DSSR | CONSULTING ENGINEERS

PROJECT | ABERDEEN CITY VISION MARKET DEVELOPMENT

RENEWABLES AND LOW & ZERO CARBON OPTION APPRAISAL

DSSR Document Reference	Version
G3705-DSSR-X-XX-RP-SUS-00001	P0

This Version

Authored by:

name: Gordon Macleod
role: Senior Project Engineer
signed:

date: 12/10/21

Reviewed by:

name: Stuart Brand
role: Regional Director
signed:

date:

Authorised for Issue by:

name: Lindsay Wood
role: Regional Director
signed:

date:

The signed original of this page is retained by the issuing team.

Version History

Version	Date	Status and Purpose	Changes Overview
P0	13/10/21	For Information	

CONTENTS

1. EXECUTIVE SUMMARY

This appraisal supports the proposed Aberdeen Market development, located on the existing market site at Hadden Street, Aberdeen.

This document highlights how the project team have taken into consideration the requirements of the 2020 Scottish Technical Standards and the policies set out in the Aberdeen Local Development Plan and Supplementary Guidance documentation, discussions with ACC Sustainability/Energy team, and provides indicative routes to achieving the following targets:

- Aberdeen Local Development Plan target for 25% of carbon emission reductions to be attributed to Low and Zero Carbon Generating Technologies
- Aberdeen Local Development Plan target for carbon dioxide emissions to be '*Platinum level*'[1] equating to net zero carbon emissions from regulated energy during building operation

Note, in complying with the Aberdeen Local Development Plan the proposals will inherently be compliant with the carbon reduction requirements of the current Scottish Technical Standards.

In complying with the carbon reduction requirements, the process includes assessing passive measures, consideration of active energy reduction measures and utilising suitable Low and Zero Carbon Generating Technologies (LZCGT) where appropriate.

Specific building data has been used in combination with industry standards, assumed 'typical values' and standardised data from the National Calculation Methodology (NCM) databases to generate an energy model of sufficient detail to identify building performance trends and provide considered comparisons. The energy models are used to assess alternative solutions available for this development and show the carbon emission reductions achievable relative to a 'typical' installation using a natural gas boiler for heat generation. The impact of utilising district heating and air source heat pump solutions are assessed and compared, with the air to water heat pump (for both space and water heating) solution proving most beneficial.

On-site energy generation is key to achieving a low carbon solution. Results from initial solar exposure studies are included herein, identifying those areas suitable for locating a photovoltaic (PV) array and quantifying the extent of the array to meet the aforementioned targets.

Compliance with the Aberdeen City council Local Development plan for 25% of the carbon emission reductions being attributed to LZCGT can be achieved by combining the air source heat pump solution with a PV array sized at approximately 200m^2 mounted on the Upper Roof's southern and western facing pitches. Extending the photovoltaic array to approximately 700m^2, spread across the high and low-level roofs, returns a CO_2 emission rate of zero, indicating net zero carbon emissions from regulated energy during building operation can be achieved for this development.

[1] Website link: https://www.gov.scot/publications/building-standards-technical-handbook-2019-domestic/7-sustainability/7-1-statement-sustainability/

2. PLANNING POLICIES & BUILDING REGULATIONS

National and local regulations, policies, plans and aspirations influence the approach taken to assess the suitability of the proposed development, including:

- Scottish Technical Standards 2020
- Aberdeen Local Development Plan 2017
- Aberdeen Proposed Local Development Plan 2020
- Aberdeen Council Climate Change Plan 2021 – 2025

Consideration is also given to the following published documentation

- Aberdeen City Centre Masterplan and Delivery Programme, Issue 2, June 2015
- Aberdeen City Council Union Street Conservation Area Appraisal, June 2007

2.1. Scottish Technical Standards

The current Scottish Technical Standards aim to achieve the following:

- Secure the health, safety, welfare and convenience of persons in or about buildings and of others who may be affected by buildings or matters connected with buildings;
- Further the conservation of fuel and power; and
- Further the achievement of sustainable development

The intention of the Energy Standards (Section 6) Scottish Technical Handbook 2020 is the limitation of building energy demand by addressing the performance of the building fabric and fixed building services as well as compliance with a carbon dioxide emission standard.

This is achieved by setting limits on the carbon dioxide emission rates of new buildings (Standard 6.1), and minimum and maximum values allowed for the performance of the building fabric and the mechanical and electrical systems servicing the building (subsequent standards).

Compliance with the 2020 Scottish Technical Standards is evidenced using approved SBEM/DSM (Simplified Building Energy Modelling / Dynamic Simulation Modelling) software, with the calculated BER (Building Emission Rate) required to improve upon the concomitant TER (Target Emission Rate) for the development.

Achieving compliance with the current building regulations demonstrates a ~60% improvement over the 2007 Scottish Technical Standards.

2.1.1. Note on Regulated and Unregulated Energy & NZEB

Building regulations in the UK limiting carbon emissions from buildings (Section 6 of Scottish Technical Standards, Approved Document Part L2 in England & Wales, Part F in Northern Ireland) consider *Regulated energy* only. That is, energy used in appliances to heat, cool, ventilate, illuminate and provide hot water to occupied and heated areas of a building. This approach disregards energy consumption from *Unregulated energy* consumers which can easily outweigh the demand from *Regulated energy* consumers.

Regulated energy is associated with fixed building systems including:

- Heating, Ventilation & Air Conditioning Plant and Equipment
- Internal Lighting
- Automatic Controls
- Domestic Hot Water Generation
- Regulated energy does NOT include lighting of unheated spaces

Unregulated energy is associated with all other energy consuming equipment or systems that could be present within a building including:

- Lifts
- External Lighting
- Small power plug-in equipment such as computers, photocopies, white goods and other office equipment
- Kitchen & Catering Facilities
- Any and all other energy consumers associated with the building

The UK Building regulations does not require measurement or verification of *Unregulated* energy, and the findings herein refer solely to *Regulated* energy. However, in the drive towards net zero emissions (during building operation) both *Regulated* and *Unregulated* energy consumers should be acknowledged, and that unregulated energy consumers will not be offset.

Where *Net Zero Emission Building (NZEB)* is discussed herein, this term refers only to carbon emissions from **regulated energy ONLY**, and excludes energy associated with occupied but unheated areas such as external Market and external spaces atop the Market Roof.

2.2. Aberdeen Local Development Plan

Aberdeen City Council's second *Local Development Plan* (LDP 2017) and the *Supplementary Guidance – Resources for New Development* provide guidance in relation to water, energy, heat networks/energy mapping and waste which are addressed in the following sections.

- Policy R6 – Waste Management
- Policy R7 – Low and Zero Carbon Buildings, Water Efficiency
- Policy R8 – Renewable and Low Carbon Energy Developments

2.2.1. Policy R6 – Waste Management

The development will accommodate an area housing recyclable materials, general waste and compostable material where appropriate. The area will be sized in accordance with the client's requirements and anticipated volume of waste streams and will take into account the guidance outlined in the Supplementary Guidance document – Resources for New Development.

