WYG Engineering
part of the WYG group

The Grandhome Trust

Grandhome, Aberdeen

Outline Energy Strategy

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1. Introduction

1.1. Background

WYG has been commissioned by Grandhome Estates to prepare this Outline Energy Strategy Report to support the planning application for the development of Grandhome. Grandhome proposes the construction of high quality residential development and supporting infrastructure, to deliver 4,700 new homes and 5 hectares (ha) of employment land. The development will be constructed in several phases depending on tenant interest, market conditions and other factors, and is expected to take over 20 years to complete. Phase 1 of development proposes the construction of 500 new homes starting 2014 and ultimately up to 7,000 dwellings may be constructed.

This Outline Energy Statement for the Grandhome development has identified numerous LZC generation technologies that could be incorporated into the development, including the widespread use district and community heating led by biomass and the further deployment of building integrated renewable technologies where development density prevents the use of district heating from being economically viable. The use of geothermal energy systems has been provisionally explored and local off-site low and zero-carbon energy generation opportunities will be explored, including connections to Aberdeen Heat and Power assets, the utilisation of local waste heat sources and perhaps the utilisation of local micro-hydro opportunities.

The report has been prepared taking into account the extended period of construction and the need to ensure flexibility to accommodate changing tenant requirements, further evolution of national and local planning, energy, or environmental policy, and ongoing technical developments in energy consuming equipment, low carbon technologies and building engineering services over long periods of time. At this stage there is not sufficient detail to provide a definitive approach to the energy strategy for the development. As reserved matters applications are made, sufficient information will be available in order to undertake a more thorough assessment of the energy use and CO_2 emissions. At this point the updated assessment will demonstrate how the CO_2 reductions can be achieved through the most economical balance of the energy efficient design vs. the utilisation of low and zero carbon technologies.

1.2. Objectives

This report is intended to provide an indication of the likely energy use and carbon emissions relating to the submission of the planning permission in principle, which includes 4,700 dwellings along with 5 ha of employment land. In addition, the Phase 1 (500 dwelling development) and the ultimate 7,000 dwelling development are also assessed.

This report provides a summary of the development of a sustainable infrastructure strategy that could be introduced to enable the delivery of a sustainable low carbon community. This document is focused on the provision of a

sustainable infrastructure strategy at Grandhome, and specifics relating to transport, drainage and other environmental issues are captured elsewhere.

The development at Grandhome will follow the principles of the energy hierarchy, i.e. reduce the need for energy in the building's design, use energy more efficiently in the building and seek to supply energy from renewable sources.

1.3. Vision

The vision for Grandhome has developed from the principles of sustainable urbanism, which promotes the design of walkable neighbourhoods offering a range of housing types, as well as shops and jobs, in order to lessen car dependency and promote a sense of wellbeing and community. This vision represents the essence of a sustainable new community. Grandhome Estates aspires that the project delivers a sustainable low, and ultimately carbon neutral development, that minimises and effectively manages resource consumption and that this is delivered within a framework of economic viability and integrated social cohesion.

This Outline Energy Strategy Report has been prepared with reference to Aberdeen City Council's adopted low and zero carbon buildings Supplementary Planning Guidance (SPG) requiring a 50% reduction in developments carbon emissions (compared to the Building Regulations requirements) delivered from low carbon or renewable energy. This report provides information on the types of low carbon and renewable technologies potentially feasible for the development and able to achieve the policy requirements of a 50% reduction in annual regulated carbon emissions compared to the Building Regulations requirements.

This energy assessment represents an initial feasibility exercise that aims to find an effective balance between achieving sustainable development objectives, planning policy obligations and working within a framework of financial viability. Any renewable energy contribution will be subject to final development proposals and developed through an update to the Outline Energy Strategy Report during the detailed design stages.

2. Planning Policy

Sustainable development is essentially about finding a way to improve quality of life for present and future generations and is increasingly embedded in national and local policy mandating and encouraging the application of more sustainable infrastructure solutions promoting the reduction of fossil fuel consumption and associated carbon dioxide emissions from new developments such as Grandhome.

Policy in this area continues to evolve and account has been taken of both current policy requirements and policy developments which are expected to occur over the planning cycle for the proposed development. The most important relevant policies and related guidance are summarised below.

2.1. International and National Policy Context

The Scottish Executive published "*Choosing our Future: Scotland's Sustainable Development Strategy*" in December 2005 in response to the UK's first sustainable development strategy published earlier that same year. The Scottish government's strategy sets the national context for embedding the delivery of a more sustainable way of life in every sector and at every level of governance throughout Scotland.

A key priority for the Scottish government, in securing a more sustainable future, is to develop a low carbon economy that will help to reduce the impacts of dangerous climate change whilst improving peoples' quality of life. An important facet of this aim is de-coupling environmental degradation and depletion of natural resources from economic activities. Breaking this link is critical to creating a more equal society as many individuals remain excluded from the benefits of increased wealth or, in some cases actually suffer as a consequence of economic growth.

2.1.1. Climate Change (Scotland) Act

In addition to the national sustainable development strategy, other Scottish policy and legislation for guiding sustainable, low carbon development is largely enshrined in **The Climate Change (Scotland) Act, 2009** and related **Energy Efficiency Action Plan** and **Renewables Policy** which in combination create a new approach to managing and responding to climate change in Scotland.

The 2009 Act sets ambitious, legally binding targets to reduce GHG emissions on 1990 baseline levels by 42% by 2020 and 80% by 2050. It does this through powers to help meet those targets, strengthening the institutional framework and establishing clear and regular accountability to the Scottish parliament.

2.1.2. The Planning etc. (Scotland) Act 2006

The Planning etc. (Scotland) Act 2006 and the second National Planning Framework (2009) set out objectives and recommendations for guiding the development of local planning policy. This includes a focus on how Development

Plans will contribute to sustainable development, stopping short of requiring mandatory sustainability appraisal but requiring formal environmental assessment for major new developments such as Grandhome.

