

**O & H Properties Ltd
Barratt Strategic Land
Marlborough Developments Ltd**



Sustainable Energy Strategy

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Executive Summary

This report sets out the high level Energy Strategy for the Great Haddon scheme, outlining renewable and low carbon technologies that will be utilised within the development, in addition to allowing flexibility in the strategy for areas where new technologies may play a part and be included in the delivery of renewable and low carbon technologies.

The policy target, as set out in the East of England Plan - Policy ENG2 Renewable Energy Targets, is for the development of new facilities for renewable power generation should be supported, with the aim that by 2010 10% of the region's energy and by 2020 17% of the region's energy should come from renewable sources.

The emerging Peterborough Core Strategy states:

- each residential unit to be delivered meets CfSH4 from the adoption of this Core Strategy to 2013; meets CfSH5 from 2013 to 2015; and meets CfSH6 from 2015 onwards as a minimum; and
- non-residential development will be compliant with a BREEAM/Eco-building assessment rating of at least 'Excellent' from the adoption of this Core Strategy; and
- at least 15% of the demand for energy will be met from on-site provision and by renewable means, and/or from a decentralised renewable or low-carbon energy supply, from adoption of the Core Strategy; rising to at least 40% from 2016 and at least 50% from 2020."

The specific targets outlined within this Energy Strategy for Great Haddon, it is proposed for each phase to incorporate innovative and experimental technologies. Innovative technologies being cutting edge / emerging technologies that have been tested but are not used often. Experimental technologies are technologies that are as yet untested.

Great Haddon is meeting 39% reduction in CO₂ emissions through the use of on-site renewable energy technologies alone, after energy efficiency measures have been applied. The incorporation of low-carbon technologies will further increase the CO₂ emission reduction beyond the 40% target required from 2016 and 50% from 2020 to accord with the Peterborough Core Strategy Preferred Option CS 9.

Renewable Energy and Low Carbon technologies considered appropriate for inclusion in the Great Haddon Energy Strategy are; Biomass Boilers, Heat Pumps, Combined Heat and Power (high density areas), Solar Thermal Panels, Wind Turbines (employment area), Solar Photovoltaic Panels, in addition to new and emerging technologies.

Options considered and discounted are; Hydro Power, Fuel Cells, Anaerobic Digestion and Energy from Waste.

The Residential time line is:

Time	Target	Renewable Technology
2010	Private housing: CfSH Level 3, 25% CO ₂ reduction	<ul style="list-style-type: none"> Energy efficiencies; CHP gas, natural ventilation, natural daylight, orientation, pre-heating, water reduction, building fabric, thermal mass,
2011	Social Housing CfSH Level 4, 44% CO ₂ reduction	<ul style="list-style-type: none"> As above plus; additional technologies such as; Biomass or Solar Thermal, etc.
2013	Private and Social Housing CfSH Level 4, 44% CO ₂ reduction	<ul style="list-style-type: none"> Energy efficiencies as above, plus some renewable technologies such as; CHP gas, (district heating) or biomass boilers for each dwelling or solar thermal, etc, (consideration also to be given to non-domestic)
2015	Social Housing CfSH Level 6, Zero Carbon	<ul style="list-style-type: none"> Energy efficiencies as above, plus all available renewables; PV, wind, CHP biomass; GSHP, ASHP, etc, and New Technologies, (yet to be established).
2016	Private and Social Housing CfSH Level 6, Zero Carbon	<ul style="list-style-type: none"> Energy efficiencies as above, plus all available renewables; PV, wind, CHP biomass; GSHP, ASHP, etc, and New Technologies, (yet to be established).

1 Introduction

- 1.1. Peter Brett Associates LLP (PBA) have been commissioned by the Great Haddon Consortium, consisting of O&H Properties, Barratt Strategic and Marlborough Developments to provide renewable energy advice in support of the potential developments of land at Great Haddon, located to the south west of Peterborough.
- 1.2. The Great Haddon sites will aim to deliver Developments of an urban extension comprising up to 5326 residential dwellings; 65 hectares of employment land (B1, B2 and B8 and a site for a household recycling centre); a district centre (with up to 9,200 square metres (99,031 sq.ft) retail floor space) and two neighbourhood centres (with up to 2,300 square metres (24,758 sq.ft) retail floor space) comprising district/neighbourhood retail (A1-A5), community and health (C2, D1), leisure (D2), residential (C3) and commercial (B1) uses. Provision for education facilities (sites for three primary and one secondary school); sports and recreational facilities; a range of strategic open spaces including new landscaping, woodland and allotments; and cemetery provision. Associated highway infrastructure (including pedestrian, bridleway and cycle routes), public transport infrastructure and car parking for all uses. Utilities and renewable energy infrastructure; foul and surface water drainage networks (including SuDS and lakes)".

All in accordance with the Development Framework Plan ref: PST021/DFP/01.

- 1.3. This assessment considers the renewable energy strategy for the site in order to guide the development of the Masterplan. The aim of this energy strategy is to provide:
 - A Review of Current and Emerging Policies
 - A Site Specific Predicted Annual Energy Demand (PED) Model
 - Energy Efficiency Design Measures
 - Renewable Energy Solutions appropriate for Great Haddon
 - A high level review of Energy from Waste
 - A review of Combined Heat and Power
 - An Example Energy Strategy for the predicted build out of Great Haddon will be provided
- 1.4. This assessment is based on information provided by the client and a number of key assumptions regarding the nature of the development which, may be subject to further change. Therefore it should be noted that the analyses presented in this document have been conducted at a preliminary feasibility level, and as such, the results and conclusions presented here should be validated during the project's development and detailed design phases.

2 Policy Review

2.1 National policy

Government's Sustainable Development Agenda - Securing the Future

2.1.1. The UK Government has four priority areas for sustainable development, these are:

- Sustainable consumption and production
- Climate change and energy
- Natural resource protection and environmental enhancement
- Sustainable communities

2.1.2. The Government recognises that encouraging a change in behaviour is a key to promoting their sustainability priorities. The principles and approaches are covered in Securing the Future - the UK Government's Sustainable Development Strategy (2005).

Planning Policy Statement 1 (PPS1) - Planning for sustainable development

2.1.3. The Government's Sustainable Communities Plan was published in February 2003 and established a key planning policy context for regeneration. The aspirations of the Communities Plan are being continually reinforced by emerging policy guidance including that in PPS 1: Delivering Sustainable Development, published in January 2005. The Statement sets out the Government's overarching planning policies on the delivery of sustainable development through the planning system. Paragraph 5 of PPS1 sets out the framework for sustainable planning which should:

- "make suitable land available for development in line with economic, social and environmental objectives to improve people's quality of life;
- contribute to sustainable economic development;
- protect and enhance the natural and historic environment, the quality and character of the countryside, and existing communities;
- ensure high quality development through good and inclusive design, and the efficient use of resources; and,
- ensure that development supports existing communities and contributes to the creation of safe, sustainable, liveable and mixed communities with good access to jobs and key services for all members of the community. "

Supplement to PPS1 (Planning and Climate Change)

2.1.4. Planning and Climate Change (published December 2007) sets out how planning, in providing for the new homes, jobs and infrastructure needed by communities, should help shape places with lower carbon emissions and resilient to the climate change now accepted as inevitable.

Planning Policy Statement 22 (PPS22) - Renewable Energy

- 2.1.5. PPS22 (2004) gives guidance on the various types of renewable energy sources and how planning authorities should consider the opportunity for incorporating renewable energy projects in all new developments. It promotes the use of “solar panels, biomass heating, small scale wind turbines, photovoltaic cells and combined heat and power schemes”. It states that local planning authorities may include policies in local development documents that require a percentage of the energy to be used in new development to come from on-site renewables.

Climate Change and Energy Bill

- 2.1.6. The use of energy has become a subject of global geopolitical importance in recent times. Energy supply and demand has therefore needed to be regulated by the Government. The main legislative driver for managing and implementing the control of energy issues is the Climate Change Bill 2008 and Energy Bill 2008.
- 2.1.7. The Energy Bill implements the legislative aspects of the 2007 Energy White Paper: “meeting the energy challenge”. It provides the basis of regulatory change to meet the needs for energy generations, energy infrastructure and promotion of low carbon technologies.
- 2.1.8. The Climate Change Bill puts into statute the UK’s targets to reduce Carbon Dioxide emissions through domestic and international action by at least 60% by 2050 and at least 26% by 2020 (against 1990 baseline).

2.2 Regional Policy

- 2.2.1. The energy related Regional Policies are referred to below as they take the place of the local plans that are being revised.

2.3 Local Policy

Peterborough Local Plan (Adopted 2005)

- 2.3.1. Policy U15 Site for Renewable Energy Production; Policy U15 refers to a specific site in Peterborough, (5.0 ha site to the south of Storey’s Bar Road) that is not near this development so does not apply.
- 2.3.2. The Local plan Policies of Peterborough City Council are under review and are planned to be replaced in 2009.
- 2.3.3. Policy U13 (Efficient use of Energy) and U14 (Energy from Renewable Resources) have not been saved and now refer to the East of England Plan and PPS22 and the PPS1 Supplement. See below for what these entail.

East of England Plan

Policy ENG2 Renewable Energy Targets

- 2.3.4. “The development of new facilities for renewable power generation should be supported, with the aim that by 2010 10% of the region’s energy and by 2020 17% of the region’s energy should to come from renewable sources. These targets exclude energy from offshore wind, and are subject to meeting European and international obligations to protect wildlife, including migratory birds, and to revision and development through the review of this RSS”

Policy ENG1 Carbon Dioxide Emissions and Energy Performance

2.3.5. “Working with regional partners, EERA should consider the performance of the spatial strategy on mitigating and adapting to climate change through its monitoring framework and develop clear yardsticks against which future trends can be measured, which should inform the review of the RSS and the preparation of Local Development Documents. To meet regional and national targets for reducing climate change emissions, new development should be located and designed to optimise its carbon performance. Local authorities should:

- encourage the supply of energy from decentralised, renewable and low carbon energy sources and through Development Plan Documents set ambitious but viable proportions of the energy supply of new development to be secured from such sources and the development thresholds to which such targets would apply. In the interim, before targets are set in Development Plan Documents, new development of more than 10 dwellings or 1000m² of non-residential floorspace should secure at least 10% of their energy from decentralised and renewable or low-carbon sources, unless this is not feasible or viable; and
- promote innovation through incentivisation, master planning and development briefs which, particularly in key centres for development and change, seek to maximise opportunities for developments to achieve, and where possible exceed national targets for the consumption of energy. To help realise higher levels of ambition local authorities should encourage energy service companies (ESCOs) and similar energy saving initiatives.”

Emerging Core Strategy

2.3.6. The emerging Core Strategy is one of the development plans for the Peterborough Local Development Framework. A draft Core Strategy has been consulted on and has yet to be finalised. It is predicted that it will be adopted in 2010.

2.3.7. The most important of the documents in terms of energy are the Preferred Options CS 9 and CS 10.

2.3.8. CS 9 states that:

“Proposals for large residential development and all major non-residential development must demonstrate that:

- each residential unit to be delivered meets CfSH4 from the adoption of this Core Strategy to 2013; meets CfSH5 from 2013 to 2015; and meets CfSH6 from 2015 onwards as a minimum; and
- non-residential development will be compliant with a BREEAM/Eco-building assessment rating of at least ‘Excellent’ from the adoption of this Core Strategy; and
- at least 15% of the demand for energy will be met from on-site provision and by renewable means, and/or from a decentralised renewable or low-carbon energy supply, from adoption of the Core Strategy; rising to at least 40% from 2016 and at least 50% from 2020.”

2.3.9. CS 10 states that:

“Permission will only be granted if the developer has satisfactorily addressed the following on an individual case by case basis:

- use of the most appropriate technology for the site;

- measures to mitigate any adverse effects on the amenities of occupiers of nearby properties during the construction, operational lifespan and decommissioning of the equipment/infrastructure;
- provision for the protection, preservation and/or mitigation for any features of strategic, cultural, agricultural, ecological, historic and/or archaeological importance, including landscape character - where relevant (as described in detail within other policies in the development plan).”
- Therefore CS 9 and CS 10 may require a significant investigation and integration wherever possible of the renewable and low carbon technologies.

Building Regulations Part L and Code for Sustainable Homes (CSH)

- 2.3.10. The build out for these developments is expected to commence in 2011 and run until 2026 approximately. The build-out will be phased and Part L of the Building Regulations is currently scheduled to be revised in 2010, 2013 and 2016. Further, for residential buildings, the “Dwelling Emission Rating” will have to be decreased in this time frame from the “Target Emissions Rating” as follows; 25% in 2010, 44% in 2013, and the residential building will have to be Zero Carbon by 2016. This is measured against current building regulations (2006). There is currently an aspiration that all new non-domestic buildings will be Zero Carbon from 2019 onwards, however, the fully trajectory of how this will be achieved leading up to 2019 has not yet been defined. As such the low Carbon and renewable technologies integrated into this development will need to reflect these changes.
- 2.3.11. It should be noted that the current definition for Zero Carbon is under review by the Communities and Local Government (CLG). The consultation runs until the 18th March 2009 and a revised definition is expected later this year. PBA are taking part in the consultation and believe that the out come will involve a 3 tiered process. Firstly, a high percentage of efficiencies must be achieved. Secondly a set emission reduction target should then be reached through the aforementioned energy efficiency measures and the use of on-site renewable energy technologies and directly connected off-site heat. This combination of measures is referred to as “Carbon Compliance”. Currently the level at which this will be is not known. Finally, in achieving zero carbon, there are the “Allowable Solutions” which will allow offsite energy to deliver the final CO₂ emission reduction to achieve zero carbon. The allowable solutions will be cost-capped to ensure that achieving zero carbon is financially viable for developments. The level at which the allowable solutions will be capped has not been decided. See Figure 1 and Appendix 13.

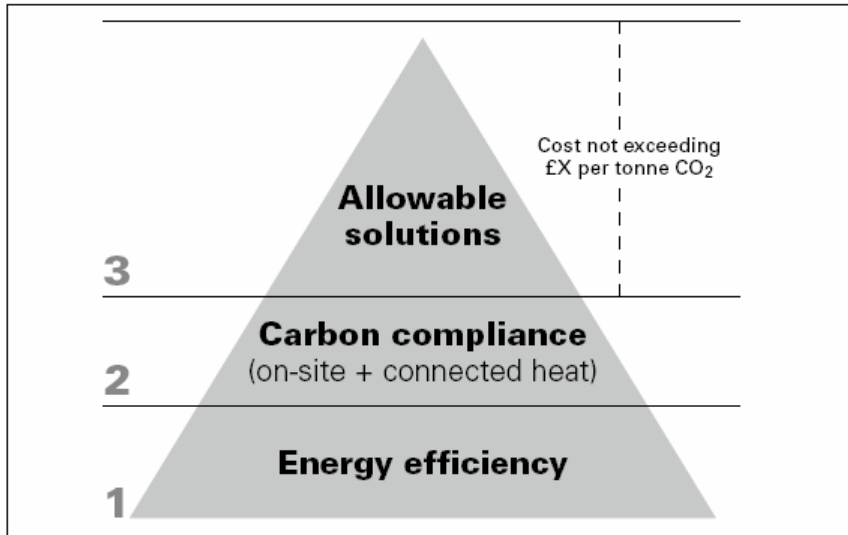


Figure 1: Predicted change to the Zero Carbon definition

2.3.12. Additionally for new socially funded and affordable housing:

- All new socially funded housing and affordable housing now has to achieve CSH level 3 (25% reduction in CO₂ emissions measured against current Part L building regulation compliance).
- From 2011 this will increase to Level 4 (44% reduction in CO₂ emissions)
- From 2015 this will increase to level 6 (Zero Carbon)

2.4 Conclusion and Chosen Options

2.4.1. following a review of current and emerging policies and taking account of mandatory compliance levels for Code for Sustainable Homes, new private dwellings will be designed to meet the following:

- Code for Sustainable Homes Level 3 from 2010 – 25% reduction (measured against current Part L building regulation compliance).
- Code for sustainable Homes Level 4 from 2013 – 44% reduction
- Code for sustainable Homes Level 6 from 2016 – Zero carbon (100% reduction plus all emissions associated with cooking and appliances.)