A waste store location has been defined on the architectural arrangements plan, with a suitable area identified within the Service area located on the Ground Floor, with means of access and collection

included, identified in Figure 1, excerpted from drawing ref *AMKT–HFM-ZZ-00-DR-A-00100, General Arrangement Plan – The Green* dated 09/21/21

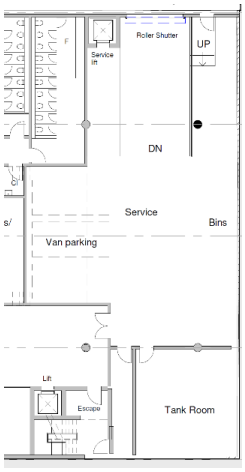


*Figure 1 – Ground Floor Plan Indicating Service Area Housing Waste Storage**

2.2.2. Policy R7 – Low and Zero Carbon Buildings & Water Efficiency

Reduction of greenhouse gas emissions is a key element of the Aberdeen Local Development Plan, reflecting international, national and regional policies. Section 72 of the Climate Change (Scotland) Act 2009 requires planning authorities to include policies within their Local Development Plans to ensure that all new buildings avoid a specified and rising proportion of the projected greenhouse gas emissions from their use.

All new buildings, must meet at least 25% of the building regulations carbon dioxide emissions reduction target applicable at the time of the application through the installation of low and zero carbon generating technology.

Year	Percentage Reduction	Building Standards Sustainability Label
2016	20%	Gold Standard for Energy
2020	25%	Platinum Standard for Energy
2025	30%	Platinum Standard for Energy

Figure 2 – Excerpt from LDP 2017 Policy R7

The requirement to achieve 'Platinum level' for Energy refers to section 7 of the Scottish Technical standards, where meeting Platinum for Energy effectively means achieving net zero carbon emissions from regulated energy during building operation.

7.1.10 Carbon dioxide emissions only at Platinum level for all other non-domestic buildings

All non-domestic buildings at this third optional upper level (in this aspect only) should meet all the standards in Sections 1 – 6 that apply to the building for the Bronze level, and in addition the building should comply with the following aspect:

Aspect Platinum level 1: Carbon dioxide emissions - This aspect only applies to all non-domestic buildings.

Under the guidance to Standard 6.1, the carbon dioxide emissions (Building Emission Rate) is to be 100% lower than the Target Emission Rate set by the 2010 Standards. To establish this, the BER from the NCM calculation should not exceed zero (this net zero carbon equivalent is a 100% improvement on the 2007 Standards).

Figure 3 – Excerpt from Technical Standards 7.1.10

2.2.3. Policy R8 – Renewable and Low Carbon Energy Developments

Aberdeen LDP 2017 promotes the development of all types of renewable heat and energy generating technologies. The Sustainability Checklist provided in the Local Development Plan Supplementary Guidance: Resources for New Developments also promotes developments to make use of decentralised energy generation to link up to an energy network where this is commercially viable.

The driver for this comes from the "*The Scottish Energy Strategy – The Future of Energy in Scotland*" report which supports the Scottish Climate Change Plan for 2017 – 2032, identifies heating as being one of the largest contributors to CO_2 emissions in the coming period.

Opportunities exists for the proposed development to be linked to an existing district heating network.

A review of the suitability of implementing or connecting to a local Heat Network as part of this development has been undertaken, reviewed by Fiona Williamson who is a certified CIBSE Heat Network Consultant.

See section 4.1.8 for discussion on the viability of connecting to the local District Heating networks.

3. ENERGY EFFICIENCY DESIGN MEASURES

DSSR Consulting Engineers have completed a preliminary energy assessment of the proposed development with regards to meeting the requirements set out in the 2020 Scottish Technical Standards and the Aberdeen Local Development Plan.

The purpose of this preliminary energy assessment is to inform both the architectural design (passive design) and the outline MEP Building Services Strategy (Active Design) as well as identify a feasible low and zero carbon solution that can provide a low energy building design whilst maintaining health & well-being for the occupants.

For regulated energy consumption such as heating, domestic hot water and lighting the *'Mean, Lean, Green'* philosophy[2] will be followed to ensure the demand for resources is lowered.

- *Mean. Reducing the demand for materials, energy, water and other resources. For example, creating guidelines for building designers to ensure demand is low from the outset, by utilising passive measures such as natural heating, lighting, ventilation and external shading.*
- *Lean. Ensuring that materials and systems are used responsibly and efficiently. For example, reducing distribution losses for energy (or water) between generation and usage. This might involve supplying heat, cooling, power and water from an on-site source.*
- *Green. Supplying any remaining requirements from renewable sources to minimise residual carbon emissions. For example, solar power or rainwater harvesting.*

Figure 4 shows the energy reduction hierarchy approach that will be taken for this project.

[2] Website link: https://www.designingbuildings.co.uk/wiki/Mean_lean_green

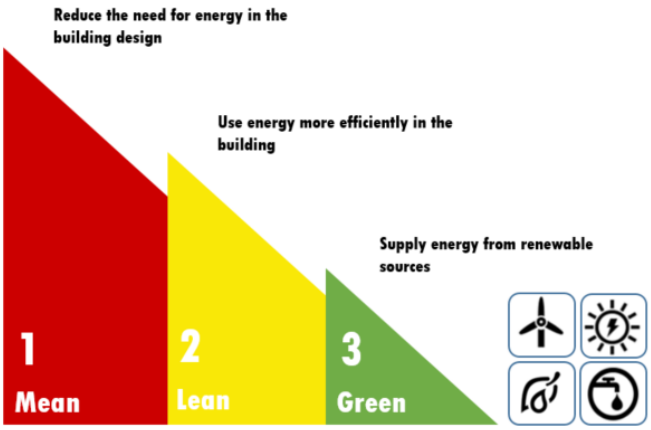
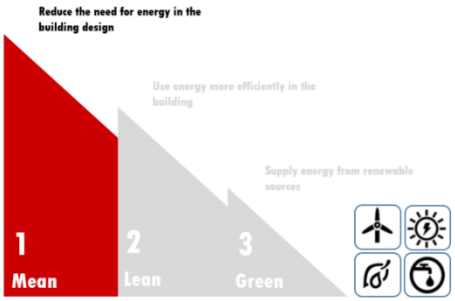


Figure 4 – Energy Reduction Hierarchy

3.1. Mean Measures



To ensure that the building has been designed to maximise energy and CO_2 savings the following *mean* measures are suggested for implementation.

Improvements to Fabric Insulation

Insulation levels of the thermal envelope either meet or improve upon the maximum backstop values allowable for thermal transfer coefficients (U-Values) stated in Standard 6.2 of the Energy Section of the current Scottish Technical Standards.

Table 1 summarises the thermal transmittance values for the current Technical Standards, both options proposed in the consultation documents for the proposed 2022 Technical Standards, and the requirements for Passivhaus certification.

Of these options tested, those values listed as '**2020+**' are deemed achievable and are recommended for consideration for this development. These U-Values are a slight improvement on the current regulations and reduce heating plant sizes, reduce energy demand for heating and contribute to achieving planning energy targets.

