26	11	69	26	565543	212157	111978	109685
		4 bed, 6 person house = 112m GIA	74	58	4,292	Detached Bungalows	100%		gross floor area	4,292	32	27	26	10	69	26	297108	112510	58827	58168
		0	0	0	-					-					-	-				
C3		0	0	0	-					-					-	-				
		1 bed, 2 person flat = 51m GIA	77	7	539	Top floor flat	100%		gross floor area	539	28	35	27	14	77	27	41234	14553	8164	7524
		2 bed, 4 person flat = 74m GIA	88	23	2,024	Top floor flat	100%		gross floor area	2,024	28	35	27	14	77	27	154836	54648	30658	28253
		3 bed, 5 person house = 85m GIA	102	99	10,098	Semi-detached	100%		gross floor area	10,098	29	29	26	11	69	26	695005	260723	137611	134794
		4 bed, 6 person house = 112m GIA	111	56	6,216	Detached	100%		gross floor area	6,216	32	27	26	10	69	26	430294	162946	85198	84243
		0	0	0																
		5.5 Non Residential Institutions (Use Class D)	0	0	**2,821**															
D1	(c)	Primary Schools	0	0	1,689	Primary school	100%		gross floor area	1,689	44	30	27	26	101	26.8	169745	45265	33609	23402
D1	(c)	Secondary School	0	0	-		100%		gross floor area	-	44	30	27	26	101	26.8	0	0	0	0
D1	(c)	Further Education Institution	0	0	-	Further & Higher Education - Teaching	100%		gross floor area	-					-	0	0	0	0	0
D1	(c)	Community Centre	0	0	422	Local authority buildings - community centres	100%		net lettable items	422	47	32	16	4	83	15.8	34963	6660	6923	3443
D1	(c)	Office	0	0	470	Emergency services	100%		treated floor area	470	55	40	75	8	103	75.05	48269	35274	9557	18236
D1	(c)	Nursery	0	0	240	Primary health care (general practitioners' surgeries and dental practices)	100%		gross floor area	240	75	55	55	28	158	55.3	37920	13272	7508	6862
D1	(c)	Private Hospital	0	0	-	Hospitals: acute	100%		heated floor area	-	-	-	-	-	-	0	0	0	0	0
D1	(c)	Outdoor Market	0	0	-		200%									0				
D1	(c)	0	0	0												0				
		0	0	0												0				
		5.6 Assembly & Leisure Facilities (Use Class D)	0	0	**-**											0				
D2		Equestrian Centre	0	0		Sports and recreation: dry sports centre	100%		treated floor area	-					-	0	0	0	0	0
D2		Tennis Academy	0	0		Sports and recreation: dry sports centre	100%		treated floor area	-					-	0	0	0	0	0
						Totals				**48,152**							**3,544,034**	**1,429,666**	**701,719**	**739,137**

Notes

1 good practice benchmarks can be assumed upper limits for new build
2 where no good practice benchmarks available, typical practice benchmarks used
3 fossil fuel taken to be gas (fossil-thermal energy)
4 benchmark figures include cooling, as applicable to building type
5 calculations are for EXEMPLAR build

