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Channel View Development, Cardiff

Energy Strategy Report

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Channel View
Energy Strategy

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SCHEDULE OF AMENDMENTS

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07/09/20	P02	-	Updated to suit discussions with CCC
01/12/20	P03	-	Updated for proposed energy strategy

SECTION 1 EXECUTIVE SUMMARY

1.01 Executive Summary

This design note details the options available as part of the energy strategy to work towards achieving the Client's aspirations for energy targets, Low Carbon or Net Zero Carbon targets, fuel poverty and affordability for the Channel View redevelopment residential scheme in Cardiff.

The design note focuses on operational energy only and does not investigate options in relation to embodied carbon.

The scheme will be developed on the principles of the energy hierarchy to drive down carbon emissions as a result of building use.

The energy target for the scheme will be based on the anticipated Part L 2025 requirement of 75-80% improvement on the current Part L standard. Provision will also be made for adaptability in the future to enable Net Zero Carbon to be achieved for operational energy.

Building Fabric

The building fabric U-Values and air tightness are recommended to be improved over the current minimum requirements for Building Regulations AD L1A compliance in accordance with UKGBC/LEFTI standards. Exact details of achievable U-Values and air tightness are to be reviewed with the Design Team and evaluated against the Client's aspirations for operational energy.

Heating and Hot Water

Proposed to provide the development with a low carbon form of heating as detailed below.

Ground Source Heat Pumps	More efficient than ASHPs but high capital cost due to ground works Implementation Strategy: • Houses – GSHP per house, borehole arrays serving 4-5 houses • Apartments - Either an GSHP per an apartment with risers close to each apartment or communal GSHP plant with centralised risers. Heat metering and billing required for communal plant

Electricity Generation

PV Array	Provided to each building within the Masterplan to generator electricity to be used generally within each dwelling.
Battery Storage	Can be implemented in each dwelling to store electricity and used to offset electricity consumed within each dwelling.

Meeting Requirements

With all options currently being discussed, it is possible that each dwelling can be provided with individual DNO meters so Tenants can select preferred Electricity Supplier.

Depending on the selected option for providing heating and hot water to each dwelling, with centralised systems serving multiple blocks/dwellings, a management system may need to be implemented to allow metering consumption for heating and hot water demands. The demand would then need to be apportioned to each dwelling, or costs included within service charges. Exact details to be confirmed during further design development.

Next Steps

- Confirm building fabric targets for U-values, thermal bridges and air tightness
- Agree approach to heating and hot water and develop plant space and riser requirements
- Agree approach to PV and battery storage and develop plant space and riser requirements
- Develop metering strategy for development.

SECTION 2 **INTRODUCTION**

2.01 Introduction

Climate change and the reduction of carbon emissions is one the biggest challenges being faced by Governments and Local Authorities. The Committee on Climate Change (CCC) has recommended a 95% reduction in greenhouse gas emissions by 2050 for Wales, which reflects the challenges of reducing emissions from agriculture. The Welsh Government has targeted to go further with an ambition to reach net-zero as part of the Prosperity for All: A Low Carbon Wales strategy. By 2030 all new buildings must operate at net zero carbon in order to meet the climate change targets.

2.02 Project Description

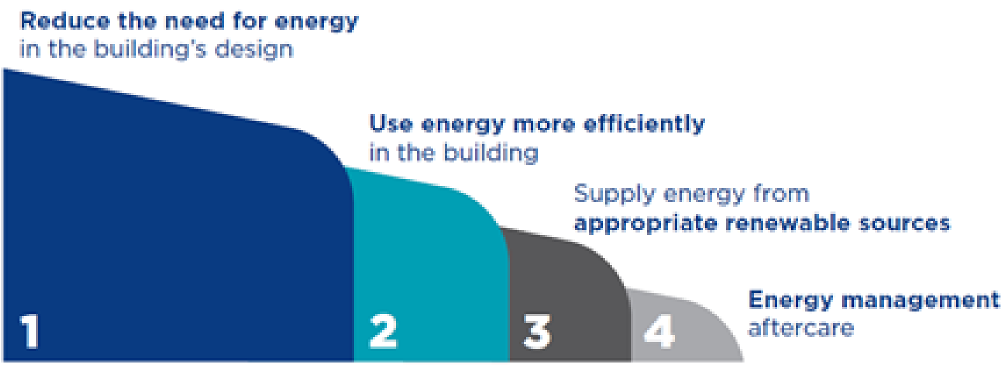
The Channel View redevelopment consists of the regeneration of the Channel View estate alongside The Marl and the River Taff in Grangetown, Cardiff to provide a mix of housing, flats and over 55's dwellings.

Channel View Draft Masterplan (Powell Dobson Architects)

SECTION 3 ENERGY HIERARCHY & PERFORMANCE INDICATORS

3.01 General Description

The scheme will be developed on the principles of the energy hierarchy to drive down carbon emissions as a result of building use.



Energy Hierarchy

Performance Indicators are another key metric of the energy strategy. The UK Green Building Council (UKGBC) and London Energy Transformation Initiative (LETI) have produced a series of guidance in regards to key features required for a new building to meet whole life carbon - a building that generates the lowest carbon emissions over its whole life. These include key performance indicators on building fabric, efficiency measures, heating and hot water and renewables which contribute towards low energy and net zero carbon buildings. The key performance indicators should be used as a guide to determine what measures should be adopted in the design of the development of achieve low or net zero carbon and whether future adaptability should be included in the design to allow the building to achieve net zero carbon.

The key performance indicators for small scale residential consisting of terraced or semi-detached housing and medium and large scale residential four floors and above can be found in Appendix A.

The recent Welsh Government Consultation on Part L detailed the proposed changes for 2020 and future direction of building energy policy in 2025. For 2020 a 37% improvement on the current Part L standard is proposed. It is envisaged that for Part L 2025 a dwelling will have a similar fabric specification to 2020 requirements but with higher specification glazing and low carbon heating via heat pumps or heat networks to achieve an anticipated reduction of 75-80% improvement on the current Part L standard.

A meeting was held with Gareth Harcombe of Cardiff Council on 29/05/20 to discuss the proposed upcoming changes to Part L and Cardiff Council's aspirations for achieving Net Zero Carbon. It was agreed that the anticipated Part L 2025 requirement of 75-80% improvement on the current Part L standard would be adopted for upcoming future projects. Provision should also be made for adaptability in the future to enable Net Zero Carbon to be achieved for operational energy.

SECTION 4 **BUILDING FABRIC**

4.01 General Description

The tables below detail the current Cardiff Living minimum standards to achieve a 17% reduction on current Part L standards, the anticipated fabric standards of Part L 2025 to achieve a 75-80% reduction on current Part L standard and UKGBC/LETI indicative design measures to achieve a whole life carbon building and the proposed building fabric values for the development.

