P3Eco (Bicester) Ltd and A2Dominion Group

NW Bicester Eco Development

Exemplar Sustainable Energy Strategy

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Exemplar Sustainable Energy Strategy

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This report has been prepared for P3Eco (Bicester) Ltd and A2Dominion Group in accordance with the terms and conditions of appointment for Exemplar Sustainable Energy Strategy dated May 2010. Hyder Consulting (UK) Limited (2212959) cannot accept any responsibility for any use of or reliance on the contents of this report by any third party.

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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 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. 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 report considers the engineering aspects of the energy requirements associated with the first phase of the development, the Exemplar site, and the implications that this has on the capacity, location and nature of the energy centre.

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:

- 393 residential units, of which 30% will be affordable
- primary school site – 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),
- 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 use.

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;
    - 1 No. gas CHP
    - 1 No. biomass boiler
    - Gas boilers for redundancy and standby operation.

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 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 gas boiler retained only for standby purposes as the Exemplar site is completed.

Further detailed design work in collaboration with potential energy providers will be required to confirm the strategy and 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 and discussions with potential operators are currently ongoing. 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 Masterplan.
- Updating the SAP and SBEM carbon reduction calculations when detail design information becomes available.
- Gas connection arrangements.
- Electrical infrastructure connections.
- Guarantees relating generator export and damages associated with none-performance.
- Importing offsite heat supplies.
- End user pricing tariff structure.

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 in 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 sustainable.

2 INTRODUCTION

2.1 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 entire 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 report considers the engineering aspects of the energy requirements associated with the initial Exemplar phase of the development.

2.1.1 Policy

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 PPS 1 Eco-town supplement specifies that "over a year the net carbon dioxide emissions from all energy use within the buildings on the eco-town development as a whole are zero or below". 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 minimise energy consumption throughout the year.

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	393	100	2011	2014/15	Home Farm Village Exemplar site
1b	277	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.

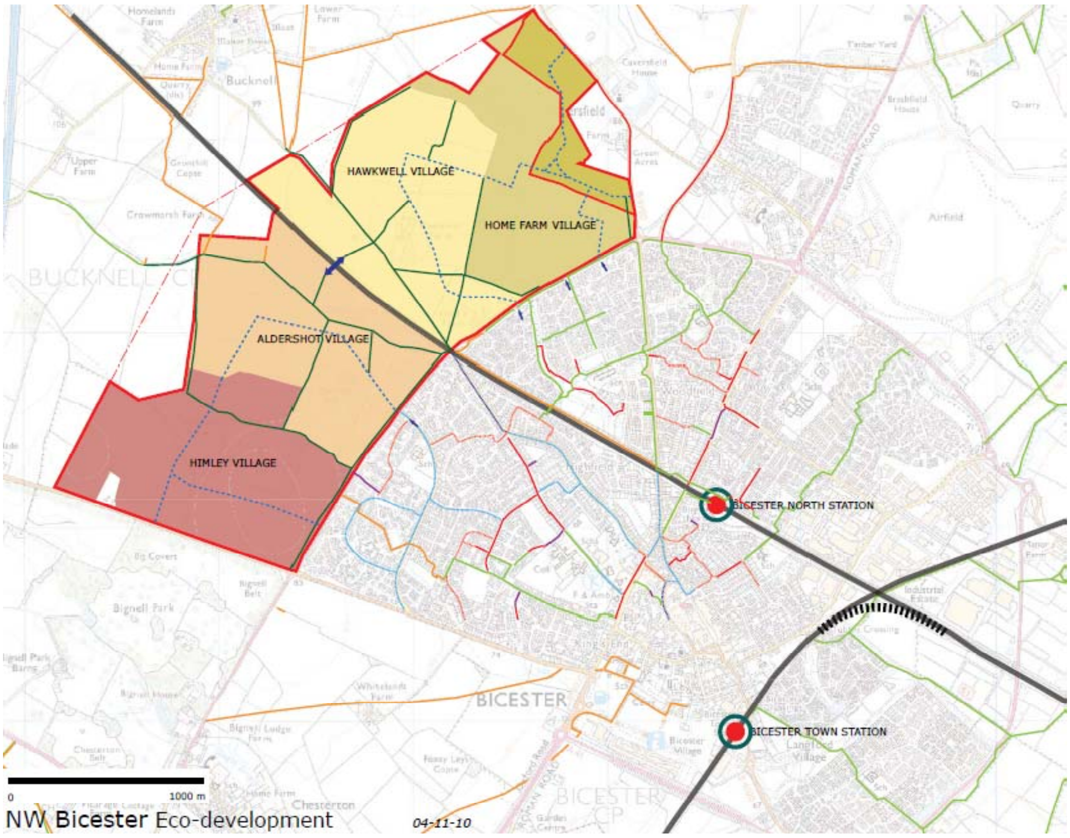

Figure 2.2 Bicester Eco-town Preliminary Phasing Plan

The first phase (Phase 1a) of development is referred to as the Exemplar site and comprises circa 393 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 393 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 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.

However recent announcements in the 2011 Budget 'The Plan for Growth' document have confirmed that the government is changing the definition of "zero carbon" to include regulated energy only (i.e. exclude unregulated energy). This will have significant implications in the development of future energy strategies.

In addition, there is ongoing discussion as to how "zero carbon" may be achieved, through the use of "allowable measures". Further definition is expected to be published in 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.

2.4 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.

Changing definition of “zero carbon” and how ‘allowable solutions’ may be incorporated will change the way in which energy strategies are applied. However, for the Exemplar site, the commitment is to provide all energy use for buildings in accordance with the PPS1 Eco Town supplement definition; in that “over a year the net carbon dioxide emissions from all energy use within the buildings on the eco-town development as a whole are zero or below”.

3 ENERGY DEMAND

The eco 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. Both P3Eco and A2Dominion have expressed a joint commitment to achieve at least Level 5 of the Code for Sustainable Homes and BREEAM Excellent in relation to the Exemplar site.

The initial demands and assumed reductions which are to be confirmed through discussions with utility / energy providers and the particular client requirements are summarised in Table 2.2. This indicates the level of energy reduction that will be anticipated across the entire eco development.

Table 3.1 Summary of Annual Demands for the Whole of the Eco 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

3.1 Exemplar Energy Demand

In order to establish the approximate energy (both thermal and electrical) for the Exemplar site, an energy model has been produced. The energy model is based on the various building types and approximate areas given below:-

- 393 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),
- 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

3.1.1 SAP calculations for dwellings

Sample SAP calculations have been undertaken for the different residential dwelling types which will be delivered in the Exemplar site. At this stage in the design process detailed and accurate design information is not yet available and therefore reasonable assumptions have been made to facilitate this process.

The assumptions on which the SAP calculations have been undertaken are as follows:-

- The building fabric elements are based on the Energy Saving Trust's (EST) standards, which are suggested in the CE292 Energy Efficiency and the Code for Sustainable Homes guidance for Code Level 5 and 6.

- All assessed dwellings are assumed to be South-West facing;
- Roof sizes are estimated as the exact roof size dimensions have not been made available;
- Quantities and dimensions of openings (windows and doors) for each dwelling type are estimated from the elevation drawings;
- The differing types of openings and their dimensions are assumed to be the same for all dwelling types;
- Cooling is assumed not to be provided to affordable or private dwellings;
- Balanced whole-house mechanical ventilation system was selected from the SAP database; and
- All internal and external lighting used throughout the dwellings is energy efficient.

The information regarding regulated energy consumption in the SAP reports has been extracted and used to develop an energy benchmark for domestic buildings.

The energy consumption for space heating, hot water and electricity for lighting per m^2 have been determined for each typical dwelling. The average energy consumption for space heating, hot water and electricity for lighting per m^2 was calculated which is used as a regulated energy benchmark for the energy demand assessment of domestic buildings.

An unregulated energy benchmark was determined based on the SAP assessment which indicates that approximately 47% of the total CO_2 emissions are from unregulated sources. It was also assumed that 46% of the unregulated emissions are associated with cooking on the basis that cooking will be electric (54% of the unregulated emissions are associated with appliances).

Once the unregulated energy benchmark was developed, the component related to cooking was reduced by 50% based on the assumption that the instead of conventional electric hobs, energy efficient induction hobs will be installed in all dwellings.

The unregulated energy benchmark was used for the energy demand assessment of domestic buildings.

The SAP report is presented in Appendix B

3.1.2 Carbon Benchmarks for non-dwellings

Similarly, detailed design information relating to the non-dwelling elements of the Exemplar site is not available at this stage in the design process and therefore in the absence of this information, the following methodology has been adopted:-

- Energy benchmark data has been taken from CIBSE Guide F for the various non-dwelling buildings.

- The CIBSE Guide F figures have then been adjusted by a minimum of a 25% reduction to more closely reflect Building Regulations Part L 2006 compliant energy usage within these buildings.

- These adjusted figures have then been entered into the spreadsheet to determine the Building Regulations Part L 2006 compliant fossil fuel and electricity usage for the whole of the Exemplar site.

The above assumptions form the part L 2006 compliant baseline against which reductions in CO_2 emissions are measured.

The energy demand for the Exemplar is shown in See Appendix A-01.

The baseline gas demand of 4,716,274MWh and electrical demand of 1,883,266MWh are reduced through accounting for Building Regulations Part L 2010 compliant buildings plus advanced practice energy efficient (APEE) measures to 1,861,153MWh and 1,586,418MWh respectively. These reduced figures also take account of the fact that in the 2006 Part L compliant figures all of the domestic cooking is assumed to be gas, whereas in 2010 since a district heating system looks favourable, the domestic cooking is assumed to be electric.

In general, the APEE measures are those associated with improved “U” values being used to reduce the requirement for space heating and all of the lighting to be energy efficient.

4 STRATEGIC OPTIONS

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. In addition, the PPS1 eco-town supplement requires the development to reduce 100% of CO_2 emissions attributable to both regulated and unregulated energy uses.

The Sustainability Strategy which has been developed for the NW Bicester site sets out three key energy related objectives; within which are a series of targets and key performance indicators. The three key energy objectives are:

1. Ensure Energy Efficiency
2. Deliver Zero Carbon Energy
3. Maximise Energy Security.

The first two elements follow the energy hierarchy, which is defined further below, and the third element recognises the importance of long term viability and security of energy to enable economic growth, social inclusion and prosperity.

4.1 Energy Hierarchy

The Energy Hierarchy is the starting point in establishing an appropriate strategy for the NW Bicester eco development.

Figure 4.1 below demonstrates the Energy Hierarchy.

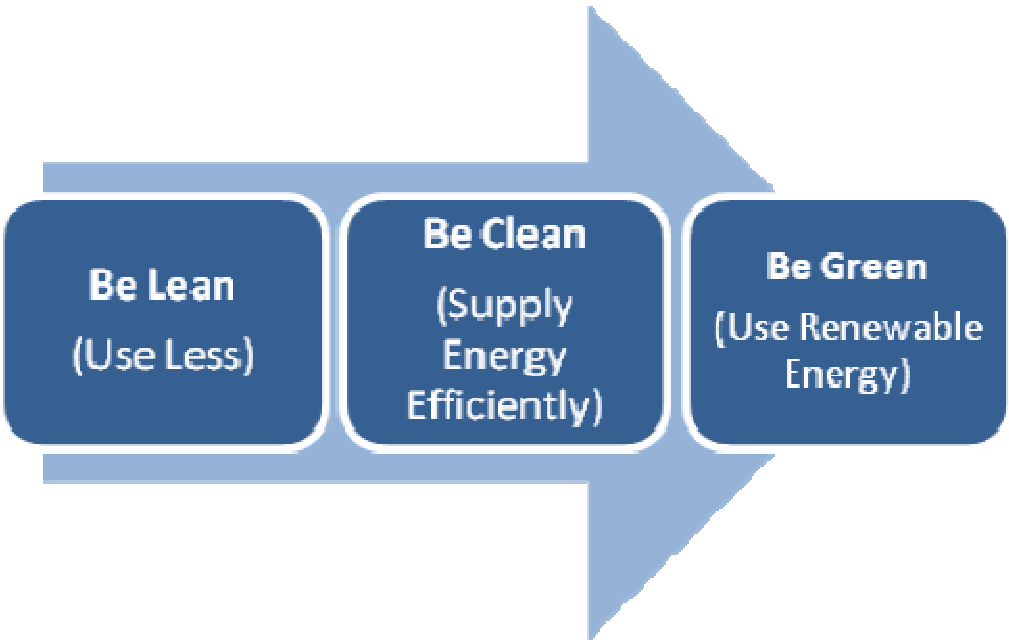

Figure 4.1 – The Energy Hierarchy

The energy hierarchy stresses the primacy of seeking to reduce energy consumption. Within the built environment this comprises adopting energy efficiency measures in both the design and construction of new buildings.