2.4.2. Additionally, new social and affordable housing will meet the following requirements with immediate effect:

- CSH Level 3 – 25% reduction in CO₂ emissions
- From 2011 this will increase to Level 4 (44% reduction in CO₂ emissions)
- From 2015 this will increase to Level 6 (Zero Carbon)

- 2.4.3. The amendments to Building Regulations Part L will deliver the following CO₂ emission reductions for non dwellings, as follows:
- 2010 – 25% reduction measured against current (2006) building regulations
 - 2013 – 44% reduction
- 2.4.4. In the absence of further information regarding future changes to Building Regulations Part L beyond 2013, it is assumed that all new non-domestic buildings will be zero carbon from 2019 onwards, in line with the UK Government's aspirations. However, it is likely that a further amendment to Part L of the Building Regulations will be provided in 2016, which may deliver an enhanced CO₂ emission reduction to that achieved by 2013 Building Regulations, and going some way further to achieving zero carbon by 2019.
- 2.4.5. We also propose to meet Peterborough's East of England Policy ENG 1: "new development of more than 10 dwellings or 1000m² of non-residential floor space should secure at least 10% of their energy from decentralised and renewable or low-carbon sources". It is considered that the emerging core strategy is just aiming to meet the building regulations at an earlier stage.
- 2.4.6. To go above and beyond predicted building regulations, it is proposed for each phase to incorporate innovative and experimental technologies. Innovative technologies being cutting edge / emerging technologies that have been tested but are not used often. Experimental technologies are technologies that are as yet untested.

3 Benchmark Predicted Energy Demand

- 3.1. This following Chapter models the predicted energy demand (PED) for gas and electricity for the both sites and calculating the total carbon emissions. This will be used in the following Chapter to break the model down into the phases of the build out which can then be used in to meet the different options as concluded previously.
- 3.2. This assessment has been undertaken at an early stage of the development's design process. At the time of developing the full Predictive Energy Demand (PED) model, the total number of residential units was taken as 5283 as per the "Great Haddon Summary Land Use Budget rev A 2-10-08". However, since this time, the masterplan and associated land use budget was amended slightly and the number of residential units increased to 5326 as per the Great Haddon Summary Land Use Budget based on PST021-DFP-01. However, further analysis has been undertaken and demonstrated that this change has no significant effect on the energy strategy proposed.
- 3.3. No further details were available so assumptions were made about the type of housing involved i.e. Terraced housing all 80 m² internal floor area. Further, there are no Standard Assessment Procedure (SAP) calculations currently available for the proposed dwellings. Therefore for the purposes of this report benchmark figures based on historical SAP Calculations have been used as an estimate for a typical residential unit i.e. for electrical use (28 kWh/m²/year) and for thermal use (79 kWh/m²/year). These assumptions are shown in Appendix 3.
- 3.4. At the time of this assessment the design of the non residential area consisted of high level data including: a district centre (with Supermarket, B1 hub, B1 Offices, local retail, A1, A2, A5), neighbourhood centres, community centres and an employment area to the north of the site (B2 and B8), as per the "Great Haddon Summary Land Use Budget rev A 2-10-08". See Appendix 1. Since this time the land use budget has been amended and the current land use budget is as given in PST021-DFP-01. However, analysis has been undertaken and demonstrates that the changes in the land use budget pose no significant changes to the overall energy strategy for the development.
- 3.5. There are no Simplified Building Energy Model calculations currently available for the non-residential buildings. Therefore for the purposes of this report, benchmark figures based on the CIBSE Guide F 2004 and historical data have been used. These have been adjusted to reflect current building regulations. Further details of these assumptions can be found in Appendix 4.
- 3.6. Using benchmark figures has allowed the Total Benchmark Energy Demand for the site to be estimated at 118,154 MWh/year. A significant proportion of this demand is made up from the non-residential units; using 72,847 MWh/year. See Appendix 3.
- 3.7. The total Carbon Dioxide emissions have been calculated to be 30,378 tonnes/year based on the Predicted Energy Demand (PED). See Table 3.1 and Appendix 3 for further details.

Table 3.1: Summary of Benchmark Predicted CO₂ Emissions for Great Haddon

Description of Land Use	Annual CO ₂ Emissions (Tonnes/Year)		
	Electricity	Gas	Total
Residential	4,994	6,494	11,488
Non-residential	8,921	9,969	18,890
Total	13,915	16,463	30,378

- 3.8. It should be noted the data presented here is based on benchmarks and PBA experience. Further work will be required to obtain a more accurate understanding of the energy demands onsite with the use of data generated from calculations carried out for example using the “Standard Assessment Procedure” (SAP) and Simplified Building Energy Model (SBEM). These calculations are produced in the detail design stage of the development as required by Building Control.
- 3.9. The results and conclusions presented here should be validated during the project’s development and detail design phases.

4 Benchmark Predicted Energy Demand Phasing

4.1 Phase 1 (2010-2013) Private Housing, Social Housing & Non Residential

- 4.1.1. The phasing of the construction of the development has yet to be confirmed and at this time assumptions have been made regarding the build-out of the development. Final phasing and construction of the development will be subject to market conditions.
- 4.1.2. It will be assumed that 1000 houses will be involved in the first phase of the build-out and 30% of these will be affordable homes (700 private, 300 affordable).
- 4.1.3. For the first phase it will be assumed that 1 Primary school will be built and a third of the non-residential units will also be built. There are no energy reduction targets envisaged for the non-residential units as built in the first phase. However in reaching the BREEAM targets some energy reductions may be required.

Table 4.1: Summary of Benchmark Predicted Carbon Dioxide Emissions for Great Haddon Option 1 Phase 1

Description of Land Use	Annual CO ₂ Emissions (Tonnes/Year)		
	Electricity	Gas	Total
Residential	331	1,229	1,560
Non-residential	2,893	3,163	6,056
Total	3,224	4,392	7,616

- 4.1.4. For Code for Sustainable Homes Levels 3 and 4 the % reductions include the all the space and water heating for the houses but only the electrical uses for lighting and pumps. It does not include the electrical uses for cooking and appliances. The benchmark figures for the electrical demand shown here are for the entire electrical uses. As there is no available data from SAP calculations, further assumptions will have to be made as to the % of the benchmark figures that contribute to lighting and pumping. For the purposes of this report it will be assumed that 20% is lighting (see Appendix 4). To calculate the % due to pumps is not as obvious, but from historical SAP data, 15% of the electrical use has been shown to be from pumps. Therefore for to take into account the electrical load for lighting and pump only, 35% of the benchmark electrical figures will be applicable for the PED for CSH Levels 3 and 4.
- 4.1.5. Meeting the Building Regulations Part L will involve for private residential:

- Level 3 from 2010 – 2013 25% reduction

Table 4.2: Summary of Benchmark Predicted Carbon Dioxide Emissions Reductions for Private Housing Phase 1

Description of Land Use	Annual CO ₂ Emissions (Tonnes/Year)		
	Electricity	Gas	Total
Residential	232	860	1,092
25% Reduction Required	58	215	273

4.1.6. For the social/ affordable housing it will be assumed that all 100 will be built after 2011. Meeting the Building Regulations Part L will involve for social/affordable homes residential:

- From 2011 this will start from Level 4 (44% reduction in CO₂ emissions)

Table 4.3: Summary of Benchmark Predicted Carbon Dioxide Emissions for Social Housing Great Haddon Phase 1

Description of Land Use	Annual CO ₂ Emissions (Tonnes/Year)		
	Electricity	Gas	Total
Residential	99	369	468
44% Reduction Required	44	162	206

4.2 Phase 2: (2013-2016) Private Housing, Social Housing & Non Residential

4.2.1. It will be assumed that 1500 houses will be involved in the second phase of the build-out and it will be assumed that 30% of these will be affordable homes (1050 private, 450 affordable).

4.2.2. For the second phase it will be assumed that 1 Primary school will be built and another third of the non-residential units will also be built.

Table 4.4: Summary of Benchmark Predicted Carbon Dioxide Emissions for Great Haddon Option 1 Phase 2

Description of Land Use	Annual CO ₂ Emissions (Tonnes/Year)		
	Electricity	Gas	Total
Residential	496	1,844	2,340
Non-residential	2,893	3,163	6,056
Total	3,389	5,006	8,396

4.2.3. Meeting the Building Regulations Part L will involve for private residential:

- Level 4 from 2013 - 44% reduction

4.2.4. For new social and affordable housing it will be assumed they are built before 2015:

- From 2011 -2015 Level 4 will be the requirement for Code compliance for social and affordable housing (44% reduction in CO₂ emissions)

4.2.5. For the purposes of this report, it will be assumed for Phase 2 all housing social and private will be built to Level 4.

Table 4.5: Summary of Benchmark Predicted Carbon Dioxide Emissions for Great Haddon Option 1 Phase 2 - Residential

Description of Land Use	Annual CO ₂ Emissions (Tonnes/Year)		
	Electricity	Gas	Total
Residential	496	1,844	2,340
44% Reduction Required	218	811	1,030

4.2.6. For the non-residential buildings the energy reduction required will be as follows:

- Level 3 2013 – 2016 - 25% reduction

Table 4.6: Summary of Benchmark Predicted Carbon Dioxide Emissions for Great Haddon Option 1 Phase 2 – Non Residential

Description of Land Use	Annual CO ₂ Emissions (Tonnes/Year)		
	Electricity	Gas	Total
Non -Residential	2,893	3,163	6,056
25% Reduction Required	723	791	1,514

4.3 Phase 3: (2016 +) Private Housing, Social Housing & Non Residential

4.3.1. It will be assumed for the final phase that the remaining residential buildings will be built.

4.3.2. For Residential both private and social/affordable housing will have to reach CfSH Level 6 from 2016, 100% of the entire emissions associated with all the energy use has to be reduced. Therefore to reach CfSH level 6 for residential buildings the entire electrical uses will be taken into account.

4.3.3. For the purposes of this report the level to be reached for non –residential buildings will be taken from predicted Building Regulations Part L:

- 2010 – 25% reduction
- 2013 - 44% reduction
- 2019 - Zero carbon

4.3.4. Therefore for the purposes of this report a sixth of the non-residential units will be built in the period 2016-2019 and the last sixth will be built from 2019 onwards.

4.3.4. The total emissions for the residential and non residential buildings from Phase 3:

Table 4.6: Summary of Benchmark Predicted Carbon Dioxide Emissions for Great Haddon Option 1 Phase 3

Description of Land Use	Annual CO ₂ Emissions (Tonnes/Year)		
	Electricity	Gas	Total
Residential	2,631	3,421	6,052
Non-residential	3,135	3,644	6,779
Total	5,766	7,064	12,830

4.3.5. Reductions for the residential:

Table 4.7: Summary of Benchmark Predicted Carbon Dioxide Emissions for Great Haddon Option 1 Phase 3 - Residential

Description of Land Use	Annual CO ₂ Emissions (Tonnes/Year)		
	Electricity	Gas	Total
Residential	2,631	3,421	6,052
100% Reduction Required	2,631	3,421	6,052

4.3.6. Reductions for the non residential (2016-2019)

Table 4.8: Summary of Benchmark Predicted Carbon Dioxide Emissions for Great Haddon Option 1 Phase 3 – Non Residential (2016-2019)

Description of Land Use	Annual CO ₂ Emissions (Tonnes/Year)		
	Electricity	Gas	Total
Non -Residential	1,709	2,126	3,835
44% Reduction Required	752	936	1,688

4.3.7. Reductions for the non residential Zero carbon (2019+)

Table 4.9: Summary of Benchmark Predicted Carbon Dioxide Emissions for Great Haddon Option 1 Phase 3 – Non Residential (2019+)

Description of Land Use	Annual CO ₂ Emissions (Tonnes/Year)		
	Electricity	Gas	Total
Non -Residential	1,426	1,517	2,943
100% Reduction Required	1,426	1,517	2,943

4.4 Summary of Carbon Dioxide Reductions

Table 4.10: Summary of Benchmark Predicted Carbon Dioxide Emissions for Great Haddon Option 1 Phase 1-3

Phases	Option 1: Emissions Reductions (Tonnes/Year)				Total Emissions Reduction (Tonnes/year)
	Phase 1	Phase 2	Phase 3	Phase 3b	
Residential	479	1,030	6,052	0	7,560
Non-Residential	0	1,514	1,688	2,943	6,145
Total Emissions Reduction	479	2,544	7,739	2,943	13,705

5 Energy Efficient Measures

A substantial proportion of the carbon reductions for the development could be delivered by reducing the energy demand. The following energy efficiency through design measures can be applied to dwellings and non residential buildings and should be considered at the earliest possible design stage.

5.1 Residential Buildings

- High performance building fabric reducing carbon emissions arising from space heating including improved U-value building elements and improved air tightness. This is discussed further in the next section.
- Good access to daylight for all living spaces, particularly kitchens and living rooms, minimising the need for electric lighting.
- Dedicated low energy light fittings should be installed as standard.
- Domestic white goods appliances supplied to have an energy label rating of at least A.
- High efficiency lamps installed in all common areas and lighting installed in areas of periodic occupation to have occupancy sensors fitted to ensure that they are only on when required (e.g. waste storage, stair wells and plant rooms).
- External lighting to be high efficiency and installed with timers and/or daylight sensors to ensure they are not operational during the day.
- Consideration of innovative passive ventilation systems can be given to enable efficient building heat extraction during warmer months of the year. Alternatively mechanical ventilation with a low specific fan power and heat recovery could be employed.
- CHP technologies and GSHP with Under Floor Heating systems can be considered to maximise use of development embedded energy generation and the efficient use of heat in district heating schemes.
- Use a combination of appropriate low carbon and renewable embedded technologies for domestic water heating and space heating requirements.
- Individual and/or smart metering for all individual units to increase awareness of energy efficiency and influence behaviour.
- Building Energy Management Systems to monitor and target energy use with a view to energy use behaviour change.
- High efficiency electric motors installed in central services and included in the enhanced capital allowances list.
- Apartment heating and hot water systems to have the facility for temperature and time control by the occupants.
- Specific user guides for residents to indicate correct use of systems and appliances and providing information on further energy reduction measures which may be adopted.

- 5.1.1. Additionally consideration should be given to reducing water usage through the implementation of water efficient fittings. Water is increasingly being recognised as a precious resource and using it more efficiently will help preserve this resource and reduce the energy associated with processing and pumping it.

Building Fabric:

Heat Loss Parameter

- 5.1.2. Space heating makes up a significant proportion of the energy requirement for a residential dwelling. In order to minimise the energy needed for this purpose the heat losses from the building should be reduced as much as is practical, a key element towards this is to ensure that buildings have excellent insulation properties expressed in terms of U-values.
- 5.1.3. Another key factor in reducing heat losses from dwellings is the air tightness of the building envelope. The less air lost through uncontrolled ventilation, the more heat is retained within the building. A measure of air-tightness is air permeability; this is defined as the air flow rate required to maintain an excess pressure of 50 Pascals during a pressurisation test.
- 5.1.4. The fabric U-values and air permeability rates are key inputs into the calculation of the heat loss parameter (HLP). This in turn is one of the factors that determines the space heating requirement of the dwelling. In order to meet the carbon reduction targets, the space heating demand should be optimised through building fabric U-values and air permeability specification.

Loss of Floor Area

- 5.1.5. For designers to implement performance improvement there will be cost benefit implications. In addition improvements may also potentially have the effect of increasing wall thickness and thus decreasing available floor area. Some research has been conducted in this area as to the likely specification required to meet the planned carbon reductions that will be expected in 2010 and 2013, the details of which are shown in Table 5.1

Table5.1: Building Material Properties & Building Characteristics for Different Carbon Emission Levels

Element	Carbon Emissions Level		
	2006 Regs ¹	Building	
		Level 3 (2010) ²	Level 4 (2013) ²
Roof (U - W/m ² K)	0.14	0.14	0.08
Wall (U - W/m ² K)	0.28	0.22	0.1
Ground Floor (U - W/m ² K)	0.22	0.17	0.09
Doors & Windows (U - W/m ² K)	1.8	0.9	0.7
Thermal Bridging Allowance (W/K)		0.04	0.02
Airtightness (m ³ /m ² /h)		3	2
Ventilation	Natural	Mech. Vent.	Mech. Vent. Heat Recovery
HLP (W/m ² K)			0.63
Nat. Gas Boiler Efficiency	85%	90%	93%
Area of Solar Collector (m ²)	0	0	4

Source:

- 5.1.6. If regular building practice is employed then this large reduction in the U-value of the walls will lead to a significant loss of floor space. For example using a masonry cavity wall filled with insulation on plasterboard dabs will require roughly a 320mm total wall thickness for a U-value of 0.28. For U-values of 0.22 and 0.1 this increases to approximately 350mm and 550mm respectively. Considering the above example this will lead to a loss of floor area in the region of 5% for a Level 3 home and 30% for a Level 4.
- 5.1.7. However there are many innovative building fabrics on the market that can achieve vastly improved U-values without such a great loss of floor area. In achieving the necessary standards a balance will need to be found between the increased cost of market leading building fabrics and the cost of reduced floor areas. Consideration will also need to be given to this subject for the non-residential buildings.
- 5.1.8. It should be stressed the example above is an indicative specification only. Each dwelling type needs to be judged on its individual design and required U-values will depend on many factors including the building size, shape and orientation and what the specification is for the heating system, ventilation solution, thermal bridging value, and the air permeability rate.

