Sustainability Report

‘Karuna’ and ‘Glenina’ Sandyford Road, Dublin 18, D18 C2H6 and D18 X5T7

April 2022

01 675 0850
info@reneng.ie
https://www.renaissanceengineering.ie
67-70 Meath Street, Dublin 8, Ireland
Renaissance Engineering | Company No: 515676 | VAT No: IE9842456U

This page is intentionally left blank

Executive Summary

This report prepared by Renaissance Engineering demonstrates the strategy for the mechanical & electrical systems including the energy performance and the sustainability of construction of the proposed development as described in the planning report.

Midsal Homes Limited intend to apply to An Bord Pleanála for permission for a strategic housing development at this site of 0.829 Ha approx. comprised of the properties known as 'Karuna' and 'Glenina' at Sandyford Road, Dublin 18, D18 C2H6 and D18 X5T7 respectively. The site is generally bound by a residential development known as 'Coolkill' to the east, a detached dwelling known as 'The Pastures' to the south, Sandyford Road (R117) to the west and a residential development (which is under construction) known as 'Cul Cuille' to the north. Works are also proposed at Sandyford Road, which include the removal of a wall and the creation of a new pedestrian connection to the existing cul-de-sac adjacent to 'Cul Cuille' to the north (0.016 Ha approx.) and at the footpath at Sandyford Road to provide a new multi-modal entrance, pedestrian/cycle entrances and landscaping (0.015 Ha approx.). In addition, works are proposed for water services (0.05 Ha approx.): water supply to be sourced by way of a new connection to the existing 250 mm diameter water main across from the proposed main entrance at Sandyford Road; surface water drainage network to discharge to the existing 525 mm diameter surface water sewer located to the north of the site at Sandyford Road via a new 150 mm surface water sewer; and foul water to discharge to the 225 mm diameter foul sewer under construction at Sandyford Road. An additional 0.01 ha has been assigned for Dún Laoghaire-Rathdown County Council to undertake road works to upgrade Sandyford Road. The residential development site, pedestrian connection, entrance works, water services and road works area will provide a total application site area of 0.92 Ha.

The proposed development principally consists of the demolition of the existing dwelling and ancillary buildings known as 'Glenina', the existing dwelling known as 'Karuna' and the existing boundary wall fronting Sandyford Road, and the construction of a residential development principally comprising 137 No. apartments (32 No. 1-bed units, 78 No. 2-bed units and 27 No. 3-bed units) in 4 No. blocks ranging in height from part-1 No. storey to part-6 No. storeys with a part-basement/part-undercroft level (at Blocks B, C and D).

The proposed development which has a gross floor space of 13,144 sq m (over a part-basement/part-undercroft level measuring 4,508 sq m, principally providing car and cycle parking and plant) also includes: internal communal amenities and support facilities (404 sq m); 137 No. car parking spaces, which include 127 No. spaces and 6 No. GoCar spaces located at basement level (accessed beneath Block B) and 4 No. set down spaces located at surface level adjacent to Block A; motorcycle parking spaces; cycle parking spaces; bin store; substation; switch room; meter rooms; plant rooms; new telecommunications infrastructure at rooftop level including microwave link dishes concealed in shrouds; hard and soft landscaping, including communal amenity space; private amenity space with balconies facing north, south, east and west; boundary treatments; and all associated works above and below ground.

The energy strategy has been approached in a holistic manner using the energy hierarchy "Be Lean, Be Clean, Be Green" to comply with Technical Guidance Document Part L – Conservation of Fuel and Energy Buildings Dwellings 2021, and Dun Laoghaire-Rathdown City Council Policy Objectives.

The design will place high emphasis on passive solar design, combining external local shading with high performance glazing to minimise solar heat gain in accordance with the Part L solar overheating criteria while maximising natural daylight access.

Key features of the energy-efficient design of ‘Karuna’ and ‘Glenina’ Sandyford Road, Dublin 18, D18 C2H6 and D18 X5T7 include enhanced building fabric performance, mechanical ventilation heat recovery and high-efficiency lighting with occupancy and daylight control where applicable. The primary heating system will either be electric with hot water heating, or will utilise natural gas heating, to be agreed with the housing provider with the aim of best meeting the needs of future tenants. The proposed energy strategy as detailed in this report is compliant with the requirements of Part L and achieves NZEB.