Secondly, the promotion of a ‘clean’ supply of energy addresses the need to ‘decarbonise’ and improve efficiency in the generation and distribution of energy. Decarbonisation means reducing the amount of carbon emissions that result from generating and distributing energy. As much as 45% to 60% of energy can be lost through national generation and distribution.

One of the key decarbonisation mechanisms is to develop local systems of energy generation and distribution that have a reduced reliance on existing large scale remote power plants fuelled by primary fossil carbon energy (i.e. gas, oil and coal). By ‘decentralising’ energy supply and distribution, greater use can be made of smaller scale low and zero carbon energy sources, such as community boilers, biomass or combined heat and power systems. In addition, by generating energy sources close to areas of demand, increased efficiencies can be achieved by reducing the losses in energy that arise through long distance transmission and distribution.

The third tier of the energy hierarchy comprises the use of ‘green’ energy systems. These are renewable sources of energy with zero carbon emissions and include, amongst others, solar generated heat and power, wind energy and biomass.

4.1.1 Lean Energy

Part L of the 2006 Building Regulations for domestic dwellings highlights the need to ensure energy efficiency in design. The introduction of the Code for Sustainable Homes in 2007 has moved this agenda further forward and has focused on ensuring buildings are well insulated and airtight (as far as practically possible), to retain warmth and reduce the need for heating.

The NW Bicester development, and more specifically, the Exemplar site will adopt appropriate Code for Sustainable Homes and BREEAM building standards to ensure energy efficiency is the first priority in achieving its zero carbon sustainability objectives.

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

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

Table 4.1 – Building Energy Efficiency Measures

4.1.2 Clean and Green Energy

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

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

Zero Carbon or renewable energy comes from harnessing natural energy flows from the sun, wind, or rain. Many such as solar, wind and hydro, directly produce energy and do no emit any carbon dioxide in the process.

Others such as biomass, use solar energy to grow renewable plant material that can subsequently be used for energy. Examples here are wood, straw, etc. However, biomass use still generates carbon dioxide when it is burnt. The difference being that this carbon is only that taken from the atmosphere when the plant grew. This is unlike carbon emissions from fossil fuels that are essentially new to the atmosphere, causing increases in atmospheric carbon dioxide levels and climate change. Therefore, when used to replace fossil fuels, biomass leads to a net reduction in carbon emissions; particularly where local supply chains can provide a sustainable supply of biomass.

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

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

4.2 Assessing the options

The NW Bicester eco development is being undertaken in a difficult economic environment yet is still aiming to achieve all the key principles of the PSS 1 Supplement on Eco Towns. It is recognised that the decisions made at the planning stage of this major project will have a lasting impact on those who will live and work here, and on their impact on climate change and the wider sustainability of their lives.

4.2.1 Strategic Approach Options

The strategic options that enable delivery of zero carbon energy provision to the development influence the preferred selection, application and commercial operation of differing LZC technologies and approaches. The following strategic options describe 3 fundamental approaches considered to deliver the sustainable benefits of zero carbon development at NW Bicester. These are:

1. '**Do the minimum'** to meet the legislation that is in force during the implementation of this development.

2. '**Maximise the asset'** where all of the features of the site and the development are utilised to maximise LZC energy provision.

3. '**Think outside the box'** where opportunities to generate LZC energy off site are included for consideration.

4.2.2 Technology Options

The individual renewable energy technologies that combine together to achieve these strategic approaches are:

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

Table 4.2 – LZC Technologies

Irrespective of whichever strategic approach and technology options are progressed, the implementation strategy must be flexible and adaptation to the development, shifting economic incentives and models, and evolving technologies.

4.2.3 Underlying Trends

The following underlying trends are also relevant:

- Energy prices continue to rise in line with current predictions driven by world oil markets, increasingly stringent environmental controls on the combustion of coal in power stations, the increasing need to import gas, etc. These prices will remain volatile.

- Building regulations continue to tighten as government drives the 'zero carbon' agenda, through the Code of Sustainable Homes.

- Fiscal incentives, such as the Feed in Tariffs and Renewable Heat Incentive, will make the economic attractiveness of certain technologies more attractive for finite periods; and therefore strategies may seek to take advantage of these.

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

- Supply of ‘green’ electricity and tradable carbon credits will reduce as others soak these up to meet their own obligations, making the price high favouring those sectors best able to buy their way out of their obligations.

4.2.4 Analysis of Options

Through discussion with the client, a strategic approach that maximises the assets of the site and planned development; whilst enabling future off-site contribution to the total solution was consider the most appropriate. This respects the energy hierarchy and enables district-scale solutions to be brought forward rather than a total reliance on individual unit solutions. This approach was favoured for the following reasons:

- Enables future technologies to be incorporated at the district scale

- Takes advantage of the significant roof space generated (for PV)

- Enables future off-site connections to a district heat network

In terms of enabling this approach, this strategy follows the energy hierarchy. Energy efficiency measures which will be adopted to facilitate the achievement of zero carbon status for Exemplar site 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 respect of the technologies to support this, it was considered appropriate to utilise both Low and Zero Carbon (LZC) energy solution for the Exemplar site to address the strategic approach and other client concerns, including the affordability of heat to domestic customers and the availability of fuel.

With these issues in mind, Hyder undertook an analysis to promote discussion with the client. This was focused around the various approaches (i.e. building integrated and district scale) and low and zero carbon technologies (e.g. wind, solar, CHP etc) which could be deployed on the site and assessed the appropriateness of each in terms of technical suitability; design, cost and programme implications, and carbon dioxide emission reductions delivered. The outcome of the analysis concluded the following;

- Large scale wind turbines would not be appropriate due to the marginal wind resource, density of housing within the development and proximity of MOD facilities.

- Small scale wind is similarly likely to be inappropriate due to the density of the development creating turbulent wind patterns and poor wind resource. Further, the technology has received mixed reviews regarding its’ effectiveness.

- Air Source and Ground Source Heat Pumps can deliver low carbon heat, but require an electrical input thereby delivering only a relatively small reduction in CO_2 emissions compared to other micro-technologies. These may be appropriate for meeting cooling requirements in the non-residential buildings.

- The scale of the Exemplar site was not considered sufficient to support the incorporation of a dedicated wastewater treatment facility, from which energy could be derived via an anaerobic digestion unit.

- Biomass CHP is a technology which has not be widely adopted in the UK. Concerns regarding fuel supply, particularly following the introduction of the Renewable Heat Incentive (RHI) in 2012, and the relatively immature technology made this option less attractive than others.

- The use of biomass boilers in a district heating system raised similar issues regarding fuel supplies that the Biomass CHP raises. However, if used as a secondary system for delivering low carbon heat, then this may be appropriate for the development.

- The mix of uses within the Exemplar site offers the opportunity to incorporate a district heating system to deliver heat and hot water to domestic properties and commercial properties; as well as the use of heat for cooling to commercial properties, if required. In addition, it provides the opportunity to enable either new or more efficient technologies to be added and/or connection to nearby off-site waste heat sources if they become available.

Due to the concerns regarding future availability of biomass, a gas district heating system is considered appropriate at this stage to deliver low carbon electricity and heat to the site. This addresses the desire for a district-wide solution to be adopted for the site. In addition, it also allow future connection to the waste heat from the Ardley Energy from Waste facility as it becomes available, thereby presenting a strategy to move away from fossil fuel in the future, and/or enable opportunities to run the gas CHP on biogas if it becomes available in the locality.

Gas CHP is therefore suggested as the main source of supply for the district heating system. It is proposed that this is supported up by biomass boiler and a small amount of solar thermal collectors.

Excellent opportunities exist for incorporation of solar technologies within the exemplar site due to the relatively high amount of roof space to be created. To complement the district heating system, the incorporation of Building Integrated Photovoltaics (BIPV) will deliver the greatest carbon dioxide emission savings for each square metre installed. In addition the current fiscal incentives available through the Feed-in-tariff (FIT) ensures that incorporation of building integrated PV to the roofs of dwellings and other buildings within the Exemplar site will be financially attractive. The use of PV further support the district heating system, providing zero carbon electricity to be generated at low cost.

5 EXEMPLAR ENERGY STRATEGY

The Exemplar site is currently forecast to commence in 2011 and run through to 2015 at a build rate of 100 units per year. The site comprises 393 residential property and includes the village centre, primary school and small retail / commercial units and an energy centre for the Exemplar in isolation which will be required to supply approximately 3,500MWh per annum of energy comprising 1,600MWh of electrical and 1,900MWh of gas respectively.

5.1 Technologies proposed

Following the above review of the technology options available and assessing their appropriateness for the Exemplar site, it is proposed that the recommended energy strategy for the exemplar site will incorporate the following:-

- 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.
- Exemplar Energy Centre – utilising efficient low carbon 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.

The strategy will be aimed at providing flexibility and robustness and therefore includes more than one technology and capitalises on existing and future fiscal incentives. In addition, the strategy is flexible to enable 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.

5.1.1 Photovoltaic

The initial plan of the scheme was generated from considerations of passive solar design. According to the energy strategy, solar PV will play a primary role in achieving the zero carbon status for the Exemplar site.

The maximum total annual solar radiation is usually at an orientation due south and at a tilt from the horizontal equal to the latitude of the site minus approximately 20 degrees. The latitude of Bicester is 51.9 degrees, therefore 32 degrees is an optimal tilt in Bicester, south facing.

The PV panels can operate at significant efficiency if they kept within a range of deviation from the optimum orientation as the solar sundial indicates below. For example a south east roof, at optimum inclination (i.e. 32 degrees for Bicester) can achieve 96% efficiency; or a south west roof at +10 degree inclination (i.e. 42 degrees for Bicester) can provide between 95% and 92% efficiency. The orientation and inclination of all roofs are designed to achieve at least 90% PV panel efficiency, and in most instances above 95% efficiency.

Solar Sundial showing energy yield relative to the inclination and orientation of your roof

The cost of the PV modules and supplementary equipment will require optimum design of the PV installations to ensure maximum electrical output per kW_p installed. There are a number of design considerations to be made to ensure the best use of the system.

The key design considerations are:

- Ensure that all parts of the PV panels are unshaded (shading caused by other buildings, greenery and roof 'furniture' such as chimneys or satellite dishes even over a small area of the panel, can significantly reduce the performance);

- Ensure correct installation of PV arrays for good ventilation (high temperatures at the back of the modules reduce electrical output); and

- Ensure that the electrical wiring from PV arrays to inverters is kept to minimum to reduce electrical losses.

It is currently assumed that circa 15,800 m^2 of area is available for PV installation. It will correspond to approximately 1,980 kW of installed capacity. Solar PV in the UK can deliver between 800 kWh/kWp and 1000 kWh/kWp per annum. This output is very much based on local conditions and PV system design however, based on the local conditions of the site and assuming that the systems will be designed to maximise the efficiency, it is assumed that the PV systems can deliver a minimum of 850 kWh/kWp per annum.

5.1.2 Gas-Fired and Biomass Engines

The initial requirements for approximately $1.6MW_e$ and $1.9MW_t$ can be provided by an energy centre comprising gas CHP and biomass boiler in combination with grid connection and PV mentioned above.

5.1.3 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.

5.1.4 Moving away from Fossil Fuel

The Ardley EfW facility has now been granted consent. However, the timing and expected duration of the construction of the facility does not coincide with the construction of the Exemplar site and therefore will not be available for this initial phase.

However, as the energy strategy proposed utilises a district heating network, the opportunity to connect to the waste heat from the Ardely EfW facility in the future is provided.

In addition, future phases of the eco development may comprise an on-site Waste water Treatment Works (WwTW) that has teh potential to generate biogas. This biogas may be utilised to supplement the natural gas fuel for the gas CHP system.

5.2 Exemplar energy centre

The energy centre established for the Exemplar site has been strategically located, at the boundary of the site, to enable possible future expansion. The energy centre will house all the centralised plant and equipment; including: gas CHP, biomass boiler, woodchip store (underground) and thermal store. In addition, solar thermal panels will be located on the roof. In addition, the energy centre will house the primary electricity sub-station and distribution sub-stations as well as the primary booster pumping station and metering on the heating network

A plan of the proposed energy centre is present in Appendix A. The DHS and HV networks will radiate out into the Exemplar development from the energy centre, providing suitable connections to all properties.