TABLE 3
BICESTER ECO-DEVELOPMENT
EXEMPLAR Carbon Reduction Calculation - MONTHLY

		JANUARY 31			FEBRUARY 28			MARCH 31		
		Demand	CO cost	CO saving	Demand	CO cost	CO saving	Demand	CO cost	CO saving
Baseline 2006										
Heat demand		742,398	146,995		669,524	132,566		589,819	116,784	
Electricity demand		296,448	153,264		267,349	138,220		235,522	121,765	
APEE heat demand	25%	557,873	110,459		503,113	99,616		443,218	87,757	
APEE elec demand	24%	225,046	116,349		202,956	104,928		178,795	92,437	
Heat output of Gas CHP system	kWth	500			500			500		
Electricity output of Gas CHP system	kWe	303			303			303		
Efficiency of Gas CHP		90%			90%			90%		
Heat to power ratio of CHP system		1.65			1.65			1.65		
hours/d		24			24			20		
Hours of operation	hrs	744			672			620		
Gas consumption of CHP	kW	892			892			892		
Total gas consumption of CHP	kWh	663,838	**131,440**		599,596	**118,720**		553,199	**109,533**	
Heat output	kWh	372,000			336,000			310,000		
Electricity output	kWh	225,455		**119,265**	203,636		**107,724**	187,879		**99,388**
PV										
elec capacity	kWp	1,984			1,984			1,984		
efficiency		72%			72%			72%		
operating hours per day		2			2			3		
monthly		62			56			93		
elec output		88,577		**46,857**	80,005		**42,323**	132,865		**70,286**
Heat output of Biomass CHP system	kWth	500			500			500		
Electricity output of Biomass CHP systen	kWe	303			303			303		
Efficiency of Gas CHP		90%			90%			90%		
Heat to power ratio of CHP system		1.65			1.65			1.65		
hours/d		-			-			-		
Hours of operation		-			-			-		
Biofuel consumed	kW	892			892			892		
Total biofuel consumption of CHP	kWh	-	-		-	-		-	-	
Heat output	KWh	-			-			-		
Electricity output	kWh	-		-	-		-	-		-
Heat output of Biomass Boiler	kWth	500			500			500		
Electricity output of Biomass CHP systen	kWe	-			-			-		
Efficiency of Boiler		80%			80%			80%		
Heat to power ratio of CHP system		-			-			-		
hours/d		12			12			9		
Hours of operation		372			336			279		
Biofuel consumed	kW	625			625			625		
Total biofuel consumption of CHP	kWh	232,500	**2,093**		210,000	**1,890**		174,375	**1,569**	
Heat output	KWh	186,000			168,000			139,500		
Electricity output	kWh	-		-	-		-	-		-
total available heat generated	kWh	558,000			504,000			449,500		
generated electricity		314,031			283,641			320,744		
individual unit condensing boiler efficiency		85%			85%			85%		
heat CO2 cost at 2006 baseline			**146,995**			**132,566**			**116,784**	
elec CO2 cost at 2006 baseline			**153,264**			**138,220**			**121,765**	
total CO2 at 2006 baseline			**300,259**			**270,785**			**238,549**	
CO2 emission from option			**83,759**			**75,492**			**33,866**	
			72%			**72%**			**86%**	

		APRIL 30			MAY 31			JUNE 30		
		Demand	CO cost	CO saving	Demand	CO cost	CO saving	Demand	CO cost	CO saving
Baseline 2006										
Heat demand		439,518	87,024		261,889	51,854		127,528	25,251	
Electricity demand		175,505	90,736		104,575	54,065		50,924	26,328	
APEE heat demand	25%	330,275	65,394		196,796	38,966		95,831	18,975	
APEE elec demand	24%	133,233	68,881		79,388	41,043		38,658	19,986	
Heat output of Gas CHP system	kWth	500			500			500		
Electricity output of Gas CHP system	kWe	303			303			303		
Efficiency of Gas CHP		90%			90%			90%		
Heat to power ratio of CHP system		1.65			1.65			1.65		
hours/d		16			9			-		
Hours of operation	hrs	480			279			-		
Gas consumption of CHP	kW	892			892			892		
Total gas consumption of CHP	kWh	428,283	**84,800**		248,939	**49,290**		-	-	
Heat output	kWh	240,000			139,500			-		
Electricity output	kWh	145,455		**76,945**	84,545		**44,725**	-		-
PV										
elec capacity	kWp	1,984			1,984			1,984		
efficiency		72%			72%			72%		
operating hours per day		3			3			4		
monthly		90			93			120		
elec output		128,579		**68,019**	132,865		**70,286**	171,439		**90,691**
Heat output of Biomass CHP system	kWth	500			500			500		
Electricity output of Biomass CHP systen	kWe	303			303			303		
Efficiency of Gas CHP		90%			90%			90%		
Heat to power ratio of CHP system		1.65			1.65			1.65		
hours/d		-			-			-		
Hours of operation		-			-			-		
Biofuel consumed	kW	892			892			892		
Total biofuel consumption of CHP	kWh	-	-		-	-		-	-	
Heat output	KWh	-			-			-		
Electricity output	kWh	-		-	-		-	-		-
Heat output of Biomass Boiler	kWth	500			500			500		
Electricity output of Biomass CHP systen	kWe	-			-			-		
Efficiency of Boiler		80%			80%			80%		
Heat to power ratio of CHP system		-			-			-		
hours/d		6			4			7		
Hours of operation		180			124			210		
Biofuel consumed	kW	625			625			625		
Total biofuel consumption of CHP	kWh	112,500	**1,013**		77,500	**698**		131,250	**1,181**	
Heat output	KWh	90,000			62,000			105,000		
Electricity output	kWh	-		-	-		-	-		-
total available heat generated	kWh	330,000			201,500			105,000		
generated electricity		274,034			217,411			171,439		
individual unit condensing boiler efficiency		85%			85%			85%		
heat CO2 cost at 2006 baseline			**87,024**			**51,854**			**25,251**	
elec CO2 cost at 2006 baseline			**90,736**			**54,065**			**26,328**	
total CO2 at 2006 baseline			**177,760**			**105,919**			**51,578**	
CO2 emission from option			**9,730**			**- 23,979**			**- 69,524**	
			95%			**123%**			**235%**	