Element	Maximum Allowable Thermal Transmittance (U-Values) W/m^2.K

	2019 Technical Standards (or Typical)	2020+	Proposed 2022 Technical Standards		Passivhaus	
			Option 1 (15% reduction)	Option 2 (25% reduction)	Range	Tested
Roof	0.2	**0.16**	0.15	0.11	0.10 - 0.15	0.11
Wall	0.27	**0.2**	0.18	0.15	0.10 - 0.15	0.13
Floor	0.22	**0.16**	0.15	0.13	0.10 - 0.15	0.10
Window	1.6	**1.6**	1.4*	0.9*	<0.8	0.797
Rooflights	2	**1.3**	1.5**	1.5**	-	1.18

Table 1 - Thermal Transfer Coefficients (U-Values)

Air Tightness

Section 6.2.6 of the Scottish Technical Standards recommends that all new non-domestic buildings are designed to achieve an air permeability of 10 $m^3/m^2/hr$ @ 50Pa or better. A result of no worse than 5 $m^3/m^2/hr$ @ 50Pa has been set as a target for this development, to be confirmed by air tightness testing to be completed prior to handover. This figure has been used throughout the energy modelling processes.

Daylighting

The project team have considered how best to maximise the use of daylighting. Maximising daylighting and utilising daylight-linked dimming in the lighting systems brings a plurality of benefits:

- reduces the extent of uncontrolled heating
- reduces internal heat gains
- reduces the energy demand for artificial lighting

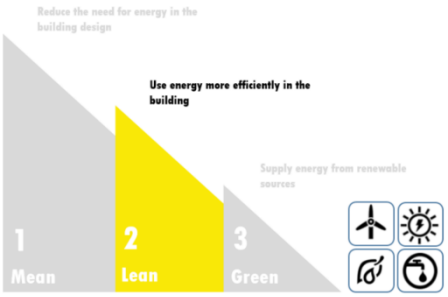
Previous iterations of the architectural arrangements included roof lights serving the first-floor seating areas. This increased the amount of daylight made available to the space and would allow the benefits listed above to be enjoyed.

Discussions surrounding roofing requirements for the inclusion of photovoltaics have prompted changes to the roof arrangements, with the current arrangements excluding rooflights and affording highly glazed areas only to the eastern and western facades which does not take full advantage of the potential for natural daylighting.

The potential for re-instating rooflights in this area should be investigated and considered alongside the roof area requirements for the photovoltaic array.

3.2. Lean Measures

After including passive design measures in the design of the building, there is scope to reduce the energy consumption and carbon emissions further by the incorporation of Low & Zero Carbon Technologies, see section 4.2.



Of the available low and zero carbon generating technologies, air-source heat pumps and photovoltaics are the currently preferred technologies for the development.

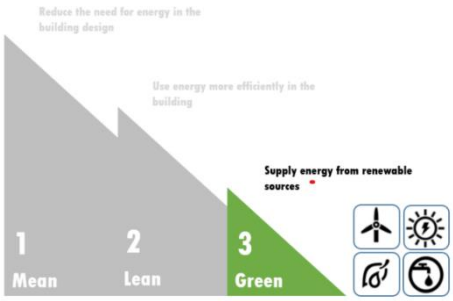
The following lists a number of active design measures that have been considered within the design, to ensure that energy demands can be met more efficiently.

- High efficiency heat generation though air to water air-source heat pumps
- Sourcing low-carbon heat from the local district heating network
-
- High efficiency heat recovery ventilation units where applicable
- Low energy LED lighting
- Lighting controls such as absence & presence detection and daylight dimming
- Building Management System
- Electric power factor correction if required
- Smart meters

3.3. Green Measures

Meeting unavoidable energy demands from renewable sources to minimise carbon emissions is managed in two ways:

- Ensuring energy supplied for building operation sourced from a renewable resource such as solar, wind and water
- Including on-site energy generation in the development, usually by means of photovoltaic arrays (PV) or combined heat & power (CHP) installations.



Energy Tariff

Business tariffs can be selected which guarantee 100% of energy is sourced from a renewable source and the building operator should make every effort to source energy from such a supplier, with Renewable Energy Guarantees of Origin (REGO) sourced for all renewable energy supplied.

On-Site Energy Generation Options

Combined Heat & Power

CHP installations bring their own energy requirements in the management of heating and electrical demands and the optimisation of on-site energy generation and consumption - optimising this balance is crucial to the success of the installation in lowering carbon emissions. The majority of CHP installations operate using natural gas which is carbon-heavy compared to biomass alternatives which bring their own issues with biomass fuel sourcing and delivery, onsite fuel storage and maintenance. CHP is not being further considered for this development.

Photovoltaics

Installing roof mounted solar PV panels requires input from architectural and structural designers in terms of the roof configuration to optimise the pitch and orientation to support a PV installation. Mounting PV cells at 'optimum' angles (typically 20° to 35° for the UK) can require a substantial steel mounting frame system, especially at coastal developments with elevated wind speeds and wind loadings. Alternatives include PV-integrated structural roof panels and flexible, modular, self-adhesive PV cells which can be attached to almost any exposed surface. Details of such a system have been used throughout the energy modelling processes, referencing the BIPVco Flextron System[3].

Minor forms of on-site energy generation, Micro-Wind and Micro-hydro, are not considered viable for this development, see section 4.2.

3.4. Mean, Lean & Green Actions Assessment

In buildings with no immediate requirement for cooling it is tempting to over-specify the extent of insulation required, justifying the recommendations with impressive figures showing reductions in energy demand. In reality the additional capex and increase in spatial requirements / reduction of gross internal floor area cannot be accommodated, especially in the redevelopment of an existing site.

The following table shows the impact increasing levels of insulation on the thermal envelope has on the heating demand experienced (refer to section 3 for U-Value breakdown):

Option	2019 U Values	2020+ U Values	2022 Opt 1 U Values	2022 Opt 2 U Values	Passivhaus U Values
Annual Space Heating load (MWh)	41.41	32.66	31.21	27.17	8.31

Table 2 – Heating Demand by Level of Insulation

It can be seen in the table above that moving to ***2020+*** levels of insulation reduces demand by 21%, with saving circulating around 25% to 35% under the 2022 proposals. Significant savings are realised when Passivhaus levels of insulation are afforded, however, not without compromise on cost and possibly floor area.

With insulation at ***2020+*** levels savings are recognised without severe impacts on capex or floor areas, and are recommended for inclusion in this development. See Section 3.1 for detail on the thermal transmittance levels tested.

Other *mean, lean and green* actions are expected to be less impactful and can be assessed/addressed at later design stages.

[3] Website link: https://bipvco.com/wp-content/uploads/2019/12/FLEXTRON_Datasheet_v3.pdf

4. LOW AND ZERO CARBON GENERATING TECHNOLOGIES (LZCGT)

4.1. ACC Planning Policy

Aberdeen City Council Local Development Plan Policy R7 notes the requirement that all new buildings must meet at least 25% of the building regulations carbon dioxide emission reduction target applicable at the time of the application through the installation of low and zero carbon generating technology (this figure increases to 30% in 2025).