U-Values

Element	Cardiff Living (W/m^2K)	Part L1A 2025 Wales (W/m^2K)	UKGBC/LETI KPI NZC (W/m^2K)	Channel View (W/m^2K)
Walls	0.18	0.13	0.13-0.15	0.13
Floor	0.13-0.15	0.11	0.08-0.10	0.11
Roof	0.10-0.13	0.11	0.10-0.12	0.11
Exposed ceilings/ floors	0.13-0.15	0.11	0.13-0.18	0.11
Windows	1.20-1.60	0.80-1.00 (triple glazing)	0.80-1.00 (triple glazing)	0.80-1.00 (triple glazing)
Doors	1.00-1.20	1.00	1.00	1.00

Air Permeability

Element	Cardiff Living ($m^3/h.m^2@50Pa$)	Part L1A 2025 Wales ($m^3/h.m^2@50Pa$)	UKGBC/LETI KPI NZC ($m^3/h.m^2@50Pa$)	Channel View ($m^3/h.m^2@50Pa$)
Air Tightness	3-4 Typically	3	<1	3

As can be seen from the tables above the Part L 2025 building fabric u-values are similar to those for UKGBC/LETI whole life carbon. It is proposed that the development building fabric meets the Part L 2025 standards, this will enable the development to meet the Part L 2025 energy target and also give future adaptability to achieve net zero carbon operational energy without costly upgrades to improve the building fabric.

The proposed air tightness is similarly based on the Part L 2025 standard. The achievable air tightness will be investigated to determine if an air tightness closer to the UKGBC/LETI whole life carbon standard can be achieved to give greater flexibility in achieving net zero carbon operational energy in the future.

SECTION 5 HEATING AND HOT WATER

5.01 General Description

As per the performance indicators heating and hot water should not be generated using fossil fuels burnt on site. Instead a low carbon form of heating should be used such as heat pumps or heat networks. Heating demand should also be a maximum of 10 W/m^2 peak heat loss including ventilation losses, the heat loss is dependent on the building fabric strategy adopted as detailed above.

5.02 Direct Electric Heating

Historically developments without gas provision have been provided with direct electric heating via panel heaters, radiators with an electrical element or storage heaters. Electric boilers are also available which can be provided in place of a traditional gas boiler providing heating to a wet central heating system and domestic hot water. It is recommended that direct electric heating is not used due to the high running costs which may lead to fuel poverty issues. Indicative running costs for the heating and hot water options are detailed later in the report.

5.03 Heat Pumps

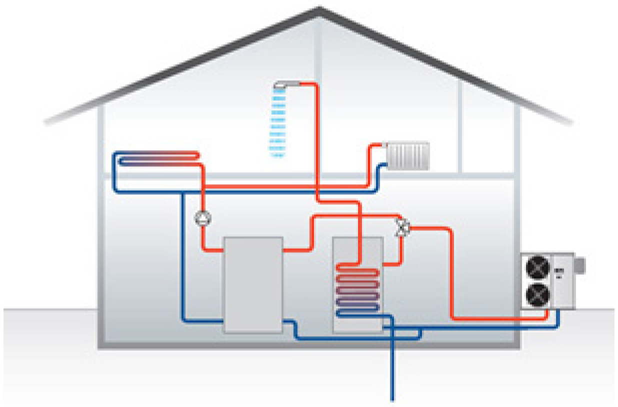
There are several heat pump options available which could serve the development as detailed below.

5.03.01 Air Source Heat Pumps (ASHPs)

Background

ASHPs operate by absorbing the heat from the outside air. This heat can then be used to warm water for radiators, under-floor heating systems or to warm the air itself. The heat is extracted from the outside air in a similar way to a fridge, which extracts heat from its inside. ASHPs can extract heat from outside air temperatures as low as -15°C; however, the units' efficiency decreases as the outside air temperature decreases.

There are two main types of air source heat pump, these are an air-to-water system and an air to air system. An air to water system uses the extracted heat from the outside to warm water whereas an air to air system uses the extracted heat to warm air. Air heating is not recommended for dwellings due to issues with imbalances between ventilation and heating requirements. Air to water systems are typically used in dwellings in combination with a low temperature form of heating such as underfloor heating or low temperature radiators to maximise efficiency. The efficiency of heat pumps is measured by a coefficient of performance (COP). This value is a measure of the amount of heat produced by a unit compared to the amount of electricity needed to run it. The seasonal efficiency (SCOP) is typically used to evaluate system performance which accounts for the varying external conditions over the year.



ASHP System

Typically, an ASHP system will consist of an ASHP mounted externally, a buffer tank inside the dwelling acting as a thermal store serving the heating system depending on the system size and a separate hot water cylinder operating at higher temperature.

ASHPs are the easiest heat pump technology to install with no groundworks required however as the outside air temperature is variable ASHPs are not as efficient as other heat pump technologies. The external unit can be seen as aesthetically displeasing by some and needs to be located in a suitable location to prevent vandalism. Noise from the external unit is also an important consideration, there have been technological developments in recent years to reduce noise levels, but unit selection and location should be considered on a case by case basis.

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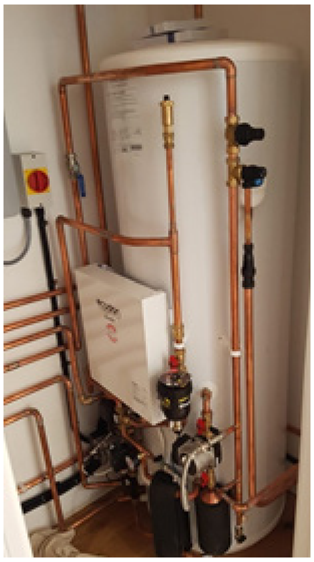
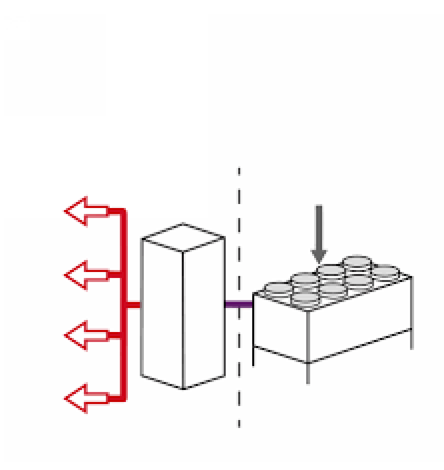
Implementation Strategy

ASHPs could be implemented on the houses of the development by mounting externally on the side of the house or in the garden. However for the apartment blocks the ASHPs would be more difficult to locate, there is limited suitable roof space without impeding on communal spaces, green spaces or using space allocated towards PV arrays. Externally the space is limited on site for locating the ASHPs at ground level. Therefore ASHPs are not deemed viable for the development and will not be investigated further in this Energy Strategy.

ASHP Mounted Externally



HWS Cylinder and Associated ASHP System components within cupboard inside dwelling



Communal ASHP

Example Communal ASHP Internal Plant Room

5.03.02 Ground Source Heat Pumps (GSHPs)

Background

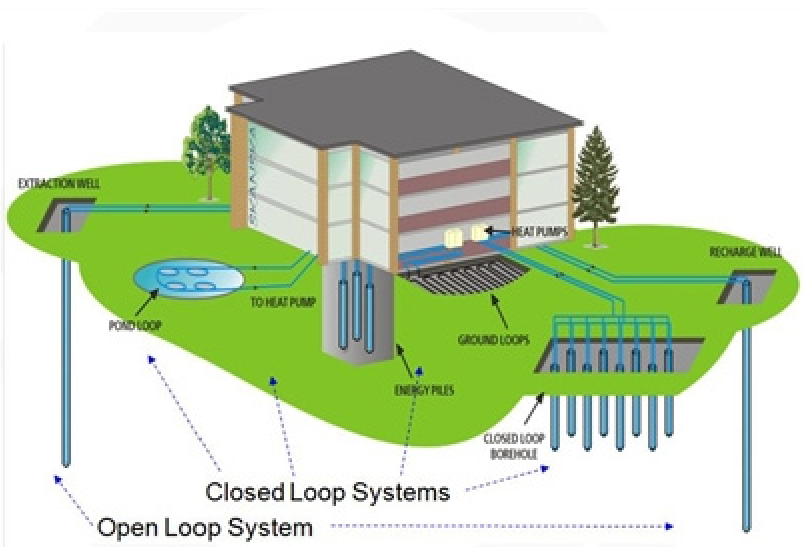
GSHPs are a proven and efficient method of heating both domestic and non-domestic developments. GSHPs can be of two main types according to the used heat source which determines the type of heat exchanger: closed loop or open loop extraction system.

