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Brandon District Heat Network Concept Design Summary Report

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List of Abbreviations

CO_2e	Equivalent carbon dioxide
CHP	Combined heat and power
BDHN	Brandon district heat network
DHW	Domestic hot water
EA	Environment Agency
GIS	Geographic Information System
GSHP	Ground source heat pump
GWP	Global warming potential
HNCoP	Heat Networks Code of Practice
LTHW	Low temperature hot water
PFD	Process flow diagram
P&ID	Process and instrumentation diagram
SPF	Seasonal performance factor

Glossary

CO_2e	A quantity that measures the global warming potential (GWP) of any mixture of greenhouse gases using the equivalent amount or concentration of carbon dioxide
Counterfactual	What would have happened without the change or intervention being considered e.g. a heating system counterfactual might be individual gas boilers, heat pumps or electric storage heating
District heating	The provision of heat to a group of buildings, district or whole city usually in the form of piped hot water from one or more centralised heat source
Energy centre	The building or room housing the heat and / or power generation technologies, network distribution pumps and all ancillary items
Energy demand	The heat / electricity / cooling demand of a building or site, usually shown as an annual figure in megawatt hours (MWh) or kilowatt hours (kWh)
GWP	GWP is a measure of how much heat a greenhouse gas traps in the atmosphere up to a specific time horizon (commonly 20 or 100 years), relative to CO_2
Heat exchanger	A device in which heat is transferred from one fluid stream to another without mixing - there must be a temperature difference between the streams for heat exchange to occur
Heat network	The flow and return pipes that convey the heat from energy centre to the customers – pipes are usually buried but may be above ground or within buildings
Heat pump	A technology that transfers heat from a heat source to heat sink using electricity (heat sources can include air, water, ground, waste heat, mine water)
Peak and reserve plant	Boilers which produce heat to supply the network at times when heat demand is greater than can be supplied by the renewable or low carbon technology or when the renewable or low carbon technology is undergoing maintenance (also called auxiliary boilers)
SPF	A measure of the operating performance of a heat pump heating system and is the ratio of the heat output to the electricity input (within the system boundary) over the year SPF_{H1} includes the electricity input for the heat pump unit only SPF_{H2} includes the electricity input for the heat pump unit and the abstraction of the heat source e.g. water from the ground SPF_{H4} as SPF_{H2} and including the distribution system components such as circulation pumps, motorised valves, etc.
Thermal store	Storage of heat, typically in an insulated tank as hot water to provide a buffer against peak demand

1 INTRODUCTION

This report details the RIBA Stage 3 design for the Brandon District Heat Network (BDHN) and includes consideration of the primary heat sources, peak and reserve boilers, ancillary energy centre equipment, utilities connections, buried heat network, and network connections.

Heat for the BDHN will be supplied from the existing energy centre located between Cornish House and Molesworth House. Two of the existing gas boilers located within the energy centre will be decommissioned and replaced with low carbon heat sources comprising 2 x 500 kW water source heat pumps and 1 x 200 kWe / 252 kWth gas CHP engine. Four boreholes are required, two for abstraction and two for discharge, to provide the water resource for the heat pumps.

The existing buried heat network will be retained, unchanged. However, consideration has been given as to how the borehole connecting pipework trench will be positioned to cross over the buried heat network.

The heating systems in all flats will be upgraded to include new heat emitters and a heat interface unit (HIU) including a heat meter. Depending on the existing building connection to the heat network, the HIUs will either be direct or indirect connections to the secondary side systems (i.e. if the building has a direct connection to the heat network, the HIUs will include an indirect connection to secondary systems, whereas if the building has an indirect connection to the network, the HIUs will include a direct connection to secondary systems).

All drawings and documents related to this design report are listed below:

Table 1: Drawing and document register

Drawing / Document Reference	Title
S2278-SEL-ZZ-XX-DR-Y-0001	Master Symbol List
S2278-SEL-EC-00-DR-Y-1001	Brandon Energy Centre General Arrangement
S2278-SEL-EC-00-DR-Y-1002	Brandon Energy Centre Elevations
S2278-SEL-EC-00-DR-Y-1003	Brandon Energy Centre Isometric 1
S2278-SEL-EC-00-DR-Y-1004	Brandon Energy Centre Isometric 2
S2278-SEL-EC-XX-DR-E-6001	Brandon Energy Centre SLD
S2278-SEL-EC-XX-DR-Y-6001	Brandon Energy Centre PFD
S2278-SEL-EC-XX-DR-Y-7001	Brandon Energy Centre P&ID
S2278-SEL-FP-XX-DR-Y-7001	Flat PID - Direct HIU Integration
S2278-SEL-FP-XX-DR-Y-7002	Flat PID - Indirect HIU Integration
S2278-SEL-HN-XX-DR-Y-5001	Indicative Abstraction Borehole Section
S2278-SEL-HN-XX-DR-Y-5002	Recharge Borehole Section
S2278-SEL-HN-XX-DR-Y-5003	Connecting Pipe Trench Details
S2278-SEL-HN-ZZ-DR-Y-4001	Heat Network Schematic
S2278-SEL-HN-ZZ-DR-Y-4002	Borehole and Connecting Pipe Arrangement

