A2Dominion Developments Ltd

NW Bicester Exemplar Local Centre

Energy Statement

Hyder Consulting (UK) Limited
2212959
Manning House
22 Carlisle Place
London SW1P 1JA
United Kingdom
Tel: +44 (0)20 3014 9000
Fax: +44 (0)20 7828 8428
www.hyderconsulting.com

A2Dominion Developments Ltd

NW Bicester Exemplar Local Centre

Energy Statement

Strategic Review - Energy

Author	T Morris	
Checker	P Harker	
Approver	P Harker	
Report No	UA005241-5110	
Date	April 2015	

CONTENTS

1 Introduction

This Energy Statement has been prepared by Hyder Consulting Ltd in support of the full planning application for the **Exemplar Local Centre** of the North West (NW) Bicester development Exemplar Phase site.

The proposed energy strategy has been guided by the following key principles:

- To meet all relevant local and national planning policy
- To be an exemplar in sustainability (whilst maintaining technical and financial viability)
- To adopt a fabric first approach to ensure that carbon emission reductions are secured for the lifetime of the development
- To mitigate adverse impacts on the surrounding environment.
- To be flexible so as to provide longevity to any proposed strategy within an evolving climate.
- To ensure the successful integration with the rest of the NW Bicester development.

The NW Bicester development is intended to provide a new form of sustainable community within Cherwell District, and to extend the benefits of this community to the existing town of Bicester. The first part of the NW Bicester development was the Exemplar Site development located in the northwest part and which is currently under construction.

This statement focuses upon the Exemplar Local Centre and how this contributes to the overall strategy to achieve the requirements of true zero carbon considering both regulated and unregulated energy use from buildings. This will incorporate an assessment of the predicted baseline energy demands and associated carbon emissions (based upon current Building Regulations 2013) before investigating the potential means of achieving the developments energy reduction and carbon emission targets.

Whilst this Energy Statement is specifically relevant to the Exemplar Local Centre, it needs to be considered in the context of the energy strategy for the Exemplar Phase site and wider NW Bicester Development.

1.1 Background

In July 2012, Cherwell District Council (CDC) granted planning permission (Ref 10/01780/HYBRID) for the development of 21 ha of land within the North West Bicester Masterplan Area, the 'Exemplar Phase'. The permission for this hybrid application included detailed consent for 393 residential homes, roads and infrastructure including an Energy Centre. It also granted outline permission for a neighbourhood centre comprising non-residential use including community facilities, local retail, a pub and office space and a new primary school.

As mentioned above, the Energy Centre received permission and is currently under construction. This has been designed to power the Exemplar Phase site wide district heat network from a primary gas combined heat and power (CHP) engine with top up gas boilers and appropriately sized thermal stores.

2 Preferred Strategic Approach

This statement, prepared on behalf of A2Dominion Developments Ltd, progresses follows the approach identified within the original Exemplar Phase Energy Statement (ref: Report No. 4502-UA001881.v2) and the options outlined within the Masterplan Energy Strategy (ref: Report No. 5022-UA005241-UE21R-01) relative to this Application. The masterplan and related documents set out the spatial vision to provide up to 6000 new homes at NW Bicester and were prepared in accordance with Planning Policy Statement: Eco-Towns A Supplement to Planning Policy Statement 1 (July 2009).

The Masterplan Energy Strategy identified various combined technology approaches to achieve the true zero carbon target - defined in the PPS1 Eco towns supplement as "*over a year the net carbon dioxide emissions from all energy use within the buildings on the eco-town development as a whole are zero or below*" (Policy ET7.1). The Masterplan Energy Strategy recognised that whilst certain technologies may go a considerable way to meeting demands and creating carbon savings; no one technology can fulfil the site's total energy demand and carbon reduction target. Therefore a combined technology solution will be required.

The strategic options considered within the Masterplan Energy Strategy were focused on achieving true zero carbon through predominantly on-site technology rather than any significant reliance on off-site/off-set allowable solutions. However, whilst a preferred approach was identified it was recognised that further optimisation of the available technical solutions would continue as detailed design progresses; such as refinement of available roof area for PV, selection and sizing of CHP engines and associated thermal store to optimise delivery of the thermal demand carbon emission reductions. The preferred strategic approach to enable the true zero carbon target to be met for the NW Bicester development was identified as follows:

- Enhanced fabric energy efficiency standards,
- Site wide District Heat Network (DHN) – providing all thermal demand across the site; linked to Energy Centres,
- On-site Energy Centres – that include Low Zero Carbon (LZC) technologies that will meet thermal demands and provide sufficient carbon emissions reduction to meet zero carbon target; in combination with,
- Roof mounted PV – optimised relative to layout and building design.

The approach was selected because:

- Technically it can achieve the true zero carbon target (i.e. delivering carbon emission savings relative to both regulated and unregulated emissions).
- Ability to be delivered entirely on-site and therefore not have any reliance on any third party agreements.
- Experience of delivering a similar solution, utilising DHN and Energy Centre with LZC, on the first phase Exemplar site of NW Bicester.
- Ability to deliver homes that maintain a traditional design approach.
- Inclusion of a DHN within the preferred option enables future proofing relative to new technology (which can be plugged into the energy centres) and/or potential connection to waste heat from the Ardley Energy from Waste (EfW) facility.

It should be noted however that the preferred approach is deemed appropriate for the NW Bicester Exemplar site as a whole. Therefore the strategy will not necessarily ensure that individual development areas will achieve the true zero carbon target independently; but instead all areas should be considered collectively relative to meeting the target. This is particularly true for the Exemplar Local Centre element of the site which has elevated levels of energy demand and a reduced potential for mitigation through renewable technologies.

3 Development Overview

3.1 Wider Development Context

Exemplar site description

The Local Centre Site is situated across 6.4ha of greenfield land approximately 1.5 km to the northwest of Bicester with a National Grid Reference of (SP 57871 24770). The Site is bordered by agricultural land. The Local Centre Site is located within the south of the wider Exemplar site which is located north of the A4095 which forms the current boundary of Bicester, west of the B4100, east of the B4030 and south of Bucknell, encompassing Crowmarsh Farm.

The Local Centre area was classified as Grade 3 agricultural land, the River Bure is located approximately 35m to the northwest of the Site. The Site is located within first phase of a wider development; part of the 'Exemplar Phase' that is currently under construction; and all of the Site is currently occupied as a temporary construction compound, materials lay down and handling area in accordance with the approved Construction Environmental Management Plan relative to the existing planning permission (Ref 10/01780/HYBRID).

The extents of the Exemplar site and the Local Centre are shown on Figure 3-1.

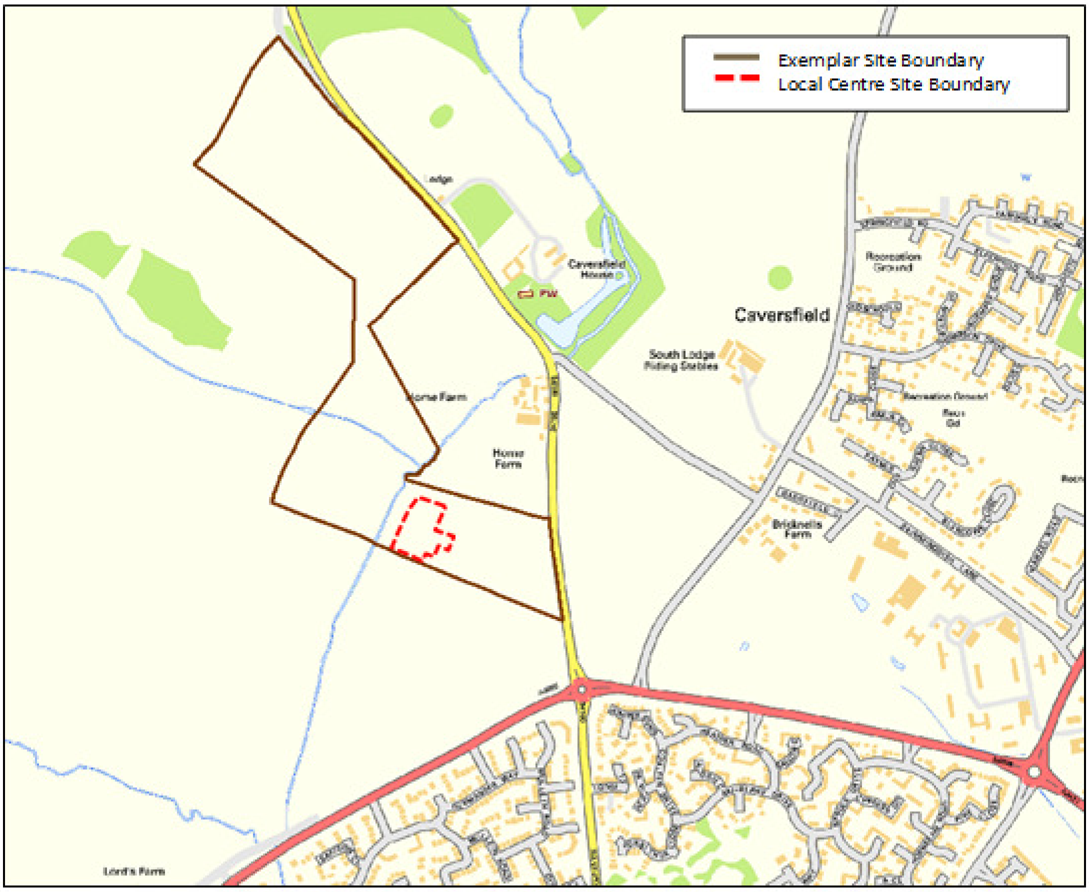


Figure 3-1 Exemplar Site and Local Centre Location

3.2 Site Area and Development Proposal

The Local Centre Site is located on the north western edge of Bicester, and access to the Site will be from the B4100 to the east of the site. Figure 3-2 below shows the location of the proposed Site (marked in red).