A closed loop system is where the same water/refrigerant circulates through the pipes repeatedly, extracting heat straight from the ground. The heat exchanger is linked to a network of deeply buried pipes, usually filled with a mixture of water and anti-freeze. These pipes then absorb heat from the ground and/or any nearby bodies of water situated underground. The heat is then transferred by the pipes back to the heat pump which transfers the heat to the heating system, increasing the temperature in the process.

With an open loop system fresh water is pumped from a water source such as a well or an aquifer. Once the heat is extracted from the water, the water flows back to the source, where more fresh water is pumped through the system in a continuous open loop. Open loop systems rely on the presence of an aquifer and are regulated to prevent the drying out of the aquifer. Due to the added complexities of open loop systems GSHP systems are typically installed in a closed loop arrangement which can be installed anywhere.

The temperature is typically increased by between 2.5 and 4 times the source temperature creating usable heat ranging from around 18°C to 48°C, based on a typical ground temperature of 12°C. In areas with a relatively stable condition of around 12°C, ground source heat pumps become inherently more efficient than air source heat pumps, which rely on varying ambient air temperatures.

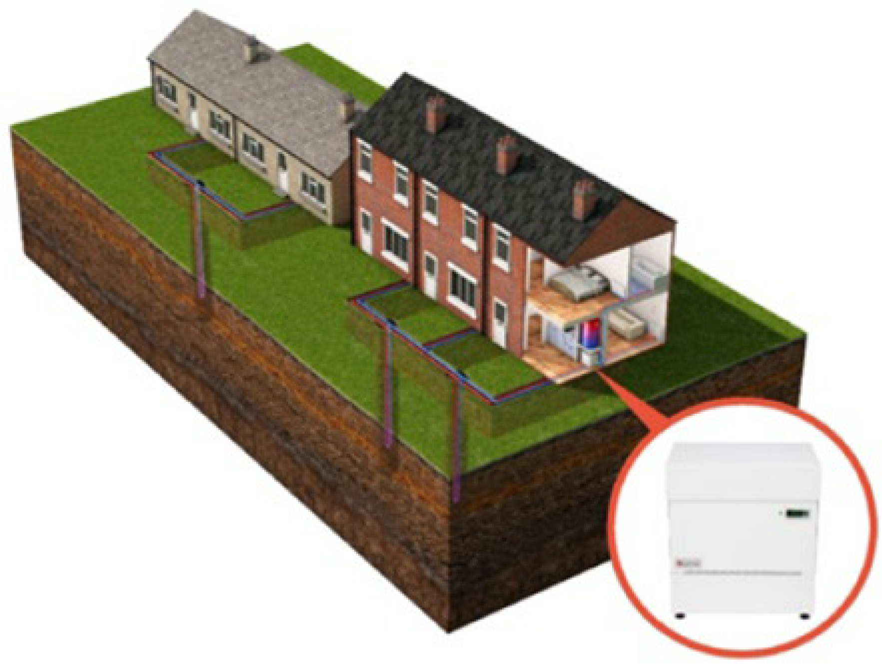
Ground source heat pumps are particularly suitable where there are acoustic restrictions or planning restrictions on roof level plant. However capital costs are higher than ASHPs due to the ground works required.



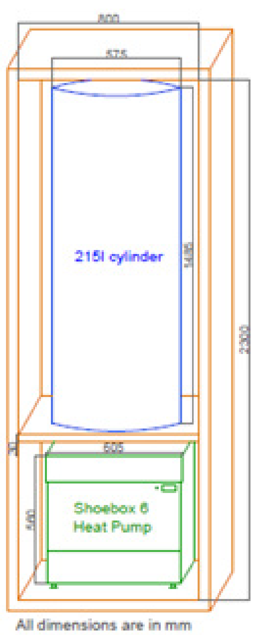
GSHP Closed and Option Loop System (GI Energy)

Implementation Strategy

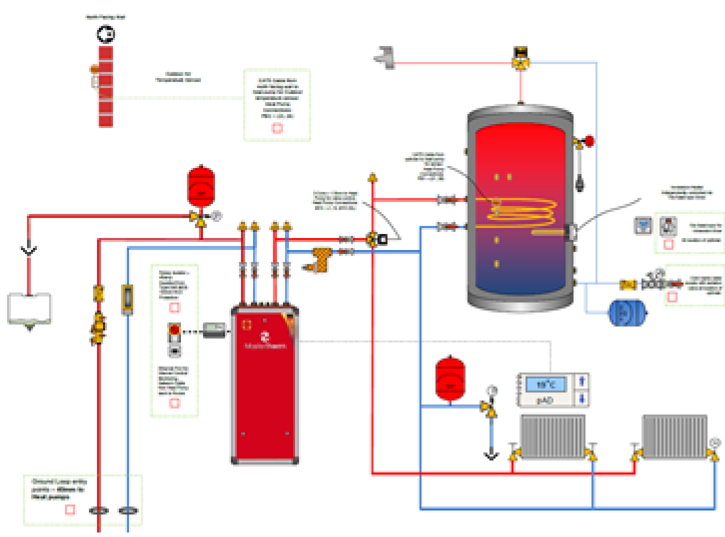
For the houses on the development a GSHP would be provided in each house, located within a service cupboard with a hot water cylinder and other associated heating system components. The GSHPs will be connected to a borehole array serving 4-5 houses which is more cost effective than an individual borehole per house. The borehole array will connect to each house by way of a manifold in the ground adjacent to the house.