S2278-SEL-PP-XX-DR-Y-7001	Napier House Plantroom PID
S2278-SEL-PP-XX-DR-Y-7002	Plantroom PID Substation Integration (1 skid)
S2278-SEL-PP-XX-DR-Y-7003	Plantroom PID Substation Integration
S2278-SEL-PP-XX-DR-Y-7004	Jack Hobbs Centre
S2278-SEL-HL-XX-DR-Z-1001	1 Napier House Studio Flat General Arrangement
S2278-SEL-HL-XX-DR-Z-1002	68 Prescott House Studio Flat General Arrangement
S2278-SEL-HL-XX-DR-Z-1003	14 Napier House 1 Bedroom Flat General Arrangement
S2278-SEL-HL-XX-DR-Z-1004	66 Walters House Studio Flat General Arrangement
S2278-SEL-HL-XX-DR-Z-1005	67 Prescott House Studio Flat General Arrangement
S2278-SEL-HL-XX-DR-Z-1006	11 Bateman House 2 Bedroom Flat General Arrangement
S2278-SEL-HL-XX-DR-Z-1007	7 Cruden House 2 Bedroom Flat General Arrangement
S2278-SEL-HL-XX-DR-Z-1008	3 Molesworth House Studio Flat General Arrangement
S2278-SEL-HL-XX-DR-Z-1009	38 Morton House 2 Bedroom Flat General Arrangement
S2278-SEL-HL-XX-DR-Z-1010	11 Molesworth House 3 Bedroom Flat General Arrangement
S2278-SEL-HL-XX-DR-Z-1011	16 Maddock Way 2 Bedroom Flat General Arrangement
S2278-SEL-HL-XX-DR-Z-1012	17 Morton House 3 Bedroom Flat General Arrangement
S2278-SEL-HL-XX-DR-Z-1013	4 Morton House Studio Flat General Arrangement
S2278-SEL-HL-XX-DR-Z-1014	Bateman House 2 Bedroom Flat General Arrangement
S2278-SEL-HL-XX-DR-Z-1015	107 Cooks Road Studio Flat General Arrangement
S2278-SEL-HL-XX-DR-Z-1016	22 Morton House 4 Bedroom Flat General Arrangement
S2278-SEL-HL-XX-DR-Z-1017	24 Maddock Way 3 Bedroom Flat General Arrangement

2 ENERGY CENTRE

2.1 Energy Centre Summary

The energy centre includes ground source heat pumps (GSHPs), gas CHP plant, thermal storage tanks, peak and reserve gas boilers (the 2 x 2.3 MW existing gas boilers will be retained), and ancillary equipment. The GSHPs and CHP plant have been sized to maintain the lowest cost of heat while still providing a carbon intensity of less than 100 gCO_2e/kWh of heat delivered. The low carbon heat will be prioritised to provide ~90% of network demand, with the gas boilers used for peak supply, or as a reserve heat source for short periods of heat pump or abstraction maintenance or failure. The CHP plant will only operate in tandem with one of the heat pumps to provide low cost electricity for the heat pump operation.

If during commercialisation, evidence is provided that O&M contractors are able to guarantee heat supply at a reasonable cost without gas boilers, they could be omitted from the energy centre design.

A summary of the proposed plant capacities is shown in Table 2.

Table 2: Brandon Estate energy centre plant summary

Plant	Equipment capacity
GSHP	2 x 500 kW
Gas CHP	200 kWe / 152 kWth
Gas boilers (existing)	2 x 2,300 kW
Thermal store	50,000 litres

2.2 Energy Centre Footprint

The existing Brandon Estate energy centre building will be reused; the floor area is approximately 220 m^2 and the ceiling height varies from circa 4m to 7m. The entrance to the energy centre is set approximately 1.5 m below the surrounding ground level. The selected plant will fit within the existing energy centre building, as illustrated in the internal views of the energy centre shown in Figure 3, Figure 4 and Figure 5 . The energy centre arrangement includes consideration of the installation, operation, maintenance, and decommissioning of key plant items. Further details are given in drawings S2278-SEL-EC-00-DR-Y-1001 to S2278-SEL-EC-00-DR-Y-1004.