		JULY 31			AUGUST 31			SEPTEMBER 30		
		Demand	CO cost	CO saving	Demand	CO cost	CO saving	Demand	CO cost	CO saving
Baseline 2006										
Heat demand		61,487	12,174		61,487	12,174		143,469	28,407	
Electricity demand		24,552	12,694		24,552	12,694		57,289	29,618	
APEE heat demand	25%	46,204	9,148		46,204	9,148		107,810	21,346	
APEE elec demand	24%	18,639	9,636		18,639	9,636		43,491	22,485	
Heat output of Gas CHP system	kWth	500			500			500		
Electricity output of Gas CHP system	kWe	303			303			303		
Efficiency of Gas CHP		90%			90%			90%		
Heat to power ratio of CHP system		1.65			1.65			1.65		
hours/d		-			-			-		
Hours of operation	hrs	-			-			-		
Gas consumption of CHP	kW	892			892			892		
Total gas consumption of CHP	kWh	-	-		-	-		-	-	
Heat output	kWh	-			-			-		
Electricity output	kWh	-		-	-		-	-		-
PV										
elec capacity	kWp	1,984			1,984			1,984		
efficiency		72%			72%			72%		
operating hours per day		4			4			3		
monthly		124			124			90		
elec output		177,154		**93,714**	177,154		**93,714**	128,579		**68,019**
Heat output of Biomass CHP system	kWth	500			500			500		
Electricity output of Biomass CHP systen	kWe	303			303			303		
Efficiency of Gas CHP		90%			90%			90%		
Heat to power ratio of CHP system		1.65			1.65			1.65		
hours/d		-			-			-		
Hours of operation		-			-			-		
Biofuel consumed	kW	892			892			892		
Total biofuel consumption of CHP	kWh	-	-		-	-		-	-	
Heat output	KWh	-			-			-		
Electricity output	kWh	-		-	-		-	-		-
Heat output of Biomass Boiler	kWth	500			500			500		
Electricity output of Biomass CHP systen	kWe	-			-			-		
Efficiency of Boiler		80%			80%			80%		
Heat to power ratio of CHP system		-			-			-		
hours/d		4			4			8		
Hours of operation		124			124			240		
Biofuel consumed	kW	625			625			625		
Total biofuel consumption of CHP	kWh	77,500	**698**		77,500	**698**		150,000	**1,350**	
Heat output	KWh	62,000			62,000			120,000		
Electricity output	kWh	-		-	-		-	-		-
total available heat generated	kWh	62,000			62,000			120,000		
generated electricity		177,154			177,154			128,579		
individual unit condensing boiler efficiency		85%			85%			85%		
heat CO2 cost at 2006 baseline			**12,174**			**12,174**			**28,407**	
elec CO2 cost at 2006 baseline			**12,694**			**12,694**			**29,618**	
total CO2 at 2006 baseline			**24,868**			**24,868**			**58,025**	
CO2 emission from option			**- 83,381**			**- 83,381**			**- 44,184**	
			435%			**435%**			**176%**	