Communal Ground Array Serving Terraced Houses (Kensa)



'Shoebox' GSHP and Hot Water Cylinder within Cupboard (Kensa)

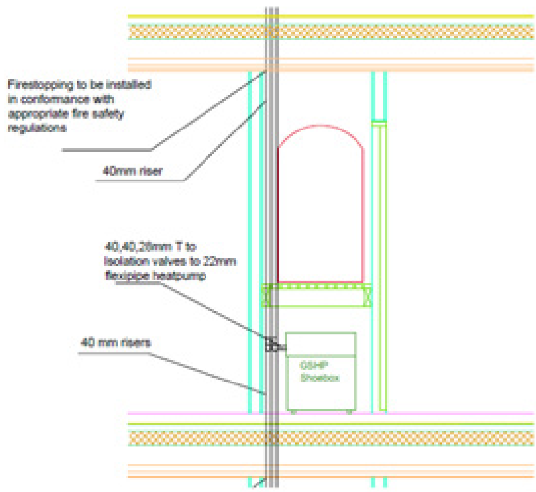


GSHP System for a typical house (Thermal Earth)

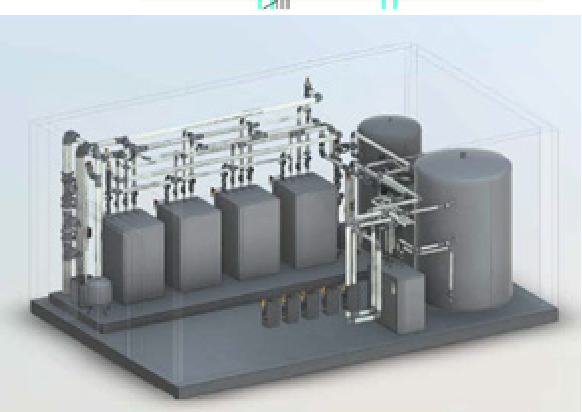
For the apartment and over 55's buildings GSHPs there are options for implementation,

- An GSHP per apartment – with this option each apartment will have a GSHP located within a service cupboard with a hot water cylinder and other associated heating system components. The GSHPs will connect to the external borehole arrays via risers throughout the building close to each apartment or cluster of apartments. As each apartment is served separately it removes the complexity of heat metering and billing. The anticipated SCOP for this arrangement is 3.7-4.0 as each apartment has individual control with full weather compensation.

- Communal GSHP per building – with this option the apartments would be served from communal plant. The GSHPs would be located within a central plant room together with buffer vessel(s) and hot water storage. The GSHPs will connect directly to the external borehole arrays without the need for risers unless the plant room is at roof level. The hot water storage would have a dedicated 2nd stage GSHP to raise the temperature to 60°C. Communal distribution of heating and domestic hot water pipework will run from the central plant room to apartments via centralised risers. With this option the riser requirements are less as the same distribution pipework serves all apartments and will distribute in central risers per core. Heat metering, hot water metering and billing per an apartment would be required. Due to the additional distribution and storage with this option the anticipated SCOP for this arrangement is slightly lower at 3.2-3.5. The apartments could have individual cylinders to avoid hot water metering, but this would require the cylinders to have direct electric immersion heaters to raise the hot water temperature to 60°C which is contradictory to low carbon guidance.



Rising borehole header between apartments (Kensa)



Communal GSHP Plantroom (Thermal Earth)

5.03.03 Water Source Heat Pumps (WSHPs)

Background

Water source heat pumps (WSHP) are designed to extract heat from either a moving or stationary body of water such as a river or lake. They are the most efficient of the heat pump options but also the most complicated system to implement. Like GSHPs they can implemented in either an open loop or closed loop system.

With an open loop WSHP the water is pumped from the source directly through to a central energy centre plant room which houses plate heat exchangers and pumping systems which pre-heats a glycol loop which can then be fed through to individual buildings with their own plant rooms. These plant rooms can the operate independently and provide heating and hot water through an internal distribution system with metering.

Open loop systems generally have a high performance due to the high incoming temperatures, but a lot of feasibility, engineering and design work is required into the method of water collection via a weir or similar and the necessary pump and pipework sizing. Maintenance of these systems can also be high with issues such as filters being locked by debris.

With a closed loop system, the closed loop pipework is placed directly into the water source. This system also has high efficiencies and avoids some of the maintenance issues of an open loop system. However, locating the pipework can be an issue. The distribution system around the development to plant rooms would be like an open loop system.

With both systems permissions would be required from National Resource Wales and the Cardiff Harbour Authority.

Open Loop WSHP (Kensa)

Implementation Strategy

The options available for houses and apartment buildings will be the same as the GSHP options internally with the borehole collector pipework replaced with a glycol loop which will connect to WSHPs within the properties.

Due to the regulatory complexities of a WSHP system compared to GSHPs and the additional maintenance requirements a WSHP has been deemed unviable for the development and will not be investigated further.

5.03.04 Exhaust Air Heat Pumps (EAHPs)

EAHPs operate on the same principles as an ASHP but instead of using outside air as the heat source EASHPs use the warm exhaust air from bathrooms and kitchens. The warm air is passed over a heat exchanger which transfers the energy to the refrigerant circuit which produces heat for heating and hot water through the heat pump cycle. The EAHP is a similar size to a full height fridge freezer and can be mounted freestanding in a kitchen or utility room.

Unlike other heat pump systems EAHPs are not widely sold in the UK and would need to be procured from mainland Europe. One reason for its limited use in UK developments is due to the fact that EAHP technology has not matured to the same extent as ASHPs and GSHPs. This is mainly due to the limitations of EAHPs, units are only suitable for properties with small heating demands and limited hot water requirements. In order for EAHPs to be effective the property needs to be highly insulated with low density occupation and limited hot water use or the EAHP will utilise direct electric to meet the demand leading to higher energy bills.

To implement EAHPs on the development a two stage Mechanical Ventilation Heat Recovery (MVHR) unit and EAHP operating in ‘heat autonomy’ mode strategy would be required. Where the system operates in ‘heat autonomy’ mode to capture and use the warm air from the property using both the MVHR unit and heat exchanger of the heat pump to maximise efficiency.

This system is still limited by the low heat output capability of EAHPs and therefore the building fabric and airtightness would need to be to the key performance indicator requirements near Passivhaus standard. To limit heat losses and prevent air loss as the system uses the MVHR supply air distribution for heating. The hot water usage would also need to be limited via low flow water fittings such as 6 litres per minute showers.

Two stage MVHR and EAHP systems are still at an early stage and have not been used in the UK market so their effectiveness is unknown. Future maintenance and replacement parts are also an important consideration, currently parts would need to be sourced from mainland Europe and a specialist installer would be required to maintain the units. In the instance of Nilan there is only one registered installer in the UK.

As such EAHPs are not deemed viable for the development and will not be investigated further in this Energy Strategy.

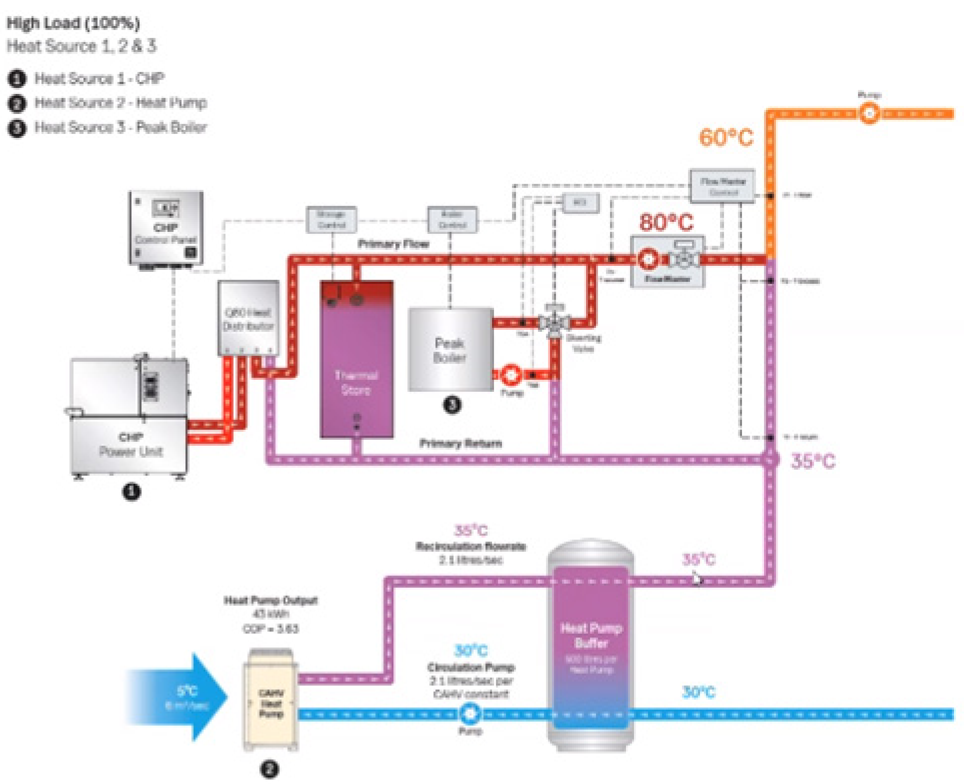
Exhaust Air Heat Pump (NIBE)