Paragraph 4.2 of the Supplementary Guidance notes that the development will comply with the requirement to install LZCGT (low and zero carbon generating technologies) if it can be demonstrated that the development will achieve a CO_2 saving 15% greater than required by the current Building Standards.

Initial dynamic thermal modelling demonstrated that the development does not comply with the Energy Section of the 2020 Scottish Technical Standards without the use of low and zero carbon technologies and a review of low and zero carbon technologies has been undertaken.

4.2. LZCGT Appraisal

Of the accepted Low and Zero Carbon Generating Technologies listed in Policy R7 notes, some are disqualified due to either the nature of the building architecture, the nature of the building's energy demand or the nature of the site setting. The following commentary on the suitability of LZCGT listed in the Policy describe the reasoning behind system selection or disqualification.

4.2.1. Biomass Boilers

Biomass Boilers will not be further considered due to the significant requirement for fuel storage and plant space, continual road deliveries of fuel, and maintenance issues surrounding auger feeding.

4.2.2. Heat Pumps

Ground source heat pumps (and Geothermal systems) will not be considered due to the nature of the existing site, located in a densely built-up area with extensive groundworks not expected for the proposed development. With heating demand reduced due to the Mean, Lean and Green approach the demand is though insufficient to warrant the extensive groundworks and system configuration required for geothermal tapping.

Air source heat pumps are considered suitable for this development and are assessed and compared against other suitable LZCGT solutions herein. High efficiency air to water heat pumps are considered a viable solution as the heat generator for space heating and ventilation systems as well as providing the primary source of heating for the domestic hot water installation.

Water source heat pumps are not further considered due to the location of the building relative to Aberdeen Harbour. Though close enough to be physically linked by interconnecting pipework the extensive groundworks and associated carbon emissions are likely to outweigh any increase in system efficiency over air source heat pumps.

Of the applicable heat pump options described above, air source heat pumps have a slightly lower coefficient of performance than ground source heat pumps but would be a more cost-effective solution with no groundworks required.

4.2.3. Hydrogen Fuel Cells

Fuel cells are not yet considered a viable solution for a development of this scale due to dependence on hydrogen deliveries from a '*hydrogen economy*' that is not yet in place. The high capital cost and requirement for a high thermal load makes this unsuitable for a site with (intentionally) low heating demand, with payback on such systems effectively disqualifying it on commercial grounds.

4.2.4. Combined Heat & Power (CHP)

CHP systems are not being considered further for this development (see section 3.3)

4.2.5. Micro-Hydro & Micro-Wind

Micro-hydro is not being considered for this development due to the lack of local hydro source and location of the site within an existing built-up environment.

Micro-Wind is not considered viable for this development due to limitations relating to siting in an existing densely built-up area, with the site and profile building profile lying lower than the surrounding existing building stock. Remote siting of micro wind is not thought suitable again due to the surrounding urban site.

4.2.6. Heat Recovery

Heat exchange recovery systems are considered suitable and incorporated into air supply systems where available. The Food Retail Units may not be able to take full advantage of this solution due to the nature of the air vitiation (grease, odours, etc.) and requirements for dedicated extract systems however heat recovery from exhaust air streams should be considered for any and all supply air systems.

4.2.7. Flue Gas Hear Recovery

Passive flue gas heat recovery devices are not considered applicable to the development. The LZCGT options being considered do not utilise (local) combustion for heat generation.

4.2.8. District heating

District heating as a low carbon source of heat generation is considered suitable for this development and is assessed and compared against other suitable LZCGT herein.

The suitability of connecting to the District Heating network will depend on total heating demand, the cost of expanding the existing network to serve the development's location, and the carbon emission reductions utilising the network may bring.

The potential for a large domestic hot water demand exists due to the aspiration for the enclosed section of the building to primarily house rood retail units. The hot water heating requirement for food preparation is dependent on the types of food outlet that will occupy the units, and is likely to change

over the lifespan of the building. As the occupants of the Food Retail Units are currently unknown the hot water demand can only be very loosely estimated and selecting a district heating system on speculative demands would introduce risk to the project.

Local availability of Heat and Energy Networks

Aberdeen City has a well-established heat network already in place within specific city locations. The energy networks, managed and operated by Aberdeen Heat and Power are growing through the city.

Linking the proposed development existing District Heating Networks would require extending the nearest existing pipelines (located at Queen Street running to the rear of buildings on Union Street / Broad Street) to at least Market Street.

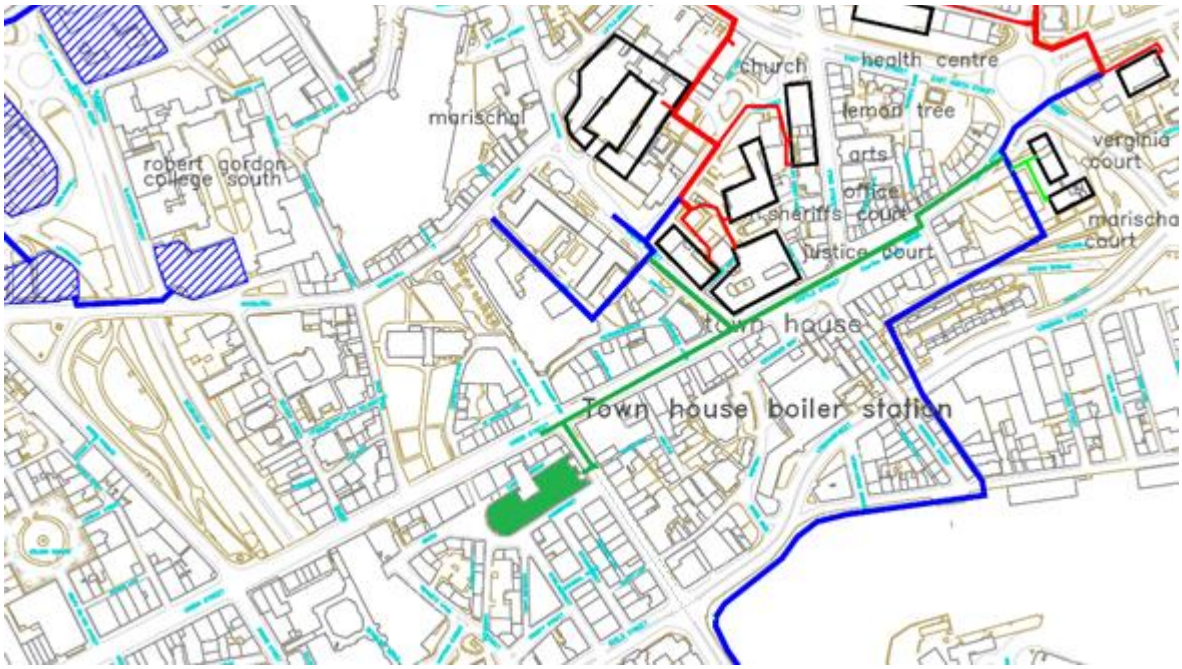
Connection to the local district heating network is likely to provide benefits in terms of carbon emission reductions due to the low carbon factor and primary energy factor for the system

System carbon factor 0.058 kgCO_2/kWh, system primary energy factor 1.2 kWh/kWh*

This is compared against alternative solutions herein, but in terms of cost-benefit the infrastructure associated with expanding the District Heating Networks is likely to make this option commercially unviable.