2.1.3. Scottish Sustainable Communities Initiative (SSCI) 2008

Launched in 2008, the Scottish Sustainable Communities Initiative (SSCI) was set up to transform the design, quality and environmental standards of new housing-led developments by helping to raise standards and to develop exemplar projects and skills in design, architecture and sustainable construction. SSCI's good practice approach and guidance was used in the Charette series that initiated Grandhome's masterplanning process in May 2009. Masterplanning took place in tandem with the preparation of the Aberdeen City Local Development Plan (LDP) and the Grandhome site is identified as opportunity site OP12 in the LDP.

2.1.4. The Low Carbon Building Standards Strategy for Scotland

The 'Low Carbon Building Standards Strategy for Scotland often referred to as the Sullivan Report was produced in December 2007. This report set out a series of tough challenges for future buildings in Scotland in the context of challenging carbon emission reduction targets which included net zero carbon buildings (regulated emissions from space and water heating, lighting and ventilation) by 2016/2017, if practical. Together with a UK wide target, this was hailed at the time as innovative and ambitious. At the same time, in England and Wales the Code for Sustainable Homes (CSH) was introduced to address a wide range of sustainability issues in new homes and development of a route to zero carbon development by 2016 is ongoing.

Section 7 (Section 2.1.6) of the Scottish Building Regulations was introduced at the end of May 2011 and is the Scottish Governments approach to addressing sustainability issues within the building regulations as a series of optional standards and enable comparison of the performance of homes and buildings.

2.1.5. Current and Future Building Regulations

The energy standards within the Building (Scotland) Regulations and supporting technical guidance were reviewed in 2009 with revised energy standards for new homes and non-domestic buildings were announced. These revised energy building standards are defined in Section 6 of the Building Regulations and came into force in October 2010 (2010 Building Regulation), and mandate that carbon dioxide (CO_2) emissions from new buildings (both domestic and non-domestic) are reduced by an approximate equivalent of 30% compared to the 2007 building standards (delivering the low carbon building phase of the strategy for Scotland).

The Scottish Government has recently announced the consultation for proposed changes to the building regulations for 2013. The results of the consultation were confirmed and published on 9th July 2013 and concluded that the 30% reduction in CO_2 for domestic be retained with a range of building fabric improvements included along with a range of levels of sustainability for dwellings and schools. At this stage sustainability requirements only relate to CO_2 emissions for all n on-domestic buildings excluding schools. These changes will come into force on 1 October 2013. All 30% of emission reductions must be captured within each building and cannot be aggregated across the site.

It is understood that Scottish Ministers have undertaken to review energy standards on a 3 yearly cycle which will lead to a further review for 2016 (zero carbon buildings, initially anticipated to be a 100% reduction from 2007 building standards according to the recommendations of the Sullivan Report, but in reality the reduction will likely be less than 100%). Whilst these standards are anticipated to continually evolve in accordance with the Low Carbon Building Standards Strategy over time, the guidance provided in the Low Carbon Buildings Standard Strategy has informed the development of the sustainable infrastructure strategy for Grandhome.

2.1.6. Section 7 of the Building Regulations

Section 7 was introduced at the end of May 2011 as an addendum to the 2010 Building Regulations with the aim of providing a standard reference point for building sustainability across Scotland. The standard applies in full to all domestic buildings and to schools, although it is anticipated this will be extended in the future to include all other non-domestic buildings. Currently, the Section 7 Sustainability standards only apply to non-domestic buildings (excluding schools) in relation to CO_2 emissions.

The intention of Section 7 is to recognise the level of sustainability already achieved by the Building Regulations using the 2010 standard as the benchmark bronze entry level credit and to encourage more demanding sustainability standards through optional enhanced upper levels will encourage consistency between planning authorities that use bespoke supplementary guidance to promote higher measures of sustainable *construction* in specific geographical areas. This standard aims to allow local aspirations to be met through selection of clear national benchmarks.

Table 2: Domestic Building Regulations Section 7 standards

Section 7 Standard	% DER/TER 2007 Building Regulations (Domestic)	% DER/TER 2010 Building Regulations	Additional Considerations	Other Considerations
Bronze (Reflective of Baseline 2013)	c30%	0%	2013 Building Regulations compliant	None
Bronze Active	c30%	0%	2013 Building Regulations compliant	Must includes the use of a low or zero carbon generating technology in respect of meeting standard 6.1 within section 6
Silver	45%	21.4%	Maximum annual demand for useful energy for space heating should be: • 40kWh/m^2 for *houses* • 30kWh/m^2 for *flats*	5% of water heating to be achieved through heat recovery technologies (including LZCGT)
Silver Active	45%	21.4%	This is the same as the silver level but, in addition, the *dwelling* includes the use of a low and zero carbon generating technology in respect of meeting at least one of the additional aspects	

Gold	60%	42.8%	Maximum annual demand for useful energy for space heating should be: • 30 kWh/m^2 for houses • 20 kWh/m^2 for *flats*	At least 50% of the *dwelling* or *domestic building's* annual energy demand for water heating should be from heat recovery and/or renewable sources with little or no associated fuel costs (e.g. solar thermal water heating and associated storage or heat recovery from grey water) that are allocated for water heating.
Platinum (Reflective of possible 2016 Baselines)	100%	100%		Net zero regulated emissions measures as 100% reduction in DER/TER

The above standards have been use by ACC in the development of their LDP and accompanying supplementary Planning Guidance (SPG) Documents (Sections 2.2.2 and 2.2.3).

2.1.7. Incentives for Renewable Energy

There are a number of financial incentives available to the owners and operators of renewable technologies, from home owners of micro generation systems to Energy Services Companies (ESCos) and management companies and special community vehicles (could include Grandhome Trust) operating larger renewable plant, that are designed to incentivise their uptake. These include the Renewables Obligation (RO) to incentivise large scale renewable electricity generation, the Feed-in Tariff (FiT) to support the uptake of small scale renewable electricity generation, and the Renewable Heat Incentive (RHI) which will provide financial assistance to generators or consumers of renewable heat.

2.1.8. National Planning Framework 3

The Scottish Government is undertaking a call for candidate national developments that are of national importance and deliverable. The criteria for assessment include the development making a significant contribution to several requirements, including assisting Scotland in delivering an 80% reduction in emissions by 2050 and achieving the renewable energy targets.