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 centre can accommodate offsite heat sources, such as waste heat from the Ardley EfW facility, which would not be readily available if energy provisions was at individual premises.
- Local energy centre can also be independent from offsite infrastructure.

5.3 Exemplar Energy Centre Capacity

Based on the estimated electrical power inputs of the Exemplar site, a combination of APEE then Gas CHP, Biomass and PV along are able to achieve a zero carbon energy solution. Detailed discussions are currently taking place with potential Energy Supply Companies (ESCO) relative to checking and confirming the assumptions of this strategy.

To assess the capacity of the energy centre, the baseload and peak requirements have influenced 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.

This detailed modelling of the strategy will continue once an ESCO operator has been commissioned.

This will include different options of required plant capacity for the ranges of heat and electricity demand. For example, 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. However, the incorporation of a thermal store associated with the energy centre should eliminate the need for use of the gas boilers in the summer months under normal operation of the energy centre.

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.

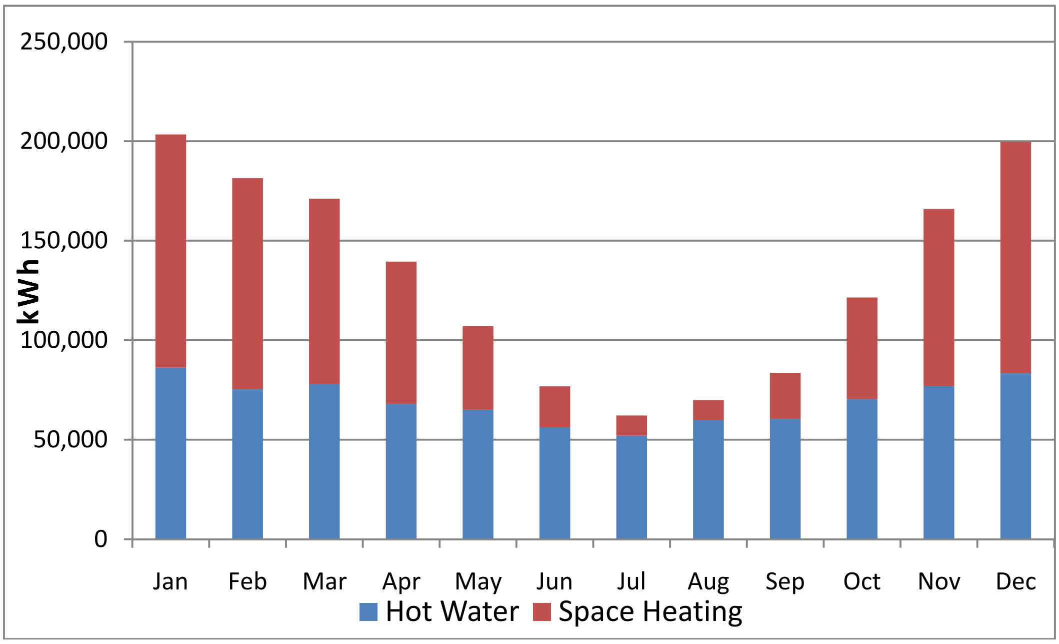

Figure 5 – Average annual thermal energy demand profile

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$_e$, however 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.

To maximise sustainability and availability whilst optimising carbon efficiency, the proposed energy strategy for the Exemplar site will therefore comprise; the efficient and low 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.

5.4 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. Throughout the development of the energy strategy soft market testing with potential ESCO / MUSCO operators was sought relative to the commercial viability and technical approach. Current detailed discussions with two potential operators confirm that the proposed strategy is commercially and technically viable in all key aspects.

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 P3Eco and A2 Dominion. These discussions are covering elements such as:

- End user price tariffs
- Local supply of woodchip
- Confirmation of strategy principles
- Type and Sizing of appropriate plant

Continued discussions with two potential operators are nearing completion and it is envisaged that a preferred ESCO/MUSCO operator will be selected and commissioned shortly.

5.5 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.

The Exemplar energy centre 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 and includes; gas CHP, biomass boiler, solar photovoltaic and solar thermal to achieve a zero carbon development.

It is proposed that the Exemplar energy solution 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).

- Energy Centre, comprising:
  - Solar thermal on the energy centre roof
  - Thermal store (within the energy centre)
  - 1 No. gas CHP
  - 1 No. biomass boiler
  - Gas boilers for redundancy and standby operation.

During the initial part of construction (and during normal operation), 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 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 will be retained for standby operation only.

6 Control Methodology

The energy strategy proposed for the Exemplar site combines various low and zero carbon technologies to provide carbon reduction and resilience. The strategy includes natural gas CHP, Biomass boiler, PV and solar thermal to achieve a carbon reduction of 100% of regulated and unregulated energy.

The technology solution proposed has been selected to match the energy profile of the proposed development ensuring effective use.

A combined heat and power (CHP) system requires a relatively consistent demand for heat throughout the year to operate effectively. The heat demand can be for space heating, domestic hot water, process heating or heat to power absorption cooling.

An assessment of the combined heat demands for the site has been carried out. The assessment shows that the estimated hot water load is expected to present a consistent load throughout the year although there will be peaks and troughs in daily use. These peaks and troughs can be managed through use of an appropriate thermal store to transform the hot water load into a consistent base load that is suitable for gas-fired CHP.

The space heating load does not present a consistent demand; it is minimised through the application of energy efficiency measures and is seasonal in nature. This load will be manly covered by a biomass boiler.

The cooling load for the development has not been estimated but it is considered to be relatively low and it is likely to be provided through conventional direct expansion units at a point of use. Therefore, the cooling heat demand has not been incorporated in the total heat demand of the development.

Following the assessment of the heat demand profile, it is proposed to size the CHP unit on the provision of hot water and space heat demand in September.

The intention is that a single CHP unit will work with the solar thermal system to supply hot water and space heating demand from June to September. The systems will be connected to a large thermal store. Heat from the CHP unit and the solar thermal system will be provided either to meet demand from the development or to charge the thermal store. If the heat demand of the development cannot be met by the CHP and solar thermal, the thermal store will discharge heat into the heating system.

The CHP unit will be adequately sized to meet all the required demand between June and September without the need to operate the biomass boiler or the gas-fired back-up boilers during that period.

Between October and May, the CHP unit will act as a lead boiler and together with the solar thermal system will operate to meet the hot water demand. The space heating demand will be met by adequately sized biomass boiler. All these systems will be connected to the thermal store.

Inclusion of the large thermal store will allow the CHP to run when there is insufficient demand to build up a reserve of hot water and space heating which can be released to provide heat at periods of peak demand. The intention is to run the CHP system at full output for the majority of the time. A longer run time also reduces the size and cost of CHP required to meet a given energy load. Furthermore, if the CHP system runs at part load, the electrical generation efficiency drops. The CHP unit can be turned down to around 50% of the nominal thermal output although this usually causes electrical generation efficiency to drop from circa 35% at full output to circa 30% at part output). At part load, there is an increase in thermal efficiency but this benefit is outweighed by the drop in electrical generation efficiency. The CHP system will be designed and operated to meet CHPQA criteria and a unit with the highest possible electrical and thermal efficiencies should be selected.

The large thermal store will also help to optimise the size and operation of the biomass boiler as the biomass boiler is best suited to being operated relatively continuously between circa 30% and 100% of its rated output.

Adequately sized thermal store will help to optimise the operation of the CHP unit and the biomass boiler and maximise the carbon savings.

The back-up gas boilers will be sized to meet the peak hot water and space heating demand in the event of failure or maintenance of the CHP unit and/or biomass boiler.

CO_2 emissions from electrical demand of the site and those which will arise from the operation of the CHP unit and the biomass boiler will be offset by the CHP unit electricity generation and roof mounted PV panels. It is currently assumed that circa 15,800 m^2 of area is available PV installation. It will correspond to approximately 1,980 kW of installed capacity. It is also assumed that the anticipated annual energy output from each $1kW_p$ of PV will be circa 850 kWh per annum. This should be sufficient to offset the CO_2 emissions and achieve the developments zero carbon requirement.

Appendix A provides a series of tables providing the baseline demand and energy balance demonstrating the above operation.

Appendix A information includes:

- Table 1 – Baseline energy demand
- Table 2 – Advance Practice Energy Efficiency (APEE) demand
- Table 3 – Energy demand profiles
- Table 4 – Energy Strategy – carbon balance
- Table 5 – Plant and Thermal store sizing
- Table 6 – Solar PV system output
- Table 7 – Solar Thermal system output
- Table 8 – Biomass storage

7 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 including the 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.

The energy strategy for the Exemplar site, will consist of a combination of energy generation sources that achieve the required carbon reduction requirements and includes gas CHP, biomass boiler, photovoltaic and solar thermal. The key premise of this strategy are:

- Maximising the asset of the site – through the significant use of PV
- Enabling future technology improvement and/or off-site heat connection – through the use of a district heat network

The adoption of a combination of low and zero carbon energy sources has the potential to achieve the carbon emission reduction targets and provide operational flexibility and sustainability. The detailed strategy to achieve the zero carbon target for the Exemplar site is proposed as:

- 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;
  - 1 No. gas CHP
  - 1 No. biomass boiler
  - Gas boilers for redundancy and standby operation

During the initial part of 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 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. The gas boiler will be retained for standby and redundancy purposes. Resilience will be maintained with the final energy solution through the retention of the gas boiler.

Further detailed design work in collaboration with potential energy provider 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 recent government announcements have readdressed the CSH "zero carbon" definition and current discussion regarding the incorporation of "allowable solutions" is likely to be clarified later 2011.

We would therefore recommend a full review of the energy strategy following the clarity of what these changes will mean and how they will be incorporated to ensure that the energy strategy solution adopted for the development and in particular to how "zero carbon" may be achieved is that which is most cost effective.

Appendix A

Drawings and Calculations

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

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

Table 1 – Baseline energy demand

Boiler efficency 85%

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 ($kWh/m^2/yr$)		Energy Use (kWh/year)				total (kWh/yr)		total (kWh/yr)		carbon dioxide emission ($kgCO_{2/yr}$)	
										(m²)	space	water	L&A	cooking	Fossil Fuel	Electricity	space	water	L&A	cooking	Energy	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	0	82212	0	0	82212	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	0	32833	0	0	32833	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	11900	35700	31500	62475	110075	31500	129500	31500	25641	16286
		5.2 Business (Use Class B)			**1,305**					-																
B1	(a)	ECO-Business Centre			930	Office, air conditioned (standard)	90%	CIBSE TM46 (General office)	treated floor area	837	70	50	95	-	120	95	49802	35573	79515	0	85374	79515	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	0	0	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	0	0	0	0	0	0
B1	(c)	Energy Centre			375	Workshops	100%	CIBSE TM46	treated floor area	375	90	90	35	-	180	35	28688	28688	13125	0	57375	13125	67500	13125	13365	6786
										-																
		5.3 Hotels & Residential Institutions (Use Class C)			**-**																					
C1		Mid-range Hotel			-	Hotels: small	100%	CIBSE TM46 (Hotel)	treated floor area	-	165	110	105	55	330	105	0	0	0	0	0	0	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	0	0	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	0	0	0	0	0
										-																
		5.4 Residential Dwellings (Use Class C)		**393**	**37,845**																					
C3										-																
		4 bed, 7person house = 250m GIA	111	9	999		100%	Approved Document L1A 2006	gross floor area	999	43	36	35	13	92	35	36342	30716	34917	11317	78375	34917	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	397252	335759	381675	123701	856711	381675	1007895	381675	199563	197326
C3					-					-																
		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	269232	268366	282876	103351	640949	282876	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	156136	131967	150014	48619	336722	150014	396143	150014	78436	77557
					-					-																
C3					-					-																
		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	16952	21075	19404	8705	46731	19404	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	63655	79138	72864	32688	175481	72864	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	330863	329800	347630	127010	787672	347630	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	226128	191124	217261	70414	487666	217261	573725	217261	113598	112324
		5.5 Non Residential Institutions (Use Class D)			**2,821**																					
D1	(c)	Primary Schools			1,689	Primary school	100%	CIBSE TM46	gross floor area	1,689	66	45	40	39	150	40	94753	64604	67560	55990	215348	67560	253350	67560	50163	34929
D1	(c)	Secondary School			-		100%	CIBSE TM46	gross floor area	-	66	45	40	39	150	40	0	0	0	0	0	0	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	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	21497	14331	8430	1791	37619	8430	44258	8430	8763	4358
D1	(c)	Office			470	Emergency services	100%	CIBSE F	treated floor area	470	70	50	95	10	130	95	27965	19975	44650	3995	51935	44650	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	19380	14280	16800	7140	40800	16800	48000	16800	9504	8686
D1	(c)	Private Hospital			-	Hospitals: acute	100%	CIBSE F	heated floor area	-					0	0	0	0	0	0	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	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	0	0	0	0	0
																0										
						Totals				**48,152**							**1,750,542**	**1,601,095**	**1,883,266**	**657,195**	**4,008,833**	**1,883,266**	**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