Water and Drainage Systems

- 5.1.9. All dwellings should include water saving devices such as aerating taps, with auto shut-off or flow regulator devices, low flow showers (less than 15 litres/min) and toilets (less than 6 litres or dual flush). Such measures will further reduce the energy required for pumping water, both at an individual household level and on a larger infrastructure level.
- 5.1.10. The feasibility of rainwater harvesting systems should be investigated for various land uses as well as using greywater systems. Buildings should aim to reduce mains supplied water demand by up to 20% which can be quantified as a tangible carbon emission saving as part of the sustainability credentials for the development.

5.2 Non-residential building

5.2.1. Building Orientation and Design:

- Building orientation and design should be considered to maximise daylighting and reduce the demand for artificial lighting.
- Consideration should be given to providing innovative designs that provide light funnelling techniques to introduce natural light into buildings.
- Large west facing windows to be avoided as these are difficult to shade, leading to potential overheating.
- Rooms containing plant should ideally seek to be located on the north facing side of the building to minimise heat gains.
- The massing and siting of buildings should be such that they allow natural ventilation. This will necessitate the depth of floor plan being no greater than 15m, where cross ventilation systems are used, or 7 metres where single sided natural ventilation is utilised. Further, the proximity of buildings to each other must be considered.

5.2.2. Passive Systems:

- Solar shading should be integrated where necessary in the form of fixed or adjustable brise soleil, built overhangs or vegetation and landscaping.

- Low E glass and blinds should be considered to further reduce solar gain during the summer.
- Where natural ventilation is not possible, wind assisted ventilation should be considered.
- Performance of the building fabric should:
 - Minimise heating requirements through air tightness and low “U” values
 - Minimise cooling requirements through consideration of thermal mass for “free cooling”

5.2.3. Active Systems:

- Low energy lighting to be installed where feasible.
- Intelligent lighting controls to be installed that respond to daylighting and occupancy.
- External lighting should be timer and photocell controlled to ensure efficient use.
- Zoning of heating systems should be explored.
- Modular plant to be installed to ensure plant is working at high efficiency.
- Where mechanical ventilation is necessary, air handling units to be fitted with variable speed motors controlled by air quality sensors, heat recovery systems should also be considered.
- All pumps and fans to be fitted with variable speed drives for maximum efficiency.
- A planned maintenance strategy should be developed to ensure plant and buildings run at optimum efficiency.

5.2.4. Further aspects that can be included in the scheme design to improve the energy efficiency of the commercial buildings. These are:

- Provide sub-metering of all major energy uses within commercial buildings to allow energy monitoring of services.
- Install intelligent metering on gas and electricity supplies to enable occupants to monitor usage and identify wastage.
- Provide commercial buildings with flexible floor places to allow their use to be adapted to suit changing markets and to increase their lifespan.

5.25. In addition to sub metering consideration should be given to Building Energy Management Systems (BEMS) to enable occupiers to plan and manage energy consumption effectively with optimisation linked to degree day data being utilised. Case studies show that energy consumption is typically reduced by 5% as a result of BEMS being installed in commercial and public amenity buildings.

5.26. As with the residential buildings, water efficient appliances will be installed to reduce potable water consumption and thereby energy associated with processing, filtering and pumping of the same, both at an individual building and infrastructure-wide level.

6 Sustainable & Renewable Energy Technologies

6.1 Renewable Opportunities and Site Constraints

6.1.1. This section considers the appropriateness of a range of technologies given the constraints of the site and the predicted performance of the technology. To be able to compare the technologies, they will each be looked at to see how they can meet the energy needs in terms of electricity and heating, for the entire site: approximately 5300 residential units together with district centre, neighbourhood centres, community centres and an employment area to the north of the site, are being proposed as per the "Great Haddon Summary Land Use Budget rev A 2-10-08". See Appendix 1. How far these technologies will go to meet CO₂ targets will also be reported on. A cost comparison is also provided for each of the renewable technologies in terms of CO₂ savings. Chapter 7 deals with CHP in terms of site wide solutions and solutions for the District Centre. Chapter 8 will then break down the options into the phases of the build out.

6.1.2. The technologies to be investigated are:

Hydro Power

Fuel Cells

Anaerobic Digestion

Energy from Waste

Solar Thermal Panels

Solar Photovoltaic Panels

Biomass Boilers

Wind Turbines

Heat Pumps

CHP

The estimation of a sizing/design etc for the individual technologies is difficult at this level as the heating and electrical loads of the development are unknown especially for the non residential buildings that have not been decided on as yet. Therefore the sizing/design etc will be based on benchmark historical data from building types and assumed loadings as per Chapter 4 and Appendix 4.

6.2 Hydro Electric Power

6.2.1. Hydro electric power utilises water turbines to harness the energy in flowing water to generate electricity.

6.2.2. For Hydro electric power systems to be viable, there needs to be a significant source of flowing water, or the potential to install a dam and release water at specific times to allow electricity to be generated as the water passes through turbines.

6.2.3. The Great Haddon site does not have a suitable water course with adequate flow to facilitate the use of hydro electric turbines. Therefore the use of hydro electric turbines is not considered further in this report.

6.3 Fuel Cells

- 6.3.1. A fuel cell is an electrochemical conversion device. It produces electricity from fuel (on the anode side) and an oxidant (on the cathode side) which react in the presence of an electrolyte.
- 6.3.2. Large scale fuel cells typically run on natural gas as the fuel source. The use of Hydrogen as a fuel source is currently very much in the research and development stage.
- 6.3.3. Large scale fuel cells are not yet commercially available and as a result this technology will not be considered further within this report. However, should fuel cells become commercially viable during the development of later phases of the development their use will be considered in delivering CO₂ emission reductions.

6.4 Anaerobic Digestion

- 6.4.1. Anaerobic Digestion is a process whereby organic matter decomposes within an oxygen-free and carefully temperature and pressure controlled environment. As the matter decomposes methane is created. This is used as the fuel source for a turbine to generate electricity.
- 6.4.2. The development at Great Haddon is not of a sufficient scale to make anaerobic digestion of organic waste viable. Further, Opportunity Peterborough have indicated that there are other Peterborough-wide proposals for Anaerobic Digestion facilities within the Peterborough area. Therefore the use of Anaerobic Digestion is not considered further within this report.

6.5 Energy from Waste

- 6.5.1. Energy from waste can take many forms, such as incineration, pyrolysis and gasification. All of these differing processes can be used to generate either heat, electricity or gas, which can then be used as the fuel in a turbine to generate electricity.
- 6.5.2. The development at Great Haddon is not of a scale to solely support an energy from Waste facility. Additionally, Peterborough City Council are currently proposing an energy from waste facility elsewhere within Peterborough, in the Fengate Area and it is proposed that organic, non-recyclable waste generated within the Great Haddon development will be exported to this facility. Therefore, the use of an energy from waste facility is not considered further within this report.

6.6 Solar Thermal Panels

- 6.6.1. Solar thermal panels provide hot water. The heat energy is collected from the sun and transferred via a circulating fluid which is used to heat the water for the building.
- 6.6.2. Solar thermal panels are considered to be appropriate for this development as the collector could be mounted on the roofs of the buildings both residential or non-residential. The visual impact of these panels is considered to be low, they can be easily installed on the roof and maintenance requirements are low.
- 6.6.3. There are two types of panels; flat plate and evacuated tubes. Flat plate panels are generally cheaper and simpler systems, and provide approximately 300 kWh/m²/year. Evacuated tubes are more expensive and complex, but their output is significantly higher than flat plate collectors and can typically produce up to 450 kWh/m²/year. Back up boilers would be required for peak demands. Therefore, the analysis assumes the use of evacuated tube collectors and that each system is appropriately oriented on unshaded, south-facing roofs.

Constraints

- 6.6.4. Ideally these panels should be mounted at 30° to the horizontal and orientated within 45° of the south direction. They can be mounted at lower angles but that reduces the productivity of the solar panels.
- 6.6.5. The panels tend to come in set sizes e.g. 2m² and 4m². This can limit the amount of roof space that can be utilised. Another option would be to use solar roof tiles which reduce the visual impact of the solar panels and means more roof area can be utilised. Roof tiles tend to be more expensive compared to flat plates and evacuated tubes.
- 6.6.6. The extent of Solar Thermal Hot Water contribution is limited by the amount of appropriate roof space available. For apartments this can be more complex than for individual dwellings, a communal system could be considered or hot water tanks could be considered for each individual flat. Roof space however, will also be limited depending on the ratio of number of dwellings to roof area.

Energy Output and Discussion

- 6.6.7. The benchmark water heating demand for the site is 29,000,000 kWh/year. Solar thermal panels can achieve up to 60% of the hot water needs which for this site is approximately 17,000,000 kWh/year. This equates to approximately 3,220,000 kg of CO₂/year. This would mean about a maximum of 11% reduction in CO₂ emissions from using solar thermal panels. See Appendix 7.
- 6.6.8. 24% reduction in CO₂ is achieved if you look solely at the residential units, which is higher than the percentage reduction which can be achieved through utilising solar thermal across the site since dwellings require more hot water as a percentage of their total energy uses compared with non-residential buildings.
- 6.6.9. The capital cost of each solar panel will be approximately £3000 which includes a 25% discount for bulk buying.
- 6.6.10. Assuming each solar thermal panel has an output of 440 kWh/m²/year, and each panel to be 2 x 2 m, to achieve 20% reduction in CO₂ emissions approximately 17,800 solar thermal panels would be required for the entire site.
- 6.6.11. In reality not all the buildings (particularly any flats) in this development are suitable for using solar thermal panels to reduce emissions. Therefore, a 20% reduction in CO₂ emissions is unlikely to be achieved through utilising solar thermal collectors alone. Further, due to the large cost implications it is not recommended to be used in large quantities as there are other more economical technologies that could be employed to deliver the required CO₂ emission reductions.
- 6.6.12. However, solar thermal may be useful in smaller quantities in terms of reaching Code for Sustainable Homes Level 4 in the residential houses. It is realistic that a 20% reduction can be delivered through energy efficiencies and the remaining 24% reduction can be met through a solar panel.
- 6.6.13. As SAP does not take into account the full electrical load for dwellings this means that any heat producing renewables have an advantage at the earlier CSH Levels. The potential CO₂ reduction can be up to 35%.
- 6.6.14. Solar thermal maybe particularly applicable for the social housing since the requirement to achieve Code Level 4 for this type of housing is in advance of .the requirement for private housing.

- 6.6.15. Another good application for solar thermal would be for schools from an energy saving and educational perspective.

6.7 Photovoltaic Panels

- 6.7.1. Solar photovoltaic (PV) cells transform the photons within sunlight into useful electrical energy. They are made from semi-conducting material and can be mounted on the roofs of buildings or integrated into the fabric of the building e.g. as a roof covering or as cladding.
- 6.7.2. PV is considered appropriate for this site as it may be possible to incorporate PV panels onto the roof level of buildings to provide power for the development. PV systems require little maintenance. However, regular inspection of the PV arrays is required for damage or dirt and annual servicing of inverters (to convert PV direct current output to alternating current) and electric controls.
- 6.7.3. PV is ideally suited to residential and non-residential applications due to its low maintenance requirement and visibility. It is however usually more expensive than other forms of renewable electricity generation and this economic factor requires careful consideration with regards to potential implementation.

Constraints

- 6.7.4. The constraints for PV panels are similar to the solar thermal panels. The optimum annual output is achieved when orientated directly south facing and inclined at an angle of 30°.
- 6.7.5. Again as for solar thermal, the panels tend to come in set sizes e.g. 2m², 4m² etc. As large quantities of PV are usually required to make meaningful contributions to the electrical demand of a building the limited size of the panels could be a restraint. A solution to this would be to integrate the solar PV panels into the roof to enable the maximum utilisation of the roof area. However, some of the roof area may be required for locating plant and space should be allowed for maintenance of any roof mounted plant.
- 6.7.6. Over-shadowing from adjacent buildings can be an issue for PV panels as the energy output can be reduced significantly.
- 6.7.7. Considering the same energy output for PV panels and for solar thermal panels, PV panels are more expensive therefore in terms of cost effectiveness solar thermal would be recommended over PV panels. See the cost comparison at the end of this Chapter.
- 6.7.8. PV panels are quoted as having a lifespan on some 25 years.

Energy Output and Discussion

- 6.7.9. The benchmark electrical demand for the site is approximately 33,300,000 kWh/year. Theoretically solar PV can meet 100% of the electrical demand. This would equate to approximately 17,880,000 kg of CO₂/year. This would mean about a maximum of almost 60% reduction in CO₂ emissions from using solar PV panels is possible. This would equate to a total PV panel area of approximately 380,500m². See Appendix 8.
- 6.7.10. In reality a 58% reduction in CO₂ emissions for the whole site will be difficult to achieve from Solar PV alone, as there is likely to be inadequate roof space. Further, it is not possible to orientate all of the required roofs in the south direction. The design of the buildings would have to be altered to maximise the south facing roof area and the south facing cladding of the buildings may have to be utilised.

- 6.7.11. The capital cost of an 8m² PV panel is approximately £4,500 which includes a 25% discount for bulk buying. On a large scale PV can be a considerable capital cost.
- 6.7.12. For one dwelling, the electricity demand is approximately 2,450 kWh/year. If this was met solely via PV this would reduce approximately 1,320 kg of CO₂ and equates to about 55% reduction in CO₂ emissions.
- 6.7.13. To meet Level 6 a renewable technology that generates all of the dwelling's electrical energy such as PV has to be employed. To reach Level 6 the required PV area would be approximately 28 m². However, the definition of Zero carbon is currently being reviewed and it is likely that off-site solutions will be allowed once the definition has been amended. Therefore, the use of PV within the Great Haddon development is likely to be extremely limited in light of more cost effective methods for achieving zero carbon.
- 6.7.14. Due to the spatial requirements and the large cost implications it is not recommended to use PV in large quantities as there are other more economical technologies that could be employed but for individual units where other more cost effective technologies cannot be employed, PV may be applicable.
- 6.7.15. Another good application for solar PV would be for schools from an energy saving and educational perspective.

6.8 Biomass Boilers

- 6.8.1. Energy from biomass, used for space and water heating, is an alternative to using conventional high carbon fuels such as gas and oil. Biomass fuel itself is considered to be carbon neutral; however there will be carbon emissions associated with the transportation of the fuel. These emission levels are related to the type of vehicle used, the volume and density of the fuel being transported and the distance of transportation. Carbon emissions associated with the transportation of the biomass fuel has been considered in the options appraisal.
- 6.8.2. Biomass is generally in the form of woodchip or pellets and it can be made from waste of by-products from industry or especially cultivated fuel crops on or off site.
- 6.8.3. Biomass can be incorporated into residential dwellings with either a single room heater/stove or a boiler, where the biomass replaces the more traditional gas or oil. There are a number of issues such as they require more cleaning and space than conventional boilers. They need to be de-coked and de-ashed.
- 6.8.4. There are several UK suppliers of biomass heating technology ranging in scale from individual dwelling to larger scale community systems. A major factor affecting the choice of boiler technology is the fuel moisture content. If the fuel moisture content is likely to be above 35%, then a moving grate type of boiler will be required, to allow combustion of the wetter fuel. If moisture content is below 35%, then a fixed hearth system can be used.
- 6.8.5. Boilers can modulate from 100% of maximum combustion rate (MCR) down to about 25% of full load, without a major loss in efficiency. A typical average efficiency, for burning fairly green wood chip, will be about 78%, with a full load efficiency of about 85%, or better.

Constraints

- 6.8.6. One of the major constraints for using biomass boilers is the availability of a reliable, local fuel supply chain.
- 6.8.7. Additionally, biomass boilers have greater space requirements for fuel storage compared with traditional gas fired boilers, where there is no storage requirement. The masterplan has allocated sufficient space to allow for the use of biomass boilers to deliver CO₂ emission reductions.
- 6.8.8. There is also a need to monitor the fuel storage so that the deliveries can match the energy demands of the buildings, where a community or centralised system can be incorporated. However, a management system would be required for communal systems to ensure that billing, maintenance, fuel delivery and storage are properly managed.
- 6.8.9. Another constraint for biomass boilers is to ensure that the air quality meets any current legislation. This would involve a appropriate flue for the biomass boiler. The flue for each boiler has to be 3m above any windows that can be opened or any “air intakes” for the building itself and for adjacent buildings. This may be difficult to achieve for flats especially so individual biomass boilers would not be recommended for individual flats. Instead a centralised biomass boiler system is considered to be preferable.
- 6.8.10. Biomass boilers as mentioned above can work on 25% load and they prefer to have a constant baseline load. It is therefore preferred to have a biomass boiler that meets the winter space and hot water heating and in the summer where there is only the demand for hot water, have a smaller biomass boiler or have an alternative source of hot water generation.
- 6.8.11. As a site wide solution, individual systems would be expensive and a site wide approach, such as district heating could be more economical and remove the need/space required in each building for a boiler.