Together, all of these national policies and policy instruments ensure that legislation adequately underpins Scotland's long-term planning, energy and climate change policies. They set the context for the scope and content of local planning policy, strategies and programmes to help actively create truly sustainable communities.

2.2. Local Policy Context

2.2.1. Aberdeen City and Shire Structure Plan – August 2009

The Aberdeen City and Shire Structure Plan sets out a vision for the future of the local area up to 2030. This spatial strategy identifies three strategic growth areas, including Aberdeen City and acknowledges the need to develop

17,000 homes by 2023. The Plan includes targets for carbon neutral buildings by 2016 and the city region's electricity needs to be met by renewable resources by 2020 and identifies local development plans as the mechanism for achieving these targets.

2.2.2. Aberdeen Local Development Plan

The Aberdeen Local Development Plan (LDP) sets out a vision for the future of the local area up to 2023. This critical local-level plan outlines Aberdeen City's approach to sustainable planning and low carbon development in line with national planning principles for sustainable development, looking at the social, economic and environmental effects. The key policy relevant to the energy use and carbon emissions for Grandhome is Policy R7, set out below

Policy R7 - Low and Zero Carbon Buildings

All new buildings, in meeting building regulations energy requirements, must install low and zero-carbon generating technology to reduce the predicted carbon dioxide emissions by at least 15% below 2007 building standards. This percentage requirement will be increased as specified in Supplementary Guidance.

This requirement does not apply to:

1. Alterations and extensions to buildings;
2. Change of use or conversion of buildings;
3. Ancillary buildings that are stand-alone having an area less than 50 square metres;
4. Buildings which will not be heated or cooled, other than by heating provided solely for the purpose of frost protection; or
5. Buildings which have an intended life of less than two years.

Compliance with this requirement will be demonstrated by the submission of a low carbon development statement. Further guidance is contained in Supplementary Guidance on Low and Zero Carbon Buildings.

This policy takes the proposed Section 7 Building Regulations and requires developments in Aberdeen to provide at least half of the predicted carbon emission reduction to be delivered through the installation of low and zero carbon generating technology (LZCGT). The policy is further expanded in the supplementary guidance 'Low and Zero Carbon Buildings, March 2012), summarised below.

2.2.3. Supplementary Guidance – Low and Zero Carbon Buildings – March 2012

Aberdeen City Council's Low and Zero Carbon Supplementary Guidance was published in March 2012. The document provides further guidance on Policy R7 from the LDP and provides the methodology for developers to demonstrate compliance with the policy.

Table 3 below summarises Table 1 from the SPG, showing the percentage reduction in carbon emissions to be delivered through LZCGT as the section 7 Building Regulation standards moves toward the 2016 net zero carbon standard.

Table 3: Percentage Reduction through LZCGT

Year	Percentage Reduction in CO_2 through LZCGT	Planned Building Standards CO_2 reduction compared to 2007 dwelling
2010	15%	30%
2013	15%	30%
2016	50%	100%*

***Assumed 2016 standards (not publicised), see section 2.1.5**

Table 3 shows that there is a requirement to deliver at least half of the carbon dioxide savings through LZCGT as the Building Regulations get progressively more onerous. The SPG also provides guidance on achieving CO_2 savings for large developments and indentifies that the use of decentralised and local renewable sources of heat and power becomes more viable.

The SPG also provides an alternative route to achieve compliance with the requirements of policy R7. The SPG states that the development will have deemed compliance with the requirement to install low and zero carbon generating technology if:

1) It can be demonstrated that the development will achieve a CO_2 saving greater than required by the current building standards (the minimum standard is likely to change over the life time of the plan as building standards are increased),

OR

2) A financial contribution of £200 per housing unit or £200 per 140m^2 for all other developments is made towards the improvement of the energy performance of the existing housing stock.

Policy Application – A typical 1kWp PV panel in Aberdeen will mitigate 406kgCO_2/yr. In order to achieve a 15% CO_2 reduction through LZCGT a 0.7kWp PV system will need to be provided per dwelling, at an estimated cost of £1,750 per dwelling.

3. Grandhome Energy and Carbon Emissions

Grandhome Estates aim to adopt best practice and be ambitious in its targets to reduce its energy use and carbon footprint. These aims form a key part of the sustainable approach to this development. The legislative requirements for the reduction in the use of energy and carbon emissions are being increased and will continue in this way over the course of the development. These requirements include targets for zero carbon development from 2016, in line with anticipated National standards. The Grandhome development provides an opportunity to deliver the necessary facilities and infrastructure that have the economies of scale and efficiencies that are required to make these requirements possible.

A total of 4,700 dwellings and 5ha of employment use are proposed at Grandhome as part of the planning permission in principle, with 500 units proposed to come forward via a reserved matters application for Phase 1. In addition, a total of 7,000 dwellings may come forward across the development area and an assessment is also made for the possible future development.

At this stage in the process the final split of dwelling types for Phase 1 and the entire masterplan area has not been developed to a sufficient level of detail, so a typical split of dwelling types has been assumed based on those proposed for similar schemes. This comprises 10% 5 bed detached, 28% 4 bed detached, 33% semi-detached and terrace and 29% flats/apartments.

For transparency energy use reference data has been based on 2007 Scottish Building Regulations compliance benchmarks as stated within the Scottish Government Building Standards Division Directorate for the Built Environment Heating Supply Options for New Development – An Assessment Method for Designers and Developers dated June 29th 2009. Compliance with 2010 Building Regulations TER reduction has also been informed by a sample of contemporary SAP 2009 calculations.

The non-residential floor areas estimated from the proposed 5ha of employment use has been combined with benchmark data from the BSRIA document 'Rules of Thumb' (5th edition, 2011) in order to estimate the baseline energy consumption for the non-residential uses.