		OCTOBER 31			NOVEMBER 30			DECEMBER 31			ANNUAL AVERAGE 365		
		Demand	CO cost	CO saving	Demand	CO cost	CO saving	Demand	CO cost	CO saving	Demand	CO cost	CO saving
Baseline 2006													
Heat demand		323,376	64,028		553,382	109,570		742,398	146,995		4,716,274	933,822	
Electricity demand		129,128	66,759		220,972	114,243		296,448	153,264		1,883,266	973,649	
APEE heat demand	25%	243,000	48,114		415,838	82,336		557,873	110,459		3,544,034	701,719	
APEE elec demand	24%	98,026	50,680		167,749	86,726		225,046	116,349		1,429,666	739,137	
Heat output of Gas CHP system	kWth	500			500			500			500		
Electricity output of Gas CHP system	kWe	303			303			303			303		
Efficiency of Gas CHP		90%			90%			90%			90%		
Heat to power ratio of CHP system		1.65			1.65			1.65			1.65		
hours/d		11			19			22			12.1		
Hours of operation	hrs	341			570			682			4,410		
Gas consumption of CHP	kW	892			892			892			892		
Total gas consumption of CHP	kWh	304,259	**60,243**		508,586	**100,700**		608,519	**120,487**		3,935,220	**779,174**	
Heat output	kWh	170,500			285,000			341,000			2,205,208		
Electricity output	kWh	103,333		**54,663**	172,727		**91,373**	206,667		**109,327**	1,336,490		**707,003**
PV													
elec capacity	kWp	1,984			1,984			1,984			1,984		
efficiency		72%			72%			72%			72%		
operating hours per day		3			3			2			3.0		
monthly		93			90			62			1,095		
elec output		132,865		**70,286**	128,579		**68,019**	88,577		**46,857**	1,564,383		**827,558**
Heat output of Biomass CHP system	kWth	500			500			500			500		
Electricity output of Biomass CHP systen	kWe	303			303			303			303		
Efficiency of Gas CHP		90%			90%			90%			90%		
Heat to power ratio of CHP system		1.65			1.65			1.65			1.65		
hours/d		-			-			-			-		
Hours of operation		-			-			-			-		
Biofuel consumed	kW	892			892			892			892		
Total biofuel consumption of CHP	kWh	-	-		-	-		-	-		-	-	
Heat output	KWh	-			-			-			-		
Electricity output	kWh	-		-	-		-	-		-	-		-
Heat output of Biomass Boiler	kWth	500			500			500			500		
Electricity output of Biomass CHP systen	kWe	-			-			-			-		
Efficiency of Boiler		80%			80%			80%			80%		
Heat to power ratio of CHP system		-			-			-			-		
hours/d		5			9			14			7.8		
Hours of operation		155			270			434			2,859		
Biofuel consumed	kW	625			625			625			625		
Total biofuel consumption of CHP	kWh	96,875	**872**		168,750	**1,519**		271,250	**2,441**		1,786,979	**16,083**	
Heat output	KWh	77,500			135,000			217,000			1,429,583		
Electricity output	kWh	-		-	-		-	-		-	-		-
total available heat generated	kWh	248,000			420,000			558,000			3,634,792		
generated electricity		236,199			301,307			295,244			2,900,873		
individual unit condensing boiler efficiency		85%			85%			85%			85%		
heat CO2 cost at 2006 baseline			**64,028**			**109,570**			**146,995**			**933,822**	
elec CO2 cost at 2006 baseline			**66,759**			**114,243**			**153,264**			**973,649**	
total CO2 at 2006 baseline			**130,787**			**223,812**			**300,259**			**1,907,471**	
CO2 emission from option			**- 13,154**			**29,554**			**83,093**			**- 168**	
			110%			**87%**			**72%**			**100%**	

CO2 based on monthly outputs	1,907,471
total CO2 at 2006 baseline	- 2,109
CO2 emission from option	**100%**

NOTES

1 CO2 factors

Gas	0.198	from mains
Electricity	0.517	from mains
Displaced Electricity	0.529	chp excess output
biodiesel	0.047	
woodchip	0.009	

2 Solar Photo-Voltaic (PV)

90%	effective due to location		
80%	output at end of life		
72.0%	Overall efficiency		
1.25	kWp output per	10	m2
15,874	Available area (m2)		