Farrells Memo Bimp0154mem0001dt 13 Oct 10

		m^3	
1	**Village Green**		
1.1	**Primary School**	403	Teaching Area
		529	Staff, Admin & storage
		757	Kitchens, toilets and plant room
		1689	**Total Internal Areas**
		6000	External
1.2	**ECO-PUB**	350	Customer, toliets, kitchen, staff and refuse areas
		350	**Total Internal Areas**
1.3	**ECO-BUSINESS CENTRE**	930	Customer, toliets, kitchen, staff and refuse areas
		930	**Total Internal Areas**
		1455	External
1.4	**ENERGY CENTRE**	375	Plant & equipment area
		25	Biomass Storage
		375	**Total Internal Areas**
		700	External
2	**Village Square**		
2.1	**Community Centre**	265.5	Reception, Hall & meeting rooms
		30	Storage
		46	Kitchens, toilets and plant room
		80	Circulation & Core
		421.5	**Total Internal Areas**
		0	External - TBA
2.2	**Convenience Store**	280	Co-operative store
		142	Storage, office, staff toliets, staff room & refuse
		88	Pharmacy & Post Office
		510	**Total Internal Areas**
		0	External
2.3	**Hairdresser**	77	Customer, toliets, staff and refuse areas
		77	**Total Internal Areas**
		0	External
2.4	**Visitors Centre/Tea Room**	180	Customer, toliets, kitchen, staff and refuse areas
		40	
		220	**Total Internal Areas**
		0	External - TBA
2.5	**Nursery**	30	Reception & Parents
		28	Office and staff room
		105	Children Areas
		57	Storage, laundry & toliets
		20	
		240	**Total Internal Areas**
		320	External
2.6	**Office**	250	Workspace, toliets, kitchen, staff and refuse areas
		0	
		250	**Total Internal Areas**
		0	External - TBA
2.7	**Outdoor Market**	0	24 Stalls
		0	
		0	**Total Internal Areas**
		0	External - TBA

Farrells Accommodation Schedule 01 7 Oct 2010

Table 2 – Advance Practice Energy Efficiency (APEE) demand

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

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

Boiler efficency **85%**

Use Class	Sub Use	Description			GIA (m^2)	assumed building type	% of GIA	basis of benchmark			good practice energy benchmark ($kWh/m^2/yr$)				good practice energy benchmark ($kWh/m^2/yr$)		Energy Use (kWh/year)				total (kWh/yr)		total (kWh/yr)		carbon dioxide emission ($kgCO_{2/yr}$)	
										(m^2)	space	water	L&A	cooking	Fossil Fuel	Electricity	space	water	L&A	cooking	Energy	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	-	-	267	-	0	267	0	0	70702	0	0	70702	0	70702	0	36553
A1	(a)	Convenience Retail			297	Shops/stores: non-food stores (hairdressers)	67%	CIBSE TM46 (General retail	sales floor area	199	-	-	142	-	0	142	0	0	28237	0	0	28237	0	28237	0	14598
A3		Restaurants & Café's			350	ECO-PUB Restaurants (with bar) and cafe	100%	CIBSE TM46 (Restaurant)	gross floor area	350	34	103	77	181	138	258	10234	30702	27090	63210	40936	90300	48160	90300	9536	46685
																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	55	40	75	-	95	75	39343	28102	62817	0	67445	62817	79348	62817	15711	32476
B1	(c)	Offices			-	Office, air conditioned (prestige)	85%	CIBSE TM46 (General office)	treated floor area	-	55	40	75	-	95	75	0	0	0	0	0	0	0	0	0	0
B1	(c)	Light Industrial			-	Light manufacturing	100%	BSRIA Rules of Thumb	gross floor area	-	39	-	24	-	39	24	0	0	0	0	0	0	0	0	0	0
B1	(c)	Energy Centre			375	Workshops	100%	CIBSE TM46	treated floor area	375	71	71	28	-	142	28	22663	22663	10369	0	45326	10369	53325	10369	10558	5361
										-						0									0	
		5.3 Hotels & Residential Institutions (Use Class C)			**-**											0										
C1		Mid-range Hotel			-	Hotels: small	100%	CIBSE TM46 (Hotel)	treated floor area	-	111	74	70	37	184	107	0	0	0	0	0	0	0	0	0	0
C1		Country Club (Golf) Hotel			-	Hotels: business/holiday	100%	CIBSE TM46 (Hotel)	treated floor area	-	111	74	70	37	184	107	0	0	0	0	0	0	0	0	0	0
C2		Assisted Living			-	Residential and nursing homes	100%	CIBSE TM46 (Long Term Resi)_	treated floor area	-	134	80	44	67	214	111	0	0	0	0	0	0	0	0	0	0
										-						0										
		5.4 Residential Dwellings (Use Class C)		**393**	**43,277**											0										
C3										-						0										
		4 bed, 7person house = 250m GIA	110.12	9	991		100%	Approved Document L1A 2006	gross floor area	991	15.45	18.34	22.07	5.14	34	27	13013	15448	21871	5097	28462	26968	33484	26968	6630	13942
		5 bed, 7person house = 250m GIA	110.12	42	4,625		100%	Approved Document L1A 2006	gross floor area	4,625	15.45	18.34	22.07	5.14	34	27	60729	72092	102063	23786	132821	125849	156260	125849	30940	65064
C3					-					-																
		3 bed, 5 person house = 85m GIA	110.12	99	10,902	Semi-detached	100%	Approved Document L1A 2006	gross floor area	10,902	15.45	18.34	22.07	5.14	34	27	143148	169931	240576	56068	313079	296644	368328	296644	72929	153365
		4 bed, 6 person house = 112m GIA	110.12	58	6,387	Detached Bungalows	100%	Approved Document L1A 2006	gross floor area	6,387	15.45	18.34	22.07	5.14	34	27	83864	99555	140944	32848	183420	173791	215788	173791	42726	89850
					-					-																
C3					-					-																
		1 bed, 2 person flat = 51m GIA	110.12	7	771	Top floor flat	100%	Approved Document L1A 2006	gross floor area	771	15.45	18.34	22.07	5.14	34	27	10122	12015	17010	3964	22137	20975	26043	20975	5157	10844
		2 bed, 4 person flat = 74m GIA	110.12	23	2,533	Top floor flat	100%	Approved Document L1A 2006	gross floor area	2,533	15.45	18.34	22.07	5.14	34	27	33257	39479	55891	13026	72735	68917	85571	68917	16943	35630
		3 bed, 5 person house = 85m GIA	110.12	99	10,902	Semi-detached	100%	Approved Document L1A 2006	gross floor area	10,902	15.45	18.34	22.07	5.14	34	27	143148	169931	240576	56068	313079	296644	368328	296644	72929	153365
		4 bed, 6 person house = 112m GIA	110.12	56	6,167	Detached	100%	Approved Document L1A 2006	gross floor area	6,167	15.45	18.34	22.07	5.14	34	27	80972	96123	136083	31715	177095	167799	208347	167799	41253	86752
																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	44	30	27	26	74	53	63484	43285	45265	44134	106769	89399	125611	89399	24871	46219
D1	(c)	Secondary School			-		100%	CIBSE TM46	gross floor area	-	44	30	27	26	74	53	0	0	0	0	0	0	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	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	40	27	13	3	67	17	14403	9602	5648	1412	24004	7060	28241	7060	5592	3650
D1	(c)	Office			470	Emergency services	100%	CIBSE F	treated floor area	470	47	34	64	7	80	70	18737	13383	29916	3149	32120	33065	37788	33065	7482	17094
D1	(c)	Nursery			240	Primary health care (general practitioners' surgeries and dental practices)	100%	CIBSE TM46 Clinic	gross floor area	240	64	47	47	23	111	70	12985	9568	11256	5628	22552	16884	26532	16884	5253	8729
D1	(c)	Private Hospital			-	Hospitals: acute	100%	CIBSE F	heated floor area	-					0	0	0	0	0	0	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	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	0	0	0	0	0
																0										
						Totals				**48,124**							**750,102**	**831,879**	**1,246,313**	**340,105**	**1,581,980**	**1,586,418**	**1,861,153**	**1,586,418**	**368,508**	**820,178**

Notes

1 good practice benchmarks can be assumed upper limits for new build
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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

	m^3	
Farrells Memo Bimp0154mem0001dt 13 Oct 10		
1 Village Green		
1.1 Primary School	403	Teaching Area
	529	Staff, Admin & storage
	757	Kitchens, toilets and plant room
	1689	**Total Internal Areas**
	6000	External
1.2 ECO-PUB	350	Customer, toliets, kitchen, staff and refuse areas
	350	**Total Internal Areas**
1.3 ECO-BUSINESS CENTRE	930	Customer, toliets, kitchen, staff and refuse areas
	930	**Total Internal Areas**
	1455	External
1.4 ENERGY CENTRE	375	Plant & equipment area
	25	Biomass Storage
	375	**Total Internal Areas**
	700	External
2 Village Square		
2.1 Community Centre	265.5	Reception, Hall & meeting rooms
	30	Storage
	46	Kitchens, toilets and plant room
	80	Circulation & Core
	421.5	**Total Internal Areas**
	0	External - TBA
2.2 Convenience Store	280	Co-operative store
	142	Storage, office, staff toliets, staff room & refuse
	88	Pharmacy & Post Office
	510	**Total Internal Areas**
	0	External
2.3 Hairdresser	77	Customer, toliets, staff and refuse areas
	77	**Total Internal Areas**
	0	External
2.4 Visitors Centre/Tea Room	180	Customer, toliets, kitchen, staff and refuse areas
	40	
	220	**Total Internal Areas**
	0	External - TBA
2.5 Nursery	30	Reception & Parents
	28	Office and staff room
	105	Children Areas
	57	Storage, laundry & toliets
	20	
	240	**Total Internal Areas**
	320	External
2.6 Office	250	Workspace, toliets, kitchen, staff and refuse areas
	0	
	250	**Total Internal Areas**
	0	External - TBA
2.7 Outdoor Market	0	24 Stalls
	0	
	0	**Total Internal Areas**
	0	External - TBA

Farrells Accommodation Schedule 01 7 Oct 2010

Table 3 – Energy demand profiles

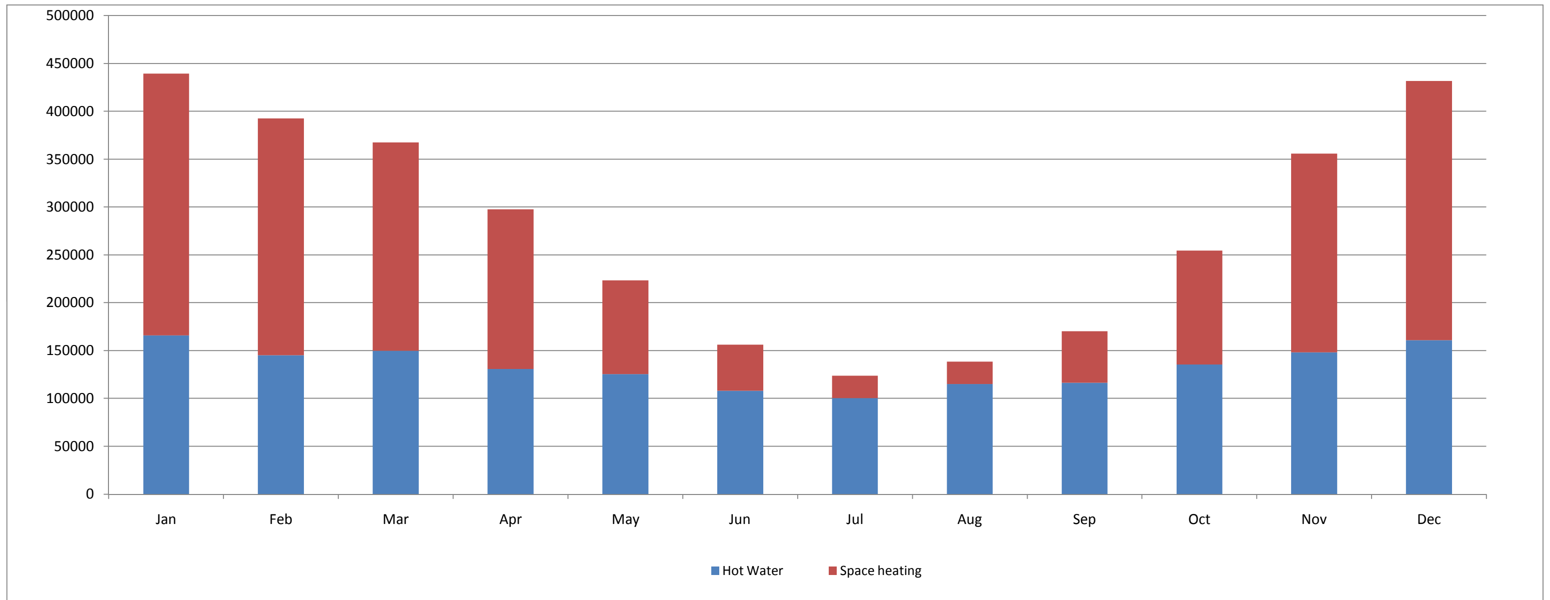
ENERGY BASELINE

Hot water and space heating calcs

	Average Floor Area from SAP	Hot water demand	Space Heating demand	Number of Units	Total Hot water demand	Total Sapce heating demand
Domesctic	110.1				1387945	1496559
Non-Domestic					213150	253983
Total					**1601095**	**1750542**