Table of Contents

1 Introduction

The proposed design will comply with national building regulations for energy performance and carbon emissions set out in the 'Technical Guidance Document Part L - Conservation of Fuel and Energy 2021 - Dwellings' (referred to in this document as 'Part L'). A provisional Building Energy Rating (BER) will also be produced in line with the EU Directive on Energy Performance in Buildings (EPBD).

The overall energy strategy of the proposed design has been approached in a holistic manner using the adopted energy hierarchy "Be Lean, Be Clean, Be Green". Energy performance has been assessed in accordance with the Domestic Energy Assessment Procedure (DEAP) methodology to demonstrate the systematic improvement in energy performance.

2 Renaissance Engineering's Approach

2.1 Energy Strategy Methodology

The proposed development will aim to exceed where feasible the requirements of Part L and achieving Nearly Zero Energy Building (NZEB) performance.

2.2 Energy Hierarchy

In order to achieve these objectives, the following energy hierarchy (referred to as "Be Lean, Be Clean & Be Green") has been used to identify and prioritise effective means of reducing carbon emissions.

Be Lean
Energy efficiency through design and use

Be Clean
Optimise energy supply infrastructure for efficiency through 'Low Carbon' strategies

Be Green
Utilise renewable energy resources where appropriate

Renaissance Engineering considers the above hierarchy, proposed and/or endorsed internationally by many local authorities, to be an appropriate set of principles for adherence to in tackling climate change. Adoption of this hierarchy as an overarching philosophy for design shall enable maximisation of CO_2 savings at each stage of the design process from early concept selection through to detailed design and realisation at later stages.

3 Legislative and Planning Requirements

Any new developments need to comply with two criteria:

1. National Legislation to meet requirements of the EU Directive on Energy Performance in Buildings (EPBD).
2. Local planning requirements as determined by the local authority.
3. Climate change assessment items as determined by the local authority.

3.1 Building Regulations Technical Guidance Document Part L

The Technical Guidance Documents Part L – Conservation of Fuel and Energy 2021 – Dwellings stipulates requirements in the following areas (applicable to new dwellings):

1. Limitation of Primary Energy Use and CO_2 Emissions.
2. Renewable Energy Technologies.
3. Building Fabric.
4. Building Services.
5. Construction quality and commissioning of services.

3.2 Nearly Zero Energy Buildings (NZEB)

Directive Recast 2010 (EPBD) stipulates all new buildings shall be Nearly Zero Energy Buildings by the 31st of December 2020 and all buildings acquired by public bodies by 31st December 2018.

The definition for Nearly Zero Energy Buildings in the Energy performance in Buildings Directive (EPBD) is "a very high energy performance, as determined in accordance with Annex 1, The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources including energy from renewable sources produced on-site or nearby".

NZEB is not separate to the building regulations, it is merely a term used to define the targeted performance of building regulations in the near future. Each member government has discretion in how the standard is applied nationally, and to comply with the NZEB requirement, the Irish government has issued the revised Building Regulations in the form of:

1. Technical Guidance Document Part L – Conservation of Fuel and Energy Dwellings (2021).
2. The Technical Guidance Document Part F – Ventilation (2019).

3.2.1 Domestic Energy Assessment Procedure (DEAP)

For new buildings, it is proposed that NZEB will be equivalent to a 25% improvement in energy performance on the 2011 Building Regulations and have a renewable energy ratio of 20%.

In order to demonstrate that an acceptable primary energy consumption rate has been achieved for NZEB, the ratio between the calculated Energy Performance Coefficient (EPC) should not be greater than the Maximum Permitted Energy Performance Coefficient (MPEPC), with a value of 0.30. Similarly, the ratio between the calculated Carbon Performance Coefficient (CPC) should not be greater than the Maximum Permitted Carbon Performance Coefficient (MPCPC), with a value of 0.35.

3.2.2 Achieving Compliance

The table below gives guidance on the acceptable levels of provisions required to ensure that heat loss through the fabric of the building is limited.