The employment use consists of up to 5ha of land take and no further details are available at this stage on the floor areas proposed. However, in order to prepare an estimate of energy use and CO_2 emissions, it is assumed that 40% of the 5ha is assumed to be the development floor area (20,000 sqm), with 10,000 sqm assumed to be B1 office use and the remaining 10,000 sqm shared equally between B2 and B8 land uses. No assessment of the retail, education, community or healthcare facilities has been undertaken at this stage, this will be assessed through revisions to the energy strategy as the detailed design is completed.

This energy assessment includes that part of the energy consumption governed by Building Regulations Section 6 i.e. **regulated energy** which captures heating, cooling, lighting, fans and pumps.

The management of energy and carbon emissions associated with occupant activities in the buildings, such as use of domestic electrical equipment, kitchen appliances, office equipment, lifts, etc. which is referred to as **unregulated energy** is anticipated to be an increasingly significant contributor to total emission impact and suitable mitigation strategies are to be considered within the sustainability and carbon reduction framework for Grandhome.

3.1. Baseline Energy Consumption

The baseline energy demand has been estimated by applying the energy reference data to the assumed development accommodation schedule. The results are summarised in **Table 4** below:

Table 4: Baseline Regulated Energy Consumption (2007 Building Regulations)

Phase	Regulated Electricity Demand (kWh/yr)	Regulated Heating and Hot Water (kWh/yr)	Total Regulated Energy Demand (kWh/yr)
Phase 1 (500 units)	436,300	3,625,945	**4,062,545**
Remaining Resi Development (4,200 Units)	3,667,440	30,457,938	**34,125,378**
5ha Employment	1,300,000	2,900,000	**4,200,000**
Total PIP	**5,404,040**	**36,983,883**	**42,387,923**
Further potential 2,300 dwellings	2,008,360	16,679,347	**18,687,707**
Total Potential Development (7,000 units + employment)	**7,412,400**	**53,663,230**	**61,075,630**

The carbon emissions intensity factors used in the assessment are summarised in **Table 5** below.

Table 5: CO_2 emission conversion factors

Fuel Source	$kgCO_2/kWh$	Fuel Source	kgCO2/kWh
Grid Supplied Electricity	0.517	Biomass	0.013
Grid Displace Electricity	0.529	Biogas	0.018
Natural Gas	0.198	Waste Heat	0.058

The predicted baseline carbon emissions footprint of the Masterplan scheme based on the energy assessment data from **Table 4** and CO_2 emission factors listed in **Table 5** is summarised in **Table 6** below.

Table 6: Baseline Regulated Carbon Dioxide Emissions (2007 Building Regulations)

Phase	Regulated Electricity CO_2 Emissions ($kgCO_2/yr$)	Regulated Gas CO_2 Emissions ($kgCO_2/yr$)	Total Regulated Energy CO_2 Emissions ($kgCO_2/yr$)
Phase 1 (500 units)	225,722	717,937	**943,659**
Remaining Resi Development (4,200 Units)	1,896,066	6,030,672	**7,926,738**
5ha Employment	672,100	574,200	**1,246,300**
Total PIP	**2,793,889**	**7,322,809**	**10,116,698**
Further potential 2,300 dwellings	1,038,322	3,302,511	**4,340,833**
Total Potential Development (7,000 units + employment)	**3,832,211**	**10,625,320**	**14,457,530**

The baseline regulated carbon emissions footprint for the Grandhome PIP prior to the integration of building fabric improvements or low carbon or renewable energy has been calculated as approximately **10,117tonnes of CO_2** per annum with **943tonnes of CO_2** per annum for Phase 1 and **9,173tonnes of CO_2** per annum for the remaining 4,200 dwellings and employment.

3.2. Reducing Energy by Design

The energy hierarchy dictates the first step to delivering sustainable energy is to reduce energy consumption and the development proposals have looked to balance visual amenity, access and practicality with due consideration of integrating passive solar design, subject to specific site limitations, with dwellings designed to maximise day lighting and minimise space heating without overheating in the summer months, improved levels of fabric thermal efficiency (walls, glazing, roofs and floors), increased levels of air tightness, natural ventilation with intermittent extract fans and dedicated low energy lighting.

A significant factor in domestic energy consumption is the behaviour and habits of home occupants. It is possible to adopt a number of measures to support effective energy management in the home including:

- **Provision of smart metering and display energy devices**
- **Electrical appliances specified as A-rated or better.**
- **Occupant user guides to promote resource conservation and sustainability**

At this stage a number of assumptions have been made with regard to the specification and thermal performance of construction materials, heating and ventilation systems and internal lighting. The analysis using approved tools has been completed for the purposes of this report to estimate annual energy consumption and associated carbon emissions only and not for the purposes of Building Regulation compliance or Energy Performance Certification.

3.3. Improved Energy Efficiency

Improvements to building fabric specification and passive design solutions are the first step in reducing the forecast demand. As the scheme is at the Masterplan stage the detailed building design, façade treatment and M & E systems design are to be finalised as the development progresses.

During the development of the Masterplan scheme, application of passive design and energy efficiency measures have been and will continually be evaluated for each phase and ultimately individual dwelling and building envelopes, and appropriate techniques and equipment incorporated into their design to meet and, where possible exceed, compliance with the building regulations.

The first phase residential buildings will aim to deliver the anticipated energy requirements of the 2013 Section 6 of the Building Regulations, equivalent to approximately 30% reduction on the 2007 Building Regulations standard (Bronze Scenario). This standard can be achieved through enhanced fabric and energy efficiency measures including improved U-value of walls, floors, roofs and glazing, the provision of 100% dedicated low energy light fittings, natural ventilation and reduced air permeability. Buildings are to be designed (where practical) to maximise the benefit of positive passive solar gain, whilst providing suitable protection against overheating.

Table 7: Improved fabric and systems specification assumptions

Element	Specification
Floor	0.15W/m2K
External Wall	0.15W/m2K
Roof	0.11W/m2K
Windows	1.20W/m2K, g-value = 0.63
Doors	1.35W/m2K
Air Permeability Rate	6m3/m2 per hour at 50 Pa
Thermal Mass Parameter	Medium
Ventilation	Natural ventilation and intermittent extract fans
Internal Lighting	100% dedicated low energy
Heating	Underfloor heating to all dwellings

Modelling indicates that improvements in the thermal performance of fabric and efficiency of services is estimated at this stage to achieve a 1.5- 3.9% improvement on 2010 Building Regulation requirements for a sample of dwelling types which is equivalent to an approximate equivalent 34% improvement on 2007 standards. At this stage this is considered the maximum economic reduction in CO_2 based wholly on fabric improvements which is based on Energy Savings Trust Advanced Standard (or equivalent standards).