Two Stage MVHR & EAHP (Nilan)

5.04 Hybrid District Heating

With the rise of heat pump technology and the uncertainty of gas a hybrid solution has been developed for district heating systems comprising of energy centre with CHP, ASHP/GSHP/WSHP and peak/backup boilers. With this strategy the CHP unit runs continuously to cover the base heating load whilst also generating electricity. Heat pumps cover the remainder of the heating load and boilers are used to provide the peak load at periods of cold spells or backup in the event of failure of the CHP or heat pumps. In the future the gas fired CHP and boilers may be replaced with low carbon alternatives. It could also be connected to a low carbon city wide district heating scheme in the future.

As this set up currently uses gas which is a fossil fuel it is against the strategy for whole life carbon and has not been investigated further in this Energy Strategy. However, it has been included for discussion purposes on the low and net zero carbon strategy for the development and can be investigated further if desired.



Hybrid District Heating System (SAV)

5.05 Indicative Costs

Installation and Maintenance

Indicative costs have been obtained for the GSHP options as detailed below.

	GSHP
Typical House	Installation Approx £7-9k including bore holes and hot water cylinder
	Maintenance Approx £120 per unit
Communal Apartment (Based on Block 18)	100kW Heat Generation £110k - £130k approx. 15 x 150m Boreholes Plant Room Size 16 - 20m^2 Central plant costs only
	Maintenance Approx. £250-350
Individual Apartments (Based on Block 18)	31 x 1-5kW GSHP, 1 per apartment with individual hot water cylinders £250-280k approx. 15 x 150m Boreholes (Shared Ground Loop) Central plant costs only
	Maintenance Approx £120 per unit

5.06 Controls

There are a range of control options for heat pump systems, the use of which will be dependent on the system set up. It is recommended that the controls are as simple as possible for the user. With heat pump systems it is key that the system manages itself and optimises itself based on the requirements of the dwelling to maintain optimum efficiency.

For a set up with individual heat pumps per a dwelling the controls can be similar to those used with traditional heating systems with a programmable thermostat controller enabling an easy transition for occupants who are used to these controls. The controllers can be linked back to a cloud server for remote control.

For communal heating systems the heat pumps can be provided with a more advanced touchscreen control panel for smaller systems enabling more control over the system or a BMS system can be incorporated enabling integration with a head end server for centralised control and monitoring. Controls within the dwellings will be similar to individual heat pump systems with a programmable thermostat controller or similar.

Programmable Thermostat Controller

Touchscreen Control Panel

5.07 Maintenance and Servicing

For individual heat pump systems the heat pumps require an annual check-up to ensure the system is running correctly. The check-up consists of a simple step by step maintenance checklist, an example of which can be found in Appendix B. Where systems are connected to a cloud it is possible to have full internet diagnostics to carry out pre-site servicing checks with alerts to notify of any issues prior to a site visit.

For communal systems a check-up on the heat pump plant is recommended every 6 months. These systems can also be remotely monitored for issues.

In order to maintain a heat pump system the engineer should be certified by the manufacturer to maintain warranty conditions. This will require undertaking a course with the manufacturer. Manufacturers have different levels of certification for the differing levels of complexity of heat pump installations.

The heating and hot water installation after the heat pump will be the same as current systems with a low temperature heating system such as underfloor heating and a domestic hot water cylinder which engineers are experienced with.

5.08 Product Life

GSHPs have an expected product life of 15-20+ years. This applies to both individual dwelling and communal installations. For comparison a typical domestic boiler has a product life of 10 years and a communal boiler installation has a product life of 15-20 years. The boreholes have an expected life of 100 years allowing replacement heat pumps to continue to use the bore holes for a number of years.

5.09 Heat Pump Comparison Matrix

A matrix comparing the key items for individual and communal GSHP systems can be found in Appendix C.

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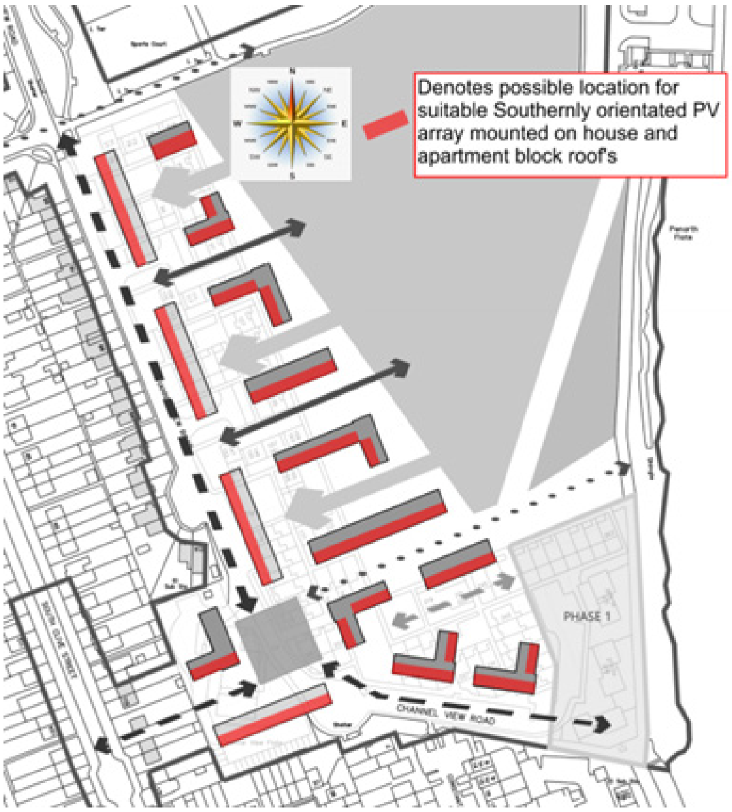
SECTION 6 **ELECTRICITY GENERATION AND STORAGE**

6.01 PV Masterplan

As part of the overall scheme's Energy Strategy, it is likely that each of the various building types on the site (ie houses, apartment blocks, over 55 living blocks) will consider utilising PV as a method of generating direct electricity for each demise.

Based on the current Masterplan, each of the individual blocks have a southernly orientation, and would be suitable for PV installation. Whilst not all of the current roof orientations are directly south, there is limited reduction in PV output in a south east, or south west orientated roof, and so should still be considered.