Fabric Elements	2011 Part L	2021 Part L (NZEB)
Pitched Roof	0.16	0.16
Flat Roof	0.20	0.20
Walls	0.21	0.18
Ground Floors	0.21	0.18
Other Exposed Floors	0.21	0.18
External Personnel Doors, Windows and Rooflights	1.6	1.4

Table 1: Maximum elemental U-value (W/m²K) for development

3.3 Renewable Energy Technologies

New developments are obligated to install some form of renewable energy technologies in the premise to comply with regulations. The permissible technologies refer to equipment that supply energy derived from renewable energy sources, e.g. solar thermal, on-site solar photovoltaic, heat pumps, combined heat and power and other on-site renewable energy systems.

The minimum level of energy provision required to satisfy regulations are presented below. For developments with more than one dwelling, every individual dwelling or the average of the development would collectively be required to contribute:

- 10 kWh/m^2/annum energy use for domestic hot water heating, space heating / cooling; or
- 4 kWh/m^2/annum of electrical energy; or
- a combination of these which would have equivalent effect.

3.4 Building Fabric

Building Regulations Part L outlines the acceptable levels of provisions necessary to ensure that heat loss through the fabric of a building is minimised. The Technical Guidance Document discusses various aspects, including:

- Insulation levels to be achieved by the plane fabric elements.
- Thermal bridging.
- Limitations of air permeability.

3.4.1 Fabric Insulation

The new development will be designed and constructed to limit heat loss and where appropriate, limit heat gains through the fabric of the building. In order to limit the heat loss through the building fabric the thermal insulation for each of the plane elements of the development will meet or exceed the area weighted average elemental U-Values as specified in Part L.

3.4.2 Thermal Bridging

To avoid excessive heat losses and local condensation problems, consideration will be given to ensure continuity of insulation and to limit local thermal bridging, e.g. around windows, doors and other wall openings, at junctions between elements and other locations. Heat loss associated with thermal bridges is considered in calculating primary energy use and CO_2 emissions using DEAP methodologies.

Acceptable Construction Details will be adopted for all key junctions where appropriate (i.e. typical/standard junctions). For all bespoke key junctions, certified details which have been certified by a third-party certification body will be used.

The default values for thermal bridging as set out in table D2, Appendix D of TGD – Part L, will be used or the certified details for any bespoke key junctions.

3.4.3 Air Permeability

In addition to fabric heat loss, reasonable care will be taken during the design and construction to limit the air permeability (Infiltration). High levels of infiltration can contribute to uncontrolled ventilation. Part L requires an air permeability level no greater than $5m^3/h/m^2$ at 50 Pascals for NZEB. Where lower levels of air permeability are achieved, it is important that purpose provided ventilation is maintained. The design intent will be to achieve an air permeability of $3m^3/h/m^2$ @ 50Pa (TBC) which represents a reasonable upper limit of air tightness.

3.5 Decarbonising Motorised Transport

The development will be providing 29 Electric car charging points as per TGD Part L requirements. By providing the car charging points will allow occupants to avail of the ever-improving efficient electric car technologies.

In addition to the electric car charging points the development has private and secure bicycle storage facilities.

The development is adjacent to regional road R117 which is a two-way two-lane road with footpaths on both sides. The R117 is served by public transport, with Dublin Bus Routes 44B and 114. The availability, proximity and ease of access to high quality public transport services contributes to reducing the reliance on the private motor vehicle for all journey types.

4 Energy Efficient and Sustainable Technologies Considered

4.1 District Heating Network

District heating systems deliver heat for both space heating and water heating needs to buildings through a network of insulated pipes. Heat is produced centrally in large plants and delivered through the district heating network. The usage is transferred to each user via a Heat Interface Unit and then metered.

District heating systems offer advantages in terms of higher energy efficiencies, reduced consumption of energy resources and are fully compatible with European and National policies and objectives for carbon dioxide reduction, energy efficiency, security of energy supply, sustainability and competitiveness. District heating can also offer capital cost savings and reduced operating and maintenance costs to commercial and residential customers.

Advantages

- Multiple sources of heat generation can be utilised: Condensing boilers, biomass, CHP and heat pumps.
- Reduces labour and maintenance costs associated with individual systems.
- Hot water available around the clock.
- Helps to manage the supply and demand of heat to avoid unnecessary production while still meeting needs.