Energy Output and Boiler Sizing

- 6.8.12. The benchmark heating (space and hot water heating) demand for the site is approximately 85,000,000 kWh/year. Theoretically biomass boilers on a district heating scheme can meet 70-85% of the heating demand meaning that about 70,000,000 kWh can be met through biomass boilers. Including emissions caused by transporting the fuel, this would equate to approximately 12,200 kg of CO₂/year. This would mean about a maximum of 40% reduction in CO₂ emissions from using biomass boilers is possible. See Appendix 9.
- 6.8.13. The size of a boiler for the whole site would be approximately for space heating approximately 25,000 - 35,000 kW and for space heating approximately 10,000 - 20,000 kW.
- 6.8.14. For each dwelling, the space heating and hot water demand is approximately 6,400 kWh/year. If this was met via biomass boilers on a district heating scheme, this would this would reduce approximately 900 kg of CO₂ and equates to about 42% reduction in CO₂ emissions. This would fall just below the reduction requirement to meet Level 4.
- 6.8.15. In PBA’s experience if biomass boilers are coupled with thermal stores and used in district wide systems a 50% reduction in CO₂ emissions reduction (approximately 1000 kg/year) and would mean a Level 4 could be achieved. This could be employed on the earlier stages of the development to help social/private houses meet their Level 4 requirement.
- 6.8.16. Additionally as with Solar Thermal Panels, due to the way SAP works, any heat producing renewables have an advantage at the earlier CSH Levels. The potential CO₂ reductions can be up to 70% for dwellings so Biomass Boiler would exceed requirements for Level 4.

- 6.8.17. An individual boiler for a residential unit would be typically of the size 8 kW, (this includes meeting peak loads).
- 6.8.18. If biomass was to be used as a site wide solution, then it would be advised to use district heating and also the use of CHP would be recommended from a cost saving perspective. This would also mitigate the need for individual boilers in every building.
- 6.8.19. Another good application for biomass boilers would be for schools from an energy saving and educational perspective.⁸

Fuel Storage

- 6.8.20. The size of the fuel storage will depend on the type of fuel and the number of deliveries. Here, weekly deliveries have been considered for wood pellets. It has been assumed that there will be one storage for the boilers to give an indication of the total amount of space required for the fuel storage.

Weekly Storage

- 6.8.21. Assuming the approximate heat energy required is just about 80,000,000 – 100,000,000 kWh a week.
- Wood Pellet: Approximate size of fuel storage for 1 week would be approximately 800-900m³.
 - This would give an approximate foot print area of 90 - 150 m².
 - This would require approximately 500-600 Tonnes of wood pellet fuel.
 - Wood chip has a lower calorific value and therefore larger volumes are required to deliver the equivalent CO₂ emission savings.

Emissions

- 6.8.22. A biomass installation will produce emissions to air and due consideration should be given to the Clean Air Act 1993. This applies mainly to small scale domestic installations and in some areas has resulted in a list of 'Exempted Fireplace Orders' being issued by DEFRA. Installations <3 MW fall under Schedule B of the Environmental Protection Act 1990 and therefore are not regulated by Integrated Pollution Control (IPC). Therefore a large scale biomass boiler is likely to come under this clause.
- 6.8.23. Boilers above 400 kW net rated thermal input burning "clean wood waste" - furniture factory waste, pallets etc - are part B processes under the EPA and are regulated under Local Air Pollution Prevention and Control (LAPPC) as detailed in guidance PG1/12. These boilers need an authorisation from the EHO and usually an annual emissions test to check the boiler emissions are within limits set out in PG1/12.
- 6.8.24. It is important to ensure that the technology selected is able to comply with all applicable legislation requirements.

6.9 Wind Turbines

- 6.9.1. Wind Turbines come in many sizes but are typically classified into micro, medium and large scale. Micro involves the use of low energy generation wind turbines producing up to 1.5 kW which are often roof mounted. Small to Medium wind turbines generate typically 1.5 - 500kW and large scale generate typically 500kW - 4MW.

- 6.9.2. The mean annual wind speed at this location is 6.2 m/s at 45m, above ground level, (according to NOABL). An average wind speed of 4-5 m/s generates usable amounts of energy and to make a wind turbine a preferable option an average wind speed of above 6 m/s is required. Therefore in terms of wind resource, this site seems promising.
- 6.9.3. A 2MW wind turbine would have a typical hub height of between 65 and 90 metres and rotor diameter between 50 and 75 metres.
- 6.9.4. There is potential for wind turbines in Peterborough with several other sites having already been exploited for wind power. In June 2008 McCain Foods started operating three 2MW wind turbines near Whittlesey, which are approximately 6 miles East of Peterborough Centre. 8 turbines of total capacity of 16 MW were constructed in 2005 in Glassmoor Bank, in Pondersbridge some 7 miles South East from Peterborough.
- 6.9.5. Two wind farms have however been denied planning permission in the Peterborough area due to MOD objections. The proposals comprised seven wind turbines at Nuts Grove Farm, near Thorney, and a further six wind turbines at Wrydecroft, also near Thorney. Both applications were North East of Peterborough.

Constraints

- 6.9.6. The contributions from small to medium sized wind turbines to reducing CO₂ would be small so if any meaningful CO₂ emissions were intended to be reduced a large wind turbine would be required. See Energy section later on.
- 6.9.7. Small to medium sized wind turbines have little constraints. Large wind turbines and wind Farms have many constraints.
- 6.9.8. A full feasibility study would need to be carried out to ascertain if large wind turbine or a wind farm was feasible. This would include a basic economic feasibility.
- 6.9.9. If this proves positive for wind then the wind resource can be measured, future wind speed predictions can be made and a full economic assessment can be carried out.
- 6.9.10. A wind farm will need an Environmental Impact Assessment (EIA) carried out. The EIA would include:
- Landscape and Visual Impact to be undertaken due to the close proximity to Worcester
 - Ecology – Proximity of Special Sites of Scientific Interest (SSSI), Proximity of Special Areas of Conservation (SAC), Proximity of Area of Outstanding Natural Beauty (AONB).
 - Ecological Issues – the presence and/or proximity of nesting birds and bats should be considered when assessing the viability of incorporating wind turbines into developments. Whilst the RSPB have recognised that climate change will render more bird species extinct that the extremely low bird kill experienced around large scale wind turbines, it should be considered none-the-less.
 - Noise and Vibration - large wind turbines should be located at least 400m from residential dwellings.
 - Topple distance – large wind turbines should be located at least base to blade tip height +20m from major trunk roads and motorways.
 - Electromagnetic Interference – Consultation will have to be carried out to find out the Proximity of Aviation, Radar & MOD facilities.

- Transport and Access – Traffic to and from the site during construction of the Wind Turbines.
- Shadow Flicker and Light Reflection
- Archaeological issues – including proximity of Scheduled Ancient Monuments
- Electricity Infrastructure
- Local Benefits

6.9.11. The location of any potential wind turbines is important. There are a number of basic parameters that can be used to assess a site's potential for renewable energy which includes proximity to housing, grid connection, nature and heritage considerations, as well as infrastructure capacity. Rules of thumb, based on British Wind Energy Association guidance, have been used to undertake a wind prospecting analysis for large scale wind could be sited for the development. The results of the analysis are presented in Figure 2.

6.9.12. The analysis shows an area to the north west of the development boundary as having the least number of constraints likely to be affected by the development of turbines.

6.9.13. Micro wind generation is capable of supplying specific developments with private energy for example small 15 kW turbines could be located in the school grounds.

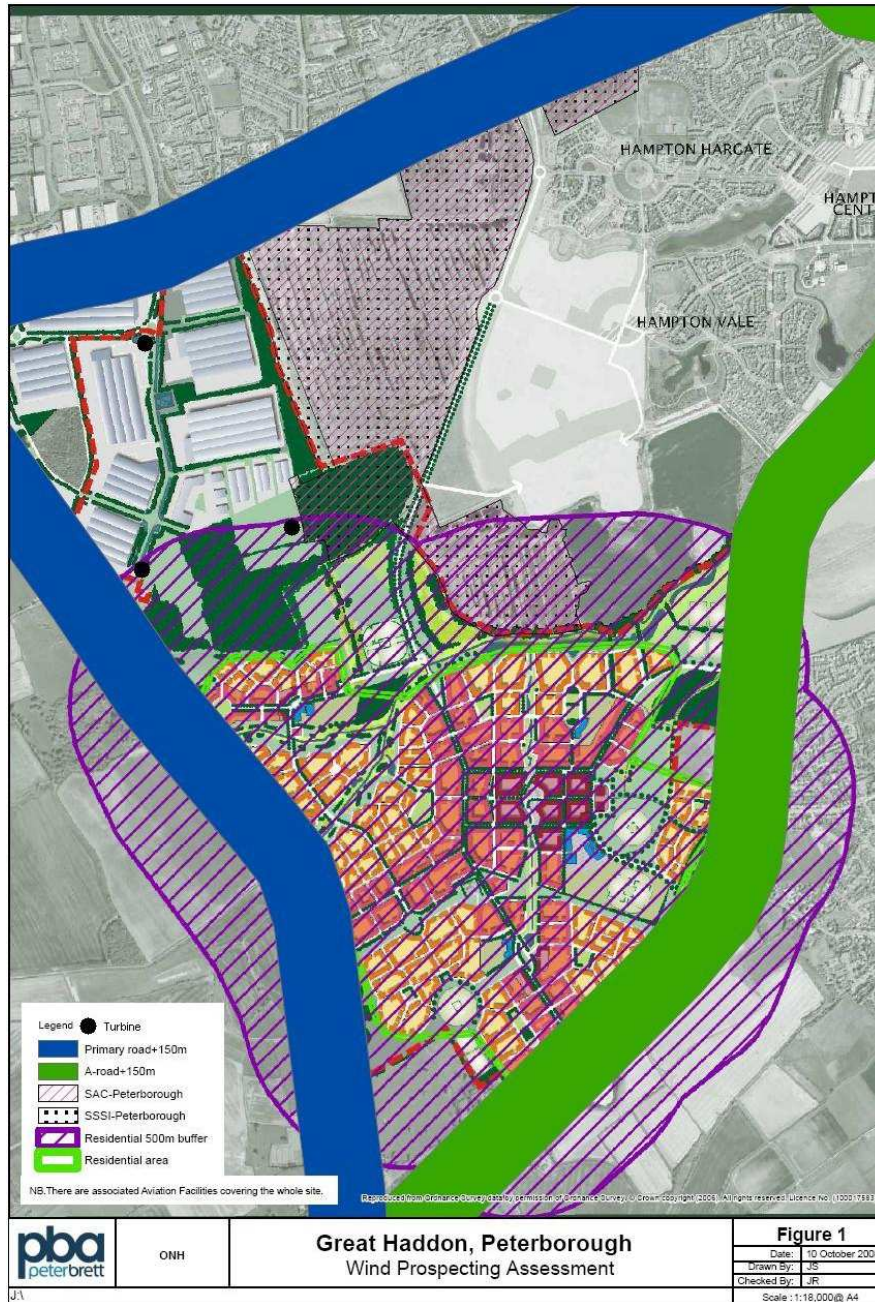


Figure 2: High Level Wind Prospecting Assessment

Energy Output

6.9.14. The benchmark electrical demand for the site is approximately 33,300,000 kWh/year. Theoretically wind can meet 100% of the electrical demand. This would equate to approximately 17,880,000 kg of CO₂/year. This would mean about a maximum of 60% reduction in CO₂ emissions from using Wind Turbines is possible. One 3 MW Wind Turbine could provide 14% CO₂ reductions. To meet the target four 3 MW Wind turbines would be required. See Appendix 10.

- 6.9.15. The location and spacing of four 3 MW turbine would need to be considered carefully. 1 wind turbine could easily be sited in the industrial area.
- 6.9.16. By reducing the energy demand using wind turbines, could reduce the burden of additional energy supply from off site. Initial investigation indicates that there is no spare electrical capacity within the current electricity network for this development, so any extra electrical capacity will be extremely beneficial if not imperative for the development to proceed.
- 6.9.17. Large turbines could be installed early on in the project and the excess electricity generated can be sold back to the grid and used to help finance the turbines. This would have to be investigated as part of the economic assessment for wind.
- 6.9.18. The inclusion of three or more large wind turbines would contribute significantly in the long term, to meet local/district/government targets for renewable energy and meeting CfSH/BREEAM requirements. This would present a likely major beneficial effect to meeting energy requirements.
- 6.9.19. Finally, the proposed changes to the definition of zero carbon homes are likely to allow greater flexibility in the use of off-site solutions which need not be directly connected to each dwelling. This is proposed as an “allowable solution” within the CLG’s consultation document, published December 2008. This, combined with high levels of energy efficiency and some on-site renewables and/or low carbon technologies may prove to be the most cost effective way of delivering the zero carbon homes and non-domestic buildings within the development.

6.10 Heat Pumps

- 6.10.1. Heat Pumps (HPs), work by upgrading low heat energy to useable energy for space and water heating, using electrical power through a refrigeration cycle. Generally for 1 kWh of electricity in, approximately 3 kWh of useful energy is produced.
- 6.10.2. HP’s work more efficiently if the temperature difference between the energy source and the heating required is low. Therefore they are best suited for low system temperatures such as under floor heating, low energy radiators etc. and not for hot water.
- 6.10.3. The main types of heat pumps available, in order of efficiency are: waste heat, water, ground and air source (waste heat, being of the highest efficiency). Ground source HP’s are generally the most often used.
- 6.10.4. Further, should the hydrogeology of the site be particularly favourable (i.e. high water table, wet clays or above an aquifer) GSHP may be particularly suitable to deliver CO₂ emission reductions.
- 6.10.5. There are two methods used for GSHPs, open loops or closed loops. Open loops would not be recommended as they require an abstraction license.
- 6.10.6. Closed loops can either be vertical or horizontal loops. Horizontal loops require a large amount of land.
- 6.10.7. Vertical closed loops require boreholes to be drilled vertically into the grounds close to the buildings. The borehole depth required can vary greatly depending of the ground characteristics but they are typically 100 m deep. Vertical loops produce a constant amount of energy all year round as the ground temperature at these depths remains fairly constant. Typical temperatures of the ground are 10°C (below 10m) and provide heat energy between 40 and 45°C. GSHPs can also provide cooling in the summer months at 6-9°C.

- 6.10.8. GSHP systems can be used for individual buildings, or on a larger scale to provide a pre-heat facility for a district or community heating system.
- 6.10.9. The ground conditions are thought to be preferable for heat pumps. High ground temperatures are expected due to the proximity of the brick kilns making this particularly favourable for both ground source and water source heat pumps to provide space heating. There are other sites in the area that have used the heat emitted by the brick kilns for heat pumps effectively.
- 6.10.10. Energy piles, whereby the structural piles are also used to accommodate GSHP pipework may be utilised in buildings having vertical piles. These are much shorter than dedicated boreholes, being typically 10 – 25 metres in depth and therefore deliver lower outputs than dedicated boreholes, but can provide a more cost-effective method of providing heating and cooling to buildings.

Site Constraints

- 6.10.11. There are many constraints of the different types of HP's but the main issues are summarised below.
- 6.10.12. GSHP systems deliver low temperature heat and therefore are most suitable to use with underfloor heating systems and large radiant panels, rather than traditional wet radiator systems. They can also be coupled with 4 pipe fan coil units in non-domestic buildings.
- 6.10.13. Horizontal GSHP systems require large areas of open land into which the horizontal pipework loops can be buried. It is unlikely that there is sufficient land to accommodate horizontal loops. Additionally, horizontal loop systems are more often provided in domestic applications. For these reasons, horizontal loops are not considered further in this report.
- 6.10.14. Open loop GSHP systems require an abstraction license from the Environment Agency. Further, discharges to watercourses would need to be strictly controlled in terms of chemical, bacterial and heat contamination. The presence of an aquifer is required to enable open loop systems to work effectively.
- 6.10.15. Closed loop GSHP systems require for the boreholes to be spaced at least 5 metres apart. Further, typical depths of dedicated boreholes is 100 metres.
- 6.10.16. Air source HP's have few constraints other than requiring a good access to air to allow the fans to operate correctly. These systems require ductwork to move the warm air to the areas where the demand exists. However, these systems. However, air source heat pump systems are highly seasonal in the efficiencies delivered and generally deliver lower efficiency levels than a typical ground source heat pump system.
- 6.10.17. Waste or exhaust air source HP's similarly have few constraints, However CO₂ reductions are usually smaller still, than those delivered by Ground source or air source heat pump systems.. These May be useful where high air tightness levels are required for buildings and mechanical ventilation systems are employed.

Energy Output

- 6.10.18. The Energy output has been based on GSHP's as the technology for the ease of this report.
- 6.10.19. Further GSHP systems can be used in reverse to provide cooling to buildings in summer months. This may be particularly useful in non-domestic buildings.
- 6.10.20. The Coefficient of Performance can be considered higher in this case as the land is in close proximity to the Kilns. For the purposes of these calculations a CoP of 4.6 is assumed.

6.10.21. The benchmark space heating demand for the site is approximately 55,800,000 kWh/year. Theoretically wind can meet 100% of the space heating demand. This would equate to approximately 5,700,000 kg of CO₂/year. This would mean about a maximum of just under 20% reduction in CO₂ emissions from using GSHP's is possible. See Appendix 11.