PV Masterplan

Each of the arrays will be connected into the building's electrical distribution network. It is likely that all the electricity generated will be utilised within each of the block's.

PV allocation for the apartment blocks and Over 5's living block would likely be roof mounted pav panels.

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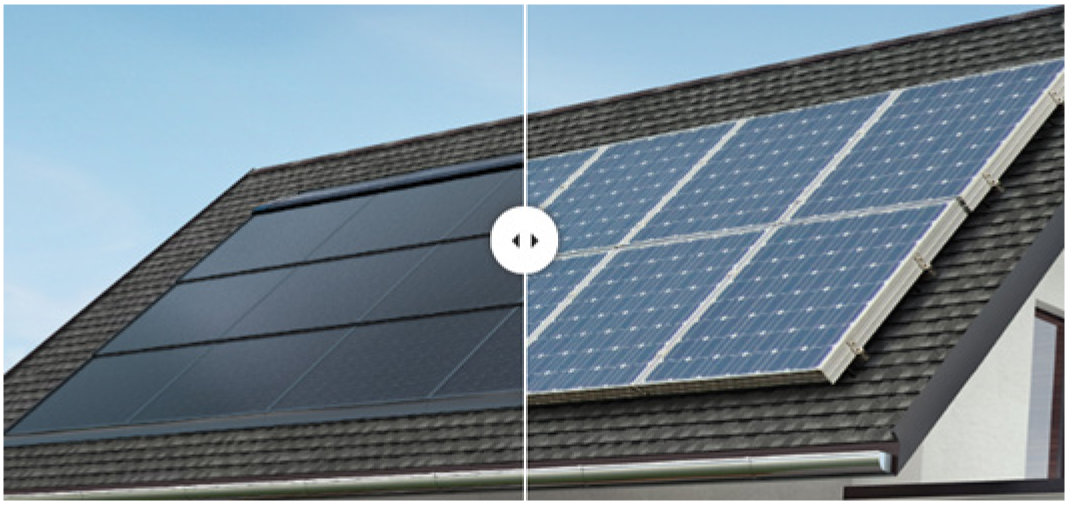
Roof Mounted PV Array

Individual houses have the opportunity of utilising over roof systems, or integrated roof systems
.
Integrated roof systems are generally more expensive, but offset the cost of the roof.



Roof Intergrated VS Roof Mounted

General benefits of PV installations:

- Reduced electricity running costs when generated electricity is used within the building.
- Contributes to reducing each dwelling's CO_2 emissions, and contribution to compliance with Building Regulation Part L1A.
- Low capital cost compared to other electricity generating technologies such as wind turbines and CHP units.

6.02 PV Battery Storage

Battery storage can be utilised to store electricity generated from either the building PV system, or exported from the grid during low peak times. The benefit being the battery system can offset electricity used within the dwelling during periods of high peak demands and costs, or used to offset the electricity required for charging electric vehicles.

Battery storage durations can be sized to accommodate each dwelling.

Typical Domestic Battery

Installing battery storage can protect against grid outages, automatically providing electricity without interruption.

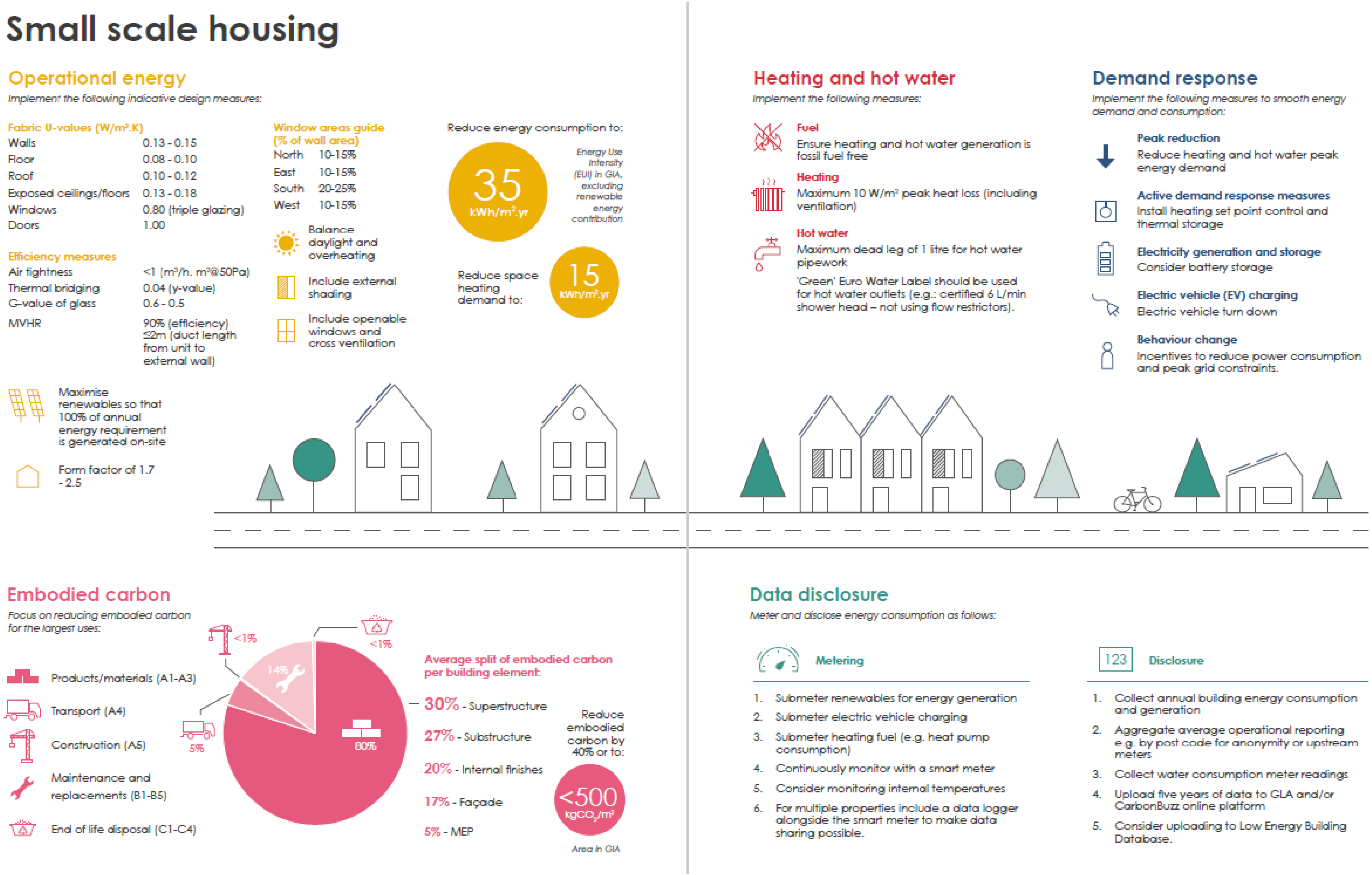
Generally, batteries can be sized to store up to 13.5kWh of energy, which equates to a typical house daily electricity consumption.