This assessment is considered realistic for a scheme at the Masterplan stage. This assessment is therefore neither a "worst case" nor a "best case" prediction of the baseline and reduced energy consumption of the completed scheme. Rather it represents a point in time estimate which may be improved on once the detailed proposals for each phase

and individual buildings are brought forward. During detailed design, application of passive design and energy efficiency measures will continually be evaluated for individual dwelling and building envelopes, and appropriate techniques and equipment incorporated into their design to meet and, where possible exceed, compliance with the Building Regulations.

3.4. Reduced Energy Consumption

The improvements in energy efficiency outlined in **Section 3.3** are anticipated to reduce the regulated CO_2 emissions of development. The predicted emissions reduction from improved energy efficiency is estimated at a minimum of 34% below the Baseline value for residential uses and 30% for the employment uses. The estimated regulated energy use following the introduction of energy efficiency improvements is set out in **Table 8** below, with associated CO_2 emissions summarised in **Table 9**.

Table 8: Reduced Regulated Energy Consumption (Design and Energy Efficiency)

Phase	Regulated Electricity Demand (kWh/yr)	Regulated Heating and Hot Water (kWh/yr)	Total Regulated Energy Demand (kWh/yr)
Phase 1 (500 units)	316,300	2,304,100	**2,620,400**
Remaining Resi Development (4,200 Units)	2,656,920	19,354,440	**22,011,360**
5ha Employment	910,000	2,030,000	**2,940,000**
Total PIP	**3,883,220**	**23,688,540**	**27,571,760**
Further potential 2,300 dwellings	1,454,980	10,598,860	**12,053,840**
Total Potential Development (7,000 units + employment)	**5,338,200**	**34,287,400**	**39,625,600**

The improved annual energy consumption of the PIP Grandhome development, following inclusion of design efficiency measures (but excluding any LZCGT) has been estimated as **24,632MWh/yr.**

Table 9: Reduced Regulated Carbon Dioxide Emissions (Design and Energy Efficiency)

Phase	Regulated Electricity CO_2 Emissions ($kgCO_2/yr$)	Regulated Gas CO_2 Emissions ($kgCO_2/yr$)	Total Regulated Energy CO_2 Emissions ($kgCO_2/yr$)
Phase 1 (500 units)	163,527	456,212	**619,739**
Remaining Resi Development (4,200 Units)	1,373,628	3,832,179	**5,205,807**
5ha Employment	470,470	401,940	**872,410**
Total PIP	**2,007,625**	**4,690,331**	**6,697,956**
Further potential 2,300 dwellings	752,225	2,098,574	**2,850,799**
Total Potential Development (7,000 units + employment)	**2,759,849**	**6,788,905**	**9,548,755**

The reduced regulated carbon emissions footprint for the Grandhome PIP development prior to the integration of low carbon or renewable energy has been calculated as approximately **6,698tonnes of CO_2** per annum with **620tonnes of CO_2** per annum for Phase 1.

This assessment has at this stage been based on benchmark data to establish the estimates of potential improvements due to improved fabric efficiency, lighting and control systems. In reality it is anticipated that these standards may be improved upon as technology and construction practices evolve over the build programme and as such will need to be continually re-evaluated as development phases and individual buildings move forward to detail design.

3.5. Summary

As a result of the energy demand and carbon footprint analysis summarised above, the annual regulated baseline energy consumption of 4,700 new homes and 5ha of employment at the Grandhome development when in operation is estimated at **42,388MWh/yr** with baseline carbon emissions of **10,117 Tonnes CO_2/yr**.

It is anticipated that Phase 1 will be granted permission prior to the proposed 2016 changes to the Building Regulations and will therefore be required to achieve a minimum 30% reduction in CO_2 against a 2007 baseline. Therefore, within this report, it is assumed that the Phase 1 development of 500 houses will be built to a Bronze Building Regulation standard, which is likely to be achieved wholly through improvements to the building fabric.

It is assumed that the remainder of the development will be built to the anticipated zero carbon (currently proposed to be a 100% reduction in regulated carbon from a 2007 baseline, although in reality this may be considerably less of a reduction).

In order to achieve the requirements of Aberdeen City Councils Policy R7, a **15%** reduction in CO_2 emission from Phase 1 would need to be met through the installation of low carbon or renewable technologies.

Table 10 below provides a summary of the estimated baseline CO_2 emissions, the reductions required under Building Regulations and the level of LZCGT required to meet the ACC low and zero carbon requirement.

Table 10: Summary of Baseline Regulated Carbon Dioxide Emission Reductions from both Building Regulations and SPG

Phase	Baseline 2007 CO_2 Emissions ($kgCO_2$/yr)	Building Regulations CO_2 Reduction *2		Minimum CO_2 Reduction Required from LZCGT in order to meet ACC R7		Maximum CO_2 Emissions Allowed ($kgCO_2$/yr)
		%	($kgCO_2$/yr)	%	($kgCO_2$/yr)	
Phase 1 *1 (500 units)	943,659	30	283,098	15	141,549	660,561
Remaining Resi Development (4,200 Units)	7,926,738	100	7,926,738	50	3,963,369	0
5ha Employment	1,246,300	100	1,246,300	50	623,150	0
Total PIP	**10,116,697**	**-**	**9,456,136**	**-**	**4,728,068**	660,561
Further potential 2,300 dwellings	4,340,833	100	4,340,833	50	2,170,417	0
Total Potential Development (7,000 units + employment)	**14,457,530**	**-**	**13,796,969**	**-**	**6,878,485**	**660,561**

[*1] Assuming Phase 1 application prior to 2016 and remaining development after

[*2] Based on 2013 Building Regulations and anticipated 2016 Building Regulations (NOT YET PUBLISHED)

Table 11 below provides a summary of the reductions in CO_2 emissions following the proposed fabric improvements and the emissions after the minimum level of LZCGT is introduced to satisfy the ACC SPG. For Phase 1, the residual emissions following fabric improvements alone will satisfy Building Regulations, although this will not meet ACC requirements. However, there is a mechanism within Policy R7 to make a contribution of £200 per property if this is not met.