3 Gas CHP

90% efficiency
1.65 Heat/Power Ratio

4 Biomass CHP

90% efficiency
1.65 Heat/Power Ratio

5 Biomass Boiler

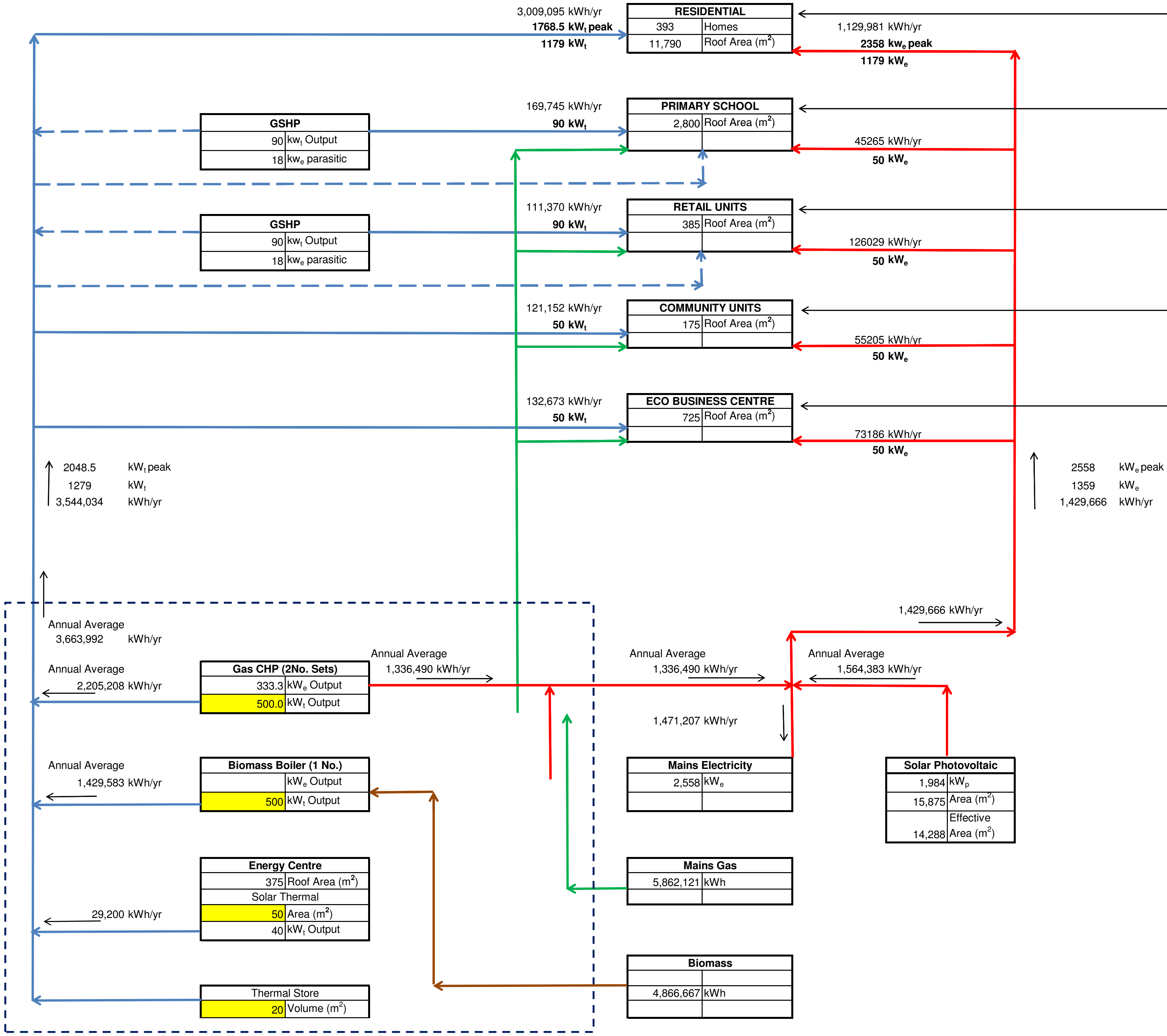
80% efficiency

6 Gas Boiler

85% efficiency - 2006 condensing type

Table 4
Bicester ECO - Development
UA001881
Summary Energy Balance - Exemplar Site

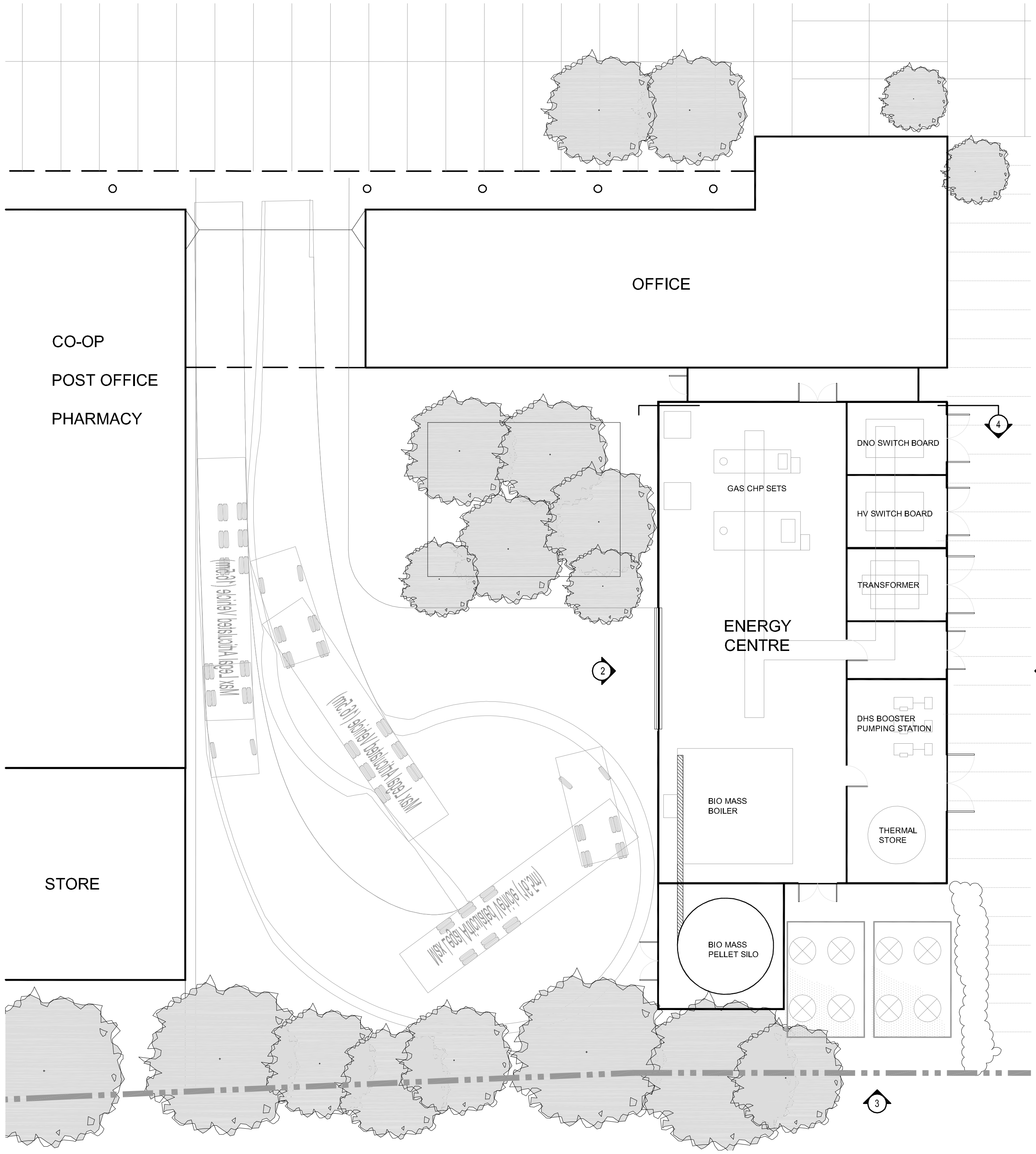
Design Requirements (kWh/yr)		
	Heat	**Electricity**
Baseline	4,716,274	1,883,266
Energy efficient	3,544,034	1,429,666
Energy Balance	3,544,034	1,429,666