Appendices

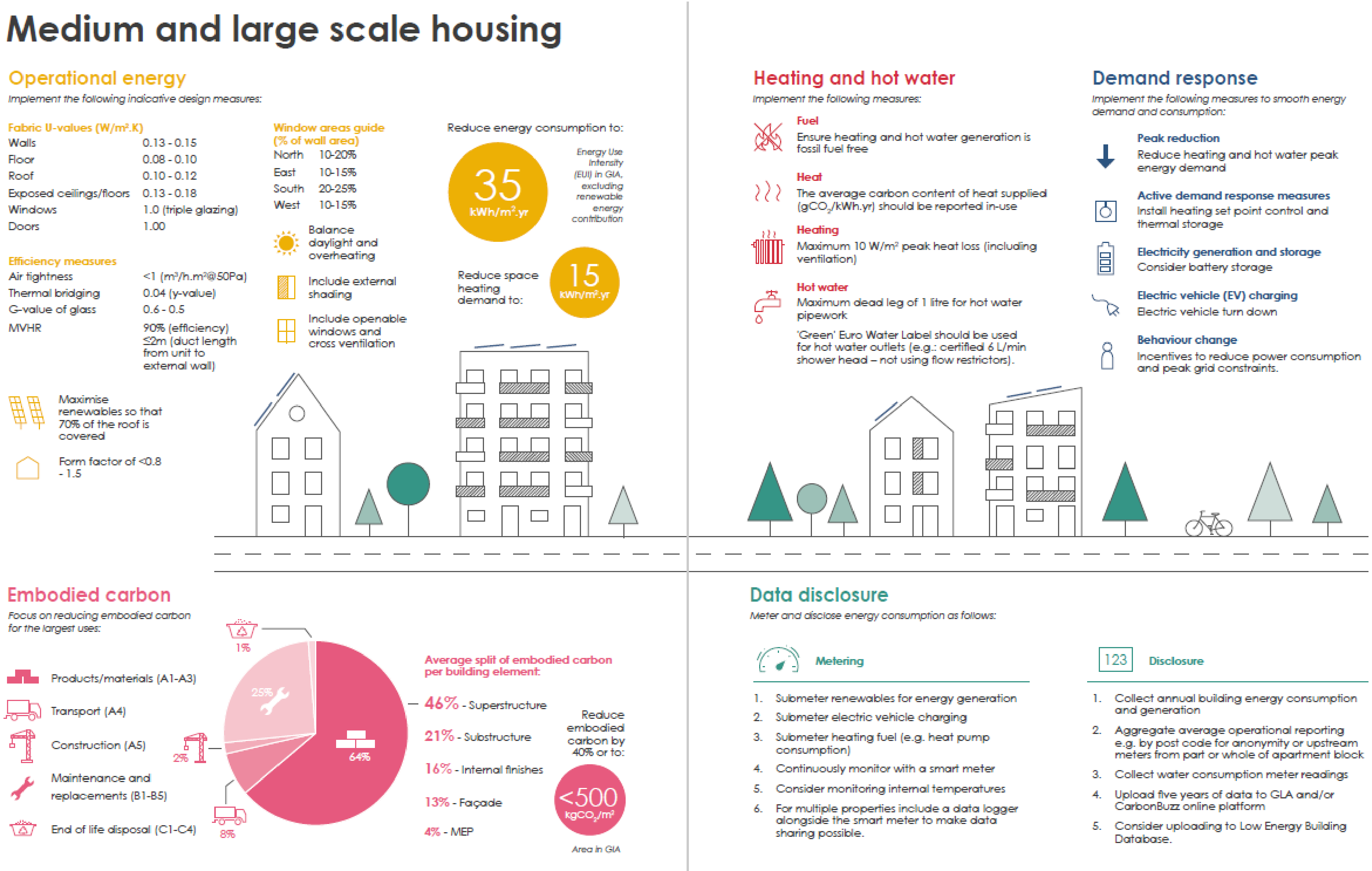
Appendix A - Key Performance Indicators to Meet Whole Life Carbon
Appendix B - Heat Pump Maintenance Checklist
Appendix C - Heating Comparison Matrices

Appendix A

Key Performance Indicators to Meet Whole Life Carbon



Key performance indicators to meet whole life carbon – small scale housing (LETI Climate Emergency Design Guide)



Key performance indicators to meet whole life carbon – medium and large scale housing (LETI Climate Emergency Design Guide)

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Appendix B

Heat Pump Maintenance Checklist

9 Maintenance

9.1 Introduction

The following text describes regular maintenance operations of heat pumps.

9.2 Personnel Qualification

The heat pumps are refrigeration equipment and for this reason the maintenance described in italics can be performed by a specialist, service technician of cooling and air-conditioning equipment with approved qualification according to the local regulations.
All work on inner components of the unit can be performed when it is turned off, the main switch in position “0”.
The Investor can choose any servicing organization approved by Master Therm company.

9.3 Quarterly Maintenance

This maintenance does not require special skills, is performed by the user.

- **mechanical check**
  - remove contingent dirt on the unit using wet cloth
  - visual inspection of external condition of the inner unit, piping, cables
  - visual inspection of the condition of the outer unit and its surrounding (vegetation)
- **inspection of hydraulic circuit**
  - inspection of overpressure and sufficient filling of hydraulic circuits
  - inspection and cleaning of filter sieves
  - inspection of anti-freeze mixtures (if used as the filling)
  - inspection of venting

9.4 Annual Maintenance

- ***inspection of refrigeration circuit during operation, temperatures and operating pressures:***
  - *condensation pressure*
  - *evaporating pressure*
  - *expansion valve setting*
  - *compressors suction temperature*
  - *compressors discharge temperature*
  - *temperature of liquid coolant*
  - *incoming temperature of liquid circuits*
  - *outgoing temperature of liquid circuits*
  - *inspection of control system settings*
  - *inspection of protection settings of the cooling circuit*
  - *inspection of operating current of all components on each phase*
  - *inspect tightness of service valves and tightness of other components*
- ***inspection of electric connection***
  - *disconnect the unit from power supply and tighten the connectors and remove dust from all components, especially: terminal boards, contactors, circuit breakers, overcurrent relays, and electric motors*
  - *inspection of operation and setting of circuit breakers*
- ***inspection of hydraulic circuit***
  - *inspect correct flow of heat exchangers*
  - *inspect tightness of liquid circuit components*

9.5 Warranty

The guarantee of the manufacturer (importer) does not cover damage resulting from force majeure, or improper handling, or connection to incorrect power supply, or use of not approved liquids, or improper usage of the equipment.
The guarantee of the manufacturer (importer) applies provided the regular maintenance in accordance with this manual is performed, and maintenance records are maintained in the operating diary of the unit.

10 Legislation

This manual does not replace the project documentation. Detailed heating and hydraulic calculations in accordance with applicable standards must be performed, and operating project documentation prepared for each installation.
European and national standards and other locally applicable regulations must be observed during design and installation.
Building permit is usually required for installation of the heat pump.
The Master Therm company is not liable for proper operation of the equipment in the case directions and recommendations from this manual are not respected.

Designated trademarks and brands are the property of their respective owners.

11 Revision history

23.05.2011 – units AQ9Z1D, AQ17ZD, AQ22ZD, EM60Z and EM75Z.
29.08.2011 – units BAxxZ, BAxxI a BAxxIC
26.04.2013 - "EM indoor split", pCO5 control, water quality
01.09.2013 - ASW
28.07.2014 - AQxxIC

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Appendix C

Heating Comparison Matrices

The below matrices detail the key items for the heating options for the houses and apartments.