6.11 Combined Heat and Power Review

6.11.1. Combined Heat and Power (CHP) is a process where by a single fuel stream will generate both heat and power. The power generated is usually in the form of electrical energy. A typical CHP plant involves a reciprocating internal combustion engine that directly drives a generator to produce electricity. The heat produced in the combustion process is recovered through heat exchangers. The ability to use this heat increases the energy efficiency making CHP a preferable option for new land development schemes.

6.11.2. The benefits of a CHP can include the following:

- Energy Efficient
- Environmentally Benefits (reduced NO_x and SO_x emissions)
- Reduced Reliance on Electrical suppliers
- Revenue from the Selling of Electricity or heat
- Renewable Obligation Certificates (if run on biomass)

6.11.3. The viability of a CHP scheme depends on the technical and financial criteria. Before considering the financial feasibility the technical appraisal needs to be completed. The limited data currently available for this site will prevent an extremely accurate technical feasibility of CHP being undertaken at this stage. However during the details design process, the thermal loads associated with the site will become more accurate and a better understanding of the viability and size of various CHP applications will be achieved.

6.11.4. Whether a scheme is suitable for CHP depends heavily on the requirement for a constant thermal demand and the resulting thermal load to power ratio for the building, system or site. CHP is a very good option where the ratio of thermal load to power demand is constant and between 1.3:1 and 2:1. A heat load to power load ratio of 4 :1 is considered well balanced therefore also a good option for CHP.

6.11.5. Additionally, good CHP systems should run for at least 5,000 hours per annum to make them economically viable. Therefore a year round thermal demand is essential in considering the feasibility of CHP systems.

6.11.6. For Great Haddon the dwellings ratio of Heat to electricity demand is 3:1, which is lower than optimal but is still good for CHP however, the heat demand is not constant and the issue of what is done with the heat in summer months when the demand for heat is minimal is one which would have to be carefully considered.

6.11.7. The non residential heat to electricity ratio is approximately 2:1, which means some of the units may be good for CHP but not all. However non-domestic buildings may have a requirement for cooling and CHP systems can be coupled with Absorption chillers to create Tri-Generation systems which provide heat, cooling and power. Therefore the thermal to electrical load ration may be more favourable when the requirement for cooling is considered.

6.11.8. The mixed use nature of the development may present opportunities for incorporating CHP, particularly where there is a mix of retail, leisure, residential and commercial facilities in close proximity of one another.

- 6.11.9. A typical CHP plant will consist of the following components; prime mover (engine that drives the generator); the fuel system; generator (generating the electricity to be used in the buildings); heat recovery system (recovering the usable heat to be fed into the buildings); cooling system; combustion and ventilation air systems; control systems; and the enclosure.
- 6.11.10. Small scale CHP units are typically below 1 MWe. The majority of UK small scale CHP units are spark ignition/ gas fuelled engines that can be from 200 kWe to 500 MWe.

CO₂ and SO_x Savings

- 6.11.11. The CO₂ and SO_x savings for using a CHP unit can be considerable if compared to the energy supplied from a traditional power station and a boiler. According to the CIBSE guide “Small Scale Combined Heat and Power for Buildings” if you compare traditional energy generation with the same energy output from a CHP unit: 135 kg of CO₂ is produced per hour for a coal power station and boiler, compared with only 58kg per hour from a CHP unit.
- 6.11.12. Considerable SO_x savings can be also made comparing CHP to coal power station and coal fired boilers. Where a CHP is instead of a gas fired plant then the SO_x savings are almost zero.

Energy Output and Scale of CHP Required

- 6.11.13. It is difficult to undertake any sizing of the CHP plant and any calculations undertaken and indicated in this section will have to be verified once more details about the site are finalised. The sizing of CHP plant is a detailed process involving the estimation of peak and base loads for all the energy uses. For the purposes of this site only the energy loads from the residential units has been looked at in more detail than the non-residential loads as there is more information available for the residential units.
- 6.11.14. The base load is assumed to come from the water heating load because this will remain fairly constant all the year round. The peak load for the water heating is estimated to be approximately 16,000 kWth. The base load for thermal demand will be approximately 6,000 kWth. It has been assumed that the CHP will run 5000 hours a year minimum. The lowest load would be in August. Looking at the thermal output from different CHP units running for 14 hours a day, every day in August the largest CHP unit that could be used to deliver only the base was approximately 2100 kWe assuming no heat can be dumped and it is all utilised within the site, thereby requiring no other hot water generation facility for the residential element of the development. See the Appendix 12 for the full assumptions made to obtain approximate CHP sizings. The overall % CO₂ reductions for just the residential emissions can be reduced by 26%. In the earlier years this % will increase as not all the emissions produced by the residential unit is taken into account due to SAP. See Previous Chapter 4. A CHP Unit in the Residential areas would reduce only 10% of the whole of the site’s emissions.

Table 7.1: Summary of Site Wide CHP Opportunity

CHP Unit Used in	Power kW		% CO ₂ Savings for Resi/Non Resi Separately	% CO ₂ Savings for whole site	CO ₂ Reduced Tonnes/year
	Electric	Thermal			
Residential	2,100	3,465	26	10	2,952
Non Residential (total)	700	1,155	8	5	1,533
Hot water	502	828			
Cooling	198	327			
Total				15	4,485

- 6.11.15. For non residential buildings, any calculations were based on very high level assumptions as the actual use and occupation of the buildings is not known. Based on these high level assumptions, the water heating load was very low so the size was limited to 500 kWe but additional cooling demand could raise this to 700 kWe. See the Table 7.1 for the CO₂ emissions reduced for the CHP Units. However the contribution the CHP units make to the reduction in emissions for the non residential uses is only 9% and to the site wide emissions-only 5% reduction.
- 6.11.16. If both 2100 and 700 kWe CHP units were used, this would only reduce 15% CO₂ emissions. In reality the implementation of CHP in this scheme depends on the phasing of the residential and non-residential units. Phased CHP has been looked at in detail in Chapter 8. The results are much better because of the lower emissions that are taken into account for Level 3 and 4 of CfSH as mentioned previously.
- 6.11.17. Currently the percentage of emissions savings can only be calculated using the heating saved in SAP, so does not take into account the savings made on the electrical front. This would increase the percentage saved. SAP is under going a review this year so this may be changed to the advantage of this site.
- 6.11.18. The viability of CHP can depend on the length of the district heating network required. It may become clear at detailed design stage that it is not be viable for all the residential and non residential units to be connected to one district network. The non-residential/employment units to the North East of the site would probably require their own CHP unit. A full cost analysis would make this clear but is beyond the scope of this report.
- 6.11.19. Another way of reducing the length of the district network is by having smaller CHP units around the site. This may also be easier in terms of the phasing of the site. A draw back of smaller/separate CHP units is that there CHP will be less efficient and its capital cost will be greater and separate energy centres will be required.
- 6.11.20. For example looking at the District Centre, there is a higher non-residential emphasis compared to residential (See Appendix 1: Land Use Budget). Despite this, CHP would be particularly suited here as there is a higher density of use and the mixed use means that the CHP unit can be run for longer hours. Approximately the CHP unit for Residential is 150 kWe and for non residential it is 200 kWe (based on cooling demand as well as water heating). See Table 7.2.
- 6.11.21. To reach Zero Carbon Currently requires renewable fuel has to be used, such as biodiesel, methane, biomass via gasification etc. The price of biodiesel currently is very high and would make the running of a biodiesel CHP unit uneconomic and unattractive to investors. There are also limited sizes of biodiesel CHP units available. However currently, the definition of Zero Carbon is being redefined and part of the definition may include a proportion of the CO₂ savings to be made through efficiencies. Gas CHP may be able to meet this. This could also be solved by initially designing the CHP unit to be dual fuel, where initially it is gas fuelled and later it can run on bio-fuel.

Table 7.2: Gas CHP Opportunities in the District Centre

CHP Unit Used in	Power kW		% CO ₂ Savings for just Residential or just Non Residential	Site Wide % CO ₂ Savings	CO ₂ From Site Tonnes/year	CO ₂ Reduction Tonnes/year
	Electric	Thermal				
Residential	150	248	<u>27</u>	<u>6</u>	868	235
Non Residential (total)	200	330	<u>12</u>	<u>9</u>	2,770	320
Hot water	114	188				
Cooling	86	142				
Total				<u>15</u>	3,638	555

Financial Savings

6.11.22. The financial feasibility of CHP is not within the scope for this report. However significant savings can be generated from the Climate Change Levy Tax. Climate Change Levy (CCL) is a duty on the use of energy in industry. An exemption from CCL can be granted for the fuel used to run Good Quality CHP and electricity generated by Good Quality CHP. The Climate Change Levy (CCL) has been charged to non-domestic electricity customers since 1st April 2001 at a rate of £4.41/MWh.

6.11.23. Renewable Obligation Certificates can also be gained if the CHP is run on a renewable energy fuel source.

6.11.24. See Figure 3 for a typical CHP unit.



Figure 3: Typical CHP Plant

6.11.25. At this stage CHP appears to be favourable for parts of the development where there is a good mix of uses presenting a constant thermal demand on both a diurnal and annual basis. However, the sizing of any CHP units cannot be determined until a more accurate understanding of the thermal loads is provided. It is expected that this can be more thoroughly interrogated within the detail design stage of the development.

7 Sustainable Energy Strategy

7.1 Summary of Carbon Dioxide Target Reductions

- 7.1.1. As previously calculated from the predicted energy demand the following carbon dioxide target reductions will be aimed for. See Table 7.1.

Table 7.1: Summary of Benchmark Predicted Carbon Dioxide Emissions for Great Haddon Option 1 Phase 1-3

Phases	Option 1: Emissions Reductions (Tonnes/Year)				Total Emissions Reduction (Tonnes/year)	CO ₂
	Phase 1	Phase 2	Phase 3	Phase 3b		
Residential	479	1,030	6,052	0	7,560	
Non-Residential	0	1,514	1,688	2,943	6,145	
Total Emissions Reduction	479	2,544	7,739	2,943	13,705	

7.2 Phase 1 (2010-2013) Private Housing, Social housing and Non Residential

- 7.2.1. There are many renewable and low carbon options available within at first phase of construction. The private housing will be able to reach the energy targets of the Level 3 of CSH through energy efficiencies alone however it would be more cost effective to use solar thermal panels. The social and affordable housing have 4 solutions to reach Level 4. Solution 1 integrates biomass boilers in each dwelling. This will meet over an above the carbon dioxide reduction required. Solution 2 uses energy efficiencies combined with a solar thermal panel that is powered by a PV cell. Solutions 3 and 4 use a solar PV panel or Wind but they cannot reduce the emissions associated with the full electrical demand as SAP at this level does not take into account the full electrical load and therefore high energy efficiencies are need to make up the short fall. See Table 7.2.
- 7.2.2. CHP was not considered here as the social houses will be integrated in different locations around the site and a biomass/solar solution would be easier to apply. However if they are to be located close to each other then Gas CHP could be an option. The non-residential buildings do not have any targets during Phase 1. It is recommended that the majority of these houses are orientated to be south facing to optimise the use of solar panels. Where this is not possible then individual biomass boilers would be recommended.

Table 7.2 Summary of Achieving Targets Phase 1 (2010-2013)

Residential	No of Units	Target	Solutions	Renewables	CO ₂ Reduction	(CO ₂ Reduction Required)
		CfSH				
Private	700	Level 3	Solution 1	25% Efficiencies	273	273
			Solution 2	4m ² Solar panel for each house	361	273
Social/Affordable	300	Level 4	Solution 1	15 kW Biomass boiler for space and water heating for every dwelling(total of 4500 kW)*	321	206
			Solution 2	11% Efficiencies**	51	206
				4 m ² Solar thermal for each house for the hot water with PV powered pump	155	
				Total	206	
			Solution 3	19% Efficiencies**	88	206
				100 kW Wind Turbine***	118	
				Total	206	
			Solution 4	23% Efficiencies**	107	206
				PV panels	99	
				Total	206	

*This solution would produce a reduction of over 44% and assumes 100% of heating demand met. Also transportation emissions have been taken into account.

** Assume efficiencies are gained from space heating.

***This solution is not currently recommended as a private wire arrangement is needed.

7.3 Phase 2: (2013-2016) Private Housing, Social housing & Non residential

7.3.1. There are many options for reaching Level 4 for the dwellings as before in Phase 1. See Table 7.3. The only difference is that Gas CHP becomes more viable as there are now 1500 houses all which need a 44% reduction in CO₂ emissions. The CHP unit reduces a greater % of CO₂ emissions because SAP does not take into account the full emissions from the site and therefore performs better at Level 4 reducing emissions by 37%. If some of the houses are not able to be connected to the district heating network then they should be orientated to make use of solar thermal panels (plus efficiencies). If solar thermal panels cannot be utilised for outstanding houses then individual biomass boilers are recommended.

7.3.2. The non-residential solutions need to reach 25% reductions in CO₂ emissions for phase 2. There have been many high level assumptions made here and there the simplest and most effective solution has been sought. As the loading for non-residential buildings tends to be electrical, it is more effective to have a wind turbine to substitute the energy that would be created by a power station. CHP could be incorporated in the non-residential areas, depending on how far away from the residential areas they are.

7.3.3. In reality once the designs are finalised for the non-residential buildings, a broader range of renewable solutions will be available.

Table 7.3: Summary of Achieving Targets Phase 2 (2013-2016)

		Target	Solutions	Renewables	CO ₂ Reduction	(CO ₂ Reduction Required)			
Residential	No of Units	CfSH							
Private/Social/Affordable	1,500	Level 4	Solution 1	15 kW Biomass boiler for space and water heating for every dwelling* (Total 22,500kW)	1606	1,030			
			Solution 2	11% Efficiencies**	255	1,030			
				4 m ² Solar thermal for each house for the hot water with PV powered pump	774				
				Total	1,030	Does not reach target			
			Solution 3	7% Efficiencies**	162	1,030			
				600 kWe Gas CHP***	868				
				Total	1,030	Therefore exceeds target			
			Solution 4	23% Efficiencies**	531	1,030			
				450 Wind Turbine****	499				
				Total	1,030	Does not reach target			
			Non Residential	Area (m ²)	BREEAM				
			1/3 of all Non Residential including 1 primary	221,237		Solution 1	One Wind Turbine 1.1 MW	1552	1,514

*This solution would produce a reduction of over 44% and assumes 100% of heating demand met.

**Efficiencies are gained from space heating.

***Currently SAP only takes into account savings from heat delivered by CHP otherwise greater savings could be made that would reach the 44% alone.

****This solution is not recommended as a private wire arrangement is currently needed.

7.4 Phase 3: (2016 +) Private Housing, Social Housing & Non Residential

- 7.4.1. The solutions available for residential units reaching Zero Carbon are more limited than Level 3 and Level 4. See Table 7.4. 100% of the emissions created from all of the energy uses has to be replaced by renewable energy or has to be reduced by energy efficiencies. 30% has been assumed to be reduced through energy efficiencies and that leaves 70% of the emissions to be reduced through renewables. The majority of the reductions through energy efficiencies are from reductions made to space heating demand.
- 7.4.2. For the emissions due to electrical uses, the most economical solution would be a 1.7 MW Wind Turbine. This would have to be situated in the North West of the site and is only an “Allowable Solution” if the definition of Zero Carbon changes as proposed in the Communities and Local Government consultation document. The only solution available which meets the current definition of Zero Carbon is to incorporate PV on all the dwellings as per Solution 2. However this is likely to be cost-prohibitive and there may be insufficient roof space, or south facing area into which the PV’s can be incorporated. This is particularly true for apartment blocks.
- 7.4.3. For the emissions due to the heating demand a 900 kWe biomass/biofuel CHP could be incorporated. However as explained in the previous CHP section, biomass/biofuel is restricted in engine availability and the fuel for biodiesel is currently expensive. There are questions about the sustainability of bio-diesel resources. Currently there is research into fuel from algae which would provide a sustainable and local fuel source. If Zero Carbon becomes more stringent and all the emissions associated with all the energy uses have to be reduced then to meet the remaining space/water heating demand the needs to be a 1.8MWth Biomass boiler.
- 7.4.4. If the biomass CHP is not an option then a 7 MWth biomass boiler would need to be implemented to meet the entire space/water heating demands.
- 7.4.5. The non-residential units will be required to reduce 44% emissions, this can be achieved through a 1.5 MW Wind Turbine. Again CHP could be incorporated in the non-residential areas, depending on the distance from the residential areas and could be used in conjunction with absorption chillers to deliver cooling as required.