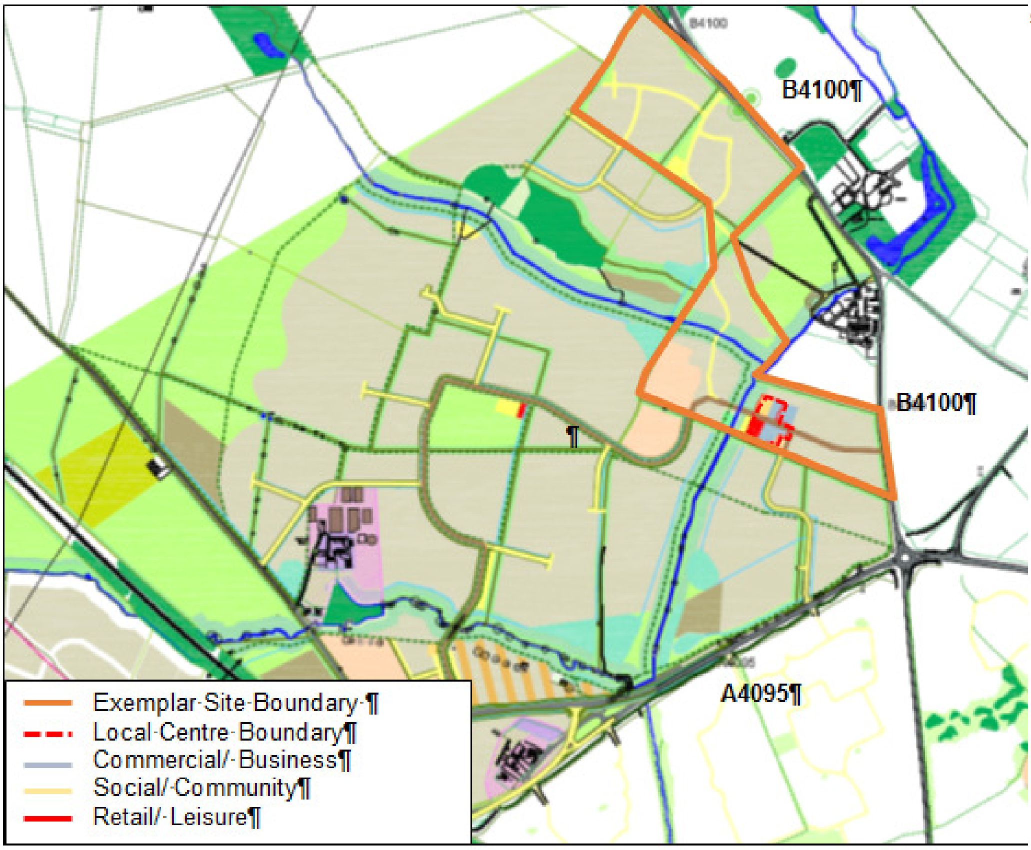


Figure 3-2 Exemplar Local Centre Application Overall Layout

3.3 Development Schedule

The Local Centre Site comprises land within the NW Bicester eco-development area and includes (GEA) a 503 m² convenience store, 444 m² of retail units, 664 m^2 pub, 523 m² community hall, 869 m² nursery, and 614 m² of commercial units with associated access, servicing, landscaping and parking".

The following tables provide a summary of the anticipated development schedule of the site which have been used as the basis for energy demand and carbon emission calculation throughout this report.

Table 3.1: Proposed Non-Residential Units

Building Type	Total Area	GIA (m^2)
D1 Nursery	860	628
B1 Office (4 units)	307	408
D1/D2 Community Centre	523	350
A1 Retail – Convenience Store	503	418
A1/A3/A5 Retail	444	369
A4 Pub	401	343
A3 Pub Restaurant	263	200
Energy Centre	375	350
Total		**2,716**

4 Planning Policy Requirements and Targets

4.1 Introduction

This section provides a summary of the relevant national, regional and local policy relative to energy and carbon emission reduction. Current and future Building Regulations and the Government's approach to delivering true zero carbon are also summarised. This is intended as an overview of the key policy and regulatory requirements that need to be met and considered as part of the scheme.

In addition, the aspirations of the client are highlighted to provide a concise and consolidated view of the targets that the scheme seeks to meet as it develops out.

The policy landscape around Climate Change has been rapidly moving with many new policies and changes to existing policy over the last number of years which will influence the way in which the energy strategy for the scheme may come forward. It is also safe to suggest that policy will continue to evolve over the period in which the development progresses; and therefore maintaining flexibility in any strategy is crucial to facilitating continued sustainable development.

4.2 National Planning and Policy Requirements

The Climate Change Act (2008)

The Climate Change Act 2008 introduced a legally binding target to reduce the UK's greenhouse gas (GHG) emissions to at least 80 per cent below 1990 levels by 2050. It also provides for a Committee on Climate Change (CCC) which sets out carbon budgets binding on the Government for 5 year periods.

In Budget 2009 the first three carbon budgets were announced which set out a binding 34% CO_2 reduction by 2020 and the Government has now proposed that the fourth carbon budget will be a 50% CO_2 reduction by 2025. The CCC also produces annual reports to monitor progress in meeting these carbon budgets. As a result of the Climate Change Act, a raft of policy at national and local level has been developed aimed at reducing carbon emissions.

The levels of the first three carbon budgets were set in fiscal budget 2009 at the "interim" level recommended by the CCC prior to global agreement on emissions reductions. The carbon budgets require a reduction in greenhouse gas emissions of 34%, against 1990 levels, by 2020. The fourth carbon budget level was set in June 2011. The carbon budget for the 2023–2027 budgetary period is 1,950,000,000 tonnes of carbon dioxide equivalent.

UK Low Carbon Transition Plan (2009)

The previous Government launched the UK Low Carbon Transition Plan on 15th July 2009. The Plan includes the Renewable Energy Strategy (white paper) and Low Carbon Industrial Strategy. The UK Low Carbon Transition Plan is a Government white paper that sets out policies required to ensure that the UK meets its legally binding commitment to reduce carbon emissions by 34% by 2020. Policies contained in the documents include:

- Getting 40% of our electrical energy from low and zero carbon sources by 2020
- Rolling out smart meters in every home by 2020

National Planning Policy Framework

The National Planning Policy Framework was published on 27 March 2012 and sets out the Government's planning policies for England and how these are expected to be applied. It sets out the Government's requirements for the planning system only to the extent that it is relevant, proportionate and necessary to do so. It provides a framework within which local people and their accountable councils can produce their own distinctive local and neighbourhood plans, which reflect the needs and priorities of their communities.

As of 27th March 2013 (12 months from the day of publication), Annex 1 of the NPPF confirms that due weight should be given to relevant policies in existing plans according to their degree of consistency with the NPPF (the closer the policies in the plan to the policies in the Framework, the greater the weight that may be given). It also confirms that, from the day of publication, decision-takers may also give weight to relevant policies in emerging plans according to:

- the stage of preparation of the emerging plan (the more advanced the preparation, the greater the weight that may be given);
- the extent to which there are unresolved objections to relevant policies (the less significant the unresolved objections, the greater the weight that may be given); and
- the degree of consistency of the relevant policies in the emerging plan to the policies in the NPPF (the closer the policies in the emerging plan to the policies in the NPPF, the greater the weight that may be given).

The NPPF was designed to make the planning system more user friendly and transparent. The framework's primary objective is sustainable development, focussing on the 3 pillars of sustainability: planning for prosperity (Economic), planning for people (Social) and planning for places (Environmental).

At the heart of the NPPF is a presumption in favour of sustainable development. The NPPF identifies 12 principles that should be at the core of land use planning; these include:

- "support the transition to a low carbon future in a changing climate, taking full account of flood risk and coastal change, and encourage the reuse of existing resources, including conversion of existing buildings, and encourage the use of renewable resources (for example, by the development of renewable energy)".

Further guidance within the NPPF is given under the heading "Meeting the challenge of climate change, flooding and coastal change"; including:

- supporting the delivery of renewable and low carbon energy infrastructure; and
- reduce greenhouse gas emissions

4.3 Planning Policy Statement 1 Eco town supplement

NW Bicester (NWB) is identified in the supplement to PPS1 entitled 'The Planning Policy Statement: Eco-Towns A Supplement to Planning Policy Statement 1' (July 2009) as one of four locations for an Eco Town. The principle of the development is supported by Cherwell District Council ('the Council') and the land to the north west of Bicester ('the Site') is identified in the emerging Local Plan as the area within which a development following eco-town principles and the standards in PPS1 Supplement could be developed.

It is anticipated that the current Government will cancel the current PPS Supplement in due course. Notwithstanding, the requirements of the Supplement to PPS1 will be carried over by Cherwell (subject to review and amendments as necessary) into the Local Plan. The Council has already set out its policy position in respect of NWB in the emerging Local Plan and granted planning permission for the Exemplar Phase of NWB for 393 new homes, local facilities and land for a primary school.

The PPS 1 Eco-town supplement defines zero carbon under paragraph ET 7.1 as:

"*over a year the net carbon dioxide emissions from all energy use within the buildings on the eco-town development as a whole are zero or below*".

As the national definition of zero carbon was redefined in 2011 (see section 4.5 below); this PPS 1 definition is referred to as "true zero carbon".

Paragraph ET 7.2 of PPS 1 Eco-town provides further clarification and states

"*This standard will take effect in accordance with a phased programme to be submitted with the planning application. It excludes embodied carbon and emissions from transport but includes all buildings – not just houses but also commercial and public sector buildings which are built as part of the eco-town development. The calculation of net emissions will take account of:*

a) emissions associated with the use of locally produced energy

b) emissions associated with production of energy imported from centralised energy networks, taking account of the carbon intensity of those imports as set out in the Government's Standard Assessment Procedure, and

c) *emissions displaced by exports of locally produced energy to centralised energy networks where that energy is produced from a plant (1) whose primary purpose is to support the needs of the eco town and (2) has a production capacity reasonably related to the overall energy requirement of the eco town.*"

The Town and Country Planning Association (TCPA) guidance for the development of energy efficient and zero carbon strategies for eco-towns, December 2009, encourage eco-towns to follow best practice to achieve zero carbon as Exemplar developments.