* Values for district heating network's carbon factor and primary energy factor supplied by *Aberdeen Heat and Power Company Ltd*.

Figure 6 shows an extract from the DH Network Drawing covering the city of Aberdeen, as provided by Aberdeen Heat and Power. The networks in **red** are currently installed, potential future network extensions are shown in **blue**, with suggested routes for extending the existing/future networks to link the proposed ACC Market development shown in **green**.



c

Figure 5 – District Heat Network (red), Future Expansion (blue) and Potential Links to Market (green)

Looking at potential routes for the district heating pipework, we anticipate that the pipework run would require a minimum ~380m link, including a 160m stretch under Union Street between Market St. and Broad St. Alternatively, connecting into the potential future-expanded network at Trinity Quay would require a ~200m link however the timeline for expanding the existing network is currently unknown.

Although this existing district heating network is *relatively* close to the proposed development site, connecting to the existing network or future-expanded network to serve the Market only is unlikely to be commercially viable unless the network was also linked to serve multiple consumers local to the Market development. On the basis that most properties along this route are private retail or commercial buildings there may not be an immediate market for new District Heating connections.

Initial discussion with Aberdeen Heat & Power Company Ltd. indicated approximate costs for connection to the District Heating network of around £800K and timescales for future expansion currently unknown. Connection to the existing or planned District Heating network would introduce an unacceptable level of risk to construction scheduling and capital expenditure.

4.2.9. Solar Thermal & Solar Power

Solar thermal water heating can be beneficial where large domestic hot water loads exist, however these systems demand area located on the roof which pits it in competition against photovoltaic installations for roof space. As the occupants of the Food Retail Units are currently unknown the hot water demand can only be very loosely estimated and selecting a solar thermal system on speculative demands would introduce risk to the project.

Electricity generation by PV is more likely to have a simultaneous consumer than domestic hot water, which may only be required at specific periods of the day. Photovoltaics are more beneficial and more cost effective than solar thermal due to the higher electrical demand than domestic hot water demand within the building.

However, installing roof mounted solar PV panels requires input from the architectural and structural design in terms of the roof configuration to optimise the pitch and orientation to support a PV installation.

Energy modelling is used to quantify the extent of the PV array required to

a) meet the Local Development Plan requirements for LZCGT contributions

b) offset sufficient carbon dioxide emissions for the building to achieve zero emissions from regulated energy during building operation (i.e., returning a Building Emission Rate of zero or less)

Targeting 15% reduction in emissions from LZCGT for Policy R7 will be achieved in pursuit of point b.

Roof Area Availability and Exposure

Roof area availability has been assessed based on architectural drawing reference *AMKT-HFM-ZZ-02-DR-A-00 102*, titled *General Arrangement Plan – Roof*, dated 09/21/21. Early discussion with the design team architects has influenced the design of the roof by accommodating with the roof pitch required for PV integration and maintaining suitable rainwater drainage routes while satisfying planning requirements.

Figure 7 identifies the roof areas associated with the various roof planes. Surface mounted and integrated PV cells can occupy 80% of the roof area available, resulting in the following PV areas (with the Market roof quadrant panels reduced to 60% coverage by PV to account for the difficult geometry:

Roof Orientation*	***Upper Roof South***	***Upper Roof West***	***Upper Roof East***	***Upper Roof North***	***Market Roof South***	***Market Roof Quadrants***
Area m^2	344	178	178	344	146	139
Array Area m^2	275	142	142	275	116	83
Array Tested m2	275	142	142	0	116	0

Table 3 - Roof Plane Power Generation Capability

*'*North*' and '*South*' refer to the building's roof geometry as opposed to 'true' north, south etc..

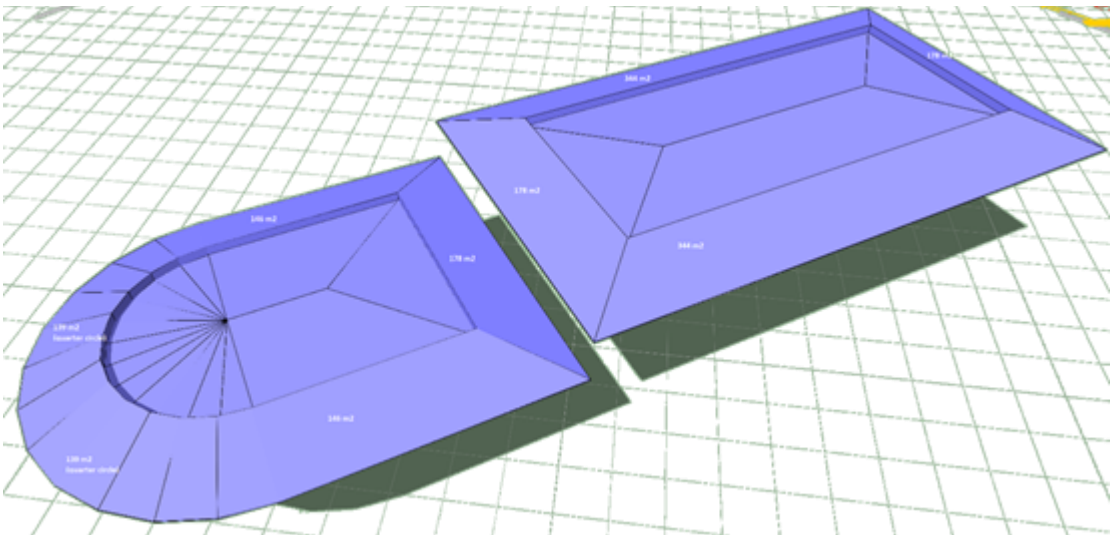


Figure 6 - Roof Space Availability for PV Array

Insolation & Shading

Preliminary energy simulations show solar insolation varies across the roof planes, with optimal exposure on the southern and western roof pitches and a drop in power generation of ~20% between on the northern and eastern roof planes. Figures 8 & 9 graphically show the variation across the roof planes with table 3 showing power generation density for the planes available on the Upper Roof.