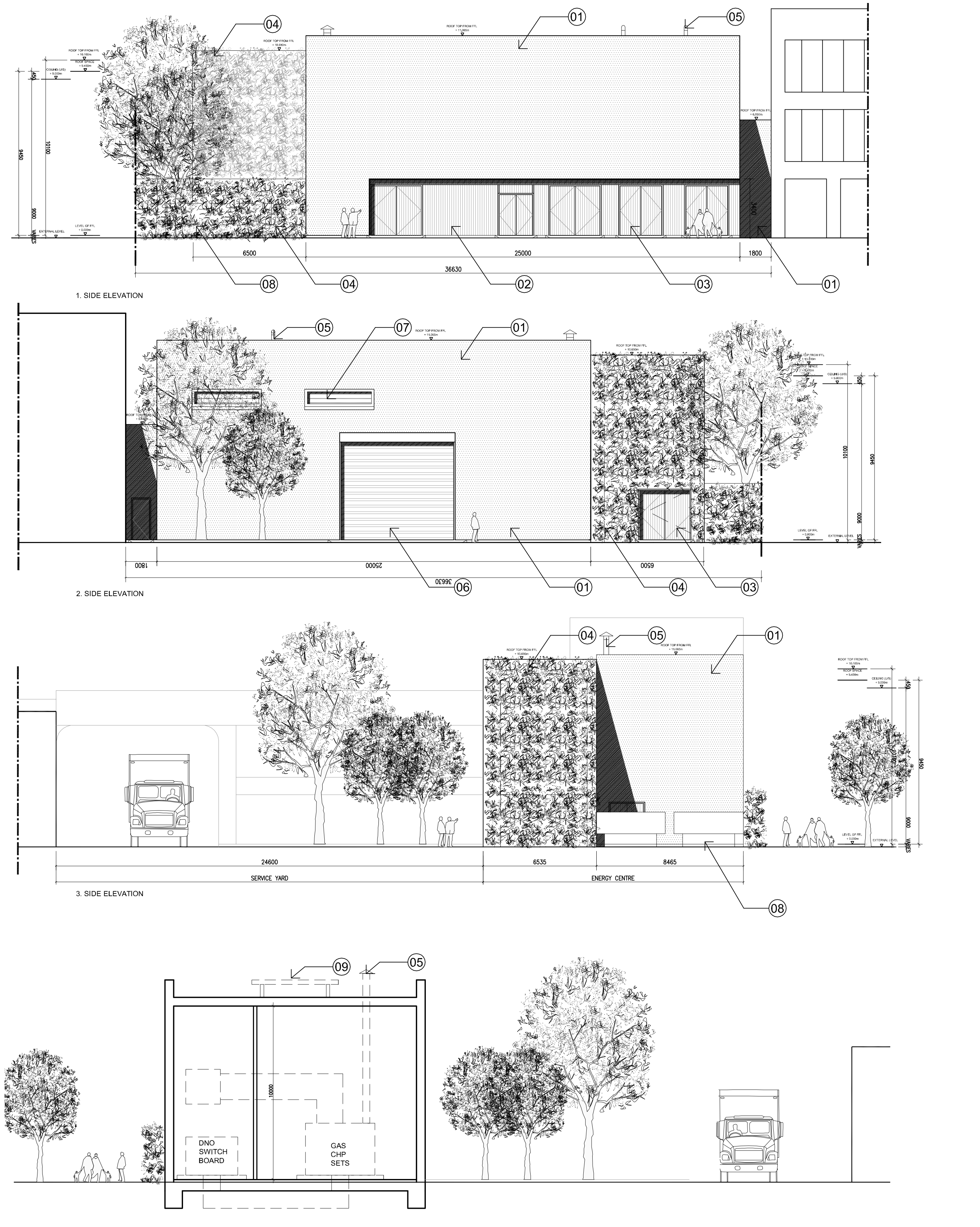
BASELINEcarbon dioxide emission ($kgCO_2$)		**CSH6 EFFICIENCY carbon dioxide emission ($kgCO_2$)**		**Carbon dioxide emission Reduction**	
Fossil Fuel	**Electricity**	**Fossil Fuel**	**Electricity**	**Fossil Fuel**	**Electricity**
794,401	778,933	595,801	584,200	25%	25%
50,163	34,929	33,609	23,402	33%	33%
25,641	75,764	22,051	65,157	14%	14%
30,365	36,128	23,988	28,541	21%	21%
33,252	47,895	26,269	37,837	21%	21%
933,822	973,649	701,719	739,137	25%	24%