Disadvantages

- If a major issue occurs, the entire site will lose heat.
- Large capital investment required.
- Responsibility for consumer billing.

4.2 All-Electric Systems

4.2.1 Electric Radiators

In the past electric heating was considered by many as one of the most inefficient heating systems on the market. This was primarily due to certain types of heaters such as night rate storage heaters and panel heaters. Today, however, electric radiators made with high thermal ceramic heating elements with digital thermostat controls are very efficient with low running costs. Electric radiators are, in fact, 100% efficient, meaning all the electricity used is converted into heat unlike conventional wet systems where there are losses in several areas of the system. There are losses in the boiler itself, the flue connecting to the boiler has its losses where wasted energy is exhausted into the atmosphere and then there are the losses in the heating pipes that travel from radiator to radiator. On average, a conventional wet system would incur losses of around 20%, making the system only 80% efficient.

Advantages

- One of the cheapest forms of heating systems. There is no requirement for expensive equipment such as boilers, pumps, valves and associated accessories.
- There are low maintenance costs associated with an electric heating system unlike a conventional wet heating system.
- Electric heaters with built-in, sensitive, thermostatic controls allow the radiator to quickly adapt to changes in room temperature.

- The future is electric and electric heating. By integrating a renewable energy source such as photo voltaic panels (PV) into the heating system, the dwelling can produce its own power to use for heating.

4.2.2 Hot Water Heat Pump Cylinder

Air-to-Water or Air-Source Heat Pump (ASHP) Systems are a standalone system suited for any dwelling. The system works on a lower operating temperature which drastically reduces running costs. Throughout the year, the heat pump will run at efficiencies of 250-450% depending on ambient temperature. The system works best in conjunction with underfloor heating and aluminium radiators but can also be installed with suitably sized steel radiators. By integrating the heat pump directly into the water cylinder, however, a hot water heat pump can be formed which will cater for the hot water requirements of a dwelling while the heating requirements can be met by electric radiators. This drastically reduces the need for pipes, pumps, valves and accessories required in the traditional wet system.

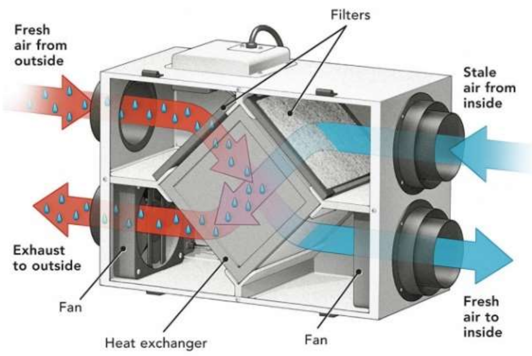
4.2.3 Solar Photovoltaic

Solar Photovoltaic (PV) systems generate electricity from sunlight. The panels produce electricity in the form of direct current (DC). As this form cannot be utilised by household electronic equipment, an inverter is used to convert the electricity to alternating current (AC).

Advantages

- Solar PV is a proven technology that, once installed, will provide free electricity for decades.
- Since there are no moving parts, PV panels require minimal maintenance. PV panels also generally have 25 years' performance warranties and a life expectancy in excess of 30 years.
- Annual solar irradiation can be estimated using historical weather data. Therefore, the electricity generated is predictable.
- Solar PV is versatile, offering multiple methods of roof, ground installations, as well as car ports, awnings, facades, etc.
- Prices of PV panels have fallen by 40% since 2014, and 75% since 2009.
- With a feed-in tariff (FiT), excess electricity can be sold back to the grid. FiT is yet to be adopted.
- Solar PV systems can be coupled with battery technology to store electricity for night-time usage. However, the overwhelming majority of systems are 'grid connected' and not battery systems.

4.2.4 Mechanical Ventilation Heat Recovery in combination with Exhaust Air Heat Pump



Mechanical ventilation with heat recovery (MVHR) is a whole-house ventilation system which supplies fresh air to dry rooms and extracts stale air from wet rooms. Both air flows are ducted and driven by two fans, one on the supply side and one on the extract side. The key element of this system is that it uses a heat exchanger to transfer heat from the warm exhaust air to the fresh air, achieving up to 85% heat recovery. The reduction in heat losses due to ventilation is significant and occupants' comfort is also increased as the air supply is warmed before entering the rooms. The MVHR unit which houses the heat exchanger and the fans is also equipped with filters which prevent outside dust entering the system and internal air particles depositing within the unit.