By introducing the proposed fabric improvements and LZCGT to the remainder of the PIP development, there is a requirement further reduce emissions by 1,989,888kgCO_2/yr in order to satisfy the Building Regulations requirements (assuming that the 2016 Building Regulations require a 100% reduction in regulated CO2 emissions). As the fabric improvements are considered to be close the maximum economically viable, it is most likely that the residual emissions will be mitigated through increased levels of LZCGT.

Table 11: Summary of Baseline Regulated Carbon Dioxide Emission Reductions from Building Regulations and SPG

Phase	Baseline 2007 CO_2 Emissions (kgCO_2/yr)	Emissions following Fabric Improvements (kgCO_2/yr)	Residual Emissions following Minimum LZCGT Requirements
Phase 1	943,659	619,739	0
Remaining Resi Development (4,200 Units)	7,926,738	5,205,807	1,242,438
5ha Employment	1,246,300	872,410	249,260
Total PIP	**10,116,698**	**6,697,956**	**1,989,888**
Further potential 2,300 dwellings	4,340,833	2,850,799	680,382
Total Potential Development (7,000 units + employment)	**14,457,530**	**9,548,755**	**2,670,270**

The feasibility of a number of different low and zero carbon technologies has been considered and a summary of the application of these technologies and their individual site suitability is provided below.

Within the ACC SPG, eligible LZCGT are set out and the document states that the technology may be introduced to the building or within the site boundary as shown on the planning application. This allows for the LZCGT to benefit more than one building and to enable it to be sited in order to maximise energy gain. Therefore, the approach below is an aggregate solution of the LZCGT in order to provide mitigation to the CO_2 emissions as set out above for Phase 1 then the remainder of the development.

4. Low Carbon and Renewable Technologies

4.1. Low Carbon and Renewable Energy Systems

As stated in 3.5 above, it is assumed that Phase 1 of the development will be built to Building Regulation standards without the need for LZCGT.

As part of the remainder of the development of the Grandhome Masterplan a full range of commercially available and potentially viable LZCGT suitable for application within the site boundary has been considered, informed by the unique characteristics of the site, the scale of the development and diverse mix of uses, the long timescale of the development and available natural resources as well as applicable constraints. The strategy at this stage is to aim to introduce the widespread use of district and community heating led by biomass, with building integrated solutions where the development density prevents the use of district heating from being economically viable.

4.1.1. District and Community Heating

Community or district heating involves the use of pre-insulated pipes to transport low temperature hot water from a decentralised generator, such as a biomass boiler, to homes and buildings in order to provide space heating and hot water. Gas, Gas CHP and biomass led district heating is an effective method of carbon emission reduction where sufficient local demand for heat exists. Application is considered to be best suited in the highest density neighbourhood centres where the mix of development provides a diversity of thermal demand for optimum operation of the plant.

In new residential led development this is best integrated as part of a community energy infrastructure solution. Large scale plant can only operate when sufficient thermal demand is realised and this critical mass is typically several hundred residential units. This style of plant is considered potentially suitable for both the earlier and the later phases of the development however the initial capital outlay and procurement risks may not be conducive to a timely and risk free start to development.

An alternative, smaller scale style of district heating is also considered suitable. Dispersed small community scale biomass district heating provides the same benefits of gas led district heating but on a smaller scale and the carbon mitigation benefits are higher e.g. a 199kW boiler would provide enough heat and water for approximately 42 dwellings. At 85% efficiency a 199kW biomass boiler on a 20% load factor will produce approximately 296,351kWh of heat with emissions estimated at 7,409kgCO_2/yr compared to 57,492kgCO_2/yr for a gas powered scheme, equivalent to an 88% reduction in regulated CO_2 for a standard dwelling.

The boilers can be housed in pre-fabricated units, located in the denser areas of development. The integration of numerous dispersed biomass heating networks in Phase 1 of development could enable usable heat produced from any low carbon or renewable energy source to be utilised and distributed to homes and buildings.

The downside of both gas/biomass led district heating and biomass led small scale community district heating are the need for suitable land, increased NO_x emissions and therefore the need for chimneys, operation and maintenance (including the quality of feedstock and supply chain management), governance and the development of unregulated energy services companies and all their legal complexity.

The Forest and Woodland Strategy for Aberdeen and Aberdeenshire promotes the use of low/mid grade timber residues as a renewable fuel source because the removal of residue helps with forest management and is readily available. The use of such wood from neglected woodlands would provide a potentially local source of readily available fuel. Investigation has identified a number of existing local biomass fuel suppliers in the Aberdeen region and it is understood that the further development of a robust supply infrastructure for biomass fuel is being promoted at regional and local levels; however variability in feedstock quality is quite an issue with poor quality fuels causing maintenance issues which could place an unwelcome burden on residents or community management vehicles. A potential option would be to provide an area of land in close proximity to the development site where biomass fuel can be grown and harvested for the local community.

4.1.2. Building Integrated

Alongside the district heating systems, it is proposed that building integrated technologies are included in the properties where development density prohibits the use of district heating on economic grounds. This is likely to include larger properties toward the edge of the development area and detached properties separated from the development centres.

Building integrated technologies assessed include;

- Solar Photovoltaics
- Solar Water Heating
- Micro Wind Power Generation
- Ground Source Heat Pumps
- Air Source Heat Pumps
- Individual Biomass Boilers

Solar PV

The available south facing roof areas, where unobstructed, provide the opportunity for inclusion of solar technologies. The development proposes a traditional design aesthetic of dwellings and the use of integrated solar

slates as part of the roof tiling is likely to be most appropriate; however, there may be opportunities for a range of design solutions. Local climate data obtained for Aberdeen/Dyce Airport defines daily solar radiation on the horizontal at 2.4kWh/m2. Whilst a comparable installation in Southampton is estimated to yield >10% more electricity and therefore provide a greater return on the investment, the potential contribution of this free and abundant energy resource is still considered significant enough across the UK (although will need 10% more solar PV array to do same job). A typical 1kWp PV is estimated to generate 767kWh of electricity per year with associated reductions in CO_2 for the grid displaced electricity of 406kgCO_2/yr.