5.4 Residential Dwellings (Use Class C)	**393**
Low Density Band = 10 dph	
4 bed, 7person house = 250m GIA	9
5 bed, 7person house = 250m GIA	42
Medium Density Band = 50 dph	
3 bed, 5 person house = 85m GIA	99
4 bed, 6 person house = 112m GIA	58
High Density Band = 72 dph	
1 bed, 2 person flat = 51m GIA	7
2 bed, 4 person flat = 74m GIA	23
3 bed, 5 person house = 85m GIA	99
4 bed, 6 person house = 112m GIA	56

Roof Area per dwelling	30	m^2
Roof Area Available	11,790	m^2
Nursery & Community Building	175	m^2
Retail Biuldings	385	m^2
Eco-business centre	450	m^2
Office	275	m^2
Primary School	2,800	m^2
	15,875	m^2



PLAN



LEGEND

01 THROUGH COLOUR RENDER
02 POWDER COATED METAL LOUVRES
03 POWDER COATED CONCEALED LOUVRED DOOR
04 VEGETATED GREEN WALL
05 FLUE
06 ROLLER SHUTTER DOOR
07 CHP INLET ATTENUATORS
08 HEAT DUMP RADIATORS
09 SOLAR THERMAL

A2 Dominion / P3 Eco

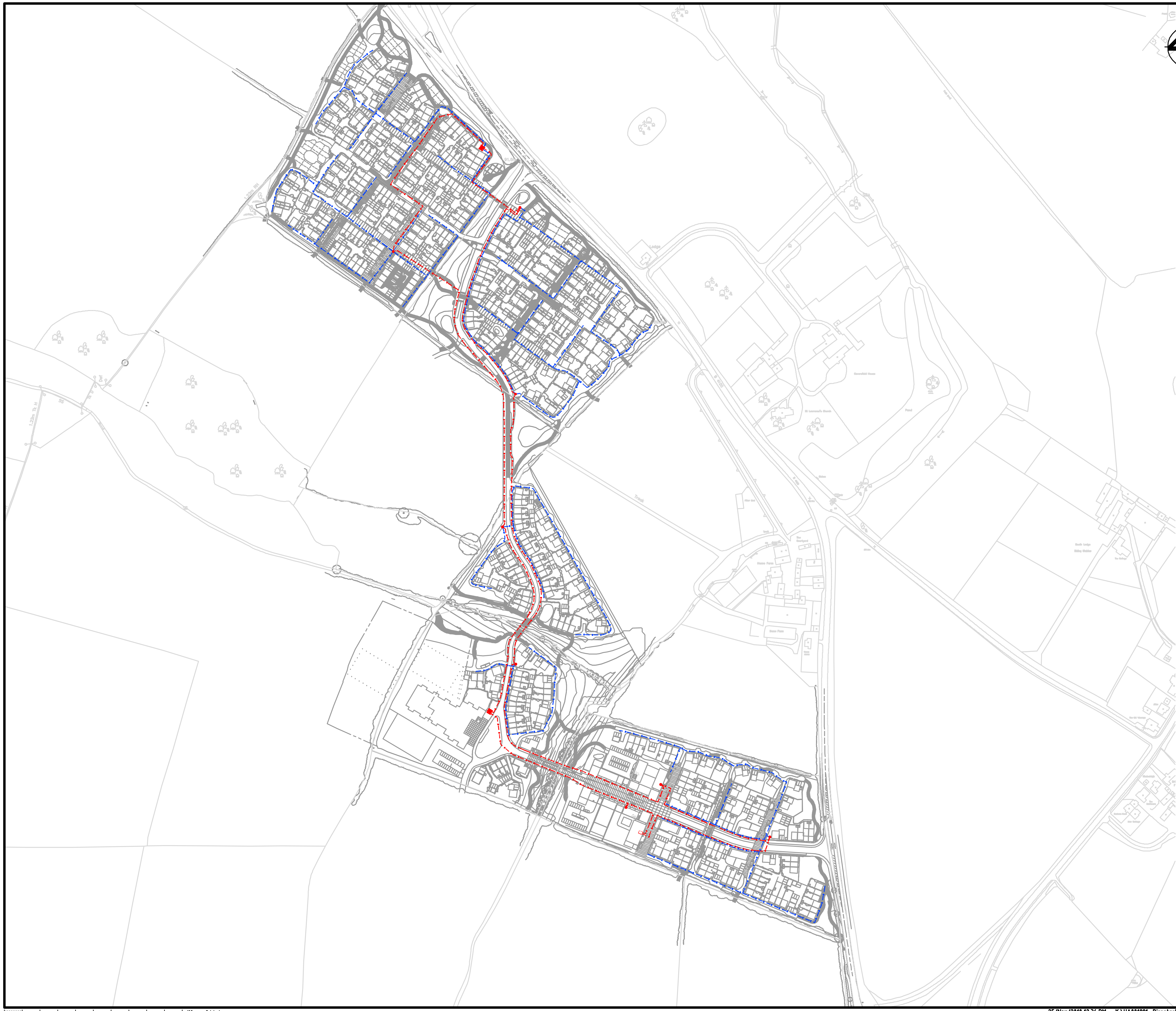
BIMP2_PA_05_100 REV B

SCALE 1:100 @ A0
13TH DEC 2010

NW BICESTER EXEMPLAR DEVELOPMENT

ENERGY CENTRE

FARRELLS



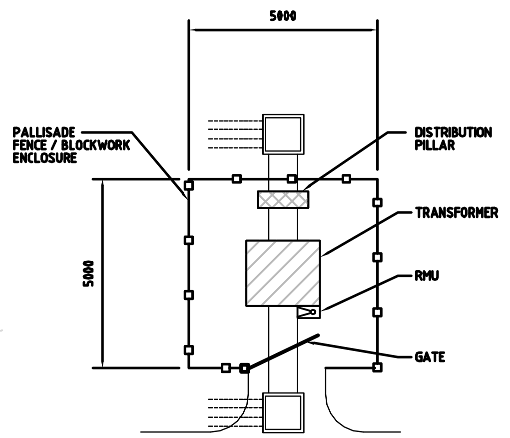
KEY

SUBSTATION (LOCATION TO BE AGREED)

DISTRIBUTION PILLAR (LOCATION TO BE AGREED)

HIGH VOLTAGE ELECTRICITY

LOW VOLTAGE ELECTRICITY



TYPICAL 2MVA DISTRIBUTION SUBSTATION
SCALE 1:100

Issue	Description	Date
01	FIRST ISSUE	25/11/10

Status