4.4 Building Regulations (Part L)

As part of the British Governments commitment to cutting carbon emissions by 80%, compared to 1990 levels (by 2050) the government is escalating Building Regulations requirements to reduce carbon emissions within the built environment. The government's proposed trajectory for Building Regulations Part L2A (Conservation of fuel and power in new dwellings) was outlined within Building a Greener Future: A Policy Statement (2007). This outlines the reductions in 'regulated' carbon emissions compared to a Building Regulations (2006) baseline outline in table 4.1 below:

Table 4.1 Carbon reduction improvement compared to Building Regulations 2006

Building type	Part L 2010	Part L 2013	Part L 2016	Part L 2018	Part L 2019
Non – domestic	25%	32%	Further improvement	Further improvement	Zero Carbon

Under the previous government there was a target for all new schools to be zero carbon from 2016, other public sector buildings from 2018 and private sector buildings from 2019. Under the Coalition Government, that target has been adjusted so now the zero carbon standard will apply to all non-domestic buildings built from 2019.

There is still a debate as to exactly what the zero carbon definition should include and Government has not announced further detail on its intentions.

The latest Building Regulations (2013) came into effect on the 6th April 2014. As outlined above the principal aim for Part L 2013 is to:

- Provide a meaningful step towards the UK Government commitment to zero carbon standards by 2018
- Drive innovation in the right direction
- Aid learning to deliver zero carbon.

Given the relatively minor reduction between 2010 and 2013 (9% non-domestic) the anticipated jump to zero carbon represents a major step change and will almost certainly require additional updates to Part L and how it is implemented. The traditional approach of building regulations is to assess the performance of a building considering only the energy use of the building and only those technologies attached to it and so directly affecting its carbon performance. If this approach were taken to zero carbon buildings it would rely on, extremely expensive, small scale renewable electricity generation. Inevitably this would mean that around half would not be able to meet the target and many of those that could meet the target would be economically unviable.

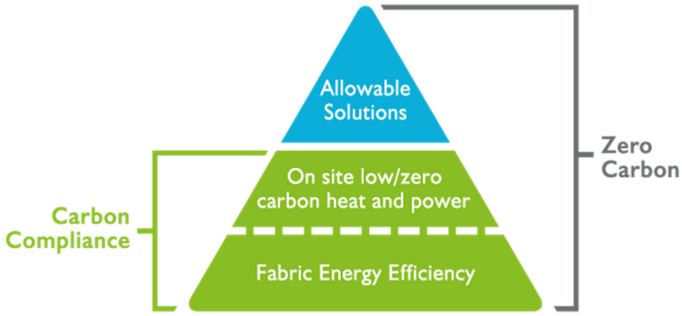
4.5 Achieving Zero Carbon

It was announced in the 2011 Budget 'The Plan for Growth' document, that a 'Zero Carbon Home' requires a 100% reduction in regulated energy (heating, hot water and fixed electrical items – pumps, fans, lights) over Building Regulations 2006. Therefore, emissions from cooking or from appliances such as computers and televisions are excluded from the definition.

The Government's commitment to achieving Zero Carbon Homes is based on the following hierarchical approach to achieving zero carbon targets:

1. Mandatory Fabric Energy Efficiency (FEE) Level – To ensure energy efficiency by energy efficient building design.
2. Mandatory onsite Carbon Compliance Level – To ensure energy efficiency by energy efficient building design and to reduce carbon emissions through on-site low carbon and renewable energy technologies and near-site heat networks.
3. Mitigate the remaining carbon emissions through use of 'Allowable Solutions'.

Figure 4.1: Showing approach to achieving Zero Carbon homes.



In February 2011 recommendations for national minimum standards of Carbon Compliance – the onsite reductions of emissions – were developed by a Zero Carbon Hub led Task Group. The Task Group found that the proposal from July 2009, to tighten the Carbon Compliance standard by 70% (equivalent to 6 kg CO_2(eq)/m^2/year), may not be achievable in all cases. In addition, it was felt that the previous method of calculating carbon compliance level was confusing and now suggest that an absolute limit in terms of CO_2 emissions per m^2 floor area per annum be the measure used. **The equivalent definition of 'Zero Carbon' for non-domestic buildings has not progressed to the same level as that of dwellings. However it is expected that a similar framework (energy efficiency, on-site carbon compliance and allowable solutions) will be developed to ensure 'Zero Carbon' is achieved by 2019 (2018 for public sector buildings) for non-domestic buildings. There are different patterns of energy use between domestic and non-domestic buildings, and between different types of non-domestic building that mean that the details need to be carefully considered to achieve a policy that is ambitious but achievable.**

4.5.1 True Zero Carbon

True zero carbon is defined, for the purpose of this report, by the PPS 1 definition which states "*over a year the net carbon dioxide emissions from all energy use within the buildings on the eco-town development as a whole are zero or below"*. Energy use within buildings is defined as both regulated and unregulated energy.

To reach true zero carbon, further consideration is needed regarding the operational carbon performance of the development over and above that described above in the standard regulatory approaches of building regulations. This approach recognises that the regulatory view of carbon and energy performance in buildings only represents a proportion of the actual "in use" energy consumption and carbon emissions.

4.5.2 Allowable Solutions

Allowable solutions have been introduced to offer flexibility and options to offset remaining emissions (beyond carbon compliance), when other on-site options are not considered technically and commercially feasible. Therefore, allowable solutions are likely to become central to the overall policy of ensuring that achieving zero carbon is affordable and can be achieved.

However, the Government has not yet defined the scope or price of allowable solutions. It is also unclear as to how allowable solutions may be delivered. The Zero Carbon Hub (Allowable Solutions for Tomorrows New Homes, June 2011)) announced its proposals for a framework for allowable solutions. This was further refined within the Zero Carbon Strategies for Tomorrow's

New Homes report released in February 2013. Again, a similar approach is expected for non-domestic buildings.

According to these proposals, the initial choice for developers will be either:

1. To pay into a carbon fund (Type 1 Allowable Solution). Here the payments from developers would be accumulated and the fund manager will take responsibility for investing in suitable Allowable Solutions projects - a wide range of carbon-saving projects could qualify as Allowable Solutions. It is expected that Local Planning Authorities will have the option to set up carbon funds and may establish local priorities for particular Allowable Solutions.

2. To invest in carbon-saving projects associated directly with their own developments (Type 2 Allowable Solution).

The range of potential Allowable Solutions can be split into the following options:

1. On-site allowable options – This might include measures such as smart appliances, site-based heat storage, electricity storage, waste management systems, LED street lights, flexible demand systems, etc

2. Near-site allowable options - This might include measures such as retrofitting low/zero carbon technologies to communal buildings, creation of local sustainable energy projects/infrastructure such as district heating or wind turbines, communal waste management, local energy storage, electric vehicle charging, etc.

3. Off-site allowable options - This might include measures such as investing in energy from waste plants, low carbon electricity generation, district heating pipe-work, low carbon cooling, energy storage, flexible demand projects to counterbalance intermittent renewable energy provision, etc.

Allowable solutions will have been designed to deliver the residual carbon emissions equal to that emitted by any new development. It is understood that the developers would pay an allowable solutions provider to deliver the required reductions. Recent DCLG consultation document discusses potential price cap strategy; of which some options would encourage competition between allowable solution providers ensuring that money is invested in the most cost-effective solutions. At present, a price cap has not been defined, however the DCLG consultation document proposes costs of between £36/tCO2 to £90/tCO2; which can make considerable difference to the total cost of achieving zero carbon and the final energy strategy for the development.

Based on the available information, it can be concluded that allowable solutions may be an important part in achieving a developments zero carbon target.

4.6 Local Policy

The existing Cherwell Local Plan (1996) saved polices do not specifically consider energy and carbon emissions. The emerging Cherwell Local Plan 2006 – 2031, that was submitted to the Secretary of State for Examination in Public on 31st January 2014. Examination in public commenced on 3 June 2014 and was subsequently suspended on 4 June 2014 for a period of 6 months to allow Cherwell DC to put forward modifications to the plan involving increased housing delivery to meet the full, objectively assessed needs of the District (see Inspector's Note No.2 – 09/06/14). The Examination hearings resumed in December 2014. Cherwell District Council is currently awaiting the Inspector's Report The emerging Local Plan includes policies on energy and carbon emissions however these are not yet adopted.

4.7 BREEAM

BREEAM (Building Research Establishment's Environmental Assessment Method) is a standard assessment method established by the Building Research Establishment (BRE), used to assess the environmental impact of non-domestic buildings. Overall BREEAM covers a range of issues and credits which are awarded where a building achieves a benchmark performance. BREEAM is a voluntary standard although central government and some planning authorities require compliance.

The BRE periodically updates BREEAM and the latest version of BREEAM New Construction came into force in May 2014. The latest version imposes more demanding standards and energy/carbon requirements than the previous standard. Because BRE have applied previous best practice carbon standards before the government has fully decided how to address the future carbon performance of nondomestic buildings, it is likely that the requirements will need to be changed again in the future to align with Part L (2013 and 2016) requirements.

BREEAM (2014) has the following mandatory energy requirements:

- Excellent: Energy Performance Ratio for New Construction of 0.375
- Outstanding: Energy Performance Ratio for New Construction of 0.60

The applicant is therefore committed to achieving a score of 0.375 or higher in all relevant buildings.

4.8 Summary of Policy Requirements

The various policy and regulations requirements are summarised in table 4.4 below:

Table 4.4: Summary of Application 1 Energy Requirements

Policy	Document	Requirement
Policy Bicester 1 – NW Bicester Eco-Town	Emerging Cherwell Local Plan 2006-2031	True Zero Carbon BREEAM Excellent
BREEAM Excellent	BREEAM New Construction 2014	Energy Performance Ratio (EPR_{NC}) of 0.375 (6 credits) or higher.
Building Regulations	Building Regulations 2019 (anticipated)	Zero Carbon from regulated energy

5 Methodology

The carbon dioxide emissions have been calculated using the available benchmarks: Chartered Institute of Building Services Engineers (CIBSE) Energy Benchmark TM 46 - 2008

The Chartered Institute of Building Services Engineers (CIBSE) describes the statutory building energy benchmarks prepared to complement the Operational Rating procedure developed by the Department of Communities and Local Government (CLG) for Display Energy Certificates (EPC) for use in England, Wales and Northern Ireland.

CIBSE carried out various studies and develops the benchmark proposals based upon CIBSE Guide F and Energy Consumption guide ECG19. There are currently 29 benchmark categories listed under this document, which also sets the energy consumption benchmarks of a typical building type. The benchmarks are expressed in terms of delivered energy used per unit of floor area, (i.e. kWh/m^2) for both electrical and fossil fuel of energy use. This generally covers lighting, heating, cooling, appliances, standard IT and small tea rooms/spaces.