Roof Orientation*	***Upper Roof South***	***Upper Roof West***	***Upper Roof East***	***Upper Roof North***
Annual kWh/m^2	116.0 (max)	114.1	94.0	91.3

Power output as % of max	100%	98%	81%	79%

Table 4 - Roof Plane Power Generation Capability

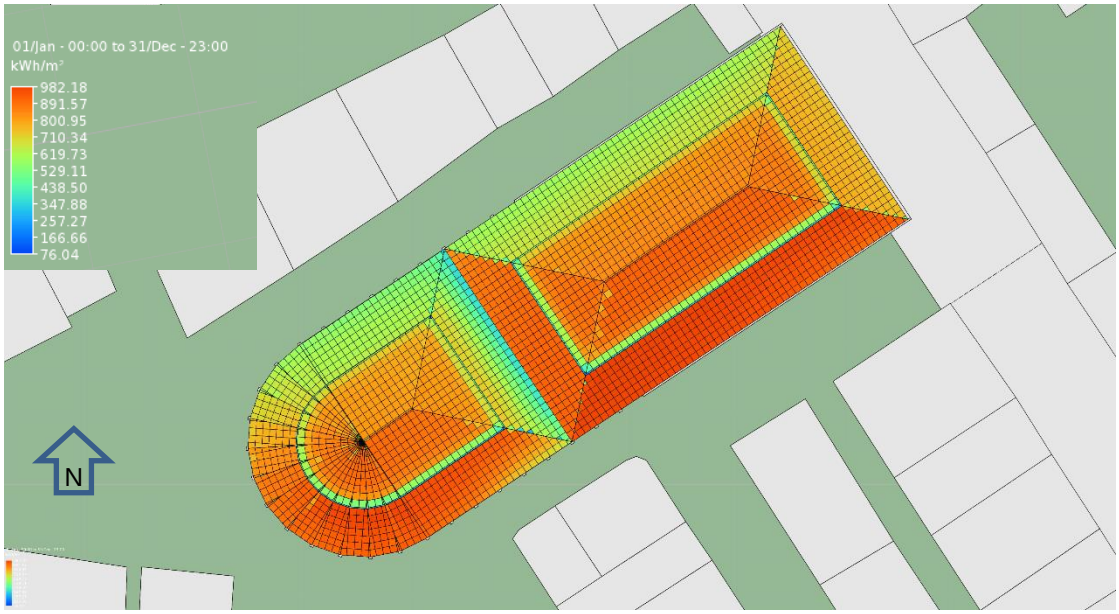


Figure 7 – Roof Insolation (Plan View)

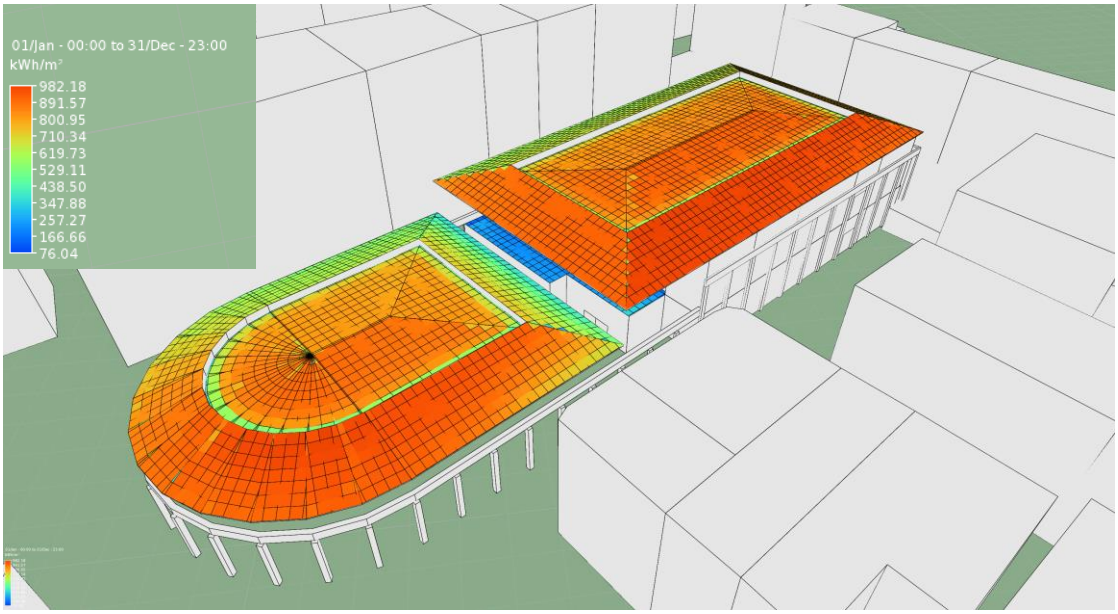


Figure 8 Roof Insolation (3D view)

4.3. LZCGT Options Summary

Of the optioned technologies, the following selection are suggested for further consideration and/or assessment.

- **Heat Pumps** - Air to water heat pumps providing heat generation for space heating and domestic hot water heating
- **District Heating** – Heat generation by the local low-carbon heating network shall be explored to identify any benefit over a heat-pump solution which does not involve extensive groundworks.
- **Photovoltaics** - It is unlikely low carbon heat generation only will meet the targeted values and the provision of a roof-mounted photovoltaic array will further offset the required amount of carbon emissions to achieve the targets.

5. LZCGT IMPACT ASSESSMENT METHOD

To allow an assessment to be made on the potential contribution of an LZC technology on the building it is necessary to populate the energy model with realistic occupancy/lighting/usage information. At this early stage and in lieu of project-specific information, usage profiles supporting the National Calculation Methodology (NCM)[4] have been used.

The NCM is UK's calculation method for assessing non-domestic buildings for compliance with the Technical Standards (Scotland) and Approved Documents (England & Wales). The NCM templates provide information typical for a range of building types, covering occupancy patterns, heating & cooling set-points, the inclusion and extent of mechanical ventilation, illumination levels and timings and so on. This information is used to create a software model interpretation of the proposed building development that can be used to quantify the impact of passive and active carbon-reducing actions, changing the primary heat generation plant to assess the impact such changes have on energy demand and the resulting carbon emission rates. Two variables are used in the reporting of NCM assessments:

TER *Target Emission Rate*	*The target CO_2 emission rate (TER) sets a minimum allowable standard for the energy performance of a building and is defined by the annual CO_2 emissions of a notional building of same type, size and shape to the proposed building. TER is expressed in annual kg of CO_2 per sq. m.*
BER *Building Emission Rate*	*The actual building emission rate (BER) for the proposed building is calculated based on its actual specification and is expressed in terms of its annual CO_2 emissions of the proposed building expressed in kg/m^2.*

The IES VE suite of software version 2021.2.0.0 with Compliance 7.0.1.3 has been used for these assessments.

[4] Website link: https://www.uk-ncm.org.uk/

5.1. LZCGT Option Assessment

The result of the LZCGT appraisal returned three technologies that are to be assesses for suitability in the development; air source heat pumps are to be considered. By comparing the resulting CO_2 emissions against a baseline model and the locally available District Heating network, the optimum solution for low carbon heat generation can be identified. Any outstanding carbon emissions requiring offset to meet Planning Conditions will be done by a rooftop mounted/integrated PV array.

5.1.1. Baseline Model

Using appropriate NCM profiles to populate and control the building within a '**2020+**' thermal envelope identified in sections 3.1, annual DSM (Dynamic Simulation Modelling) models are simulated against Test Reference Year weather files to predict the building's operational performance.

For comparison of LZCGT, the baseline model will utilise a natural gas boiler for space heating and domestic hot water generation.