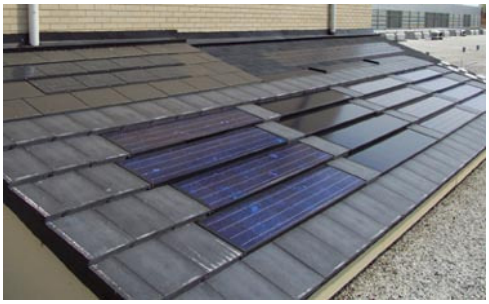

Figure 1: Roof mounted PV

Figure 2: Roof mounted SHW

Solar Hot Water (SHW)

Solar Thermal technology could be incorporated into the development in areas where it is not viable to provide connections to a district heating network. It can only provide a percentage of the hot water demand for a dwelling and will not help to mitigate the CO_2 emissions associated with space heating and electricity but can provide a part of the building integrated solution.

Micro Wind Power

The wind resource at the site is relatively good, estimated at 6m/s at 45m above ground level. However the proximity of existing overhead infrastructure will be restrictive and as the development is relatively high density, there is not sufficient room for an onsite large scale wind development. Research shows that micro scale wind turbines at an individual dwelling level provide very little yield and the vibration introduces structural complexity into the dwelling if attached.

Figure 3: Micro wind turbine

Figure 4: GSHP pipework

Ground Source Heat Pumps

Ground Source Heat Pumps (GSHP) use buried pipes to extract heat from the ground which passes through a heat exchanger and this heat can then be used to heat radiators, underfloor or warm air heating systems and hot water. GSHP requires large areas of available land for horizontal loops, or alternatively vertical boreholes. The ground temperature in Aberdeen is c 4.4ºC in winter rising to 14ºC in summer meaning that any systems will likely need a deeper borehole or longer trench for a given kW capacity due to the lower ground temperature. This technology is likely to be particularly suitable for the larger dwellings at the rural fringe where the economic viability of connecting to a district heating network is much lower and these larger detached properties have sufficient available non-communal land for the installation of lowest cost horizontal loop systems or alternatively vertical borehole systems. If there are a large number of units proposed, the additional electrical load required to power the pumps could have abnormal reinforcement costs

Air Source Heat Pumps

Air Source Heat Pumps (ASHP) operate on a similar principle to GSHP, but extract heat from the air. Although easier to design and install than the GSHP, there are mixed reports about the level of performance achieved through this technology. In addition, the lower ambient air temperatures at this location may reduce performance further. Again if there are a large number of units proposed, the additional electrical load required to power the pumps could have abnormal reinforcement costs

Figure 5: ASHP

Figure 6: Individual biomass boiler

Biomass Boilers

It is technically feasible to install individual dwelling biomass wood pellet boilers or stoves with supplementary heating and a number of local biomass fuel supply sources have been identified within 20km of the site. However, there are a number of practical design and operational constraints to utilising individual biomass heating systems including the additional space and access requirements truck movements for fuel delivery and an increased operational and maintenance burden for home owners. However, this may provide a solution to mitigate CO_2 emissions for the larger individual dwellings within the development.

The feasibility of a number of different building integrated low and zero carbon technologies has been considered and a summary of the application of these technologies and their individual site suitability is provided in **Table 12** below.

Table 12: Low and Zero Carbon Generating Technology

Technology	Feasibility	Rank
Photovoltaic (PV) Panels	Individual dwellings at Grandhome will likely have a proportion of pitched roof space able to accommodate installation of solar photovoltaic panels. The introduction of the Feed in Tariff (FIT) in 2010 has resulted in a significant reduction in the capital cost of the installation of PV systems, although tariff subsidies are being reduced, and either roof mounted or building integrated systems such as solar slates can be used. Systems should be installed within 30 degrees of south and free from over-shading.	1
Biomass Heating	It is technically feasible to install individual dwelling biomass wood pellet boilers or stoves with supplementary heating and a number of local biomass fuel supply sources have been identified within 20km of the site. However, there are a number of practical design and operational constraints to utilising individual biomass heating systems including the additional space and access requirements truck movements for fuel delivery and an increased operational and maintenance burden for home owners.	2
Solar Thermal Hot Water	Solar thermal hot water systems are a proven and mature technology in the UK and well suited to year round domestic demand for hot water. Systems are restricted to only meeting a proportion of domestic hot water demand (typically in the region of 50%).This does limit the technologies ability to achieve high levels of emission reduction. There are also the additional spatial requirements for dedicated solar thermal storage within each dwelling if combination condensing boilers are proposed. The number of dwellings required for installation to achieve the policy requirements is significant and may ultimately be restricted by roof design and dwelling orientation.	2
Ground Source Heat Pumps (GSHP)	Either individual or communal ground source heating systems could be installed at the site. This would involve horizontal ground loop collectors installed in garden or other communal space or alternatively vertical boreholes at approximately 100m per dwelling. Spatial restrictions and any existing or future below ground constraints such as buried services and sewerage infrastructure could constrain deployment. Systems can be very expensive particularly vertical boreholes and if a large proportion of properties are to be freehold this will result in further constraints to the location of individual domestic systems.	3
Air Source Heat Pumps (ASHP)	ASHP is an alternative renewable heat pump however low seasonal efficiency of air to water pump systems is estimated to result in potential carbon emission increase as opposed to saving when compared with high efficiency gas condensing boilers and given the limited evidence of high heating CoP in operation is not recommended at this stage.	4
Micro Wind Turbines	The installation of micro wind turbines would potentially have significant aesthetic, design and structural impacts. These turbines would also give rise to vibrational noise which would need to be dampened and the electrical energy produced is subject to significant fluctuation. Recent studies suggest low energy yields and only a small number of micro turbines are eligible for the Feed in Tariff.	5