Weighted space heating											
0.156	0.141	0.124	0.095	0.056	0.027	0.014	0.014	0.031	0.068	0.119	0.155
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month
233792	211423	186168	142873	83703	41130	20204	20204	46181	101743	177509	231627
39677	35881	31595	24247	14205	6980	3429	3429	7837	17267	30125	39310
273469	**247304**	**217763**	**167120**	**97909**	**48110**	**23633**	**23633**	**54019**	**119010**	**207634**	**270937**

	Weighted hot water											
	0.104	0.091	0.094	0.082	0.078	0.068	0.063	0.072	0.073	0.085	0.093	0.100
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month
	143879	125841	129856	113213	108632	93735	86859	99676	100864	117552	128497	139343
	22096	19326	19942	17386	16683	14395	13339	15307	15490	18053	19734	21399
	165975	**145167**	**149798**	**130600**	**125314**	**108130**	**100198**	**114983**	**116354**	**135604**	**148230**	**160742**
TOTAL	**439444**	**392471**	**367561**	**297720**	**223223**	**156241**	**123831**	**138616**	**170372**	**254614**	**355864**	**431679**



APEE ENERGY ENERGY BASELINE

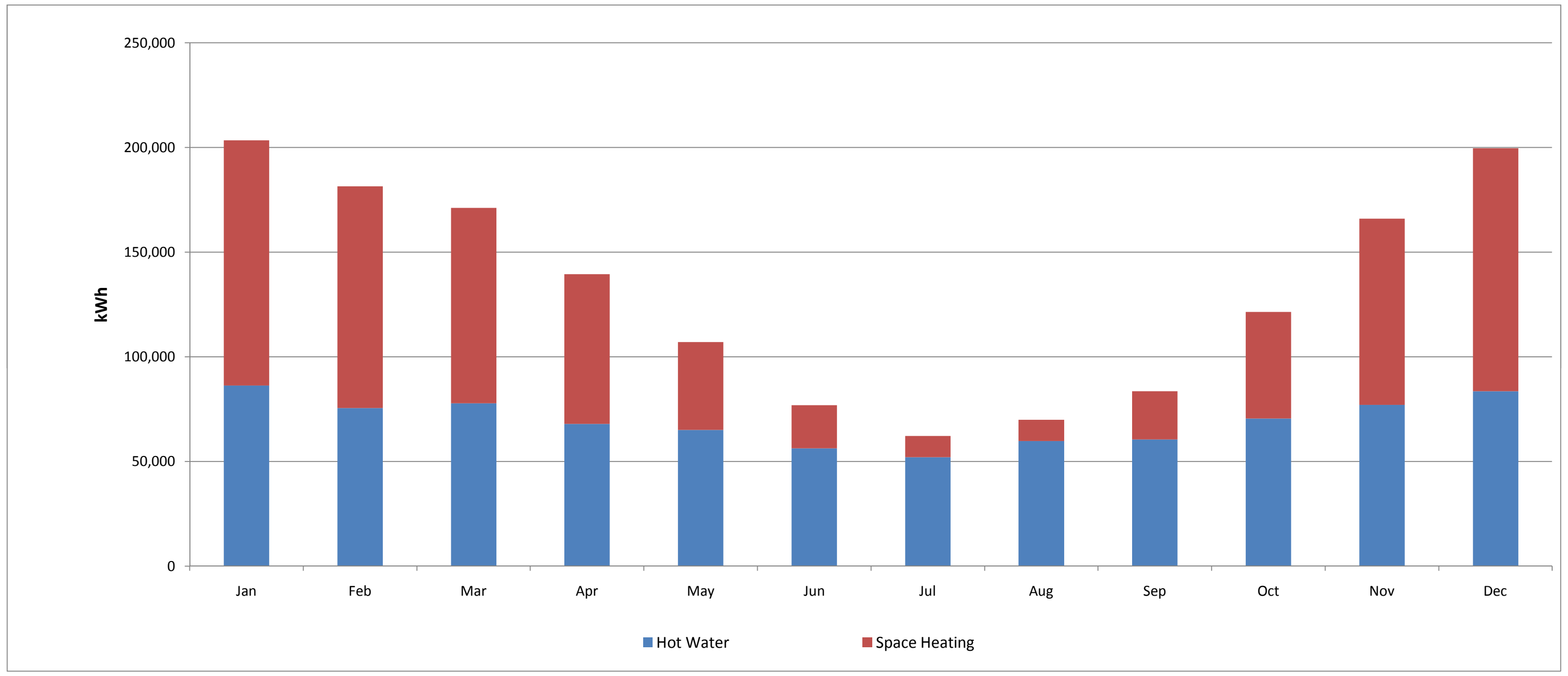
Hot water and space heating calcs

	Average Floor Area from SAP	Hot water demand	Space Heating demand	Number of Units	Total Hot water demand	Total Sapce heating demand
Domesctic	110.1	1716.47	1445.94	393	674574	568253
Non-Domestic					157305	181849
Total					**831879**	**750102**

Weighted space heating											
0.156	0.141	0.124	0.095	0.056	0.027	0.014	0.014	0.031	0.068	0.119	0.155
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month
88772	80279	70689	54250	31783	15617	7672	7672	17535	38632	67401	87950
28408	25690	22621	17361	10171	4998	2455	2455	5612	12363	21569	28145
117181	**105969**	**93311**	**71610**	**41954**	**20615**	**10127**	**10127**	**23147**	**50995**	**88971**	**116096**

Weighted hot water											
0.104	0.091	0.094	0.082	0.078	0.068	0.063	0.072	0.073	0.085	0.093	0.100
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month	kWh/month
69929	61162	63113	55024	52798	45558	42215	48445	49022	57133	62452	67724
16307	14262	14717	12831	12312	10624	9844	11297	11432	13323	14563	15793
86235	**75424**	**77830**	**67855**	**65109**	**56181**	**52060**	**59742**	**60454**	**70456**	**77016**	**83516**

TOTAL	**203416**	**181393**	**171141**	**139466**	**107063**	**76796**	**62186**	**69868**	**83601**	**121451**	**165986**	**199612**



Month	**Heat Demand (kWh)**					**Fossil Fuel (Gas) Demand (kWh)**					**Electricity Demand (kWh)**	
	BASELINE			**APEE**		**BASELINE**			**APEE**		**BASELINE**	**APEE**
	Hot Water	**Space heating**	**Cooking**	**Hot Water**	**Space heating**	**Hot Water**	**Space heating**	**Cooking**	**Hot Water**	**Space heating**	**Electricity**	**Electricity**
Jan	165975	273469	54766	86235	117181	195265	321729	64431	101453	137860	156939	132202
Feb	145167	247304	54766	75424	105969	170785	290946	64431	88734	124669	156939	132202
Mar	149798	217763	54766	77830	93311	176233	256191	64431	91565	109777	156939	132202
Apr	130600	167120	54766	67855	71610	153647	196612	64431	79830	84248	156939	132202
May	125314	97909	54766	65109	41954	147429	115187	64431	76599	49357	156939	132202
Jun	108130	48110	54766	56181	20615	127212	56600	64431	66095	24253	156939	132202
Jul	100198	23633	54766	52060	10127	117880	27804	64431	61247	11914	156939	132202
Aug	114983	23633	54766	59742	10127	135274	27804	64431	70284	11914	156939	132202
Sep	116354	54019	54766	60454	23147	136887	63551	64431	71122	27232	156939	132202
Oct	135604	119010	54766	70456	50995	159534	140012	64431	82889	59995	156939	132202
Nov	148230	207634	54766	77016	88971	174388	244276	64431	90607	104671	156939	132202
Dec	160742	270937	54766	83516	116096	189108	318750	64431	98255	136583	156939	132202
Total	**1,601,095**	**1,750,542**	**657,195**	**831,879**	**750,102**	**1,883,642**	**2,059,461**	**773,171**	**978,681**	**882,472**	**1,883,266**	**1,586,418**

Table 4 – Energy Strategy – carbon balance

		JANUARY 31			FEBRUARY 28			MARCH 31			APRIL 30		
		Demand	CO cost	CO saving	Demand	CO cost	CO saving	Demand	CO cost	CO saving	Demand	CO cost	CO saving
BASELINE 2006													
Gas demand		581,424	115,122		526,162	104,180		496,855	98,377		414,689	82,109	
Electricity demand		156,939	81,137		156,939	81,137		156,939	81,137		156,939	81,137	
APEE ENERGY BASELINE													
APEE gas demand		239,313	47,384		213,404	42,254		201,342	39,866		164,078	32,487	
APEE elec demand		132,202	68,348		132,202	68,348		132,202	68,348		132,202	68,348	
SOLAR THERMAL													
Installed capacity	kW	35			35			35			35		
Thermal output	kWh/m	531		**202**	797		**303**	1,328		**506**	1,594		**607**
GAS CHP													
Heat output of Gas CHP system	kWth	**218**			**218**			**218**			**218**		
Electricity output of Gas CHP system	kWe	138			138			138			138		
Efficiency of Gas CHP		85%			85%			85%			85%		
Heat to power ratio of CHP system		1.58			1.58			1.58			1.58		
Heat demand	kWh	85,704			74,627			76,502			66,262		
Efficiency of heat distribution system		80%			80%			80%			80%		
Heat output from Gas CHP		107,130			93,284			95,628			82,827		
hours/d		**16**			**15**			**14**			**13**		
Hours of operation	hrs	492			428			439			380		
Gas consumption of CHP	kW	419			419			419			419		
Total gas consumption of CHP	kWh	206,020	**40,792**		179,393	**35,520**		183,900	**36,412**		159,283	**31,538**	
Electricity output	kWh	67,986		**35,965**	59,200		**31,317**	60,687		**32,103**	52,563		**27,806**
BIOMASS BOILER													
Heat output of Biomass Boiler	kWth	**650**			**650**			**650**			**650**		
Efficiency of Boiler		85%			85%			85%			85%		
Heat Demand		117,181			105,969			93,311			71,610		
Efficiency of heat distribution system		80%			80%			80%			80%		
Heat output from biomass boiler		146,476			132,461			116,638			89,513		
Hours of operation		**7**			**7**			**6**			**5**		
Total biofuel consumption		225			204			180			138		
Total biofuel consumption	kWh	172,325	**1,551**		155,837	**1,403**		137,221	**1,235**		105,310	**948**	
PV													
Elec capacity	kWp	1,984			1,984			1,984			1,984		
Elec output	kWh/m	53,757		**28,437**	80,635		**42,656**	134,391		**71,093**	161,270		**85,312**
Total available heat generated	kWh	254,137			226,542			213,594			173,934		
Generated electricity		121,743			139,835			195,078			213,833		
Heat CO2 cost at 2006 baseline			**115,122**			**104,180**			**98,377**			**82,109**	
Elec CO2 cost at 2006 baseline			**81,137**			**81,137**			**81,137**			**81,137**	
Total CO2 at 2006 baseline			**196,259**			**185,317**			**179,515**			**163,246**	
CO2 emission from option			**46,087**			**30,995**			**2,293**			**- 12,891**	
			77%			**83%**			**99%**			**108%**	