5.1.2. Heat Generation Options

Benefits of the different heat generation options are quantified by comparing the resulting carbon emissions against the base model. The two options being assessed are a) space and water heating from the district heating scheme, and b) space and water heating by air source heat pump.

Only changes associated with each heat generation type are included within the energy models, as described in the table 5.

Space Heating	DHW Heating	Boiler Energy (MWh / yr)	TER	BER	Improvement on TER
Natural Gas Boiler 96% efficiency	Natural Gas Boiler 96% efficiency 1500 litre storage	56.1	8.7	**14.6**	No improvement on TER
District Heating CF 0.058 kgCO2/kWh PEF 1.2 kWh/kWh	District Heating CF 0.058 kgCO2/kWh PEF 1.2 kWh/kWh 1500 litre storage	54.9	8.6	**13.7**	No improvement on TER
ASHP SCoP 3.5	ASHP SCoP 3.5 4500 Litre Storage	18.2	9.2	**13.4**	No improvement on TER

Table 5 – Heat Generation Options Results

Results of the DSM simulation show the district heating scheme returns a carbon emission rate slightly higher than that for the ASHP. As the extensive groundworks associated with extending the existing district heating system to the proposed development would incur significant costs (and carbon emissions, relative to on-site solutions), the benefit in connecting to the DHS must be significant compared to on-site solutions for it to be considered for inclusion.

Using a heat pump solution over any other will reduce the ongoing running costs of the heating systems, with annual energy consumption approximately one third of that for non-heat pump solutions. This is the inherent benefit of heat pump solutions, with >300% efficiency of systems results in a consistently lower requirement for energy for heating, reflected in both the carbon emissions and fuel costs associated with space and water heating.

Between all solutions assessed the most efficient in terms of carbon emission reductions is the air source heat pump solution, returning a figure of 13.4 $kgCO_2.m^2.yr$ compared against the base model using natural gas (14.6 $kgCO_2.m^2.yr$) and the District Heating Solution (13.7 $kgCO_2.m^2.yr$).

Solutions utilising grid electricity will benefit from the ongoing decarbonising of the National Grid. This decarbonisation will not be recognised in fossil-fuel based solutions like the natural gas fired District Heating network. This results in the air source heat pump solution noted as favoured now becoming even more far more attractive over the lifespan of the building. See section 7 for consideration of predicted National Grid carbon intensities and the impact on the proposed solution.

Based on the assumptions described herein, an air to water heat pump solution is proposed for space heating and primary domestic hot water generation. The heat pump alone is insufficient to meet planning requirements and further carbon emission offsetting is required through inclusion of a photovoltaic array.

5.1.3. Photovoltaic Arrays

The extent of the PV array is constrained by the physical size of the roof planes available and guided by the orientation and level of exposure to sunlight (see section 4.2.9 for comment).

Sizing PV arrays can be an iterative process, the summarised key findings are presented in tables 6 and 7, showing the extent of PV array tested and the impact in terms of passing the carbon reduction requirements of Section 6 of the Scottish Technical Standards and achieving net zero carbon emissions from regulated energy in building operation.

Roof Orientation	Upper Roof South	Upper Roof West	Upper Roof East	Upper Roof North	Market Roof South	Market Roof Quadrants
Roof Area m^2	344	178	178	344	146	139
Max Array Area m^2	275	142	142	275	116	83
Option A Array Tested m^2	190	0	0	0	0	0
Option B Array Tested m^2	275	142	142	0	116	0

Table 6 - Roof Plane Power Generation Capability

Figure 10 identifies the extent of the PV coverage (in red) required to achieve Platinum level for Energy, a net zero carbon emissions development, for further detail.

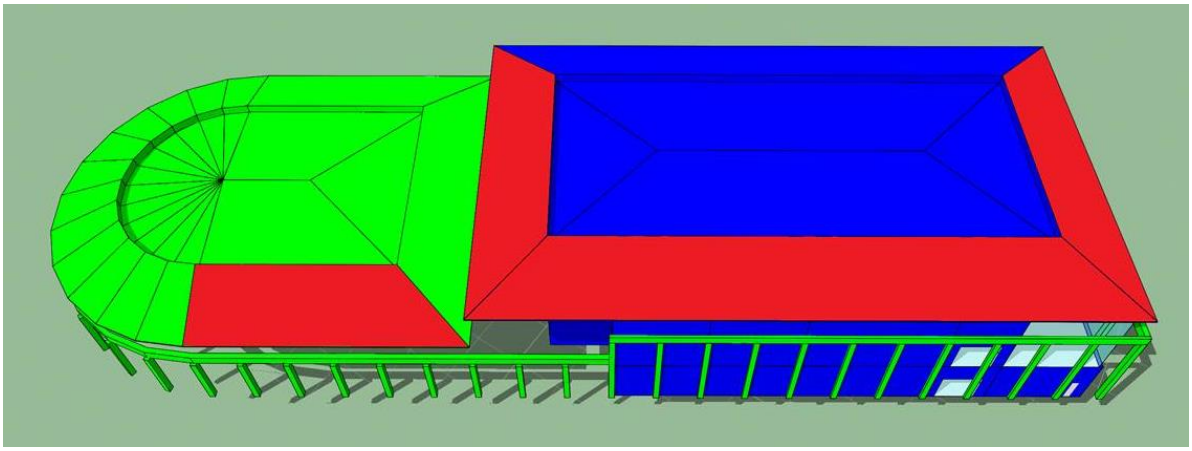


Figure 9 – Extent of PV Coverage Targeting NZEB

Option	Space Heating	DHW Heating	Photovoltaics	TER	BER	Improvement on TER
A	ASHP SCoP 3.5	ASHP SCoP 3.5 4500 Litre Storage	Upper Roof South **190 m² total**	9.2	9.1	0.87%
B	ASHP SCoP 3.5	ASHP SCoP 3.5 4500 Litre Storage	275m2 Upper Roof South + 142m2 on both West & East Upper Roofs+116 on Lower Roof South **675 m² total**	9.2	-0.9	110%

Table 7 - Roof Plane Power Generation Capability

5.2. LZCGT Assessment Summary

The findings of the LZCGT assessment are summarised as follows:

- The District Heating Network performs slightly worse than Air Source Heat Pumps
- Air Source Heat Pumps alone are insufficient to meet the targets of
  - Scottish Technical Standards requirement for carbon reductions
  - the LDP 2017 requirement for 25% of CO_2 reductions to be attributed to LZCGT or
  - the LDP 2017 requirement for Platinum level in energy
- A PV array sized at 190m^2
  - will meet the requirement for 25% of CO_2 reductions to be attributed to LZCGT but
  - will not achieve Platinum level for energy.

- A PV array sized at 675m^2
    - will meet the requirement for 25% of CO_2 reductions to be attributed to LZCGT and
    - will achieve Platinum level for energy (net zero emissions from regulated energy consumers during building operation)
    - can be accommodated by the current roof and roof pitch proposals.

6. ESTIMATED ANNUAL REGULATED CARBON EMISSIONS

The current City of Aberdeen Local Development Plan requires in 2020 a 25% carbon emission reduction through the use of Low and Zero Carbon Generating Technologies. A relaxation is noted for new buildings which can achieve a 15% improvement on the Section 6 target emission rate (TER).