Table 7.4: Summary of Achieving Targets Phase 3 (2016-2019)

	No of Units	Target	Solutions	Low Carbon/ Renewables	CO ₂ Reduction (Tonnes)	(CO ₂ Reduction Required)	
Residential (2016+)		CfSH					
Private/ Affordable Social/ 2,783	Zero Carbon	Solution 1	Efficiencies 30% *	1,850	6,052		
			Community Large Scale Wind 1.7 MW **	2,343			
			0.9 MWe Community Biomass CHP ***	2,277			
			1.8 MW Biomass Boilers****	16,324			
			Total	22,794		Therefore exceeds target	
			Solution 2	Efficiencies 30% *		1,850	6,052
				PV 24m2 - 28m2 per house (approximately a total of 67500 m2)		2,343	
				0.9 MWe Community Biomass CHP ***		2,277	
				1.8 MW Biomass Boilers****		16,324	
				Total		22,794	
Non Residential - 2016-2019		BREEAM					
1/6 of all Non Residential including 1 primary and 1 secondary schools	143,535	44% CO ₂ Reduction	Solution 1	1.5 MW Large Wind Turbine	2,187	1,688	
				Total	2,187	Therefore exceeds target	

*Efficiencies are made from 80% reduction of space heating, 10% reduction in water heating and 30% reduction in electrical demand

**Wind meets the full electrical demand for the site

**** Meets total remaining heat demand. When the definition of Zero Carbon is reviewed the Biomass boilers may not be needed as the carbon reduction figure has already been reached with the previous solutions

7.5 Phase 3b: (2019 +) Non Residential

7.5.1. It has been assumed the remaining non-residential buildings will need to meet Zero Carbon and the same assumptions have been made as for residential units; 100% of the emissions associated have to be reduced through renewables. It has been assumed that 30% as energy efficiency and 70% as renewables. As the electrical demand is high, a 1.32 MW Wind Turbine can be implemented. Energy Efficiencies and a Wind Turbine account for the emissions of the non-residential site. However, if the Zero Carbon definition becomes more stringent then the remaining water/space heating demand may have to be met and this would require a 1.4 MW biomass boiler. See Table 7.5.

Table 7.5: Summary of Achieving Targets Phase 3b (2019 +)

	No of Units	Target	Solutions	Low Carbon/ Renewables	CO ₂ Reduction (Tonnes)	(CO ₂ Reduction Required)
Non Residential - Post 2019		BREEAM				
1/6 of all Non Residential	107,702	Zero Carbon	Solution 1	30% Efficiencies*	883	2943
				1.32 MW Wind**	1,905	
				1.4 MW Biomass Boilers***	432	
				Total	3,220	Therefore exceeds target

* Efficiencies are made from the space heating

** This meets all the electrical demands

*** This meets all the heat needs (CHP is not an option as there is too little load)

7.6 Phases 1-3b: Summary of Solutions

7.6.1. It can be seen from Table 7.6 of the summary of the recommended solutions, that the renewables and energy efficiencies are combined to achieve the required Carbon Dioxide Targets as calculated in previous sections.

Table 7.6 Chosen Solution and Contribution to CO₂ Reductions

Phases	Renewable Energy	CO ₂ Savings in Tonnes/year	CO ₂ Targets Tonnes /year
Phase 1 (private residential)	4m ² Solar panel for each house	361	273
Phase 1 (affordable residential)	11% Efficiencies	51	206
	4 m ² Solar thermal for each house for the hot water with PV powered pump	774	
Phase 2 resi	11% Efficiencies	162	1,030
	600 kWe Gas CHP	868	
Phase 2 Non Resi	One Wind Turbine 1.1 MW	1,552	1,514
Phase 3a Resi	Efficiencies 30%	1,850	6,052
	Community Large Scale Wind 1.7 MW	2,343	
	0.9 MWe Community Biomass CHP	2,277	
Phase 3a Non Resi	1.5 MW Large Wind Turbine	2,187	1,688
Phase 3b Non Resi	30% Efficiencies	883	2,943
	1.32 MW Wind	1,905	
Total		14,626	13,705

7.7 Schools

7.7.1. There are 3 primary Schools and 1 secondary school planned at this site. They have been included in the non-residential solutions. It is known that the CO₂ emissions reduction trajectory is as shown below:

- 2010 - 25% reduction
- 2013 - 44% reduction
- 2016 - 100% reduction

7.7.2. Schools are prime areas for the implementation of renewables and energy efficiencies. There are also advantageous for educational purposes as the subject of energy efficiency and global warming issues usually feature in the curriculum. However it is not known when they will be built. Therefore a range of % CO₂ reductions has been looked at and the cost implications given.

7.7.3. The cost of implementation will depend greatly on;

- CO₂ reductions targets that the school will be aiming for
- Whether it is a primary or secondary school
- The energy demand of the school.

7.7.4. Based on current masterplans, if one primary school aimed for 5% CO₂ reductions with a small wind turbine (10kW), the approximate cost = £30-35k. If 24% CO₂ reductions were aimed for with 2 small wind turbines (20k) then the approximate cost = £100k-120k.

7.7.5. If one primary school aimed for 25% CO₂ reductions with a biomass boiler the approximate cost = £50k-£80k. If 44% CO₂ reductions were aimed for then the approximate cost =£60k-100k.

7.7.6. If the secondary school aimed to reduce 60% of its CO₂ reductions with a biomass boiler and 2 small wind turbines (20 kW) the approximate cost = £350-500k.

8 Going Beyond the Building Regulations & CSH and Policy Targets

8.1 Innovative Technologies

8.1.1. To go above and beyond predicted building regulations, it is proposed for each phase to incorporate innovative technologies. Innovative technologies are defined as cutting edge technologies that have been tested but are not used often. These may not be energy related. Currently innovative energy technologies could include:

- Biomass Gasification
- Micro CHP
- Fuel Cells
- Wind Channelling Designs with Wind Turbines
- Solar PV and Wind Powered Ventilation
- Hemp Constructions with Lime Render
- Cob buildings
- Intelligent Glazing
- Vacuum double/triple glazing

8.1.2. When the final design of this development is undertaken these technologies may not be considered innovative so are subject to change.

8.2 Experimental Technologies

To go above and beyond predicted Building Regulations it will be recommended that experimental technologies will be employed at each phase. Experimental technologies are defined as technologies that are untested. They may not be energy related. Currently experimental technologies could include:

- Generating energy from algae/seaweed by:
- Seaweed fermentation to ethanol
- Gasification of seaweed to produce CO and H₂ then Fischer Tropsch to a crude oil
- Pressing high oil content algae to extract oil then transesterify to make biodiesel
- Anaerobic digestion to produce biogas
- Transport Fuel from fungi
- Wind Turbines with energy storage via water storage, hydrogen storage
- PV with alternatives of energy storage
- Green Concrete

8.2.2. When the final design of this development is undertaken these technologies may not be considered experimental or may not be appropriate, so are subject to change.

8.3 10% Policy Target

The Peterborough policy target was for 10 % renewable energy to be provided. Great Haddon exceeds this target by just under 4 times! As shown in Table 8.1.

Therefore the 10% target is easily met if predicted tightening of building regulations are followed.

Table 8.1: Chosen Solution and Contribution to Policy target for Renewable Energy

Phases	Renewable Energy	CO ₂ Savings in Tonnes/year	Policy Target for Renewables:
			10%
Phase 1 Private	4m ² Solar panel for each house	361	3,038
Phase 1 Social	4 m ² Solar thermal for each house for the hot water with PV powered pump	774	
Phase 2 Resi	600 kWe Gas CHP***	0	
Phase 2 Non Resi	One Wind Turbine 1.1 MW	1,552	
Phase 3a Resi	Community Large Scale Wind 1.7 MW **	2,343	
	0.9 MWe Community Biomass CHP ***	2,277	
Phase 3a Non Resi	1.5 MW Large Wind Turbine	2,187	
Phase 3b Non Resi	1.32 MW Wind**	1,905	
	1.4 MW Biomass Boilers***	432	
Total		11,401	
Therefore		3.75	times the target is reached!

It is further worth mentioning that the proposed energy strategy should also deliver the CO₂ emission reductions required to accord with the emerging Peterborough Core Strategy Preferred option CS 9.

9 Conclusions & Recommendations and Further Work

This report has investigated the possible energy efficient methods that could be incorporated into this development. A range of renewable energy technologies were examined, solar thermal, solar PV, biomass, wind turbines, GSHPs and Gas and Biofuel Combined Heat and Power.

- 9.1.1. As precise details size and mix of the development have yet to be agreed, broad assumptions have been made on the likely energy requirements of the site, based largely on best practice benchmarks, the building regulations and PBA's experience. These assumptions have been used to generate costs and energy yields of a range of technologies.
- 9.1.2. The aim has been to identify the most appropriate renewable energy technology and energy efficiency mix for the development by considering environmental, technical and approximate economic factors.
- 9.1.3. The main conclusions of this report are:-
- Energy Efficiency measures should be implemented where possible in order to reduce energy demand. The maximum level assumed is 30% for Zero Carbon.
 - It is technically feasible that sustainable energy technologies can contribute towards the target emissions reduction and if emission reductions are achieved by meeting CfSH and Building regulations targets, then the 10 % Local Policy reduction target can be easily reached.
 - The most suitable renewable energy applications for the proposed development are as Shown in Table 9.1

Table 9.1 Chosen Solution and Contribution to CO₂ Reductions

Phases	Renewable Energy	CO ₂ Savings in Tonnes/year	CO ₂ Targets Tonnes /year
Phase 1 (private residential)	4m ² Solar panel for each house	361	273
Phase 1 (affordable residential)	11% Efficiencies	51	206
	4 m ² Solar thermal for each house for the hot water with PV powered pump	774	
Phase 2 resi	11% Efficiencies	162	1,030
	600 kWe Gas CHP	868	
Phase 2 Non Resi	One Wind Turbine 1.1 MW	1,552	1,514
Phase 3a Resi	Efficiencies 30%	1,850	6,052
	Community Large Scale Wind 1.7 MW	2,343	
	0.9 MWe Community Biomass CHP	2,277	
Phase 3a Non Resi	1.5 MW Large Wind Turbine	2,187	1,688
Phase 3b Non Resi	30% Efficiencies	883	2,943
	1.32 MW Wind	1,905	
Total		15,215	13,705

- Alternatives have been suggested if the above solutions are not able to be implemented.
- Solar thermal panels would be a cheaper alternative and potentially can achieve the majority of the 44% emissions reductions targets, when combined with Energy Efficiency measures.

- A gas fired CHP system may be considered most economic at present. However, a single system may not be suitable for the whole site as economies depend on the length of the district heating network.
- Biomass/Biofuel CHP is not preferable at the moment but may be preferable in the future with better fuel price security. It is a more economic solution compared with individual biomass boilers.
- Solar thermal panels are also preferable to Communal Biomass boilers due to the constraints of flue emissions, fuel delivery, fuel storage, security of fuel supply and management issues.
- Communal Biomass Boilers could be a technology explored for this site and could easily supply the CO₂ emissions reduction required. However, it would depend on whether local suppliers can be sourced, the space available on site to put the biomass boilers and fuel storage units.
- A wind turbine installation is feasible for both non-residential and residential. However, there are constraints in the size of wind turbines used due to the current requirement for a private wire arrangement. Therefore PV may have to be implemented. The private wire requirement is currently under review.
- To go beyond the Building Regulations it has been recommended to implement innovative and experimental technologies.

Further work recommended:

- To recalculate Energy Demand Assessment demonstrating CO₂ emissions appropriate for each Target using:
 - SAP Calculations of the residential units.
 - SBEM for the non-residential units
- Evaluation of Chosen Renewable Technology to see if it can produce 20% renewable energy based on the actual Predicted Energy Demand.
- A CHP Options Appraisal - this will specifically look at the CHP and community heating options. This will establish the preferred CHP option in terms of engine size, use of thermal storage and the heat network design. It will also provide an indication of the cost of the CHP option, the heat network and private wire networks.
- To undertake a detailed biomass fuel resource assessment to establish availability and costs.
- To investigate potential funding/grant sources.
- This report needs to be reviewed when; the definition of Zero Carbon, the review of SAP and Building Regulations Part L are completed.
- To develop a business case for a sustainable energy scheme with a view to accessing finance and/or making an application of grant funding.
- To work with the sustainability team and the architects to achieve the most cost efficient way of achieving the Code Levels and % CO₂ reductions required.

10 References

1. Building Regulations Part L (L1A – New Dwellings, L2A New Buildings other than Dwellings), Conservation of Fuel and Power, April 2006
2. Code For Sustainable Homes, Technical Guide, Communities and the Local Government, October 2008
3. Definition of Zero Carbon Homes and Non-Domestic Buildings, Communities and Local Government, December 2008
4. GPG 343, Good Practise Guide Schools- Saving Energy – A Whole School Approach – Carbon Trust, March 2003
5. Wind in the Community
6. Good Practise Guide Small Scale CHP
7. CIBSE Guide CHP
8. Consumption Guide 19, Energy Use in Office, Action Energy/Carbon Trust, P20, Appendix B, Table B1, 2003
9. Rules of thumb, Guidelines for Building Services, P12. Table 1: Cooling Loads, BSRIA, 2003
10. London Renewables Toolkit
11. <http://earth2tech.com/2008/12/18/scotland-looks-at-seaweed-for-biofuel/> 2008
12. <http://www.guardian.co.uk/environment/2008/nov/04/biofuels-energy> 2008

Appendix 1: Great Haddon Summary Land Use Budget

(rev A 2-10-08)

Land Use	Area(Ha)		
Primary Schools	7.84		
Secondary Schools	8.43		
Open Space	116.73		
Playing Fields	14.67		
Existing Woodland	21.14		
Proposed Woodland	0.76		
Planting Buffer	3.88		
Primary Streets	23.39		
Existing Dwellings	0.48		
Residential:			
		Density	Dwellings
Higher Density Residential	40.55	50	2020
Medium Density Residential	80.35	35	2803
District Centre (Gross parcel area)	5.76	70	399
Neighbourhood Centres (Gross parcel area)	1.26	50	61
Total	325.24		5283
Commercial Floorspace:			
		Plot Ratio	Floorspace (sqm)
Northern Employment Area	65.41	0.5	327,060
District Centre (Gross parcel area)	5.76	0.4	23,013
Neighbourhood Centres (Gross parcel area)	1.27	0.4	5,059
Community Sites	1.38	0.25	3,456
Total	73.82		358,588
Total Area			
	392.04		
Unallocated Parcel 1 (shown hatched on DFP)	4.02		
Unallocated Parcel 2 (shown hatched on DFP)	1.35		
TOTAL AREA (within Red Line)			
	397.41		

Great Haddon Sustainable Energy Strategy

Split of Employment Use (sq.m)		Totals	% B1	% B2	% B8	% Retail	% Community	% Other (Flexible)*	
N Empl Area	327,060	15	49,059	40	130,824	45	147,177	0	0
Dist Centre, incl:	23,013	12	2,650	0	0	40	9,200	0	49
Supermarket	4,200								
B1 Enterprise Hub	650								
Local retail (A1, A2, A5)	5,000								
B1 Office	2,000								
*Balance of other uses (incl. hotel/comparison retail/commercial leisure)	11,163								
Nhood Centres	5,059	30	1,518	0	0	45	2,300	25	1,265
Comm Sites	3,456	0	0	0	0	0	100	3,456	0
Total	358,588	15%	53,227	36%	130,824	41%	147,177	3%	11,500

Jobs Generated (est)		Total	B1 jobs	B2 jobs	B8 jobs	Retail jobs	Community/Edu.	Other
N Empl Area	8,270	2,582	3,848	1,840	0	0	0	0
Dist Centre	1,738	691 *	0	0	460	0	0	588
Nhood Centres	261	80	0	0	115	67	0	0
Community Sites	182	0	0	0	0	182	0	0
Schools (est)	300	0	0	0	0	300	0	0
Total	10,751	3,353	3,848	1,840	575	548	588	