Advantages

- Waste heat from extract air is recovered, reducing the heating load.

Disadvantages

- Increased capital outlay in comparison with mechanical extract, passive supply systems.
- Central systems will require larger than normal ceiling voids and riser space to distribute ductwork.

4.3 Centralised System utilising Gas Boilers and CHP

Combined Heat & Power (CHP) increases the efficiency of energy generation from internal combustion of either natural gas, LPG, oil or bio-diesel.

CHP or cogeneration is the simultaneous generation of heat and electricity from the one piece of equipment. Heat that is usually lost in the power generation process is captured and used to heat water.

By capturing heat that is usually wasted, the much higher running efficiencies (in some cases greater than 99%) achieved can generate significant carbon and energy savings for the user. These savings are recognised in TGD L - Buildings other than Dwellings 1.2.5 as making CHP an acceptable alternative to renewable technology:

"As an alternative to providing the RER (Renewable Energy Ratio) as outlined in sub-section 1.2.1 the use of a combined heat and power (CHP) system which contributes to the space and water heating energy use would be acceptable.

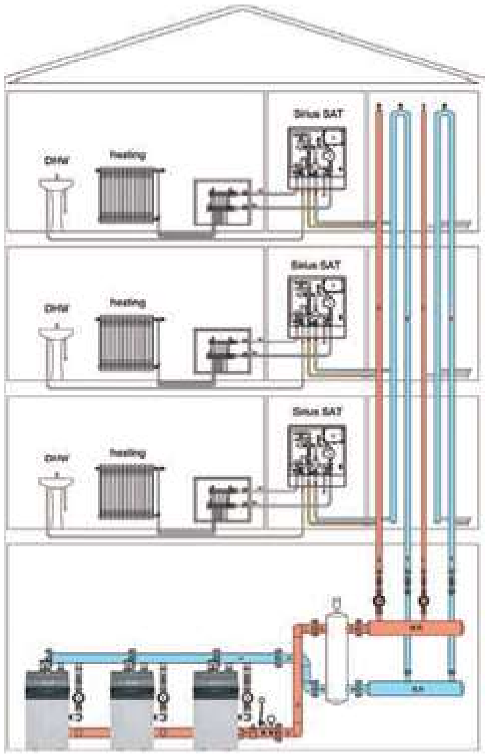
The primary energy savings due to the use of CHP should be equivalent to the RER of 0.20 or 0.10 as applicable contributing to the thermal energy use within the building. The calculation methodology for the primary energy saving contribution is provided in the NEAP calculation.

The design of the CHP system should take account of the output rating of the appliance and the design thermal profile for the development for which it is designed. It should be suitable for the building application (simultaneous electrical and thermal profile requirements) and not oversized."

The heating system comprises a combination of gas boilers and a CHP unit, sized appropriately to meet the objective of Part L and to optimise the cost of installation and operation. Water is heated in the plantroom and circulated throughout the building, via one or more buffer vessels, to each apartment. The heat is transferred to the apartment circuit via a heat exchange device termed a Heat Interface Unit (HIU).

A HIU is an integrated solution for delivering and recording the heat consumed by an individual dwelling served from a centralised heating plant or district heating scheme. HIUs provide localised control and metering in a self-contained package, allowing simple integration of individual dwellings into a larger heating and hot water system. These units can be installed either internally within each dwelling, or recessed into the dividing wall between dwelling and landlord space, allowing ease of access for inspection and maintenance.

An example of a system utilising heat interface units and centralised heating plant is shown below (Source: https://www.cibsejournal.com/cpd/modules/2011-03/)



Advantages

The use of a centralised boiler and CHP system incorporating HIUs has many advantages versus installation of boilers in individual apartments; among them:

- Improved safety due to elimination of gas distribution pipework to apartments
- Individual flue terminals (with associated plumbing) in each apartment are not required
- Gas safety inspections are typically restricted to the plant room;
- Reduction in operating costs owing to reduced boiler service;
- If installed facing into landlord areas, HIUs reduce maintenance access issues;
- Meter reading and energy billing can be carried out remotely from a central location – this can be very attractive to councils and those with a large portfolio of buildings;
- Effective integration of low to zero carbon technology can be far simpler with a central scheme, versus a combination of individual apartment boilers with a technology such as solar photovoltaic, which is potentially complicated to install and offers reduced benefits for the building owner or occupants.