The following non-domestic units have been used to estimate the energy demands on the basis of their gross internal area,

- A1 - Shops - Retail shops etc.
- A2 – Business Hubs
- A3 - Food & Drink - Restaurants/ Café
- B1 - Business Office/ Light Industrial
- B2 to B8 - Commercial
- D1 - Primary health care (general practitioners' surgeries and dental practices)
- D2 - Assembly & Leisure
- Public Buildings

The above building classification has been used to estimate the target emissions under Building Regulations 2013. This was considered an appropriate approach given the limitation of modelling to predict in-use (unregulated) energy; whereas the benchmark data provide total energy use (both regulated and unregulated). Therefore at this stage this approach was considered suitable and can be adopted to demonstrate the carbon emissions and proposed improvements.

6 Baseline Energy Demand and Carbon Emission

In order to establish the approximate baseline energy demand (both thermal and electrical) for the development, an energy model has been produced. The assessment of the energy performance of the proposed design solution is based on the energy consumption of 'notional' non-domestic buildings on site which are compliant with Part L 2013 Building Regulations.

Although this is a full planning application, by the shell and core nature of the development and without confirmed occupiers there is still some uncertainty about the energy needs of the future occupants of non-domestic buildings. Without knowing the occupants or precise uses of the proposed units, it is difficult to accurately predict the unregulated energy demand. As such, standard benchmarks taken from CIBSE publication TM46 2008 and Guide F have been used to estimate as far as possible non-domestic energy use; notwithstanding potential issues associated with this approach. For instance the benchmarks are intended to be representative of the UK building stock as a whole and so tend to estimate higher demand profiles than would typically be required for new buildings. As such, this approach will tend to overestimate the overall energy demand.

Therefore, the non-domestic energy benchmarks, which reflect Part L 2013 Building Regulations and have been determined by assuming that the CIBSE TM46 2008 and GUIDE F energy benchmarks, are reflective of energy consumption of 2006 Part L compliant buildings and so have been reduced by 31.75% to obtain the energy demand for non-domestic buildings reflective of new buildings, built to current Building Regulations. This is based upon the estimated improvement of 25% from 2006 to 2010 Building Regulations and 9% from 2010 to 2013 Building Regulations.

These benchmarks were used in the energy model to determine the baseline energy demand.

The following tables provide a summary of the energy demand and carbon emission relative to anticipated accommodation schedule of the Exemplar Commercial Centre. The tables provide the baseline energy demand and carbon emission values based upon meeting Building Regulations 2013.

Table 6.1 Non - Residential - Baseline Energy Demand and Carbon Emission (Building Regulations 2013)

Non – Residential Buildings	BR2013 Building Demand	BR2013 Building Emissions
Total Electricity	214,039 kWh	111,086 kgCO2
Total Gas	324,452 kWh	70,082 kgCO2
Space and Water Heating	280,692 kwh	60,629 kgCO2
Cooking	43,760 kwh	9,452 kgCO2
Sub Total	**538,491 kWh**	**188,051 kgCO2**

The table provides a summary of the total energy demand and carbon emission for Commercial Centre of the Exemplar site of the proposed NW Bicester Eco Town Development. These figures differ to those estimated within the original Exemplar Energy Strategy (Report No 4502-UA001881.v2). This is a result of revised proposals for the building layouts and uses, including the exclusion of the Eco Business Centre. The figures have also been updated to reflect current

2013 Building Regulations which represents a 9% improvement over 2010 Building Regulations and utilises a carbon factor of 0.216 kgCO2/kwh for gas consumption.

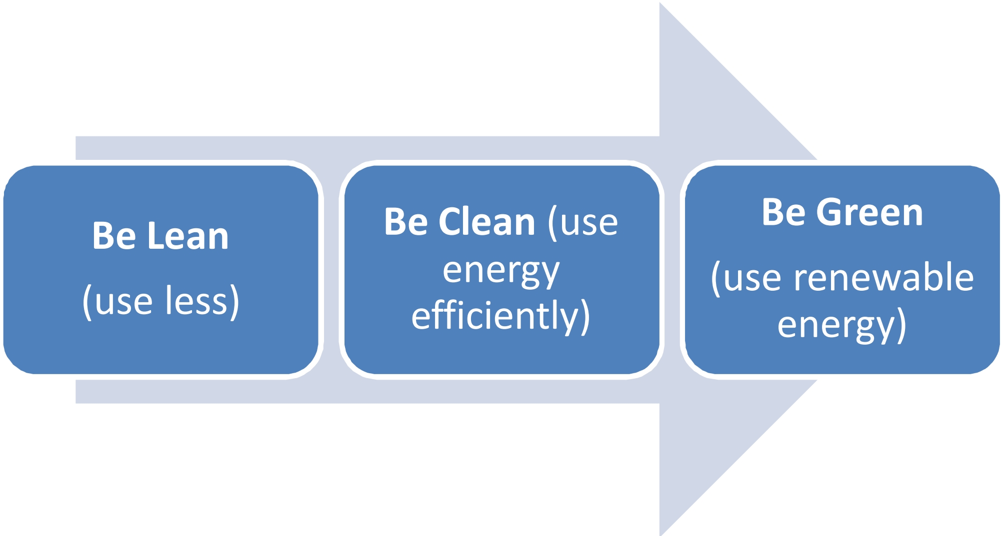
7 Strategic Approach and Carbon Reduction Targets

This report considers the strategic energy approach that may be adopted at the site to meet policy and regulatory requirements as well as client aspirations. The strategies considered follow the energy hierarchy outlined below:

1. **Be Lean:** Use less energy. Minimise energy demand through efficient design and the incorporation of passive measures;

2. **Be Clean:** Supply energy efficiently. Reduce energy consumption through use of low-carbon technology; and

3. **Be Green:** Use renewable energy systems.



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

7.1 Energy Efficiency Measures (Be Lean)

7.1.1 Approach

The 'Be Lean' approach seeks to minimise energy use through demand reduction and passive measures, such as maximising insulation and use of natural ventilation, which minimise the use of energy and utilise energy more effectively (e.g. energy efficient lighting). The NW Bicester development will adopt appropriate future proofed building standards to ensure energy efficiency is the first priority in achieving its carbon reduction and sustainability objectives.

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

Table 7.1 Building Energy Efficiency Measures

Passive Design	Technology
Air tightness	"A" rated appliances
Insulation	Automatic controls and monitoring
Reduce thermal bridging	Energy management systems
Solar shading	Energy efficient lighting
Use of natural daylight	High performance glazing
Natural ventilation	Energy efficient systems
Passive solar orientation	

Passive design is the process of best employing the conventional elements of construction to reduce energy consumption and to maximise the use of the natural elements such as daylight, sunlight and natural ventilation. The simplest and most effective method of achieving carbon reduction is often initially through the passive measures proposed above (and in section 7.2 below).

The development is proposed to be designed to utilise natural daylight in all the habitable spaces for the health and wellbeing of the building occupants. All the buildings will incorporate suitable window sizes relative to occupied spaces. This will allow the development to achieve good daylighting standards as well as controlling solar gains. The careful choice of glazing and window U values will maintain the solar gain and also minimise the solar intensity to reduce potential overheating impact.

The development is also intended to incorporate high efficiency lighting throughout. The proposed target is to provide 100% of all light fittings as low energy lighting, and will accommodate the compact fluorescent or fluorescent luminaires only.

Real time energy monitors will be provided to each building to enable occupiers to understand and adapt their energy use. These monitors may be combined with systems that also enable real time passenger information in relation to public transport serving the development.

7.1.2 Thermal Performance and Air Tightness

High performance building fabric, airtightness and low thermal bridging will reduce winter heat loss and consequently the required heating energy. The key energy reduction strategies to be employed will be:

- The provision of high thermal performance by means of increased insulation and high-performance window systems to reduce the heat loss
- Air tight construction techniques such as to minimise unwanted air infiltration, and post completion air pressure testing to ensure a high level of air tightness
- Attention to detail at junctions and service penetrations to improve both air tightness and thermal bridging performance

As fabric efficiency improves, the ratio of heat lost through infiltration to overall heat loss increases. The applicant is proposing limits on air permeability with a requirement for a Q50 test result of 5 m3/m2/hr or better to help further reduce heating demand. The testing has twin benefits as not only does it verify the effectiveness of the improvements included in the fabric design but also quality checks the builders work identifying any areas where improvements are needed due to poorer standards of workmanship. Thermo-graphic testing of the building will also be conducted post-completion to highlight any areas where remedial work may be required to further improve thermal performance.

7.1.3 Natural ventilation & thermal comfort

Wherever possible, natural ventilation will be used to provide fresh air, limit CO_2 concentrations and mitigate the risk of summertime overheating. Natural ventilation offers a fresh, healthy environment without using unnecessary electricity for fan power or active cooling.

Some shallow depth rooms such as offices and group rooms can use single sided natural ventilation. However, in deeper plan spaces, cross ventilation is required.

The aim in winter and shoulder months is to supply the minimum fresh air that would keep CO_2 concentrations low and dissipate odours while not creating an oversupply of fresh air which would add unnecessary heating loads. In summer, the aim is to move large volumes of air through the buildings using wind and buoyancy effects to mitigate overheating risk. This is managed by using ventilators with multiple opening positions.

7.1.4 Mechanical Ventilation

It is proposed that the buildings will be predominantly naturally ventilated, however there are areas which will inevitably require continuous mechanical ventilation, such as the toilets and kitchen/food preparation areas.

7.1.5 Daylight optimisation

Natural daylight can make an important contribution to sustainability by reducing the electrical energy used for the artificial lighting. It also contributes to the wellbeing of the occupants and the amenity of the space.

Natural light levels are usually measured by calculating the “daylight factor” within a space. The daylight factor measured at a point inside a room is a percentage of the total amount of light which would be available outside at an unobstructed point. A space with an average daylight factor between 2% and 5% is considered well lit and should require little or no additional lighting during daytime.