Appendix 2: Great Haddon Outline Development Plan

Great Haddon Sustainable Energy Strategy

From DLA, August 2008



Appendix 3: Benchmark Predicted Energy Demand

Great Haddon Sustainable Energy Strategy

Description of Land Use	Building Type	Assumed Unit Floor Area m ²	No.	Floor Area*No.	Annual Estimated Energy Consumption (MWh/year)					Annual CO ₂ Emissions (Tonnes/Year)				
					Electricity	Gas - Water & Space Heating	Gas - Water Heating	Gas - Space Heating	Total (Elec + Gas)	Electricity	Gas - Space & Water Heating	Gas - Water Heating	Gas - Space Heating	Annual Total (Gas + Elec)
					Annual	Annual	Annual	Annual		Annual	Annual	Annual	Annual	
Residential Housing														
Housing	Houses - 1 bed terrace/semi-detached	80	5,283	422,640	11,834	33,473	23,431	10,042	45,307	4,993.9	6,493.8	4,546	1,948	11,487.7
Total Floor Area:		422,640	m ²											
Sub Totals (Energy in MWh)			5,283		11,834	33,473	23,431	10,042	45,307	4,993.9		4,546	1,948	11,487.7
Non-Residential Commercial, Retail & Public Buildings														
Financial and professional services building	Banks and Building Societies (all-electric)	2,984	1	2,984	262	0	0	0	262	110.6	0.0	0	0	110.6
Industrial Buildings	B2 - General manufacturing	130,824	1	130,824	6,123	21,193	3,179	18,014	27,316	2,583.7	4,111.5	617	3,495	6,695.3
Education (Schools)	Primary	5,833	3	17,500	295	1,978	79	1,898	2,272	124.3	383.6	15	368	507.9
Education (Schools)	Secondary	30,000	1	30,000	574	2,479	99	2,379	3,052	242.1	480.8	19	462	723.0
Catering	Restaurant (with bar)	2,866	1	2,866	1,341	2,270	567	1,702	3,611	566.0	440.4	110	330	1,006.4
Catering	Public Houses	3,740	1	3,740	1,077	2,020	202	1,818	3,097	454.5	391.8	39	353	846.3
Catering	Fast-food restaurant	642	1	642	379	222	44	178	601	160.0	43.0	9	34	203.0
Sports and Recreation	Combined Centre	9,968	1	9,968	689	1,895	682	1,213	2,584	290.8	367.6	132	235	658.3
Storage and distributions warehouses	B8 - Storage and distribution warehouses	147,177	1	147,177	3,265	15,200	456	14,744	18,465	1,377.9	2,948.7	88	2,860	4,326.6
Local authority buildings	Park and Ride*	53,700	1	53,700	161	0	0	0	161	68.0	0.0	0	0	68.0
Offices	B1 - Air conditioned, standard	53,227	1	53,227	4,905	3,717	268	3,449	8,623	2,070.1	721.2	52	669	2,791.2
Superstores	Small food shops	7,184	1	7,184	2,069	414	62	352	2,483	873.1	80.3	12	68	953.4
Other	Primary Streets**	233,900	1	233,900	320	0	0	0	320	0.0	0.0	0	0	0.0
Total Floor Area:				693,712	m ²									
Sub Totals (Energy in MWh)		1,116,352	15	693,712	21,460	51,387	5,639	45,747	72,847	8,921		1,094	8,875	18,890.1
Totals		1,116,352	5,298	693,712	33,294	84,860	29,071	55,789	118,154	13,915		5,640	10,823	30,378

Note: Energy Benchmark data based CIBSE Guide F and reduced by 23% for natural ventilation & 28% for air-conditioned to reflect Part L 2006, Compliant Benchmarks and current best practice dwelling energy consumption data for a range of residential units

NB/ Totals may not add up due to rounding errors

** Assuming average hourly
 area 233,900 m²
 total 234 kW
 Diversity 0.3
 hours annually 4,563 (365 days a year summer assume 9 hours a day, winter assume 16 hours/day)
 Annual electrical demand 320 Mwh/year

Appendix 4: Benchmark Figures for Residential and Non-Residential

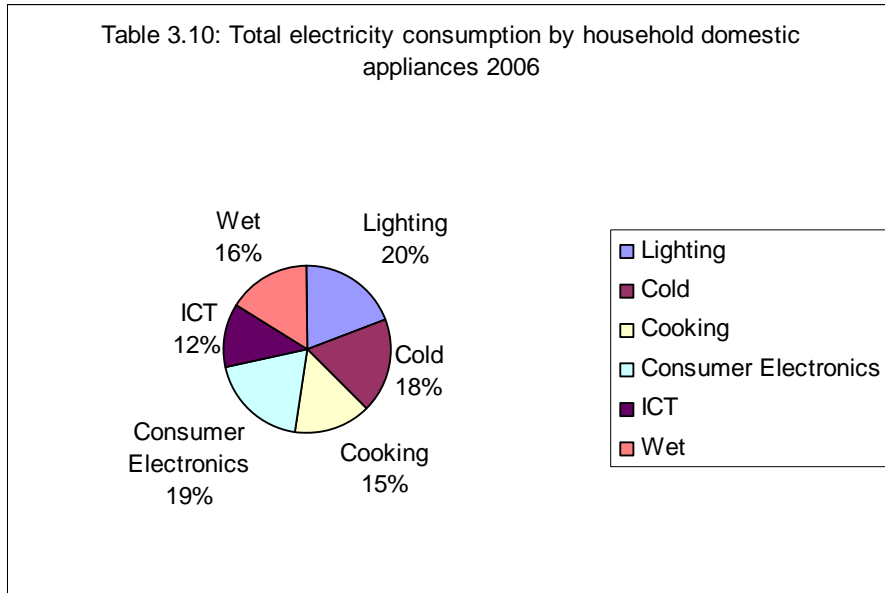
Great Haddon Sustainable Energy Strategy

Building Category	Building Use	Conversion Factors						Benchmark Source
		Energy Factor (kWh/m ² /yr)				CO ₂ Factor (kgCO ₂ /kWh)		
		Electricity	Gas (Space & Water Heating)	Gas - Water Heating	Gas - Space Heating			
		Annual	Annual	Annual	Annual	Electricity	Gas	
Residential								
Housing	Houses – 2/3 bed terrance/semi-detached	28	79	55	24	0.422	0.194	CIBSE
Non-Residential								
Financial and professional services building	Banks and Building Societies (all-electric)	88	0	0	0	0.422	0.194	BMI
Industrial Buildings	General manufacturing	47	162	24	138	0.422	0.194	EEO IEE
Industrial Buildings	Factory - office	52	108	16	92	0.422	0.194	EEO IEE
Industrial Buildings	Light manufacturing	33	134	20	114	0.422	0.194	EEO IEE
Education (Schools)	Primary	17	113	5	108	0.422	0.194	CIBSE
Education (Schools)	Secondary	19	83	3	79	0.422	0.194	CIBSE
Catering	Restaurant (with bar)	468	792	198	594	0.422	0.194	EEO IEE
Catering	Public Houses*	288	540	54	486	0.422	0.194	CIBSE

Great Haddon Sustainable Energy Strategy

Building Category	Building Use	Conversion Factors						Benchmark Source
		Energy Factor (kWh/m ² /yr)				CO ₂ Factor (kgCO ₂ /kWh)		
		Electricity	Gas (Space & Water Heating)	Gas - Water Heating	Gas - Space Heating			
		Annual	Annual	Annual	Annual	Electricity	Gas	
Catering	Fast-food restaurant	590	346	69	276	0.422	0.194	EEO IEE
Sports and Recreation	Combined Centre	69	190	68	122	0.422	0.194	CIBSE
Storage and distributions warehouses	Storage and distribution warehouses	22	103	3	100	0.422	0.194	EEO IEE
Local authority buildings	Park and Ride*	3	0	0	0	0.422	0.194	CIBSE
Offices	Air conditioned, standard	92	70	5	65	0.422	0.194	CIBSE
Superstores	Small food shops	288	58	9	49	0.422	0.194	CIBSE
Superstores	Small food shops (all-electric)	317	0	0	0	0.422	0.194	CIBSE

Appendix 5: Approximate Uses in a Domestic House



Energy consumption in the United Kingdom: Domestic Data Tables Update (BERR)

<http://www.berr.gov.uk/whatwedo/energy/statistics/publications/ecuk/page17658.html>

Appendix 6: Phase 1, Private Residential

Great Haddon Sustainable Energy Strategy

Description of Land Use	Building Type	Assumed Unit Floor Area m ²	No.	Floor Area*No.	Annual Estimated Energy Consumption (MWh/year)					Annual CO ₂ Emissions (Tonnes/Year)			
					Electricity	Gas - Water & Space Heating	Gas - Water Heating	Gas - Space Heating	Total (Elec + Gas)	Electricity	Gas - Space & Water Heating	Gas - Water Heating	Gas - Space Heating
					Annual	Annual	Annual	Annual		Annual	Annual	Annual	Annual
Residential Housing													
Housing	Houses - 2/3 bed terrace/semi-detached	80	900	72,000	2,016	5,702	3,992	1,711	7,718	850.8	1,106.3	774	332
Total Floor Area:		72,000	m ²										
Sub Totals (Energy in MWh)			900		2,016	5,702	3,992	1,711	7,718	850.8	1,106.3	774	332

Assuming 10% is affordable housing

Appendix 7: Solar Thermal Calculations for Hot Water for Residential and Non- Residential

Great Haddon Sustainable Energy Strategy

Table 1: Predicted Energy Use Required for Hot Water using Benchmark Figures (to be Confirmed by SAP Data) and the CO₂ Emissions Reduced

Land Use	Building Type	Assumed Unit Floor Area (m ²)	No. Units	Total Thermal Energy for Hot Water Required (kWh/year)	60% of Total Hot Water to be Provided by Solar Panel (kWh/year)	Annual CO ₂ Emissions Reduced by Solar Panel (kg/year)
Housing	Houses - 2/3 bed terrace/semi-detached	80.00	5,283	23,431,162	14,058,697	2,727,387

Table 2: Summary of CO₂ Emissions Reduced for Residential for Solar Thermal

10%	Residential CO ₂ target:	1,148,769	kg/year
	CO ₂ emissions		
	Reduced:	2,727,387	kg/year
Percentage Reduced for Residential Only:		24%	(equivalent to 1 house)

Table 3: Predicted Energy Use Required for Hot Water using Benchmark Figures and the CO₂ Emissions Reduced

Land Use	Building Type	Assumed Unit Floor Area (m ²)	No. Units	Total Thermal Energy for Hot Water Required (kWh/year)	60% of Total Hot Water to be Provided by Solar Panel (kWh/year)	Annual CO ₂ Emissions Reduced by Solar Panel (kg/year)
Financial and professional services building	Banks and Building Societies (all-electric)	2,984.00	1	0	0	0
Industrial Buildings	B2 - General manufacturing	130,824.00	1	3,179,023	1,907,414	370,038
Education (Schools)	Primary	5,833.33	3	79,100	47,460	9,207
Education (Schools)	Secondary	30,000.00	1	99,144	59,486	11,540

Great Haddon Sustainable Energy Strategy

Catering	Restaurant (with bar)	2,866.00	1	567,468	340,481	66,053
Catering	Public Houses	3,740.00	1	201,960	121,176	23,508
Catering	Fast-food restaurant	642.00	1	44,375	26,625	5,165
Sports and Recreation	Combined Centre	9,968.00	1	682,098	409,259	79,396
Storage and distributions warehouses	B8 - Storage and distribution warehouses	147,177.00	1	455,991	273,595	53,077
Local authority buildings	Park and Ride*	53,700.00	1	0	0	0
Offices	B1 - Air conditioned, standard	53,227.00	1	268,264	160,958	31,226
Superstores	Small food shops	7,184.00	1	62,070	37,242	7,225
Other	Primary Streets**	233,900.00	1	0	0	0
Total		682,045.33	15	5,639,493	3,383,696	656,437

Table 4: Summary of CO2 Emissions Reduced for Non Residential and Residential for Solar Thermal

10%	CO ₂ target for whole site:	3,037,776	kg/year	Total energy required to heat water (kWh/year) =	<u>29,070,655</u>
Total	CO ₂ emissions Reduced:	3,383,824	kg/year	Total energy produced by Panels to heat water(kWh/year)=	<u>17,442,393</u>
Total Percentage that can be reached for non-residential:				11.1%	-
The CO ₂ target of:				10%	CAN <u>be reached</u>

Appendix 8: Predicted Electrical Energy Use and PV for Residential and Non- Residential

Table 1: Predicted Benchmark Electrical Energy for Residential usage if all units are to be fitted with PV (to be confirmed by SAP data) and the CO₂ emissions Reduced

Land Use	Building Type	Assumed Unit Floor Area (m2)	No. Units	Total Electrical Energy Required (kWh/year)	Annual CO ₂ Emissions Reduced by PV (kg/year)
Housing	Houses - 2/3 bed terrace/semi-detached	80.00	5283	11,833,920	6,354,815
Total		80.00	5,283	11,833,920	6,354,815

Table 2: Summary of CO₂ Emissions Reduced For Residential Using PV

10%	Residential CO ₂ target:	1,148,769	kg/year
	CO ₂ emissions Reduced:	6,354,815	kg/year
	Percentage Reduced for Residential Only:	55%	(equivalent to 1 house)

Table 3: Predicted Benchmark Electrical Energy for Non Residential usage if all units are to be fitted with PV and the CO₂ emissions Reduced

Land Use	Building Type	Assumed Unit Floor Area (m2)	No. Units	Total Electrical Energy Required (kWh/year)	Annual CO ₂ Emissions Reduced by PV (kg/year)
Financial and professional services building	Banks and Building Societies (all-electric)	2984.00	1	262,115	140,756
Industrial Buildings	B2 - General manufacturing	130824.00	1	6,122,563	3,287,816
Education (Schools)	Primary	5833.33	3	294,525	158,160
Education (Schools)	Secondary	30000.00	1	573,750	308,104
Catering	Restaurant (with bar)	2866.00	1	1,341,288	720,272
Catering	Public Houses	3740.00	1	1,077,120	578,413
Catering	Fast-food restaurant	642.00	1	379,037	203,543
Sports and Recreation	Combined Centre	9968.00	1	688,988	369,987
Storage and distributions warehouses	B8 - Storage and distribution warehouses	147177.00	1	3,265,122	1,753,370
Local authority buildings	Park and Ride*	53700.00	1	161,100	86,511
Offices	B1 - Air conditioned, standard	53227.00	1	4,905,400	2,634,200
Superstores	Small food shops	7184.00	1	2,068,992	1,111,049
Other	Primary Streets**	233900.00	1	320,151	171,921
Total		682,045.33	15	21,460,150	11,524,101

Table 4: Summary of CO2 Emissions Reduced for Non Residential and Residential for Solar PV

10%	CO ₂ target:	3,037,776	kg/year	Total energy required to for elec (kWh/year) =
Total	CO ₂ emissions Reduced:	17,878,916	kg/year	Total energy produced by Panels (kWh/yea
Percentage that can be reached:		58.9%		Area of PV Panels (m2):
The CO ₂ target of:	10%	CAN	<u>be reached</u>	-
				-

Appendix 9: Approximate Sizes of Fuel Storage for Biomass Boiler

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Table 1: Predicted Benchmark Heat Energy (Space and hotwater heating) for Residential usage if all units are to be fitted with biomass boilers (to be confirmed by SAP data) and the CO2 emissions Reduced

Land Use	Building Type	Assumed Unit Floor Area (m ²)	No. Units	No. Units Required for the Biomass Boiler	Total Floor Area (m ²)	Total Thermal Energy Requirements Met (kWh/year)	Annual Emissions Created by Transportation of Biomass (kg/year)	CO ₂ Emissions Created by Fuels (kg/year)	Annual Emissions That Would be Created by Gas Heating (kg/year)	CO ₂ Emissions Saved by Biomass Boilers (kg/year)
Housing	Houses - 2/3 bed terrace/semi-detached	80.00	5,283	5,283	422,640	28,452,125	711,303	5519712.2	4,808,409.1	

NB/ 85% of demand met

Table 2: Summary of CO2 Emissions Reduced For Residential (District Heating) Using Biomass Boilers

10% Residential CO ₂ target:	1,148,769 kg/year
CO ₂ emissions Reduced:	4,808,409 kg/year
Percentage Reduced for Residential Only:	42% (equivalent to 1 house on a district heating scheme)
for 1 house the space and hot water demand is:	6,336 kWh/year

Table 3: Summary of CO2 Emissions Reduced For A Residential Using One Biomass Boilers

for 1 house the space and hot water demand is:	6,336 kWh/year
CO2 for a house:	2,174 kg/year
CO2 Reduced for a house:	1,071 kg/year
Percentage Reduced for Residential Only:	49% (equivalent to 1 house if one biomass boiler is installed)

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Table 4: Predicted Benchmark Heat Energy (Space and hot water heating) for Non Residential usage if all units are to be fitted with biomass boilers (to be confirmed by SAP data) and the CO2 emissions Reduced

to Meet: 85% of the Demand

Land Use	Building Type	Assumed Unit Floor Area (m ²)	No. Units	Total Floor Area (m ²)	Total Thermal Energy Requirements (kWh/year)	Annual CO ₂ Emissions Created by Transportation of Biomass Fuels (kg/year)	Annual CO ₂ Emissions That Would be Created by Gas Heating (kg/year)	CO ₂ Emissions Saved by Biomass Boilers (kg/year)
Financial and professional services building	Banks and Building Societies (all-electric)	2,984.00	1	2,984	0	0	0.0	0.0
Industrial Buildings	B2 - General manufacturing	130,824.00	1	130,824	18,014,465	450,362	3,494,806.2	3,044,444.6
Education (Schools)	Primary	5,833.33	3	17,500	1,680,875	42,022	326,089.8	284,067.9
Education (Schools)	Secondary	30,000.00	1	30,000	2,106,810	52,670	408,721.1	356,050.9
Catering	Restaurant (with bar)	2,866.00	1	2,866	1,929,391	48,235	374,301.9	326,067.1
Catering	Public Houses	3,740.00	1	3,740	1,716,660	42,917	333,032.0	290,115.5
Catering	Fast-food restaurant	642.00	1	642	188,594	4,715	36,587.2	31,872.4
Sports and Recreation	Combined Centre	9,968.00	1	9,968	1,610,510	40,263	312,438.9	272,176.2
Storage and distributions warehouses	B8 - Storage and distribution warehouses	147,177.00	1	147,177	12,919,749	322,994	2,506,431.3	2,183,437.6
Local authority buildings	Park and Ride*	53,700.00	1	0	0	0	0.0	0.0
Offices	B1 - Air conditioned, standard	53,227.00	1	53,227	3,159,768	78,994	612,994.9	534,000.7
Superstores	Small food shops	7,184.00	1	7,184	351,729	8,793	68,235.4	59,442.1
Other	Primary Streets**	233,900.00	1	0	0	0	0.0	0.0
Total		682,045.33	15	406,112	43,678,550	1,091,964	8,473,639	7,381,675