Disadvantages

However, compared with alternative options for meeting the Energy Performance Coefficient (EPC), Carbon Performance Coefficient (CPC) and Renewable Energy Ratio as required by Part L, this system may be considered disadvantageous for the following reasons:

- High efficiencies in heat generation are reduced by high circulation losses due to the need to transport hot water throughout the building, as opposed to other systems where the source of hot water is local to the demand. Overall heating system efficiencies may be as low as 65%.
- These circulation losses may lead to overheating in landlord areas, as hot water circulation is required 24/7 to serve instantaneous hot water demand in each apartment.
- Equally, lower efficiencies may mean a large gas connection is required.
- Installation is expensive compared with alternative systems capable of meeting the requirement, as a result of centralised plant, associated plantroom and civil works and pipe distribution network.
- This system requires the landlord to set up and operate an energy supply and metering system and manage payment from tenants.
- Centralised plant is more expensive to design and maintain.

4.4 External Lighting

The proposed lighting scheme within the development consists of LED public lighting pole mounted fittings on 6m high poles with a combination of wall lights and low-level LED strip lights. Each light fitting shall be controlled via an individual Photoelectric Control Unit (PECU). The operation of the lighting shall be on a dusk-dawn profile.

All fittings will be directional and downward facing fittings illuminating the task areas.

Advantages

- Lighting will be designed to achieve the required standards, provide a safe environment for pedestrians, cyclists, and vehicular traffic, provide surveillance, and limit the impact of the artificial lighting on surrounding existing flora and fauna.
- Having PECU allows for the optimum operation of lighting which minimizes energy usage.
- Having all directional task lighting reduces light pollution.

5 Mechanical and Electrical Services Strategy

With the current insulation levels associated with NZEB standards, amalgamated by the modern efficiencies and simplistic M&E designs associated with electric technologies, choosing an all-electric solution is more cost effective to install and operate for a large development predominantly comprised of residential units.

Renaissance Engineering is currently consulting on a 3rd Generation District Heat Network in Liverpool consisting of 540 No. apartments, 7,000m^2 of commercial space, a 180-bed hotel and a 200-bed aparthotel under development for future connection. The heating scheme operates at a flow and return temperature of 80°C and 60°C respectively, feeding each unit via a Heat Interface Unit or a heat exchanger. The heat consumed is metered and then distributed around each unit via a hydronic system and its associated ancillary equipment such as pumps and valves. These items will drastically increase the installation costs associated with the development as well as introduce additional complexity in the design and increase the maintenance costs pertinent to each unit in the development

As district heating schemes operate on the basis of ensuring hot water availability around the clock, high temperature water is continuously circulated throughout the extensive pipe network of the development. This results in thermal losses throughout the year, being predominantly higher during the summer months when the thermal demand is lower due to the lack of space heating requirements. There will also be losses through the pipework in the units as well as losses in the radiators' ability to dissipate heat. This is a similar issue to that encountered with a centralised system, which may use gas boilers supplemented with a source of renewable energy (ground/water/air-source heat pump/solar PV) or high-efficiency energy (CHP as discussed in the previous section).

On the other hand, electrical radiators do not suffer the same compounded effect of losses from a hydronic system. Aided by their ability to reach temperature quickly, the 100% efficient electric radiators can modulate their output/turn on and off with ease and on short notice to ensure the radiators are active to combat the unit's thermal losses. This characteristic is one feature which makes electric systems cost-effective to operate even though electricity rates are higher than natural gas prices.

Air-source heat pumps, both those using outdoor or ventilated exhaust air as a heat source, likewise do not experience these circulation losses, but most systems require a minimum level of continuous ventilation to maintain the heating system and do not treat incoming fresh air via MVHR. This means that the heat added to the wet system radiators must counterbalance the additional load due to steadily introduced cool or cold air.