The external illuminance is greater than 7000 lux for around 80% of the annual occupied hours, therefore an average 5% daylight factor would equate to a lux level of 350lux

One of the principle design measures will be to provide high daylight levels throughout the buildings. The fenestration will be designed in conjunction with the architect to offer the best balance of daylighting, views out and reduction of summertime solar gains which can contribute to overheating. The glazing will let through a high percentage of visible light but limit the thermal energy transmission.

Where solar gain does increase along with the daylight the increase in internal gains can be balanced by the reduction in internal gains attributed to the artificial lighting which of course are now able to be switched off.

The relationship between the façade and energy consumption is quite complex and a simple addition or subtraction of glazing doesn't linearly increase or reduce energy consumption. Any improvement in the façade and the daylight provision will only be of benefit to the site's energy consumption if daylight levels are monitored and then used to automatically control the output of artificial lighting systems.

Automatic controls monitoring daylight levels and occupancy are therefore a useful means of controlling the artificial lighting.

7.1.6 Artificial lighting

Lighting energy contributes to a significant portion of a buildings energy demand. Low energy lighting and efficient controls will be used to exceed the minimum efficacy standards which is a challenging level of performance.

The lighting used within the scheme will comprise of either fluorescent or LED based lighting as a result. Lighting will be specified to offer the best balance of performance and efficiency.

7.1.7 Energy Monitoring

Actively monitoring energy use is a crucial aspect of the performance of the building in use. In order to run a building efficiently, it is necessary to readily be able to identify where energy is being used. Sub-metering linked to the BMS will allow remote monitoring and easy collation of metering data.

Metering data should be reviewed regularly and a process of 'continual improvement' be instigated to try to drive down energy use once the buildings are occupied.

7.2 Resulting Energy Demand and Carbon Emissions

Due to the nature of the energy demand profiles of the buildings it is expected that fabric enhancements outlined above will only marginally reduce the energy demand. This is because the energy demand for non-domestic buildings tends to be predominantly the result of the services and plant equipment.

For the purposes of representing a worst case scenario the energy demand profile and carbon emissions following the Be Lean enhancements is assumed to be unchanged from the baseline scenario.

The table below gives the breakdown of energy consumption and carbon emissions for space heating, hot water, lighting, pumps and fans (regulated energy) for domestic buildings and non-domestic units.

8 Low Carbon Technology (Be Clean and Be Green)

8.1 Introduction

After the initial savings through energy efficiency measures, the next step in a sustainable energy strategy is the consideration of ‘onsite’ low carbon (be clean) and renewable energy (be green); referred to as low and zero carbon (LZC) technology.

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

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

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

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

The Exemplar Local Centre forms part of the Exemplar Phase site which already has a determined energy strategy as outlined below.

8.2 Preferred Approach

The preferred approach to delivering the energy and carbon reduction consists of the following strategy in accordance with the original Exemplar Phase Energy Strategy (ref: Report No 4502-UA001881.v2):

- Enhanced fabric energy efficiency
- Site wide District Heat Network – providing all thermal demand across the site
- LZC technology sited within an Energy Centre providing hot water to the DHN and power
- Thermal demand regulated by inclusion of thermal stores
- Roof space to be used for Solar PV (orientated in southerly direction)

8.2.1 District Heat Network and Thermal Stores

A District Heat Network (DHN) is a network of insulated pipes used to deliver heat, in the form of hot water or steam, from the point of generation to the end user. They provide the means to transport heat efficiently provided distances do not become too far. A DHN enables heat to be delivered to point of use from a centralised location.

Inclusion of a thermal store(s) is proposed to regulate the heat demand. This will enable the hot water generated at the Energy Centre to be buffered, stored and released into the distribution network as needed.

8.2.2 LZC Technology: Gas CHP (Be Clean)

It is proposed to utilise Combined Heat and Power (CHP) as the primary engine(s) within the Energy Centre; as this integrates the production of usable heat and power (electricity), in one single, highly efficient process. It is proposed to utilise a gas-fired reciprocating CHP engine.

Gas-fired reciprocating engines have intake, compression, power, and exhaust cycles. In the intake phase, as the piston moves down in its cylinder, the intake valve opens, and the upper portion of the cylinder fills with fuel and air. When the piston returns upward in the compression cycle, the spark plug emits a spark to ignite the fuel-air mixture. This controlled reaction, or "burn," forces the piston down, thereby turning the crank shaft and producing power. Reciprocating engines can be used in a variety of applications because of their small size, low unit cost, and useful thermal output. They offer low capital cost, easy start-up, proven reliability, good load-following characteristics, and heat recovery potential.

The proposed CHP technology has been sized to meet 90% of the thermal demand, allowing for maintenance and downtime and to avoid significant heat dumping. The remaining thermal demands (10%) will be met by highly efficient conventional gas boilers.

The use of CHP technology also contributes to meeting the electrical needs of the development at the same time, however, it is recognised that further LZC technology will be required to meet the True Zero Carbon target as described below.

8.2.3 Solar PV (Be Green)

It is proposed that further carbon reductions will be achieved through the provision of roof mounted Solar PV, plus framed Solar PV over part of the northern car park area.

Solar Photovoltaic (PV) systems convert energy from the photons within sunlight into electricity through the aid of photocells; made of semi-conductor material, usually Germanium or Silicon. PV systems are suitable for any type of building but they require significant unshaded south facing space.

The maximum total annual solar radiation is usually at an orientation due south and at a tilt from the horizontal equal to the latitude of the site minus approximately 20 degrees. The latitude of Bicester is 51.9 degrees. Therefore 32 degrees is the optimal tilt in Bicester, south facing. However, efficiencies of up to 95% can be achieved within an orientation arc from south-west to south-east facing roofs and inclination from 15 to 50 degrees; which provides some flexibility in layout and design. It is therefore likely that tilts in the region of 15 degrees will maximise productivity of the available flat roof space due to the reduced overshadowing.

8.3 Reduced Energy Demand and Carbon Emissions

Following the Be Lean measures the remaining carbon reductions required are 181,168 kgCO_2.

8.3.1 CHP Technology

To estimate the carbon emissions reductions secured by a CHP driven DHN the following assumptions have been made:

Thermal demands:

- Gas CHP 90%
- Conventional high efficiency gas boiler 10%

Gas CHP (Data sheets provided in Appendix A):

- Power to heat ratio: 1.03:1
- Carbon content of fuel: 0.216 kgCO_2/kWh

Based on these assumptions and the CIBSE CHP calculation method a GAS CHP driven DHN to meet 90% of the thermal demands will reduce the carbon emissions as follows:

Table 2.2 CIBSE Method Calculations

Electricity Demand (P)	214,039	*kWh*
Thermal Demand (H)	238,588	*kWh*
Useful Heat Generation from CHP (H_{CHP})	214,729	*kWh*
($H-H_{CHP}$) Heat (Demand - Generation)	23,859	*kWh*
[($H-H_{CHP}$)/$\eta_b$oiler X $E_{f,boiler}$] 85% eff	6,063	*kgCO2*
F_{CHP} - Gas Fuel to run CHP	694,489	*kWh*
(F_{CHP} X $E_{f,CHP}$) - Gas fuel X fuel factor	150,010	*kgCO2*
Electricity Generated from CHP (P_{CHP})	266,848	*kWh*
($P-P_{CHP}$) Elect. (Demand - Generation)	- 52,809	*kWh*
($P-P_{CHP}$)X electricity fuel factor	- 27,408	***kgCO2***
Total Emissions with CHP	**128,665**	**kgCO2**
	129	**tonnes**

The CHP will therefore reduce the carbon emissions by approximately **43,051 kgCO$_2$**. This leaves a further reduction of 138,117 kgCO$_2$ to be achieved through the provision of roof mounted solar PV.

8.3.2 Solar PV technology

To calculate the Solar PV requirements the following general assumptions have been made:

- Roof mounted PV
  - Annual PV output per kWp: 850.00 kWh/year
  - PV peak output per 10m^2: 1.41 kWp at 850 kWh
- Car Park Cloth Arrangement
  - Annual PV output per kWp: 850.00 kWh/year
  - PV peak output per 10m^2: 1.00 kWp at 850 kWh
- Total PV area: 1,399 m^2

Based on these assumptions the following calculations can be made:

Table 2.3: Building Mounted Solar PV

All Buildings	**Enhanced FEE Emissions**
Remaining carbon emissions	138,117 kgCO2
Solar PV generation	- 80,111 kgCO2
Sub Total	**58,006 kgCO2**

The above table demonstrates that the provision of 154,356 kwh/year through solar PV on the available south facing roof space would achieve an approximate reduction of 80,111 kgCO$_2$.

This leaves residual carbon emissions of 58,006 kgCO2 to be mitigated by carbon savings achieved elsewhere within the NW Bicester Eco Town Development.

The residual carbon emissions for the local centre within the original Exemplar Energy Strategy (Report No 4502-UA001881.v2) was 76,623 kgCO2. Although not directly comparable, the Exemplar Local Centre does result in is a similar small amount of residual carbon that need to be off-set across the wider NW Bicester Eco Town Development or alternatively off-set via allowable solutions.

9 Summary

Following the Be Lean enhancements the remaining carbon reductions required for the Exemplar Commercial Centre are 181,168 $kgCO_2$.

The proposed CHP DHN would reduce the carbon emissions by approximately 43,051 $kgCO_2$. This leaves a further reduction 138,117 $kgCO_2$ to be achieved through the provision of roof mounted solar PV. The provision of solar PV would achieve an approximate reduction of 80,111 $kgCO_2$. This leaves a residual of carbon emission of 58,006 $kgCO_2$.

This falls short of the reduction required to achieve true zero carbon target for the Exemplar Local Centre when considered in isolation. However this relatively small amount of residual carbon will be able to be mitigated through additional savings secured elsewhere within the NW Bicester Eco Town Development or alternatively off-set through an allowable solution route to be agreed with the Local Council.

9.1 Summary of requirements

The strategy outlined within this statement achieves a 68% reduction in carbon emissions from the 2013 Building Regulation benchmark building (note this is equates to a 78% improvement from 2006 Building Regulations) through adoption of energy efficiency measures and on-site energy centre supply a DHN and solar PV technology.

The table below provides a summary of the development requirements and the current proposals to address them.