	MAY 31			JUNE 30			JULY 31			AUGUST 31		
	Demand	CO cost	CO saving	Demand	CO cost	CO saving	Demand	CO cost	CO saving	Demand	CO cost	CO saving
BASELINE 2006												
Gas demand	327,047	64,755		248,244	49,152		210,114	41,603		227,509	45,047	
Electricity demand	156,939	81,137		156,939	81,137		156,939	81,137		156,939	81,137	
APEE ENERGY BASELINE												
APEE gas demand	125,957	24,939		90,349	17,889		73,160	14,486		82,198	16,275	
APEE elec demand	132,202	68,348		132,202	68,348		132,202	68,348		132,202	68,348	
SOLAR THERMAL												
Installed capacity	35			35			35			35		
Thermal output	1,926		**733**	2,125		**809**	2,058		**784**	1,926		**733**
GAS CHP												
Heat output of Gas CHP system	**218**			**218**			**218**			**218**		
Electricity output of Gas CHP system	138			138			138			138		
Efficiency of Gas CHP	85%			85%			85%			85%		
Heat to power ratio of CHP system	1.58			1.58			1.58			1.58		
Heat demand	63,184			74,671			60,128			67,943		
Efficiency of heat distribution system	80%			80%			80%			80%		
Heat output from Gas CHP	78,980			93,339			75,160			84,928		
hours/d	**12**			**14**			**11**			**13**		
Hours of operation	363			429			345			390		
Gas consumption of CHP	419			419			419			419		
Total gas consumption of CHP	151,884	**30,073**		179,499	**35,541**		144,538	**28,619**		163,324	**32,338**	
Electricity output	50,122		**26,514**	59,235		**31,335**	47,698		**25,232**	53,897		**28,511**
BIOMASS BOILER												
Heat output of Biomass Boiler	**650**			**650**			**650**			**650**		
Efficiency of Boiler	85%			85%			85%			85%		
Heat Demand	41,954			-			-			-		
Efficiency of heat distribution system	80%			80%			80%			80%		
Heat output from biomass boiler	52,442			-			-			-		
Hours of operation	**3**			-			-			-		
Total biofuel consumption	81			-			-			-		
Total biofuel consumption	61,696	**555**		-	**-**		-	**-**		-	**-**	
PV												
Elec capacity	1,984			1,984			1,984			1,984		
Elec output	194,868		**103,085**	215,026		**113,749**	208,307		**110,194**	194,868		**103,085**
Total available heat generated	133,347			95,464			77,218			86,854		
Generated electricity	244,989			274,261			256,004			248,764		
Heat CO2 cost at 2006 baseline		**64,755**			**49,152**			**41,603**			**45,047**	
Elec CO2 cost at 2006 baseline		**81,137**			**81,137**			**81,137**			**81,137**	
Total CO2 at 2006 baseline		**145,893**			**130,290**			**122,740**			**126,184**	
CO2 emission from option		**- 31,356**			**- 42,004**			**- 39,243**			**- 31,643**	
		121%			**132%**			**132%**			**125%**	

	SEPTEMBER 30			OCTOBER 31			NOVEMBER 30			DECEMBER 31			TOTAL		
	Demand	CO cost	CO saving	Demand	CO cost	CO saving	Demand	CO cost	CO saving	Demand	CO cost	CO saving	Demand	CO cost	CO saving
BASELINE 2006															
Gas demand	264,869	52,444		363,977	72,067		483,095	95,653		572,289	113,313		4,716,274	933,822	
Electricity demand	156,939	81,137		156,939	81,137		156,939	81,137		156,939	81,137		1,883,266	973,649	
APEE ENERGY BASELINE															
APEE gas demand	98,354	19,474		142,884	28,291		195,278	38,665		234,838	46,498		1,861,153	368,508	
APEE elec demand	132,202	68,348		132,202	68,348		132,202	68,348		132,202	68,348		1,586,418	820,178	
SOLAR THERMAL															
Installed capacity	35			35			35			35			35		
Thermal output	1,726		**657**	1,328		**506**	797		**303**	531		**202**	16,667		**6,346**
GAS CHP															
Heat output of Gas CHP system	**218**			**218**			**218**			**218**			**218**		
Electricity output of Gas CHP system	138			138			138			138			138		
Efficiency of Gas CHP	85%			85%			85%			85%			85%		
Heat to power ratio of CHP system	1.58			1.58			1.58			1.58			1.58		
Heat demand	81,874			69,128			76,219			82,985			879,228		
Efficiency of heat distribution system	80%			80%			80%			80%			80%		
Heat output from Gas CHP	102,343			86,410			95,274			103,732			1,099,035		
hours/d	**16**			**13**			**15**			**15**			**14**		
Hours of operation	470			397			438			476			5,048		
Gas consumption of CHP	419			419			419			419			419		
Total gas consumption of CHP	196,813	**38,969**		166,172	**32,902**		183,219	**36,277**		199,484	**39,498**		2,113,528	**418,479**	
Electricity output	64,948		**34,358**	54,837		**29,009**	60,462		**31,984**	65,830		**34,824**	697,464		**368,959**
BIOMASS BOILER															
Heat output of Biomass Boiler	**650**			**650**			**650**			**650**			**650**		
Efficiency of Boiler	85%			85%			85%			85%			85%		
Heat Demand	-			50,995			88,971			116,096			686,086		
Efficiency of heat distribution system	80%			80%			80%			80%			80%		
Heat output from biomass boiler	-			63,744			111,213			145,120			857,608		
Hours of operation	-			**3**			**6**			**7**			**4**		
Total biofuel consumption	-			98			171			223			1,320		
Total biofuel consumption	-	**-**		74,993	**675**		130,839	**1,178**		170,729	**1,537**		1,008,950	**9,081**	
PV															
Elec capacity	1,984			1,984			1,984			1,984			1,984		
Elec output	174,709		**92,421**	134,391		**71,093**	80,635		**42,656**	53,757		**28,437**	1,686,613		**892,218**
Total available heat generated	104,069			151,482			207,284			249,382			1,973,309		
Generated electricity	239,657			189,228			141,097			119,586			2,384,077		
Heat CO2 cost at 2006 baseline		**52,444**			**72,067**			**95,653**			**113,313**			**933,822**	
Elec CO2 cost at 2006 baseline		**81,137**			**81,137**			**81,137**			**81,137**			**973,649**	
Total CO2 at 2006 baseline		**133,581**			**153,205**			**176,790**			**194,451**			**1,907,471**	
CO2 emission from option		**- 20,119**			**1,318**			**30,859**			**45,919**			**- 19,785**	
		115%			**99%**			**83%**			**76%**			**101%**	

CO2 based on monthly outputs	1,907,471
total CO2 at 2006 baseline	- 19,785
CO2 emission from option	**101%**

NOTES

1 CO2 factors

Gas	0.198	from mains
Electricity	0.517	from mains
Displaced Electricity	0.529	
woodchip	0.009	

2 Solar Photo-Voltaic (PV)

1.25 kWp output per 10 m2
15,874 Available area (m2)

3 Gas CHP

52% Thermal efficiency
33% Electrical efficiency
85% efficiency
1.58 Heat/Power Ratio

4 Biomass CHP

55% Thermal efficiency
29% Electrical efficiency
84% efficiency
1.90 Heat/Power Ratio

5 Biomass Boiler

85% efficiency

6 Gas Boiler

85% efficiency - 2006 condensing type

7 Heat Distribution System (Including Storage)

80% efficiency

Table 5 – Plant and Thermal store sizing

Gas CHP sizing

Minimum total heat demand required per month	83601	kWh	September
Heating delivery efficiency (including storage)	80%		
Heat input to system	104501		
Minimum total heat demand required per day	3483	kWh	
Estimated CHP run time per day	16	hours	
CHP operation days	365	days	
CHP Run time per year	5840	hours	
CHP thermal output	218	kWth	
Thermal efficiency	52%		
Electrical efficiency	33%		
CHP electrical output	138	kWel	
Annual gas consumption	2,445,050	kWh	
Heat generated	1,271,426		
Useful heat supplied	1,017,141		
Electricity output	806,866		

Back-up gas boiler sizing

Domestic hot water	35	kW	per dwelling (assumed)
Domestic Space heating	1.5	kW	per dwelling (assumed)
Non-domestic	0.08	kW	per m2 (assumed)
Peak heat demand domestic	14345	kW	
Peak heat demand non-domestic	422.6	kW	
TOTAL PEAK DEMAND - INDIVIDUAL	14767	kW	
Diversity	15%		
TOTAL PEAK DEMAND - INCLUDING DIVERSITY	2215	kW	
Design margin	10%		
Boiler size	2437	kW	

Biomass boiler sizing

Total max heat demand required per month	117181	kWh
Heating delivery efficiency (including storage)	80%	
Heat input to system	146476	
Minimum total heat demand required per day	4725	kWh
Estimated Biomass boiler run time per day	8	hours
Design margin	10%	
Boiler size	650	kW

Thermal store sizing

CHP and Biomass boiler capacity	867	kW		
Peak demand	2215	kW		
Shortage of demand	1348	kW		
Peak demand period	2.5	hours	Assumed	
Energy demand required to store	3369	kWh		
delta T	0.001167	kWh/kg/K		
	85	degC		
	45	degC		
Volume required	40	degC		
Thermal store size				
Height of store	**One Store**		**Two stores**	
Diameter of store	72196	litres	36098	36098
Thermal store size	72	m3	36	36
Height of store	6.0	m	5	5
Diameter of store	3.91	m	3.03	3.03

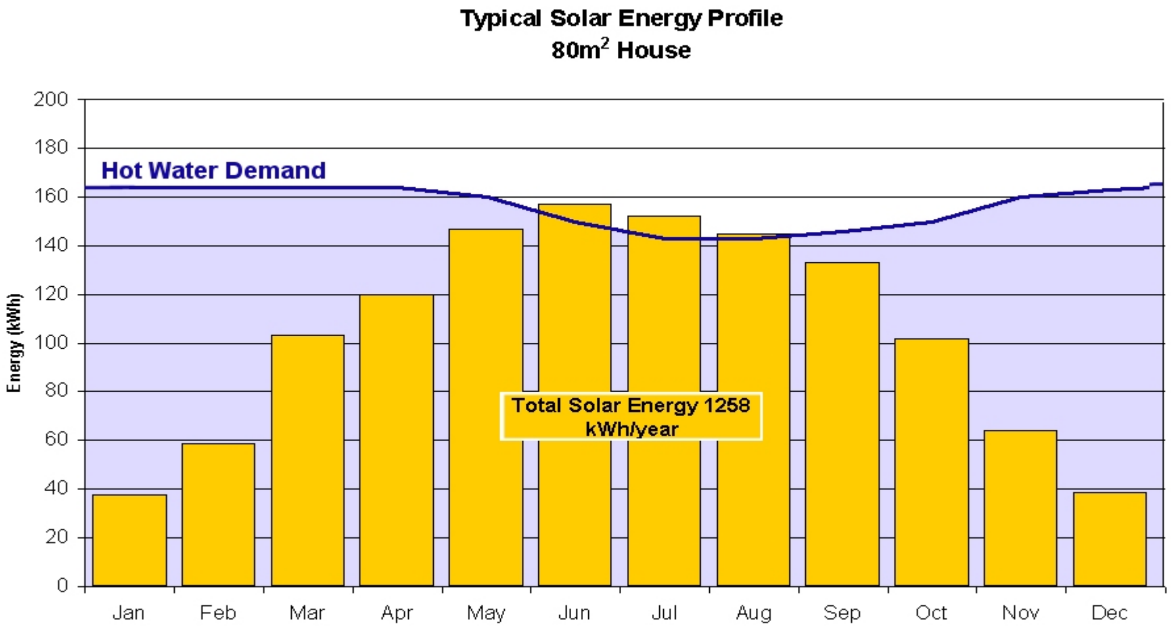
Table 6 – Solar PV system output

INPUTS

	Solar Photo-Voltaic (PV)			
Annual PV output per 1kWp	850	kWh/year		
PV peak output	1.25	kWp output per	10	m2
Total available PV area	15,874	m2		
Total PV Installed capacity	1,984	kW		
Total annual output from PV	1,686,613	kWh/year		

SOLAR ENERGY PROFILE

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
40	60	100	120	145	160	155	145	130	100	60	40
0.032	0.048	0.080	0.096	0.116	0.127	0.124	0.116	0.104	0.080	0.048	0.032
53,757	80,635	134,391	161,270	194,868	215,026	208,307	194,868	174,709	134,391	80,635	53,757