A CIBSE-published article from November 2019 (*"Autonomous State"*, Chris Twinn, www.cibsejournal.ie) compared 11 system options for heating high-density residential schemes across five separate criteria:

- Zero-carbon future-proofing
- Energy saving
- Service charge
- Bills (operating cost)
- Capital cost

The 11 systems, several of which are discussed in the previous section, are as follows:

System	Key considerations
1. Individual gas boilers in each dwelling	Traditional baseline. No longer London planning carbon-compliant (Part L less 35%). No straightforward adaption to zero carbon future.
2. Gas boiler district heating with dwelling HIU for heating and instantaneous DHW	Conventional high-density solution. Higher efficiency boilers. No longer London planning carbon-compliant (Part L less 35%). Mains losses larger than previously assumed, based on recent operating feedback.
3. Gas boiler and CHP district heating with dwelling HIU for heating and instantaneous DHW	Recent norm. No longer London planning carbon-compliant (using new lower grid carbon factors). Mains losses larger than previously assumed, based on recent operating feedback. High service charges. No straightforward adaption to zero carbon future.
4. Gas boiler and central ASHP district heating with dwelling HIU for heating and instantaneous DHW	Adapts system 3 to allow use of low carbon grid electricity. ASHP not at optimum COP because of relatively high-temperature district heating to serve DHW. High mains standing losses. High service charges.
5. Gas boiler and central GSHP district heating with dwelling HIU for heating and instantaneous DHW	Adapts system 3 to allow use of low carbon grid electricity. GSHP has better winter COP than ASHP, but not optimum because of relatively high-temperature district heating to serve DHW. High mains standing losses. High service charges.
6. Central ASHP with heat network and HIU for heating and direct-electric top-up DHW	Mid-temperature heat network to improve COP of ASHP. Direct-electric used to lift final DHW temperature, often with DHW storage. Higher bills because of direct-electric element. Limited demand-side management options.
7. Central ASHP with heat network and individual WSHP for heating and DHW with storage	Low-temperature heat mains (15-25°C) to improve COP of ASHP. Dwelling WSHP lifts mains temperature for low-temperature heating and to higher temperature only for DHW storage. Low mains losses. Demand management potential is good because of DHW storage and ability for 24/7 trickle heating.
8. Individual dwelling ASHP with DX outdoor unit and direct electric DHW top-up	Generally suited to space temperature heating. Poor COP for generating DHW. May use direct-electric to top-up DHW. Summer heat discharge compromises NV cooling, prompting risk of added mechanical cooling.
9. Dwelling one-stage EAHP with direct-electric heating	Captures heat from extracted exhaust air to heat DHW storage with direct-electric for top-up and heating. Substantial untreated fresh air comfort issues and direct-electric heating very sensitive to incorrect control.
10. Dwelling one-stage EAHP and gas boiler district heating, and HIU for heating and DHW top-up	Captures heat from extracted exhaust air to heat DHW storage, with district heating for space heating. Mains standing losses. Reintroduces capital cost and service charges for centralised system.
11. Dwelling two-stage MVHR and EAHP for heating and DHW	Captures heat from extracted exhaust air using MVHR followed with second stage heat recovery using EAHP. Heats DHW storage and then heats top-up to fresh air supply. Low-capacity system.

Abbreviations

Part L = Building Regulations (England) carbon code-compliant	ASHP = air-source heat pump	DX = refrigerant piped (often reverse-cycle)
HIU = heat interface unit	COP = coefficient of performance of heat pump	NV = natural ventilation
DHW = domestic hot water	GSHP = ground source heat pump	EAHP = exhaust air source heat pump
CHP = combined heat and power unit (gas-fired)	WSHP = water source heat pump	MVHR = mechanical ventilation heat recovery unit

Figure 3: System descriptions and key characteristics

The study concluded by assigning a relative ranking to each system in each criterion, associating a score based on that ranking (5 = best, 1 = poor) and finally summing all performance scores to achieve a single figure for overall comparison.