Policy	Requirement	Exemplar Local Centre Proposals
Policy Bicester 1 – NW Bicester Eco-Town	True Zero Carbon BREEAM Excellent	68% of True Zero Carbon achieved on-site BREEAM Excellent
BREEAM Excellent	Energy Performance Ratio (EPR_{NC}) of 0.375 (6 credits) or higher.	Energy Performance Ratio (EPR_{NC}) of 0.375 (6 credits) or higher.
Building Regulations	Zero Carbon from regulated energy	Zero Carbon from regulated energy

Appendices

Appendix A: Gas CHP Datasheets

Technical Description

Cogeneration Unit

JMS 412 GS-N.L

dyn. Gridcode BDEW (DEU, DNK, AUT, BEL, GBR)

Bicester Eco Project

Electrical output **889 kW el.**

Thermal output **913 kW**

Emission values

NOx < 500 mg/Nm^3 (5% O_2)

0.01 Technical Data (at module)

Data at:				**Full load**	**Part Load**	
Fuel gas LHV		kWh/Nm³		9.5		
				100%	75%	50%
Energy input		kW	[2]	2,071	1,596	1,121
Gas volume		Nm³/h	*)	218	168	118
Mechanical output		kW	[1]	916	687	458
Electrical output		kW el.	[4]	889	665	440
Recoverable thermal output						
~ Intercooler 1st stage		kW		171	85	26
~ Lube oil		kW		120	103	83
~ Jacket water		kW		230	203	166
~ Exhaust gas cooled to 120 °C		kW		392	323	243
Total recoverable thermal output		kW	[5]	913	714	518
Total output generated		kW total		1,802	1,379	958
Heat to be dissipated						
~ Intercooler 2nd stage		kW		63	49	33
~ Lube oil		kW		~	~	~
~ Surface heat	ca.	kW	[7]	81	~	~
Spec. fuel consumption of engine electric		kWh/kWel.h	[2]	2.33	2.40	2.55
Spec. fuel consumption of engine		kWh/kWh	[2]	2.26	2.32	2.45
Lube oil consumption	ca.	kg/h	[3]	0.27	~	~
Electrical efficiency		%		42.9%	41.7%	39.3%
Thermal efficiency		%		44.1%	44.8%	46.2%
Total efficiency		%	[6]	87.0%	86.4%	85.4%
Hot water circuit:						
Forward temperature		°C		95.0	90.7	86.3
Return temperature		°C		75.0	75.0	75.0
Hot water flow rate		m³/h		39.2	39.2	39.2

*) approximate value for pipework dimensioning
[_] Explanations: see 0.10 - Technical parameters

All heat data is based on standard conditions according to attachment 0.10. Deviations from the standard conditions can result in a change of values within the heat balance, and must be taken into consideration in the layout of the cooling circuit/equipment (intercooler; emergency cooling; ...). In the specifications in addition to the general tolerance of ±8 % on the thermal output a further reserve of +5 % is recommended for the dimensioning of the cooling requirements.

Main dimensions and weights (at module)

Length	mm	~ 6,000
Width	mm	~ 1,800
Height	mm	~ 2,200
Weight empty	kg	~ 11,600
Weight filled	kg	~ 12,200

Connections

Hot water inlet and outlet	DN/PN	100/10
Exhaust gas outlet	DN/PN	300/10
Fuel Gas (at module)	DN/PN	125/16
Water drain ISO 228	G	½"
Condensate drain	DN/PN	50/10
Safety valve - jacket water ISO 228	DN/PN	1½"/2,5
Safety valve - hot water	DN/PN	40/16
Lube oil replenishing (pipe)	mm	28
Lube oil drain (pipe)	mm	28
Jacket water - filling (flex pipe)	mm	13
Intercooler water-Inlet/Outlet 1st stage	DN/PN	100/10
Intercooler water-Inlet/Outlet 2nd stage	DN/PN	65/10

Output / fuel consumption

ISO standard fuel stop power ICFN	kW	916
Mean effe. press. at stand. power and nom. speed	bar	20.00
Fuel gas type		Natural gas
Based on methane number|Min. methane number	MZ d)	94|75
Compression ratio	Epsilon	12.5
Min./Max. fuel gas pressure at inlet to gas train	mbar	80 - 200 c)
Allowed Fluctuation of fuel gas pressure	%	± 10
Max. rate of gas pressure fluctuation	mbar/sec	10
Maximum Intercooler 2nd stage inlet water temperature	°C	40
Spec. fuel consumption of engine	kWh/kWh	2.26
Specific lube oil consumption	g/kWh	0.30
Max. Oil temperature	°C	85
Jacket-water temperature max.	°C	95
Filling capacity lube oil (refill)	lit	~ 315

c) Lower gas pressures upon inquiry
d) based on methane number calculation software AVL 3.1 (calculated without N2 and CO2)

0.02 Technical data of engine

Manufacturer		GE Jenbacher
Engine type		J 412 GS-B305
Working principle		4-Stroke
Configuration		V 70°
No. of cylinders		12
Bore	mm	145
Stroke	mm	185
Piston displacement	lit	36.66
Nominal speed	rpm	1,500
Mean piston speed	m/s	9.25
Length	mm	3,200
Width	mm	1,495
Height	mm	2,085
Weight dry	kg	5,200
Weight filled	kg	5,695
Moment of inertia	kgm²	9.42
Direction of rotation (from flywheel view)		left
Radio interference level to VDE 0875		N
Starter motor output	kW	7
Starter motor voltage	V	24

Thermal energy balance

Energy input	kW	2,071
Intercooler	kW	234
Lube oil	kW	120
Jacket water	kW	230
Exhaust gas cooled to 180 °C	kW	306
Exhaust gas cooled to 100 °C	kW	420
Surface heat	kW	46

Exhaust gas data

Exhaust gas temperature at full load	°C [8]	389
Exhaust gas temperature at bmep= 15 [bar]	°C	~ 410
Exhaust gas temperature at bmep= 10 [bar]	°C	~ 434
Exhaust gas mass flow rate, wet	kg/h	4,732
Exhaust gas mass flow rate, dry	kg/h	4,410
Exhaust gas volume, wet	Nm³/h	3,751
Exhaust gas volume, dry	Nm³/h	3,350
Max.admissible exhaust back pressure after engine	mbar	60

Combustion air data

Combustion air mass flow rate	kg/h	4,589
Combustion air volume	Nm³/h	3,551
Max. admissible pressure drop at air-intake filter	mbar	10

Sound pressure level

Aggregate b)	dB(A) re 20µPa	95
31,5 Hz	dB	87
63 Hz	dB	88
125 Hz	dB	95
250 Hz	dB	95
500 Hz	dB	94
1000 Hz	dB	90
2000 Hz	dB	86
4000 Hz	dB	84
8000 Hz	dB	86
Exhaust gas a)	dB(A) re 20µPa	117
31,5 Hz	dB	105
63 Hz	dB	120
125 Hz	dB	115
250 Hz	dB	113
500 Hz	dB	113
1000 Hz	dB	111
2000 Hz	dB	108
4000 Hz	dB	109
8000 Hz	dB	107

Sound power level

Aggregate	dB(A) re 1pW	115
Measurement surface	m²	95
Exhaust gas	dB(A) re 1pW	125
Measurement surface	m²	6.28

a) average sound pressure level on measurement surface in a distance of 1m according to DIN 45635, precision class 2.
b) average sound pressure level on measurement surface in a distance of 1m (converted to free field) according to DIN 45635, precision class 3.
The spectra are valid for aggregates up to bmep=19 bar. (for higher bmep add safety margin of 1dB to all values per increase of 1 bar pressure).
For operation with 1200 rpm see above values, for operation with 1800 rpm add 3 dB to the above values.
Engine tolerance ± 3 dB

0.03 Technical data of generator

Manufacturer		STAMFORD e)
Type		PE 734 C e)
Type rating	kVA	1,335
Driving power	kW	916
Ratings at p.f. = 1,0	kW	889
Ratings at p.f. = 0.8	kW	881
Rated output at p.f. = 0.8	kVA	1,101
Rated reactive power at p.f. = 0.8	kVar	661
Rated current at p.f. = 0.8	A	1,532
Frequency	Hz	50
Voltage	V	415
Speed	rpm	1,500
Permissible overspeed	rpm	1,800
Power factor (lagging - leading)		0,8 - 0,95
Efficiency at p.f. = 1,0	%	97.1%
Efficiency at p.f. = 0.8	%	96.2%
Moment of inertia	kgm²	36.30
Mass	kg	2,967
Radio interference level to EN 55011 Class A (EN 61000-6-4)		N
Construction		B3/B14
Protection Class		IP 23
Insulation class		H
Temperature (rise at driving power)		F
Maximum ambient temperature	°C	40

Reactance and time constants (saturated)

xd direct axis synchronous reactance	p.u.	1.96
xd' direct axis transient reactance	p.u.	0.12
xd'' direct axis sub transient reactance	p.u.	0.09
x2 negative sequence reactance	p.u.	0.13
Td'' sub transient reactance time constant	ms	10
Ta Time constant direct-current	ms	20
Tdo' open circuit field time constant	s	2.23

e) GE Jenbacher reserves the right to change the generator supplier and the generator type. The contractual data of the generator may thereby change slightly. The contractual produced electrical power will not change.