The initial dynamic thermal modelling has demonstrated that the current proposals cannot achieve the targeted 15% improvement on the current Building Standards through the use of lean, clean and green design measures and that LZCGT is required to meet the carbon reduction requirements of the Scottish Technical Standards and achieve zero emissions from regulated energy during building operation. The following energy modelling results have been calculated for the proposed development.

	Option A **LZCGT Contribution** **Of Minimum 25%**	**Option B** **Net Zero Emissions Building** **from Regulated Energy (BER <= 0)**
LZCT System(s)	ASHP for Space and DHW Heating + PV array (**190** m^2 total)	ASHP for Space and DHW Heating + PV array (~**700** m^2 total)
Target Emission Rate (TER)	9.2 $kgCO_2/m^2.yr$	9.2 $kgCO_2/m^2.yr$
Building Emission Rate (BER)	9.1 $kgCO_2/m^2.yr$	-0.9 $kgCO_2/m^2.yr$
Section 6 Compliance (BER < TER)	PASS	PASS
ACC LDP Planning Requirement: Platinum level for Energy (BER <= 0)	FAIL	PASS
% Improvement due to LZCGT Technologies*	25.3%	71.3%
ACC LDP Planning Requirement: LZCGT Contribution =>25%	PASS	PASS

Table 8 - Initial Modelling Results – Current Proposal including LZCT

*The percentage improvement due to LZCGT Technologies is calculated in accordance with the procedure defined in Table 4 of the *Local Development Plan 2017 Supplementary Guidance - Resource for New Development*. This calculation process involves calculating the BER using the calculation process used in 2007. As the referenced procedure is now 14 years old no software is currently available which calculates the 2007 BER (for DSM as opposed to SBEM).

The 2007 TER has therefore been estimated by including the approx. 60% improvement factor between the 2007 and 2015 Technical Standards.

2015 TER / 40% = *2007 TER*

8.7 (2015 TER with no LZCGT) / 0.4 = *21.75 $kgCO_2/m^2.yr$*

Included below is the completed 'Table 6' of the *Local Development Plan 2017 Supplementary Guidance - Resource for New Development*, which is to be submitted with each planning application.

LZCGT Calculation Template Low and Zero Carbon Generating Technologies		**Option A** **Achieving LZCGT Contribution** **Of Minimum 25%**	**Option B** **Achieving NZEB from Regulated** **Energy (BER<0)**
Step	**Task**		
1	(TER) based on proposed building constructed to 2007 Building Regulations standards.	21.75	21.75
2	(DER/BER at the time of the application) based on actual building constructed WITH LZCGT.	9.1	-0.9
3	Calculate the reduction from step 1 to step 2: step 1- step 2	12.65	22.65
4	Calculate the reduction in step 3 as a % reduction on the 2007 TER: (Step 3 ÷ Step 1) x 100	58%	104%
5	(DER/BER at the time of the application) based on the proposed building constructed WITHOUT LZCGT	14.6	14.6
6	Calculate the reduction beyond the 2007 standard (step 5 – step 2)	5.5	15.5
7	Calculate the percentage reduction beyond the 2007 standard as a result of LZCGT (Step 6 ÷ step 3) x Step 4	25.3%	71.3%
	Does the building comply with the target emission set out in Table 1 – Y / N	Y	Y

Table 9 –LZCGT Calculation from Local Development Plan 2017

7. FUTURE PROJECTIONS FOR CO_2 EMISSIONS

Throughout this report, the Part L2A (2013) carbon factors of 0.519 and 0.216 kgCO_2/kWh for electric and gas have been used respectively. This section looks to bring this into context moving forward, with the CO2 emissions associated with electrical use having decreased notably over the last 10 years and are expected to decline further in the years to come.

Using figures from SAP 10 and SAP 10.1, current figures taken from the *Conversion factors 2020: condensed set (for most users)* published by the Government[5], and anticipated 2040 figures, the below chart has been produced to compare the percentage improvement using each set of data to estimate carbon dioxide emissions relating to building operation, when compared to the 2013 Notional Buildings CO_2 emissions.

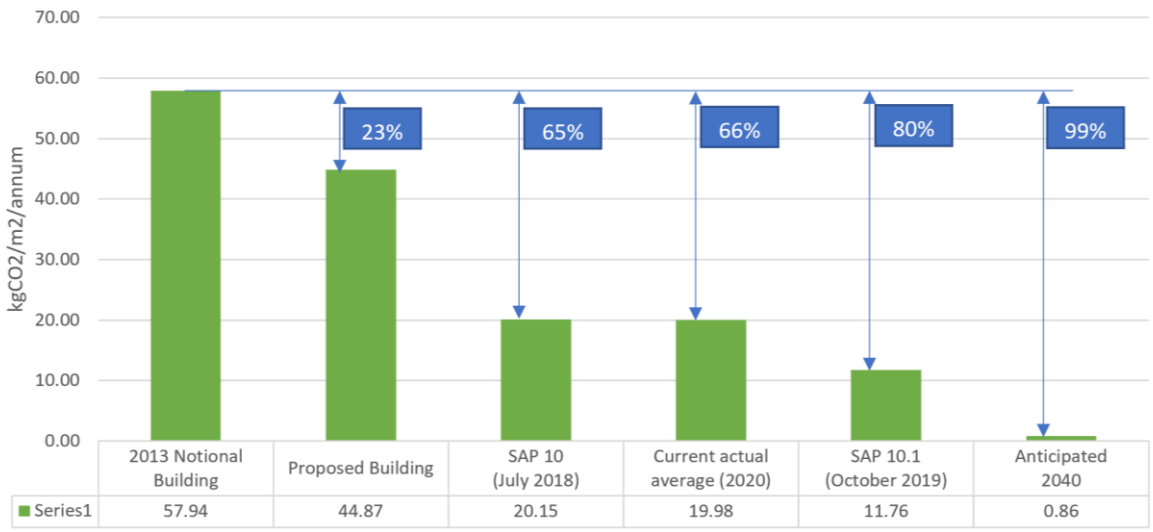


Figure 10 – Future Regulated Energy CO_2 Emissions

Solutions utilising grid electricity such as the air source heat pump solution currently favoured will benefit from the ongoing decarbonising of the National Grid, with reductions in emissions being recognised as soon as the improvement to the grid is realised. Fossil-fuel based solutions such as the natural gas fired District Heating network will not reflect those improvements, and with plans for decarbonising the District Heating network at early stages those reductions will not occur in the shorter term, strengthening the argument for heat pump solutions.

[5] Website link: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020

Offices at:
Glasgow
T 0141 334 6161
F 0141 357 1993
E glasgow@dssr.co.uk

Harrogate
T 01423 520252
F 01423 520325
E harrogate@dssr.co.uk

London
T 020 8567 5621
F 020 8579 5649
E london@dssr.co.uk

Manchester
T 0161 872 4811
F 0161 872 7325
E manchester@dssr.co.uk