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Table 5: Summary of CO2 Emissions Reduced for Non Residential and Residential for Biomass Boilers

10%	CO ₂ target:	3,037,776	kg/year	Total energy required to for heating space&hotwater (kWh/year) =	<u>84,859,617</u>
Total	CO ₂ emissions Reduced:	12,190,084	kg/year	Total energy produced by Biomass boilers (kWh/year)=	<u>72,130,675</u>
Percentage that can be reached:		40.1%		CO2 Reduced (kg/year)=	<u>12,190,084</u>
The CO ₂ target of:	<u>10%</u>	CAN	<u>be reached</u>		

Appendix 10: Wind Turbine Sizing

Table 1: Summary of CO2 Emissions Reduced for Wind Turbines

Turbine Rating (kW)	3,000
Electricity generated per year (kWh/year)	8,146,800
CO2 emissions Reduced (kg/year)	4,374,832
CO2 reduced by 1 Turbine	14.40%
No. turbines required to meet target	4
Total Electricity generated per year (kWh/year)	34,216,560
Total Electricity required per year at site (kWh/year)	33,294,070
Total CO2 reduced by Turbines	60%

Appendix 11: GSHP

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Table 1: Thermal Energy and the CO₂ Emissions Reduced that can be Produced by Site if GSHP Meet the Full 100% Demand of the Units

Land Use	Building Type	Assumed Unit Floor Area (m ²)	No. Units	Total Thermal Energy Requirements (kWh/year)	No. Heat Pumps Required to Meet Thermal Energy Requirements	Annual CO ₂ Emissions Created by GSHP system (kg/year)	Annual CO ₂ Emissions that would be Created by Gas Heating (kg/year)	CO ₂ Emissions Saved by GSHP (kg/year)
Housing	Houses - 2/3 bed terrace/semi-detached	80.00	5,283	10,041,926	437	922,070	1,949,894	1,027,824

Table 2: Summary of CO₂ Emissions Reduced For Residential Using GSHP

10%	Residential CO ₂ target:	1,148,769	kg/year
	CO ₂ emissions Reduced:	1,027,824	kg/year
	Percentage that can be reached:	3.4%	
	Percentage Reduced for Residential Only:	9%	(equivalent to 1 house)

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Table 3: Thermal Energy and the CO₂ Emissions Reduced that can be Produced by Site if GSHP Meet the Full 100% Demand of the Units

Land Use	Building Type	Assumed Unit Floor Area (m ²)	No. Units	Total Thermal Energy Requirements (kWh/year)	No. Heat Pumps Required to Meet Thermal Energy Requirements	Annual CO ₂ Emissions Created by GSHP system (kg/year)	Annual CO ₂ Emissions that would be Created by Gas Heating (kg/year)	CO ₂ Emissions Saved by GSHP (kg/year)
Financial and professional services building	Banks and Building Societies (all-electric)	2,984.00	1	0	0	0	0	0
Industrial Buildings	B2 - General manufacturing	130,824.00	1	18,014,465	783	1,652,631	3,494,806	1,842,175
Education (Schools)	Primary	5,833.33	3	1,898,400	83	174,158	368,290	194,132
Education (Schools)	Secondary	30,000.00	1	2,379,456	103	218,289	461,614	243,325
Catering	Restaurant (with bar)	2,866.00	1	1,702,404	74	156,177	330,266	174,089
Catering	Public Houses	3,740.00	1	1,817,640	79	166,749	352,622	185,873
Catering	Fast-food restaurant	642.00	1	177,500	8	16,284	34,435	18,151
Sports and Recreation	Combined Centre	9,968.00	1	1,212,619	53	111,245	235,248	124,003
Storage and distributions warehouses	B8 - Storage and distribution warehouses	147,177.00	1	14,743,714	641	1,352,575	2,860,280	1,507,705
Local authority buildings	Park and Ride*	53,700.00	1	0	0	0	0	0
Offices	B1 - Air conditioned, standard	53,227.00	1	3,449,110	150	316,418	669,127	352,709
Superstores	Small food shops	7,184.00	1	351,729	15	32,267	68,235	35,968
Other	Primary Streets**	233,900.00	1	0	0	0	0	0
Total		682,045	15	45,747,036	1,989	4,196,793	8,874,925	4,678,132

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Table 4: Summary of CO2 Emissions Reduced for Non Residential and Residential for GSHP

10%	CO ₂ target:	3,037,776	kg/year	Total energy required for space heating (kWh/year) =	<u>55,788,962</u>
Total	CO ₂ emissions	5,705,956	kg/year	Total energy produced by GSHP for space heating (kWh/year)=	<u>55,798,036</u>
Percentage that can be reached:	Reduced:	18.8%			
<u>The CO₂ target of:</u>	<u>10%</u>	CAN	<u>be reached</u>		

Appendix 12: High Level Sizing of CHP

Table 1: Residential Space Heating

		Space heat demands kWth	no of units	total demand kWth	hours/year	yearly demand kWh/yr	Areas m2
Flats/houses	2 Bed	1.5	5,283	7,925	1,200	9,509,400	51
Total	Total		5,283	7,925		9,509,400	

From the PED the annual heating demand for the residential: 10,041,926 kWh/year
 From the PED the summer heating demand for the residential: 2,008,385 kWh/6months

Table 2: Residential Domestic Hot Water (DHW)

	Water heat demands kWth	no of units	total demand kWth	hours	yearly demand kWh/yr	Areas m2	Total kWh/year
Flats/houses	3.0	5,283	15,849	900	14,264,100	51	23,773,500
Total		5,283	15,849		14,264,100		23,773,500

Therefore Peak Heat Load = Heating + Hot water

Therefore Peak Heat Load = 23,774 kWth

From the PED the annual hot water demand for the residential:	23,431,162	kWh/year
From the PED the summer hot water demand for the residential:	10,544,023	kWh/6months
<u>From the PED the summer hot water demand for the residential:</u>	<u>1,757,337</u>	<u>kWh/month</u>
<u>Therefore assume an august load to be approximately:</u>	<u>1,493,737</u>	<u>kWh/month</u> (15% less)

FIRST check of sizing, assume its running in August for:

14 hours 31 days Total = 434 hours

Power of CHP is therefore limited to base hot water load: 3,442 kWth

Power of CHP is therefore limited to base hot water load: 2,086 kWe

Total Space and Water heating demand from peak load demand and benchmark figures= 33,282,900 kWh/yr

Actual Space And Water heating demand from PED based on CIBSE Guide F 33,473,088 kWh/yr

If it was to run 5000 hours a year the heat produced would be: 17,208,946 kWh/yr

therefore OK!

the electricity demand per year is 11,833,920 kWh/yr

If it was to run 5000 hours a year the electricity produced would be: 10,429,665 kWh/yr

therefore ok again!

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Table 3: Non- Residential Hot Water

Building Uses	Areas m2	hours	PED hot water yearly demand kWh/yr	PED Summer 6 months Hotwater demand kWh/yr	PED monthly Hot demand water kWh/yr	PED August Hot water demand demand kWh/yr
Banks and Building Societies (all-electric)	2,984.0	2,100	0	0	0.00	0.00
B2 - General manufacturing	130,824.0	2,285	21,193,488	1,430,560	238426.74	202662.73
Primary	17,500.0	2,500	1,977,500	35,595	5932.50	5042.63
Secondary	30,000.0	2,500	2,478,600	44,615	7435.80	6320.43
Restaurant (with bar)	2,866.0	4,000	2,269,872	255,361	42560.10	36176.09
Public Houses	3,740.0	3,300	2,019,600	90,882	15147.00	12874.95
Fast-food restaurant	642.0	2,500	221,875	19,969	3328.13	2828.91
Combined Centre	9,968.0	2,300	1,894,717	306,944	51157.37	43483.77
B8 - Storage and distribution warehouses	147,177.0	2,100	15,199,705	205,196	34199.34	29069.44
Park and Ride*	53,700.0	2,100	0	0	0.00	0.00
B1 - Air conditioned, standard	53,227.0	2,100	3,717,374	120,719	20119.81	17101.84
Small food shops	7,184.0	2,100	413,798	27,931	4655.23	3956.95
Primary Streets**	233,900.0	2,100	0	0	0.00	0.00
Total	693,712	31,985	51,386,529	2,537,772	422,962	359,518

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FIRST check of sizing, assume its running in August for:
 14 hours 31 days Total = 434 hours
 Power of CHP is therefore limited to base hot water load: 828 kWth
 Power of CHP is therefore limited to base hot water load: 502 kWe

Table 4: The Hot Water and Cooling Loads

Cooling

Assuming offices		From BSRIA guide load need is	75	W/m2	
	p 12		120	W/m2	60% glazing
		4th Edition Rule of Thumb	180	W/m2	65% glazing
Assuming hours	3 months June/July/august ..part may be September				
10 hours a day	31 days =	930 hours			
Restaurant			220	W/m2	
Retail Buildings			140	W/m2	
Banks	Rules of thumb, Guidelines for Building Services, P12. Table1: Cooling Loads, BSRIA, 2003				

Table 5: The Hot Water and Cooling Loads

Therefore the cooling part of the CHP Unit could be sized as:

Assuming a CHP Unit would run in summer months for	930	hours
Assuming the Summer Cooling demand is :	352,816	kWh
There the size of the CHP =	379	kWth
There the size of the CHP =	230	kWe

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Therefore total CHP unit for non residential could be for =	1208	kWth
(hot water and cooling)	732	kWe

Assume	700	kWe
	1155	kWth

Table 6: Gas CHP Opportunities in the District Centre followed Principles as for Site Wide CHP

CHP Unit Used in	Power kW		% CO2 Savings for just Residential or just Non Residential	Site Wide % CO2 Savings	CO2 From Site Tonnes/year	CO2 Reduced Tonnes/year
	Electric	Thermal				
Residential	150	248	27	6	868	235
Non Residential (total)	200	330	12	9	2,770	320
Hot water	114	188				
Cooling	86	142				
Total				15	3,638	555

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Appendix 13: Recommended Renewable/Low Carbon Solutions for Phase 1 (2010-13)

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Table 1: Summary of Achieving Targets Phase 1 (2010-2013)

Residential	No of Units	Target	Solutions	Renewables	CO ₂ Reduced	(CO ₂ Reduction Required)	Approximate	Capital	
							Cost	Cost	
							Cost (£/dwelling)	Cost (£)	
Private	700	Level 3	Solution 1	25% Efficiencies	273	273	-	-	
			Solution 2	4m ² Solar panel for each house	361	273	£3,000	£2,100,000	
Social/Affordable	300	Level 4	Solution 1	15 kW Biomass boiler for space and water heating for every dwelling (total of 4500 kW)*	321	206	£4,800	£1,440,000	
			Solution 2	11% Efficiencies**	51	206	-	-	
				4 m ² Solar thermal for each house for the hot water with PV powered pump	155		£3,000	£900,000	

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Residential	No of Units	Target	Solutions	Renewables	CO ₂ Reduced	(CO ₂ Reduction Required)	Approximate Cost	Capital		
							Cost (£/dwelling)		Cost (£)	
				Total	206		Therefore target	exceeds		
			Solution 3	19% Efficiencies**	88	206	-		-	
				100 kW Wind Turbine***	118			£333		£100,000
				Total	206			Therefore target	exceeds	
			Solution 4	23% Efficiencies**	107	206	-		-	
				PV panels	99			£4,500		£1,350,000
				Total	206			Therefore target	exceeds	

*This solution would produce a reduction of over 44% and assumes 100% of heating demand met. Also transportation emissions have been taken into account.

** Assume efficiencies are gained from space heating

***This solution cannot be achieved currently as a private wire is needed

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Appendix 14: Recommended Renewable/Low Carbon Solutions for Phase 2 (2013-16)

Great Haddon Sustainable Energy Strategy

Table1: Summary of Achieving Targets Phase 2 (2013-2016)

Residential	No of Units	Target CfSH	Solutions	Renewables	CO ₂ Reduction	(CO ₂ Reduction Required)	Approximate Capital Cost	
							£cost/dwelling	£cost
Private/ Social/ Affordable	1,500	Level 4	Solution 1	15 kW Biomass boiler for space and water heating for every dwelling* (Total 22,500kW)	1606	1,030	£4,800	£7,200,000
			Solution 2	11% Efficiencies**	255	1,030	-	-
				4 m2 Solar thermal for each house for the hot water with PV powered pump	774		£3,000	£4,500,000
				Total	1,030		Does reach target	
			Solution 3	7% Efficiencies**	162	1,030	-	-
				600 kWe Gas CHP***	868		£3,693	£5,540,000
				Total	1,030		Therefore exceeds target	
			Solution 4	23% Efficiencies**	531	1,030	-	-
				450 Wind Turbine****	499		£300	£450,000
				Total	1,030		Does reach target	

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Non Residential	Area (m ²)	BREEAM					£cost/1000m	£cost
1/3 of all Non Residential including primary 1	221,237		Solution 1	One Wind Turbine 1.1 MW	1552	1,514	£4,751	£1,051,184

*This solution would produce a reduction of over 44% and assumes 100% of heating demand met.

**Efficiencies are gained from space heating

***Currently SAP only takes into account savings from heat otherwise greater savings could be made that would reach the 44% alone. The costing for CHP is very high level and a full financial feasibility needs to be undertaken. It depends heavily on the length of the district heating network. For the purposes of this report it has been assumed £1000/m - at 5000 m.

****This solution cannot be achieved currently as a private wire is needed

Appendix 15: Recommended Renewable/Low Carbon Solutions for Phase 3 (2016-19)

Great Haddon Sustainable Energy Strategy

Table 1 Summary of Achieving Targets Phase 3 (2016-2019)

	No of Units	Target	Solutions	Low Carbon/ Renewables	CO ₂ Reduction (Tonnes)	(CO ₂ Reduction Required)
Residential (2016+)		CfSH				
Private/ Affordable Social/	2,783	Zero Carbon	Solution 1	Efficiencies 30% *	1,850	6,052
				Community Large Scale Wind 1.7 MW **	2,343	
				0.9 MWe Community Biomass CHP ***	2,277	
				1.8 MW Biomass Boilers****	16,324	
				Total	22,794	
			Solution 2	Efficiencies 30% *	1,850	6,052
				PV 24m2 - 28m2 per house (approximately a total of 67500 m2)	2,343	
				0.9 MWe Community Biomass CHP ***	2,277	
				1.8 MW Biomass Boilers****	16,324	
				Total	22,794	
Non Residential - 2016-2019		BREEAM				
1/6 of all Non Residential including 1 primary and 1 secondary schools	143,535	44% CO ₂ Reduction	Solution 1	1.5 MW Large Wind Turbine	2,187	1,688
				Total	2,187	Therefore exceeds target

*Efficiencies are made from 80% reduction of space heating, 10% reduction in water heating and 30% reduction in electrical demand

**Costing includes any ROC's and wind meets the full electrical demand for the site

***The costing for CHP is very high level and a full financial feasibility needs to be undertaken. It depends heavily on the length of the district heating network. For the purposes of this report it has been assumed £1000/m - at 8000 m.

**** Meets total remaining heat demand. When the definition of Zero Carbon is reviewed the Biomass boilers may not be needed as the carbon reduction figure has already been reached with the previous solutions

**Appendix 16: Recommended Renewable/Low Carbon Solutions for Phase 3
(Non Residential 2019+)**

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Table 1: Summary of Achieving Targets Phase 3b (2019 +)

	No of Units	Target	Solutions	Low Carbon/ Renewables	CO2 Reduction (Tonnes)	(CO ₂ Required) Reduction	Approximate Capital Cost	
Non Residential - Post 2019		BREEAM					Cost (£/1000m2)	£cost
1/6 of all Non Residential	107,702	Zero Carbon	Solution 1	30% Efficiencies*	883	2943	-	-
				1.32 MW Wind**	1,905		£12,535	£1,350,000
				1.4 MW Biomass Boilers***	432		£9,440	£1,016,688
				Total	3,220	Therefore target exceeds		

* Efficiencies are made from the space heating

** This meets all the electrical demands

*** This meets all the heat needs and the costings include the biomass boiler plus pellet storage (CHP is not an option as there s too little load)