4.1.3. Wider Area Opportunities

In addition, opportunities have been considered for the application of LZC technologies as part of wider area opportunities that may exist beyond the site boundary which may provide potential mitigation of any residual emissions that cannot be achieved onsite. These include:

- Geothermal
- Micro-Hydro along the River Don
- Connection to Local Heat Networks
- Allowable Solutions

Geothermal

Deep geothermal energy is utilised through deep boreholes in suitable locations drilled down 1km to 2km in depth. There are two technologies use to provide energy,

- Hot Rock – Water pumped onto hot rocks to create hot water/steam to use in a district heating network or to turn a turbine and create electricity
- Sedimentary Aquifiers – Cold water pumped down and warm/hot water pumped to surface

WYG has recently attended a national event and liaised with an expert 'Ed Stephens' from St Andrews University and unfortunately the granite under Aberdeen does not appear suitable for either technologies. The geological map for the Aberdeen area shows that the granite underlying Aberdeen is rather cold, the development would need to be in the region of Ballater or elsewhere in the Grampians rather distant from the Grandhome development to get close to a "hot" granite that might support geothermal energy. However, even if we were near a hot granite, the technology is rather risky and still unproven

Micro-Hydro along the River Don

The River Don runs along the development boundary to the west of the site and therefore the potential to use the movement of water to generate electricity has been considered. However, the river is only adjacent to the development for a short section and therefore there is a limited Right of Access for both plant and electricity export infrastructure. Research shows that there about 7 small weirs where Grandhome Trust has riparian rights (half river), one of the weirs has a 3m fall and all were used by working mills so are able to generate a level of power. This may offer the opportunity to invest in generating equipment although this method of providing LZCGT is seen as risky. It is recommended that the micro-hydro feasibility report is undertaken to provide an indication of the likely level of energy that can be tapped into from the River Don.

Connection to Local Heat Networks

The opportunity to connect into local heat networks has been investigated. Aberdeen Heat and Power . AHP is a not for profit company set up by ACC to operate district heating and CHP. They operate 3 schemes at Stockethill, Hazlehead and Seaton. However, the current networks are not joined together and their closest heating network is at Stockethill which is approximately 3.5km from the site. The costs of connecting to this network are considered prohibitive, although if any networks are developed on-site, Aberdeen Heat and Power would consider involvement in their operation.

Two closer opportunities have been identified, there is a small scale district heating network operating at the nearby Aberdeen Science and Energy Park and the Stoneywood Mill papermill located to the west of the River Don has recently submitted a planning application to develop a biomass CHP site. Although the Aberdeen Science Park is closer to the site, the boiler is small at only 200kW and it is unclear whether any 'spare' heat will be available. If so the Heat Purchase Agreement and pipe network installation may prove restrictive; there is also a risk of longevity of

supply. Stoneywood Mill may provide a suitable opportunity to purchase spare heat, although the scheme does not have planning permission yet, if the scheme goes ahead it may be worth investigating further.

Allowable Solutions

Aberdeen City Council has a capital investment pot for improving energy efficiency in the City's existing building stock. If dwellings are unable to demonstrate compliance with the LZC SPG, a payment of £200 per non-compliant dwelling is possible to comply with their policy. This provides a method for ensuring that all dwellings are able to comply with the policy. Grandhome Estate could alternatively establish a Private Energy Fund or work in partnership with ARG, the City Council or Scottish Enterprise etc. to support funding of wider low and zero-carbon projects and contribute capital on a unit cost per tonne of CO_2 not mitigated onsite.

The geothermal energy, micro-hydro and connection to local heat networks do not appear to offer a solution for the proposed development. However, it may be possible to utilise the allowable solutions and this will be explored further as the development progresses.

4.1.4. Summary

Phase 1 of the PIP development (500 houses) will likely be delivered prior to the review of Building Regulations in 2016 and can therefore deliver the required reductions in CO_2 through improvements to building fabric, without the need for LZCGT.

The remainder of the PIP application – (4,200 dwellings and 5ha employment) and ultimately the total masterplan development of 7,000 dwellings will likely require the introduction of LZCGT within the site. The chapter above has provided an overview of the technologies that may be applicable for the Grandhome development.

This energy assessment represents an initial feasibility exercise that aims to find an effective balance between achieving sustainable development objectives, planning policy obligations and working within a framework of financial viability. Any renewable energy contribution will be subject to final development proposals and developed through an update to the Outline Energy Strategy Report during the detailed design stages.

5. Conclusion

5.1. Conclusion

This Outline Energy Strategy supports a planning application in principle (PIP) to Aberdeen City Council for the development of up to 4,700 new dwellings together with approximately 5ha of employment land and associated retail, education and community services at the site known as Grandhome. In addition, a review of the entire masterplan development of 7,000 dwellings in included.

No assessment of the retail, education, community or healthcare facilities has been undertaken at this stage, this will be assessed through revisions to the energy statement as the detailed design is completed.

This document illustrates the proposed development, the relevant planning policy framework for the development, provides an estimate of the energy and carbon dioxide emissions and investigates options for how carbon emissions can be reduced and low and zero-carbon (LZC) could be utilised.

Baseline energy use and CO_2 emissions are presented based on the current Building Regulation standards. Further reductions in energy use and CO_2 emissions will be achieved, as required, by following the energy hierarchy i.e. reduce the need for energy in the building's design, use energy more efficiently in the building and seek to supply energy from renewable sources.

A review of potential low and zero carbon generation technologies is presented. As the development of the detailed design for Grandhome, a full range of commercially available and potentially viable renewable energy generation technology suitable for application within the site boundary will be considered, informed by the unique characteristics of the site, the scale of the development and diverse mix of uses, the long timescale of the development and available natural resources as well as applicable constraints.

Any renewable energy contribution will be subject to final development proposals and developed through updates to the Outline Energy Statement Report during detailed design.

At the current time, based on 2013 Building Regulations, Phase 1 of the development can largely be delivered from good building design capturing high levels of building fabric energy efficiency systems.