0.04 Technical data of heat recovery

General data - Hot water circuit

Total recoverable thermal output	kW	913
Return temperature	°C	75.0
Forward temperature	°C	95.0
Hot water flow rate	m³/h	39.2
Nominal pressure of hot water	PN	10
min. operating pressure	bar	3.5
max. operating pressure	bar	9.0
Pressure drop hot water circuit	bar	1.20
Maximum Variation in return temperature	°C	+0/-5
Max. rate of return temperature fluctuation	°C/min	10

General data - Cooling water circuit

Heat to be dissipated	kW	63
Return temperature	°C	40
Cooling water flow rate	m³/h	20
Nominal pressure of cooling water	PN	10
min. operating pressure	bar	0.5
max. operating pressure	bar	5.0
Loss of nominal pressure of cooling water	bar	~
Maximum Variation in return temperature	°C	+0/-5
Max. rate of return temperature fluctuation	°C/min	10

Exhaust gas heat exchanger

Type	shell-and-tube	
PRIMARY:		
Exhaust gas pressure drop approx	bar	0.02
Exhaust gas connection	DN/PN	300/10
SECONDARY:		
Pressure drop hot water circuit	bar	0.20
Hot water connection	DN/PN	80/10

connection variant F

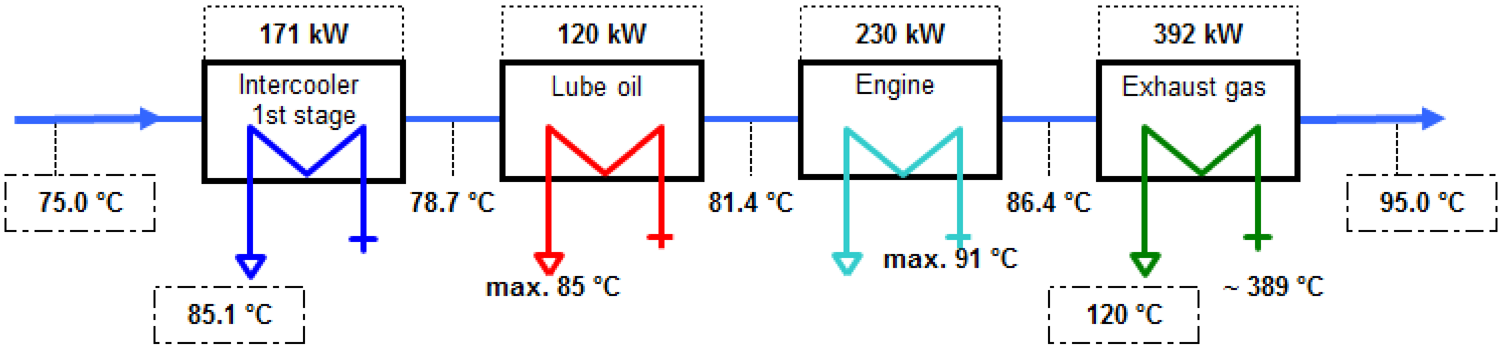
Bicester Eco Project J 412 GS-B305

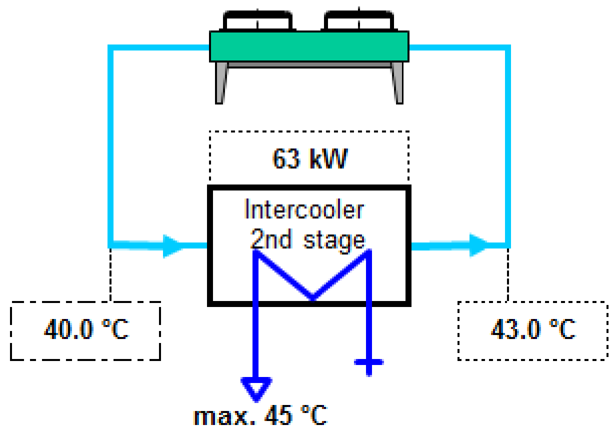
Hot water circuit

Recoverable thermal output = 913 kW

(±8 % tolerance +5 % reserve for cooling requirements)

Hot water flow rate = 39.2 m^3/h





Low temperature circuit (calculated with Glykol 37%)

Heat to be dissipated = 63 kW

(±8 % tolerance +5 % reserve for cooling requirements)

Cooling water flow rate = 20.0 m^3/h

0.10 Technical parameters

All data in the technical specification are based on engine full load (unless stated otherwise) at specified temperatures and the methane number and subject to technical development and modifications.

All pressure indications are to be measured and read with pressure gauges (psi.g.).

(1) At nominal speed and standard reference conditions ICFN according to DIN-ISO 3046 and DIN 6271, respectively
(2) According to DIN-ISO 3046 and DIN 6271, respectively, with a tolerance of +5 %.
Efficiency performance is based on a new unit (immediately upon commissioning).Effects of degradation during normal operation can be mitigated through regular service and maintenance work.
(3) Average value between oil change intervals according to maintenance schedule, without oil change amount
(4) At p. f. = 1.0 according to VDE 0530 REM / IEC 34.1 with relative tolerances
(5) Total output with a tolerance of ±8 %
(6) According to above parameters (1) through (5)
(7) Only valid for engine and generator; module and peripheral equipment not considered (at p. f. = 0,8)
(8) Exhaust temperature with a tolerance of ±8 %

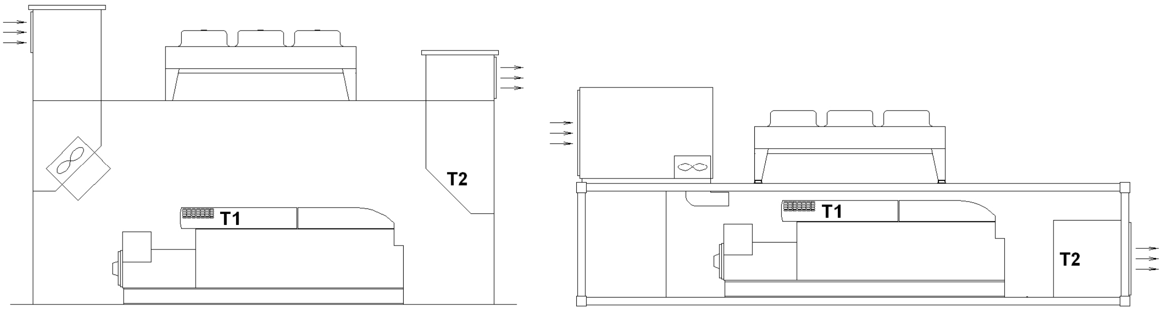
Radio interference level
The ignition system of the gas engines complies the radio interference levels of CISPR 12 and EN 55011 class B, (30-75 MHz, 75-400 MHz, 400-1000 MHz) and (30-230 MHz, 230-1000 MHz), respectively.

Definition of output

- ISO-ICFN continuous rated power:
  Net break power that the engine manufacturer declares an engine is capable of delivering continuously, at stated speed, between the normal maintenance intervals and overhauls as required by the manufacturer. Power determined under the operating conditions of the manufacturer's test bench and adjusted to the standard reference conditions.
- Standard reference conditions:
  Barometric pressure: 1000 mbar (14.5 psi) or 100 m (328 ft) above sea level
  Air temperature: 25°C (77°F) or 298 K
  Relative humidity: 30 %

- Volume values at standard conditions (fuel gas, combustion air, exhaust gas)
  Pressure: 1013 mbar (14.7 psi)
  Temperature: 0°C (32°F) or 273 K

Output adjustment for turbo charged engines
Standard rating of the engines is for an installation at an altitude ≤ **500 m** and an air intake temperature ≤ **30 °C** (T1)
Maximum room temperature: **50°C** (T2) -> engine stop



If the actual methane number is lower than the specified, the knock control responds. First the ignition timing is changed at full rated power. Secondly the rated power is reduced. These functions are carried out by the engine management system.
Exceedance of the voltage and frequency limits for generators according to IEC 60034-1 Zone A will lead to a derate in output.

Parameters for the operation of GE Jenbacher gas engines
The genset fulfills the limits for mechanical vibrations according to ISO 8528-9.
If possible, railway trucks must not be used for transport (**TI 1000-0046**).
The following "Technical Instruction of GE JENBACHER" forms an integral part of a contract and must be strictly observed: **TI 1100-0110, TI 1100-0111, and TI 1100-0112.**

Parameters for the operation of control unit and the electrical equipment
Relative humidity 50% by maximum temperature of 40°C.
Altitude up to 2000m above the sea level.

1.00 Scope of supply - module

Design:
The module is built as a compact package. Engine and generator are connected through a coupling and are mounted to the base frame. To provide the best possible isolation from the transmission of vibrations the engine is mounted to the frame by means of anti-vibrational mounts. The remaining vibrations are eliminated by mounting the module on isolating pads (e.g. Sylomer). This, in principle, allows the module to be placed directly on any floor capable of carrying the static load. No special foundation is required. Prevention of sound conducted through solids has to be provided locally.

1.01 Spark ignited gas engine

Four-stroke, air/gas mixture turbocharged, aftercooled, with high performance ignition system and electronically controlled air/gas mixture system.
The engine is equipped with the most advanced

LEANOX® LEAN-BURN COMBUSTION SYSTEM

developed by GE JENBACHER.

1.01.01 Engine design

Engine block
Single-piece crankcase and cylinder block made of special casting; crank case covers for engine inspection, welded steel oil pan.

Crankshaft and main bearings
Drop-forged, precision ground, surface hardened, statically and dynamically balanced; main bearings (upper bearing shell: 3-material bearing / lower bearing shell: sputter bearing) arranged between crank pins, drilled oil passages for forced-feed lubrication of connecting rods.

Vibration damper
Maintenance free viscous damper

Flywheel
With ring gear for starter motor

Pistons
Single-piece, made of light metal alloy, with piston ring carrier and oil passages for cooling; piston rings made of high quality material, main combustion chamber specially designed for lean burn operation.

Connecting rods
Drop-forged, heat-treated, big end diagonally split and toothed. Big end bearings (upper bearing shell: sputter bearing / lower bearing shell: sputter bearing) and connecting rod bushing for piston pin.

Cylinder liner
Chromium alloy gray cast iron, wet, individually replaceable.

Cylinder head
Specially designed and developed for GE JENBACHER-lean burn engines with optimised fuel consumption and emissions; water cooled, made of special casting, individually replaceable; Valve seats, valve guides and spark plug sleeves individually replaceable; exhaust and inlet valves made of high quality material.

Crankcase breather
Connected to combustion air intake system.

Valve train
Camshaft, with replaceable bushings, driven by crankshaft through intermediate gears, valve lubrication by splash oil through rocker arms.

Combustion air/fuel gas system
Motorized carburetor for automatic adjustment according to fuel gas characteristic. Exhaust driven turbocharger, mixture manifold with bellows, water-cooled intercooler, throttle valve and distribution manifolds to cylinders.

Ignition system
Most advanced, fully electronic high performance ignition system, external ignition control.
MORIS: Automatically, cylinder selective registration and control of the current needed ignition voltage.

Lubricating system
Gear-type lube oil pump to supply all moving parts with filtered lube oil, pressure control valve, pressure relief valve and full-flow filter cartridges. Cooling of the lube oil is arranged by a heat exchanger.

Engine cooling system
Jacket water pump complete with distribution pipework and manifolds.