Scales	1:2000 1:4000 @ A3	Author PR. WILLIAMS
Original Size	A1	Checker D. BRAITHWAITE
Height Datum	-	Approver SA. DAVIES
Grid	O.S.	© Copyright reserved

7300-UA001881-UP21D-01- PROPOSED SERVICES LAYOUT - ELECT

Client

a2dominion

P3Eco Ltd

Hyder Consulting

Hyder Consulting (UK) Limited
29, Bressenden Place
London
SW1E 5DZ

Tel: +44 (0)870 000 3006
Fax: +44 (0)870 000 3906

Project

BICESTER
ECO DEVELOPMENT

Title

EXEMPLAR SITE
PROPOSED DEVELOPMENT
ELECTRICAL DISTRIBUTION
NETWORK

Drawing No.	Project No.	Issue
7300	UA001881	01

100mm on Original

25/Nov/2010 12:36 PM K:\UA001881 BicesterEco\E-OurDrawings\7300-UA001881-UP21D-01- PROPOSED SERVICES LAYOUT - ELECTRICITY

Issue	Description	Date
01	FIRST ISSUE	25/11/10

Status

Scales	1:2000 1:4000 @ A3	Author PR.WILLIAMS
Original Size	A1	Checker D.BRAITHWAITE
Height Datum	-	Approver SA. DAVIES
Grid	O.S.	© Copyright reserved

7305-UA001881-UP21D-01- PROPOSED SERVICES LAYOUT - DISTRICT

Client

a2dominion

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Hyder Consulting

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29, Bressenden Place
London
SW1E 5DZ

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Project

BICESTER ECO DEVELOPMENT

Title

EXEMPLAR SITE PROPOSED DEVELOPMENT DISTRICT HEATING NETWORK

Drawing No.		Project No.		Issue
7305	—	UA001881	—	01