Houses

System	Description	Additional HVAC services within Services Cupboard or elsewhere	Plant Space Requirements	Installation Cost	SCOP (Seasonal Coefficient of Performance)	Running Heating Cost for a typical 3 Bed House (not including standing charge or other usage)	Maintenance Period	Maintenance Cost (if by Manufacturer/Installer)	Product Life (years)	Heat Metering and Billing required?	Controls	Comments
Direct Electric Heating												
Electric Radiators	Heating via oil or gel filled radiators in each room heated via an electric element	Hot water cylinder, MVHR	N/A	Not investigated	1.0	£551	N/A	N/A	5	No	Via 7 day programmer on heater	It is recommended that direct electric heating is not used due to the high running costs which may lead to fuel poverty issues. Electric heating will not achieve Cardiff Council energy target of 75-80% improvement over current Part L standards.
Electric Panel Heaters	Heating via direct electric panel heaters in each room	Hot water cylinder, MVHR	N/A	Not investigated	1.0	£551	N/A	N/A	5	No	Via 7 day programmer on heater	
Storage Heaters	Heating via storage heaters in each room	Hot water cylinder, MVHR	N/A	Not investigated	1.0	£551	N/A	N/A	5	No	Via 7 day programmer on heater	
Electric boiler	Heating via an electric boiler feeding a traditional wet radiator system	Hot water cylinder, MVHR	Similar to a traditional gas boiler	Not investigated	0.95 (taking account of distribution losses)	£634	Annually	£50	10	No	Via central heating programmer	
Heat Pumps												
Air Source Heat Pump (ASHP)	ASHP externally at side of house of in garden	Hot water cylinder, mini buffer vessel, MVHR ventilation unit and underfloor heating manifold(s)	1200x600mm footprint externally for ASHP	£6-7k including hot water cylinder	2.5-2.8	£221	Annually	£90	15-20	No	Programmable Thermostat Controller. Link to cloud for remote monitoring	
Exhaust Air Heat Pump (ESHP)	EAHP in kitchen or services cupboard comprising a double height unit with mini hot water cylinder and integral MVHR	Underfloor heating manifolds(s)	700x700mm footprint and 2.4m room height	£9k	1.50-2.0	£315	Annually	£90	10-15	No	Programmable Thermostat Controller	EAHPs are not recommended due to limitations detailed in the energy strategy report
Ground Source Heat Pump (GSHP)	GSHP in services cupboard or under stairs	Mini buffer vessel, MVHR ventilation unit and underfloor heating manifold(s)	900x800mm footprint and 2.4m room height if within services cupboard, flexibility in options i.e. with GSHP under stairs	£7-9k Including bore holes and hot water cylinder	3.7-4.0	£149	Annually	£120	15-20+	No	Programmable Thermostat Controller. Link to cloud for remote monitoring	

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Apartments

System	Description	Mechanical Services within Services Cupboard or elsewhere	Plant Space Requirements	Installation Cost	SCOP (Seasonal Coefficient of Performance)	Running Energy Cost for a typical 2 bed apartment (not including standing charge or other usage)	Maintenance Period	Maintenance Cost (if by Manufacturer/Installer)	Product Life	Heat Metering and Billing?	Controls	Comments
Direct Electric Heating												
Electric Radiators	Heating via oil or gel filled radiators in each room heated via an electric element	Hot water cylinder, MVHR	N/A	Not investigated	1.0	£320	N/A	N/A	5	No	Via 7 day programmer on heater	It is recommended that direct electric heating is not used due to the high running costs which may lead to fuel poverty issues. Electric heating will not achieve Cardiff Council energy target of 75-80% improvement over current Part L standards.
Electric Panel Heaters	Heating via direct electric panel heaters in each room	Hot water cylinder, MVHR	N/A	Not investigated	1.0	£320	N/A	N/A	5	No	Via 7 day programmer on heater	
Storage Heaters	Heating via storage heaters in each room	Hot water cylinder, MVHR	N/A	Not investigated	1.0	£320	N/A	N/A	5	No	Via 7 day programmer on heater	
Electric boiler	Heating via an electric boiler feeding a traditional wet radiator system	Hot water cylinder, MVHR	Similar to a traditional gas boiler	Not investigated	0.95 (taking account of distribution losses)	£368	Annually	£50	10	No	Via central heating programmer	
Heat Pumps												
Individual ASHP per apartment	ASHP externally at side of apartment block, on roof or in external compound	Hot water cylinder, mini buffer vessel, MVHR ventilation unit and underfloor heating manifold	1200x600mm footprint externally for ASHP	£7.7-8.4k including hot water cylinders	2.5-2.8	£128	Annually	£90	15-20	No	Programmable Thermostat Controller. Link to cloud for remote monitoring	
Communal ASHP Plant	ASHPs externally in external compound. Buffer vessels in plant area on GF. Hot water cylinder and valve station in apartments. Communal heating mains (high and low temperature) via riser	Hot water cylinder, valve station, MVHR ventilation unit and underfloor heating manifold	10 - 14m² for buffer tanks and hydraulic equipment only	£65-75k (~£2.1-2.4k per an apartment based on a 31 apartment block) Central plant cost only – does not include distribution pipework or equipment and cylinder within apartments	2.2-2.5	£145	Annually	~£13 per an apartment based on a 31 apartment block	15-20	Yes	Advanced control unit or BMS for plant and programmable thermostat controls in dwellings Link to cloud for remote monitoring	
EAHP per apartment	EAHP in kitchen or services cupboard comprising a double height unit with mini hot water cylinder and integral MVHR	Underfloor heating manifolds	700x700mm footprint and 2.4m room height	£9k	1.50-2.0	£183	Annually	£90	10-15	No	Programmable Thermostat Controller	EAHPs are not recommended due to limitations detailed in the energy strategy report
Individual GSHP per apartment	GSHP, mini buffer unit and hot water cylinder in services cupboard. Borehole array via riser	GSHP, mini buffer vessel, hot water cylinder, MVHR ventilation unit and underfloor heating manifold	900x800mm footprint and 2.4m room height within services cupboard (heat pump plant only – not including space requirements for MVHR or underfloor manifold)	£8-9k Including bore holes and hot water cylinders	3.7-4.0	£86	Annually	£120	15-20+	No	Programmable Thermostat Controller. Link to cloud for remote monitoring	
Communal GSHP Plant	GSHP and buffer vessels in plant area on GF. Hot water cylinder and valve station in apartments. Communal heating mains (high and low temperature) via riser	Hot water cylinder, valve station, MVHR ventilation unit and underfloor heating manifold	15 x 150m Boreholes Plant Room Size 16 - 20m² 900x800mm footprint and 0.9m height compartment within services cupboard of each apartment for valve station and hot water cylinder – not including space requirements for MVHR or underfloor manifold	£30-40k (~£3.5-4.2k per an apartment based on a 31 apartment block) Central plant cost only – does not include distribution pipework or equipment and cylinder within apartments	3.2-3.6	£100	Every 6 months	~£15 per an apartment based on a 31 apartment block	15-20+	Yes	Advanced control unit or BMS for plant and programmable thermostat controls in dwellings Link to cloud for remote monitoring	

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