Exhaust system
Turbocharger and exhaust manifold

Exhaust gas temperature measuring
Thermocouple for each cylinder

Electric actuator
For electronic speed and output control

Electronic speed monitoring for speed and output control
By magnetic inductive pick up over ring gear on flywheel

Starter motor
Engine mounted electric starter motor

1.03 Module accessories

Base frame
Welded structural steel to accommodate engine, generator and heat exchangers.

Flexible coupling
With torque limiter to couple engine with generator. The coupling isolates the major subharmonics of engine firing impulses from the generator.

Bell housing
To connect engine with generator housing. With two ventilation and control windows.

Anti-vibration mounts
Arranged between engine/generator assembly and base frame. Isolating pads (SYLOMER) for placement between base frame and foundation, delivered loose.

Exhaust gas connection
Connection of exhaust gas turbocharger; including flexible connection to compensate for expansions and vibrations.

Combustion air filter
Dry type air filter with replaceable filter cartridges, including flexible connection to carburetor and service indicator.

Interface panel
Totally enclosed sheet steel cubicle with front door, wired to terminals, ready to operate. Cable entry at bottom.

Painting: RAL 7035

Protection: IP 54 external, IP 20 internal (protection against direct contact with live parts)

Design according to IEC 439-1 (EN 60 439-1/1990) and DIN VDE 0660 part 500, respectively.
Ambient temperature: 5 - 40 °C (41 - 104 °F),Relative humidity:70 %

Dimensions:

- Height: 1000 mm (39 in)
- Width: 800 mm (32 in), **[-> at type 4 1000 mm (39 in)]**
- Depth: 300 mm (12 in)

Power supply from the starter battery charger.

Power distribution to the engine mounted auxiliaries (power input from the supplier of the auxiliaries power supply):
3 x 415/240 V, 50 Hz, 16 A

Essential components installed in interface panel:

- Terminal strip
- Decentralised input and output cards, connected by a data bus interface to the central engine control of the module control panel.
- Speed monitoring
- Relays, contacts, fuses, engine contact switch to control valves and auxiliaries
- Measuring transducer for excitation voltage
- Air conditioning system **(option)**

1.03.01 Engine jacket water system

Engine jacket water system
Closed cooling circuit, consisting of:

- Expansion tank
- Filling device (check and pressure reducing valves, pressure gauge)
- Safety valve(s)
- Thermostatic valve
- Required pipework on module
- Vents and drains
- Electrical jacket water pump, including check valve
- Jacket water preheat device

1.07 Painting

- Quality: Oil resistant prime layer
  Synthetic resin varnish finishing coat

- Colour: Engine: RAL 6018 (green)
  Base frame: RAL 6018 (green)

Generator:	RAL 6018 (green)
Module interface panel:	RAL 7035 (light grey)
Control panel:	RAL 7035 (light grey)

1.20.03 Starting system

Starter battery:
2 piece 12 V Pb battery, 200 Ah (according to DIN 72311), complete with cover plate, terminals and acid tester.

Battery voltage monitoring:
Monitoring by an under voltage relay.

Battery charging equipment:
Capable for charging the starter battery with I/U characteristic and for the supply of all connected D.C. consumers.
Charging device is mounted inside of the module interface panel or module control panel.

- **General data:**

• Power supply	**3 x 320 - 550 V, 47 - 63 Hz**
• max. power consumption	1060 W
• Nominal D.C. voltage	24 V(+/-1%)
• Voltage setting range	24V to 28,8V (adjustable)
• Nominal current (max.)	40 A
• Dimensions	240 x 125 x 125 mm
• Degree of protection	IP20 to IEC 529
• Operating temperature	0 °C - 60 °C
• Protection class	1
• Humidity class	3K3, no condensation.
• Natural air convection	
• Standards	EN60950,EN50178 UL/cUL (UL508/CSA 22.2)

Signalling:

Green Led:	Output voltage > 20,5V
Yellow Led:	Overload, Output Voltage < 20,5V
Red Led:	shutdown

Control accumulator:
- Pb battery 24 VDC/18 Ah

1.20.05 Electric jacket water preheating

Installed in the jacket water cooling circuit, consisting of:
- Heating elements
- Water circulating pump

The jacket water temperature of a stopped engine is maintained between 56°C (133 °F) and 60°C (140°F), to allow for immediate loading after engine start.

1.20.08 Flexible connections

Following flexible connections per module are included in the GE Jenbacher -scope of supply:

No. Connection	Unit	Dimension	Material
2 Warm water in-/outlet	**DN/PN**	**100/10**	Stainless steel
1 Exhaust gas outlet	**DN/PN**	**300/10**	Stainless steel
1 Fuel gas inlet	**DN/PN**		Stainless steel
2 Intercooler in-/outlet	**DN/PN**	**65/10**	Stainless steel
2 Lube oil connection	**mm**	**28**	Hose

Sealings and flanges for all flexible connections are included.

2.00 Electrical Equipment

Totally enclosed floor mounted sheet steel cubicle with front door wired to terminals. Ready to operate, with cable entry at bottom. Naturally ventilated.

Protection: IP 42 external
IP 20 internal (protection against direct contact with live parts)

Design according to EN 61439-2 / IEC 61439-2 and ISO 8528-4.
Ambient temperature 5 - 40 °C (41 - 104 °F), 70 % Relative humidity

Standard painting: Panel: RAL 7035
Pedestal: RAL 7020

4.00 Delivery, installation and commissioning

4.01 Carriage
According to contract.

4.02 Unloading
Unloading, moving of equipment to point of installation, mounting and adjustment of delivered equipment on intended foundations is not included in GE Jenbacher scope of supply.

4.03 Assembly and installation
Assembly and installation of all GE Jenbacher -components is not included in GE Jenbacher scope of supply.

4.04 Storage
The customer is responsible for secure and appropriate storage of all delivered equipment.

4.05 Start-up and commissioning

Start-up and commissioning with the GE Jenbacher start-up and commissioning checklist is not included.

4.06 Trial run

After start-up and commissioning, the plant will be tested in an 8-hour trial run. The operating personnel will be introduced simultaneously to basic operating procedures.
Is not included in GE Jenbacher scope of supply.

4.07 Emission measurement (exhaust gas analyser)

Emission measurement by GE Jenbacher personnel, to verify that the guaranteed toxic agent emissions have been achieved (costs for measurement by an independent agency will be an extra charge).

5.01 Limits of delivery

Electrical
- Module:
  - At terminals of module interface panel
  - At terminals of generator terminal box
    (screwed glands to be provided locally)
- Module control panel:
  At terminal strips
- Auxiliaries:
  At terminals of equipment which is supplied separately

Warm water
- At inlet and outlet flanges on module
- At inlet and outlet flanges of the exhaust gas heat recovery system

Low temperature water
At inlet and outlet flanges at module

Exhaust gas
- At outlet flange of exhaust gas connection
- At inlet and outlet flanges of the exhaust gas heat recovery system

Combustion air
The air filters are set mounted

Fuel gas
- At inlet and outlet flanges of gas train
- At inlet flange of gas pipework on module

Lube oil
At lube oil connections on module

Draining connections and pressure relief
At module

Condensate
At condensate drain on exhaust gas heat exchanger

Insulation
Insulation of heat exchangers and pipework is not included in our scope of supply and must be provided locally.

First filling
The first filling of module, (lube oil, engine jacket water, anti freeze-, anti corrosive agent, battery acid) is not included in our scope of supply.

The composition and quality of the used consumables are to be strictly monitored in accordance with the "Technical Instructions" of GE JENBACHER.

Suitable bellows and flexible connections **must be provided locally** for all connections.
Cables from the module must be flexible.

5.02 Factory tests and inspections

The individual module components shall undergo the following tests and inspections:

5.02.01 Engine tests
Carried out as combined Engine- and Module test according to DIN ISO 3046 at GE Jenbacher test bench. The following tests are made at 100%, 75% and 50% load, and the results are reported in a test certificate:
- Engine output
- Fuel consumption
- Jacket water temperatures
- Lube oil pressure
- Lube oil temperatures
- Boost pressure
- Exhaust gas temperatures, for each cylinder

5.02.02 Generator tests
Carried out on test bench of the generator supplier.

5.02.03 Module tests
The engine will be tested with natural gas (methane number 94). The performance data achieved at the test bench may therefore vary from the data as defined in the technical specification due to differences in fuel gas quality.
Carried out as combined Engine- and Module test commonly with module control panel at GE Jenbacher test bench, according to ISO 8528, DIN 6280. The following tests are made and the results are reported in a test certificate:
Visual inspection of scope of supply per specifications.
- Functional tests per technical specification of control system.
  - Starting in manual and automatic mode of operation
  - Power control in manual and automatic mode of operation
  - Function of all safety systems on module
- Measurements at 100%, 75% and 50% load:

- Frequency
- Voltage
- Current
- Generator output
- Power factor
- Fuel consumption
- Lube oil pressure
- Jacket water temperature
- Boost pressure
- Mixture temperature
- Exhaust emission (NOx)

The module test will be carried out with the original generator, except it is not possible because of the delivery date. Then a test generator will be used for the module test.
To prove characteristics of the above components, which are not tested on the test bench by GE JENBACHER, the manufacturers' certificate will be provided.

5.03 Documentation

Preliminary documentation 60 days after receipt of a technically and commercially clarified order:
- Module drawing 1)
- Technical diagram 1)
- Drawing of control panel 3)
- List of electrical interfaces 2)
- Technical specification of control system 2)
- Technical drawing auxiliaries (if included in GE Jenbacher-limit of delivery) 1)

At delivery:
- Wiring diagrams 3)
- Cable list 3)

At start-up and commissioning (or on clients request):
- Operating and maintenance manual 4)
- Spare parts manual 4)
- Operation report log 4)

Available Languages
1) DEU, GBR
2) DEU, GBR, FRA, ITA, ESP
3) DEU, GBR, FRA, ITA, ESP, NLD, HUN, RUS, POL, TUR, CZE
4) DEU, GBR, FRA, ITA, ESP, NLD, HUN, RUS, POL, TUR, CZE, SLOWEN, SLOWAK, SERB, SCHWED, ROM, PRT, NORWEG, LITAU, LETT, BULGAR, CHINA, DNK, ESTN, FIN, GRC, KROAT