Source: http://www.viridiansolar.co.uk/Image%20sub%20windows/Graph%20of%20Energy.htm

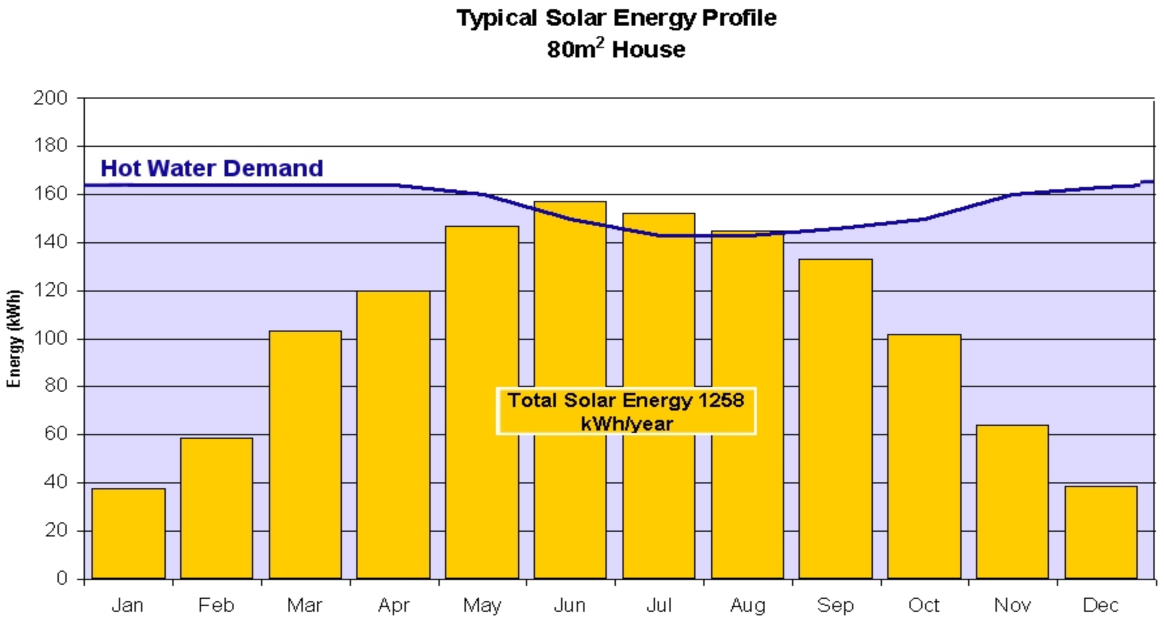
Table 7 – Solar Thermal system output

Solar Termal System Output

Assumed total solar panel area	50	m2
Annual energy output per 1 m2 of panel area	333	kWh/m2/year
Peak output per unit area	0.7	kW/m2
Installed capacity	35	kW
Total annual energy output from the system	16,667	kWh/year

SOLAR ENERGY PROFILE

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
40	60	100	120	145	160	155	145	130	100	60	40
0.032	0.048	0.080	0.096	0.116	0.127	0.124	0.116	0.104	0.080	0.048	0.032
531	797	1,328	1,594	1,926	2,125	2,058	1,926	1,726	1,328	797	531



Source: http://www.viridiansolar.co.uk/Image%20sub%20windows/Graph%20of%20Energy.htm

Table 8 – Biomass storage calculations

	Peak Output (kW)	Annual heat energy delivered (kWh)	Energy Density by Volume - Lower Limit - Wood chip at 30% moisture content (kWh/m3)	Energy Density by Volume - Upper Limit - Wood chip at 30% moisture content (kWh/m3)	Wood chip volume combusted per annum - Lower Limit (m3)	Wood chip volume combusted per annum - Upper Limit (m3)
Biomass boiler	649.7	857,608	694	868	1,236	988
Biomass CHP	0.0	0			0	0

DELIVERY VEHICLE SIZE

TYPE	VOLUME (m3)
Flexible hose from a blower tanker	20
Topper Trailer	30
Walking floor trailer	60

TOTAL DELIVERIES PER ANNUM

LOWER LIMIT	Fuel	m3	Flexible hose from a blower tanker	Topper Trailer	Walking floor trailer
Biomass boiler	Wood chip combusted volume per annum	1,236			
Biomass CHP	Wood chip combusted volume per annum	0	62	41	21

UPPER LIMIT	Fuel	m3	Flexible hose from a blower tanker	Topper Trailer	Walking floor trailer
Biomass boiler	Wood chip combusted volume per annum	988			
Biomass CHP	Wood chip combusted volume per annum	0	49	33	16

PEAK DELIVERIES PER DAY

LOWER LIMIT	Fuel	kWh combusted per day peak	m3 combusted per day peak	Flexible hose from a blower tanker	Topper Trailer	Walking floor trailer
Biomass boiler	Wood chip combusted volume per annum	15593	22.5	0.9	1.3	2.7
Biomass CHP	Wood chip combusted volume per annum	0	0.0			

UPPER LIMIT	Fuel	kWh combusted per day peak	m3 combusted per day peak	Flexible hose from a blower tanker	Topper Trailer	Walking floor trailer
Biomass boiler	Wood chip combusted volume per annum	15593	18.0	1.1	1.7	3.3
Biomass CHP	Wood chip combusted volume per annum	0	0.0			

AVERAGE DELIVERIES PER DAY

LOWER LIMIT	Fuel	m3 combusted per day average	Flexible hose from a blower tanker	Topper Trailer	Walking floor trailer
Biomass boiler	Wood chip combusted volume per annum	3.39			
Biomass CHP	Wood chip combusted volume per annum	0.00	0.17	0.11	0.06

UPPER LIMIT	Fuel	m3 combusted per day average	Flexible hose from a blower tanker	Topper Trailer	Walking floor trailer
Biomass boiler	Wood chip combusted volume per annum	2.71			
Biomass CHP	Wood chip combusted volume per annum	0.00	0.14	0.09	0.05

PEAK STORAGE VOLUMES

LOWER LIMIT	Fuel	Peak daily combusted volume (m3) storage	Peak 2 day storage	Peak 3 day storage	Peak 5 day storage	Peak 7 day storage	Peak 2 week day storage
Biomass boiler	Wood chip combusted volume per annum	22.5					
Biomass CHP	Wood chip combusted volume per annum	0.0	44.9	67.4	112.3	157.3	314.5

LOWER LIMIT	Fuel	Peak daily combusted volume (m3) storage	Peak 2 day storage	Peak 3 day storage	Peak 5 day storage	Peak 7 day storage	Peak 2 week day storage
Biomass boiler	Wood chip combusted volume per annum	18.0					
Biomass CHP	Wood chip combusted volume per annum	0.0	35.9	53.9	89.8	125.7	251.5

STORE DIMENTIONS

LOWER LIMIT

Height (m)			3.0	3.0	3.0	3.0	3.0
Footprint (m2)			15.0	22.5	37.4	52.4	104.8
Length (m)			3.9	4.7	6.1	7.2	10.2
Width (m)			3.9	4.7	6.1	7.2	10.2

UPPER LIMIT

Height (m)			3.0	3.0	3.0	3.0	3.0
Footprint (m2)			12.0	18.0	29.9	41.9	83.8
Length (m)			3.5	4.2	5.5	6.5	9.2
Width (m)			3.5	4.2	5.5	6.5	9.2

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
- 09 SOLAR THERMAL
- 10 6.5m x 6.5m BIOMASS STORE

A2 Dominion / P3 Eco

BIMP2_PA_05_100 REV C

SCALE 1:100 @ A0
6TH APRIL 2011

NW BICESTER EXEMPLAR DEVELOPMENT

ENERGY CENTRE

FARRELLS

Appendix B

SAP report

P3Eco (Bicester) Ltd

NW Bicester Eco Development

Energy and Carbon Assessment of Typical House Types

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NW Bicester Eco Development

Energy and Carbon Assessment of Typical House Types

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Checker	Marc Chapman
Approver	Philip Harker
Report No	
Date	07 February 2011

CONTENTS

1 SUMMARY

This document is intended to identify and recommend a combination of energy efficiency measures for different types of dwellings proposed for the Exemplar site of Bicester Ecotown, which can help to achieve Code Level 5 for energy related credits. It investigates how Code Level 5 for energy related credits can be achieved with the recommended energy efficiency measures and proposed energy strategy.

The study covers the energy performance of nine house types, which has been assessed using SAP based on the architect's drawings. The results of this study are summarised in the table below.

Dwelling Type ref.	Description	TER	DER	% improvement DER/TER	Fabric Energy Efficiency (kWh/m^2/year)	Code Level (Energy)	Code Credits		
							ENE 1	ENE 2	ENE 7
Type 1	2 bed terraced private	18.34	-10.55	157.5	38.89	Level 5	9	8.8	2
Type 2	3 bed terraced private	18.61	-10.02	153.9	40.57	Level 5	9	8.4	2
Type 3	2 bed terraced social	18.97	-11.16	158.9	40.32	Level 5	9	8.2	2
Type 4	3 bed terraced social	17.45	-8.29	147.5	39.99	Level 5	9	8.5	2
Type 6	4 bed detached social	17.69	-5.71	132.3	44.52	Level 5	9	7.4	2
Type 7	4 bed detached private	17.48	-6.69	138.3	40.61	Level 5	9	8.3	2
Type 8	2 bed sdbungalow dis	20.1	-11.86	159.0	43.27	Level 5	9	7.7	2
Type 9	3 bed sdbungalow dis	18.83	-8.86	147.0	43.61	Level 5	9	7.6	2
Type 10 – Option 1	5 bed detached private	16.92	-4.66	127.5	43.69	Level 5	9	7.6	2

The results of the study show that by implementing the recommended energy efficiency standards and the energy strategy Code Level 5 energy related standards can be achieved for all nine dwelling types.

2 INTRODUCTION

2.1 Background

Hyder Consulting (UK) Ltd. has been instructed by A2Dominion Group Ltd. and P3Eco (Bicester) Ltd. 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 Town and Country Planners guidance for the development of energy efficient and zero carbon strategies For Eco-Towns Encourages 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 CO2 emissions attributable to both regulated and unregulated energy uses. Energy efficiency measures which will be adopted to facilitate the achievement of 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; and
- 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;
- District Heating 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; and
- Solar Photovoltaic – comprising the use of integrated PV, utilising roof space on buildings to generate renewable electricity.

The strategy will be aimed at providing flexibility and robustness and will 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 been formally released yet by the Government including how allowable solutions may be used. However, SAP 2009 carbon contribution table remains available and will be used until the information is updated.

This study has been carried out to investigate how Code Level 5 for energy related credits can be achieved for different types of dwellings proposed for the Exemplar site of Bicester Ecotown based on the aforementioned energy strategy and energy efficiency measures. The study considers how the fabric and other efficiency measures as well as the low carbon and renewable energy technologies can contribute to achieving the Code Level 5 targets.

2.2 Objectives

The main objectives of this study are:

- to identify and recommend a combination of energy efficiency measures, which can help to achieve Code Level 5 for energy related credits;
- to investigate how Code Level 5 for energy related credits can be achieved for different dwelling types based on the recommended energy efficiency measures and proposed energy strategy.

2.3 Assessment Approach

This study focuses on achieving Code Level 5 under energy related credits for the proposed typical dwellings. The performance of nine house types has been assessed using SAP, based on the drawings provided by the architect. SAP is a methodology which is used for energy performance assessment of domestic buildings. Assessment of the typical flats has not been included in the study as the design of flat plans has not been finalised yet.

Rather than undertaking full Code assessments the study focuses on carbon and related Code credits in isolation including:

1. ENE1 (TER/DER);
2. ENE2 (Fabric/HLP); and
3. ENE7 (proportion of energy from renewable sources).

A number of other credits in the Code are influenced by energy and house design (e.g. HEA1 (daylight) and POL2 (NOx) and credits relating to lifetime homes, footprint, private space, home office, cycle storage and recycling/composting facilities). These have not been considered in the study.

Advice covers choice of construction including consideration of glazing, structurally insulated panels, airtightness and thermal bridging. This has been limited primarily to energy performance issues and so will not include detailed consideration of sustainability issues (i.e. impact on materials credits in the Green Guide, impact on construction waste, etc.).