System	Zero carbon future	Energy saving	Service charge	Bills	Capital cost	Sum
1. Individual gas boilers	1	1	3	3	5	13
2. Gas boiler district heating	1	1	2	2	2	8
3. Gas boiler + CHP district heating	1	2	1	1	1	6
4. Gas boiler + ASHP district heating	3	3	1	1	1	9
5. Gas boiler + GSHP district heating	3	3	1	1	1	9
6. Central ASHP + heat network + direct-electric DHW	4	3	2	2	3	14
7. Central ASHP + heat network + individual WSHP	5	4	2	4	2	17
8. Individual ASHP with direct-electric DHW top-up	4	3	5	3	5	20
9. One-stage EAHP + direct-electric heating	4	2	4	2	4	16
10. One-stage EAHP + gas boiler district heating	1	3	2	3	2	11
11. Two-stage MVHR+EAHP	5	5	4	5	4	23
Key considerations:	Grid electricity accessibility; peak demand management; smoothing of demand peaks	Code compliance; standing losses; COPs; source temperature; network temperature	System extent; network losses; component count; interface units; billing system; gas servicing	Energy billed; service charges; standing losses; outsourcing overhead	System extent; component count; construction interfaces; modularisation potential	

Ranking: 1 Poor, 2, 3 Mid, 4, 5 Best

Figure 4: Ranking of systems

An example of the system which performed the highest in the study ("Two-stage MVHR+EAHP") is the Nilan Compact P. This system is defined by the article as being the one which "harnessed most of its heat from that already available inside each dwelling".

The article also states that the "unitary configuration and lack of distribution pipework makes it ideal for modular offsite building fabrication" and that this unitary/"all-in-one" configuration (space heating, ventilation and hot water heating within a single device) ensures that the maximum possible amount of assembly is conducted offsite, reducing exposure to issues of workmanship or difficult asembly conditions.

The efficient recycling of heat, while simultaneously providing a level of ventilation that results in a healthy air quality and eliminates issues of condensation, makes this strategy "two-stage mechanical ventilation heat recovery and exhaust air heat pump" – embodied by the Nilan Compact P device – our recommended proposal at this point for the Garters Lane development.

By the review of the options listed above, the proposed development will include items listed in sections 5.1 and 5.2.

5.1 Mechanical Services

- Each apartment shall be fitted with a mechanical ventilation heat recovery system and supplementary electric radiators.
- Each habitable room shall be fitted with a supply ventilation grille delivering air at a temperature designed to maintain the apartment setpoint.
- The overall system shall be suitably sized to overcome heat losses.
- The bathrooms shall be fitted with appropriately sized electric towel radiators.
- DHW for the apartment shall be generated from the air-to-water heat pump which is integrated into a single unit also responsible for control of space heating via electric radiators and MVHR. This unit shall also incorporate the hot water storage for the apartment.
- Each apartment shall be fitted with a mechanical ventilation heat recovery (MVHR) unit and its associated duct work.
- The MVHR unit shall extract air via ventilation ducts positioned in the wet rooms of the apartments such as bathrooms, kitchens, and utility rooms.
- All rooms will be controlled by a thermostat connected back to the central unit.
- Mains water will be supplied to each apartment from a suitably-sized storage tank.
- Hot water shall be generated by the cylinder's integrated heat pump.
- Cold water storage and supply requirements shall be maintained by the cold-water storage tank.
- Hot and cold water shall be boosted via a booster pump to all sanitary ware items.
- Soils and waste pipework shall be installed to all sanitary ware items.
- There will be pressurised water services throughout the dwelling including all showers and taps.

5.2 Electrical Services

- A suitably-sized distribution panel shall be located in the utility room of each apartment.
- Electrical sockets / outlets with USB ports and dimmable light switches will be strategically installed throughout the dwelling. Shaver sockets shall be supplied in the bathrooms.
- All socket outlets & light switches shall be White Plastic Type MK Logic or equal throughout.
- Lighting will be energy efficient LED throughout.
- Each apartment shall be supplied with a fire alarm system via the landlord system which shall be independent of the apartment fire alarm system.
- Each room within the apartment shall have a mains smoke/heat detector installed.
- An audio and visual intercom system shall be linked from each apartment to the entrance.
- Complete CAT6 cabling installation for use with telephone/data services shall be provided.
- The development will be provided with electric vehicle charging stations.