2.4 Assumptions and Estimations

For the purpose of this study, the following assumptions and estimations have been made:

- all assessed dwellings are assumed to be South-West facing;
- roof sizes are estimated as the exact roof size dimensions have not been made available;
- quantities and dimensions of openings (windows and doors) for each dwelling type are estimated as this information has not been made available;
- a number of openings and their dimensions are assumed to be the same for all dwelling types;

- all windows are assumed to be openable but they will not be required for ventilating the rooms;
- cooling is assumed not to be provided to affordable or private dwellings; and
- balanced whole-house mechanical ventilation system was selected from the SAP database.

2.5 SAP 2009

The government's approved carbon assessment methodology for dwellings (SAP) has been used to assess the carbon performance of standard house types considering South-West orientation.

SAP 2009 version 9.90 was used to provide assessment of energy use and carbon emissions associated with space heating, water heating, lighting, pumps and fans. The 2009 edition of SAP applies from October 2010 for compliance with Part L building regulations in England & Wales.

2.6 Code for Sustainable Homes

Since the launch of the Code in April 2007 four? further versions have been released. This study considers the latest version of the Code, which came into force in November 2010. The principal changes to the Code in the carbon/energy section have been around the rules for fabric energy efficiency, communal technologies and offsite renewables and how these can contribute to achieving carbon targets.

In order to achieve the Code Level 5 energy requirements, the following criteria must be met:

- ENE 1 – 100% or more of the emissions associated with regulated energy use should be reduced. **This is a mandatory credit.**
- ENE 2 – fabric energy efficiency should be no greater than 39 kWh/m2/year for apartments and mid-terrace houses and 46 kWh/m2/year for end-terrace, semi-detached and detached houses. **This is a mandatory credit.**
- ENE 7 – energy should be supplied by accredited low carbon and renewable energy technologies in such a way that it reduces carbon dioxide emissions by either at least 10% for 1 credit or at least 1% for 2 credits. **This is not a mandatory credit but without renewable contribution Code Level 5 is unlikely to be achieved.**

3 PROPOSED ENERGY EFFICIENT DESIGN AND ENERGY STRATEGY

The proposed energy strategy for the development should focus on three factors:

1. Minimisation of energy demand through the incorporation of passive measures;
2. Reduction of energy consumption through use of energy efficient design and low-carbon technology; and
3. Inclusion of renewable energy systems.

The suggested energy strategy considers the energy profile of the proposed development ensuring effective energy use.

3.1 Passive Design

This section details the potential building fabric standards that can be applied to the provided standard house types in order to achieve Code Level 5.

3.1.1 Building Orientation

The initial plan of the scheme was generated from considerations of passive solar design. According to the energy strategy, solar PV will play a primary role in achieving the Code Level 5 status for the Exemplar site. A study was carried out to identify optimal orientation of roofs to maximise output from roof integrated solar PV systems.

The maximum total annual solar radiation is usually at an orientation due south and at a tilt from the horizontal equal to the latitude of the site minus approximately 20 degrees. The latitude of Bicester is 51.9 degrees, therefore 32 degrees is an optimal tilt in Bicester, south facing.

3.1.2 Building Envelope

To achieve high performance building envelope, improvements to the insulation properties, i.e. the U-values, of the various building elements should be considered with the aim of reducing carbon emissions. In addition to reducing U-values, the thermal performance can also be improved by a reduction of thermal bridging (loss of heat through the building fabric by conduction), which can be improved through best practice detailing of joints.

The other opportunity is improvement of buildings' air-tightness – the reduction of heat loss because of buildings' 'leakiness'. This is also mitigated through better design detailing and is one of the advantages of using modern method of construction (MMC) that applies larger pre-fabricated components and therefore reduces the incidence of poorly fitted joints.

The building elements will have to comply with Building Regulation Part L2A 2006 standards as a minimum. This defines minimum properties for building elements in order to reduce heating and cooling energy use. It is required to go well beyond the limiting Building Regulations Part L2A 2010 standards to achieve Code Level 5. The minimum building fabric requirements for Part L2A and the proposed specification for individual elements are presented in Table 3.1.

Table 3.1 Proposed U-values for individual building elements

Element	U-values W/m2.K	
	2010 Building Regulations: area-weighted values	Proposed specification: area weighted values
External walls	0.30	**0.15**
Party walls	0 - 0.50	**0.00***
Roof	0.20	**0.13**
Ground floor	0.25	**0.15**
Windows (vertical)	2.00	**0.80**
Pedestrian doors	2.00	**0.80**
Airtightness	10 ($m^3/s/m^2$ @50pa)	**3 ($m^3/s/m^2$ @50pa)**
y - value	0.15	**0.04**

** No heat transfer through party walls*

The considered improvements are based on the Energy Saving Trust's (EST) standards, which are suggested in the Energy Efficiency and the Code for Sustainable Homes guidance[1].

3.2 Energy Efficiency

This section details the potential energy efficiency standards of space and water heating, cooling, ventilation and lighting that can be applied to the provided standard house types in order to achieve Code Level 5.

3.2.1 Heating

The following design considerations are proposed to achieve the energy efficient heating system:

- Use high efficiency gas CHP and Biomass boiler plant (gas CHP – thermal efficiency 52%, heat/power ratio 1.58; biomass boiler – 85%);
- Insulate all heating distribution pipework and valves to environmental standards in BS5422;
- Install low temperature variable flow system: use high efficiency motors and variable speed pumps for circulation of hot water in the heating system;
- Consider high temperature differentials between flow and return;
- Consider optimisation of start/stop times;
- Select an insulated plate heat exchanger with small volume to minimise heat losses (for the purpose of the study the following is assumed: volume - 5 litres, insulation thickness - 80 mm); and

[1] CE292 Energy Efficiency and the Code for Sustainable Homes guidance for Code Level 5 and 6, Energy Saving Trust, May 2008 edition

- Install appropriate temperature and time controls (for the purpose of the study the following controls are assumed: programmer and TRVs).

Due to limitations of SAP, some of the aforementioned measures cannot be simulated but should be taken into account during the detailed design process.

It should be noted that DER is very sensitive to heat fraction supplied by gas CHP and Biomass boiler. At this early stage in the design, it is not possible to accurately determine the heat fraction from the gas CHP and the biomass boiler. For the purpose of this study, it was estimated that 60% of the total thermal energy for heating and water will come from the CHP and 40% will come from the biomass boiler. Higher percentage contribution from the biomass boiler will help to further improve carbon performance of each dwelling.

The combination of improved heating system efficiency, fabric, airtightness and inclusion of heat recovery in the ventilation system can reduce the carbon emissions for space heating by >70% compared to the notional building.

3.2.2 Hot Water

As the hot water supply comes from the same district heating system, all the design considerations mentioned in Section 2.2.2 except those related to dwelling heating temperature control are also applicable for the hot water supply system.

3.2.3 Cooling

It is assumed that cooling is not provided to affordable or private dwellings.

3.2.4 Ventilation

In order to achieve Code Level 5, it is recommended to use balanced whole-house mechanical ventilation system with heat recovery.

It is proposed to design the ventilation system to meet Specific Fan Powers of less than 1W/l/s which will require relatively low face velocities, high efficiency fan motors and radiused bends and turning vanes in ductwork.

Mechanical ventilation units and ducts will be specified to meet the highest standards of air leakage and to ensure that heat recovery complies with ECA criteria for efficiency and low pressure drops.

The combination of an airtight building2, energy efficient mechanical ventilation and excellent heat recovery helps to reduce the heat load considerably (as discussed above) which leads to a reduction in emissions from auxiliary energy use.

3.2.5 Lighting

Lighting accounts for a significant proportion of the building energy use. Therefore, only high efficiency internal and external lighting should be used throughout the dwellings in conjunction with a lighting control system as appropriate.

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[2] The windows will be openable but they will not be required for room ventilation. This will be required to avoid summer overheating.

3.3 Renewable Technologies

3.4 Solar PV

Optimal roof orientation of dwellings for installation of solar PV panels is discussed in Section 2.1.1. The PV panels can operate at significant efficiency if they kept within a range of deviation from the optimum orientation as the solar sundial indicates below. For example a south east roof, at optimum inclination (i.e. 32 degrees for Bicester) can achieve 96% efficiency; or a south west roof at +10 degree inclination (i.e. 42 degrees for Bicester) can provide between 95% and 92% efficiency. We would recommend that all roofs orientation and inclination are designed to achieve at least 90% PV panel efficiency.

Solar Sundial showing energy yield relative to the inclination and orientation of your roof

The high cost of the PV modules and supplementary equipment will require optimum design of the PV installations to ensure maximum electrical output per kWp installed. There are a number of design considerations to be made to ensure the best use of the system.

The key design considerations are:

- Ensure that all parts of the PV panels are unshaded (shading caused by other buildings, greenery and roof 'furniture' such as chimneys or satellite dishes even over a small area of the panel, can significantly reduce the performance);
- Ensure correct installation of PV arrays for good ventilation (high temperatures at the back of the modules reduce electrical output); and
- Ensure that the electrical wiring from PV arrays to inverters is kept to minimum to reduce electrical losses.

Detailed design of the solar PV systems has not been developed yet. In the absence of specific system details of the proposed solar PV systems, the following SAP inputs have been assumed for each dwelling type:

- 30m^2 available roof area for PV panels;

- 1.25 kWp PV installed capacity per 10 m^2;
- Tilt of PV panels - 30°;
- Orientation of PV panels – South West; and
- Overshadowing - None or very little (for more details refer to a separate overshadowing and daylighting study).

The precise area of the roof available for installation of PV panels for each dwelling type as well as the other aforementioned details will become available as the design progresses.

3.5 Solar Thermal

The energy strategy suggests installation of 50 m2 solar thermal panels on the roof of the energy centre. The solar thermal installation will be linked to a thermal store and the district heating system.

Detailed design of the solar thermal system has not been developed yet. In the absence of details of the proposed solar thermal system the following SAP inputs have been assumed:

- Area of thermal collectors - 50 m^2;
- Circa 330 kWh per year per 1 m^2 solar collector area;
- Tilt of thermal collector - 30°;
- Orientation of thermal collector - South West; and
- Overshadowing - None or very little.

4 RESULTS OF SAP ANALYSIS

Nine types of dwellings have been assessed using SAP and the results have been summarised in Table 4.1

Table 4.1 SAP assessment results for nine dwelling types

Dwelling Type ref.	Description	TER	DER	% improvement DER/TER	Fabric Energy Efficiency (kWh/m^2/year)	Code Level (Energy)	Code Credits		
							ENE 1	ENE 2	ENE 7
Type 1	2 bed terraced private	18.34	-10.55	157.5	38.89	Level 5	9	8.8	2
Type 2	3 bed terraced private	18.61	-10.02	153.9	40.57	Level 5	9	8.4	2
Type 3	2 bed terraced social	18.97	-11.16	158.9	40.32	Level 5	9	8.2	2
Type 4	3 bed terraced social	17.45	-8.29	147.5	39.99	Level 5	9	8.5	2
Type 6	4 bed detached social	17.69	-5.71	132.3	44.52	Level 5	9	7.4	2
Type 7	4 bed detached private	17.48	-6.69	138.3	40.61	Level 5	9	8.3	2
Type 8	2 bed sdbungalow dis	20.1	-11.86	159.0	43.27	Level 5	9	7.7	2
Type 9	3 bed sdbungalow dis	18.83	-8.86	147.0	43.61	Level 5	9	7.6	2
Type 10 – Option 1	5 bed detached private	16.92	-4.66	127.5	43.69	Level 5	9	7.6	2

The study results show that the suggested energy efficiency measures coupled with the energy strategy can achieve Code Level 5 energy standards for all the assessed dwelling types.

It should be noted that the design is still in development and the output of the SAP model can be very sensitive to small changes in the input parameters. The government also periodically updates the modelling software and Code standards which can also have significant effects on the resultant CO2 emissions predictions[3]. It is therefore recommended that the outputs of the SAP model are treated with some caution.

[3] As the SAP methodology and Code for Sustainable Homes guidance have been recently updated, it is not envisaged to have a major update in the near future.

5 CONCLUSIONS

The results of the study show that implementation of the recommended energy efficiency standards and the energy strategy will help to achieve Code Level 5 standards.

The suggested advanced fabric standards are the most cost effective way of reducing carbon emissions and they have significant impact on emissions of CO2. However, meeting the advanced fabric standards is not straightforward and should be discussed and agreed with the architect prior to progressing with the design.

The suggested energy efficiency standards should be discussed and agreed with the architect and the M&E consultant prior to progressing with the design.

All major changes related to the energy efficiency standards and the energy strategy should be tested with SAP software to ensure that the dwellings can still achieve the required Code level.