An extract of the Process and Instrumentation Diagram drawing S2278-SEL-EC-XX-DR-Y-7001 outlining the key functionality of the energy centre plant is shown in Figure 1.

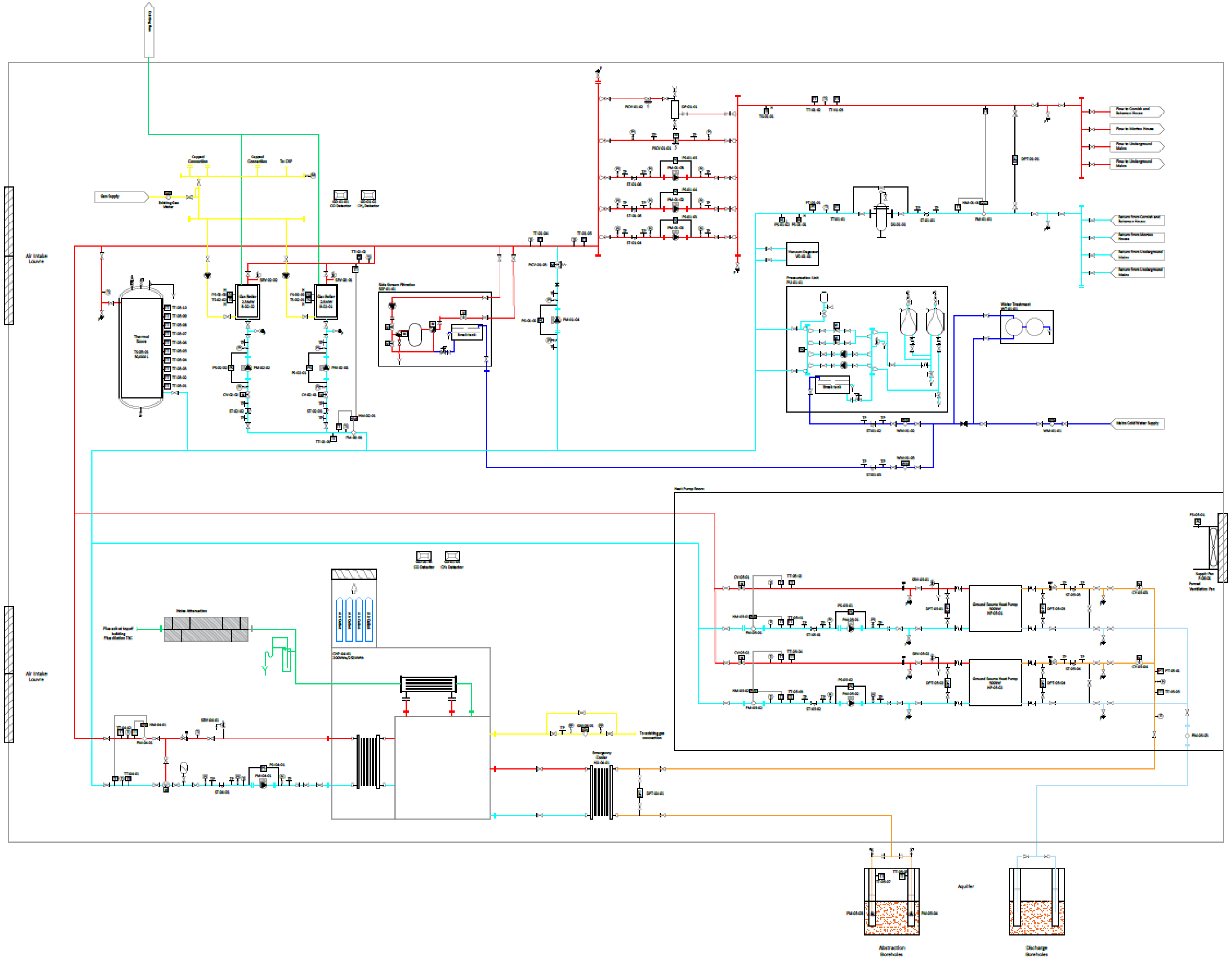

Figure 1: Energy Centre P&ID (extract from drawing S2278-SEL-EC-XX-DR-Y-7001)

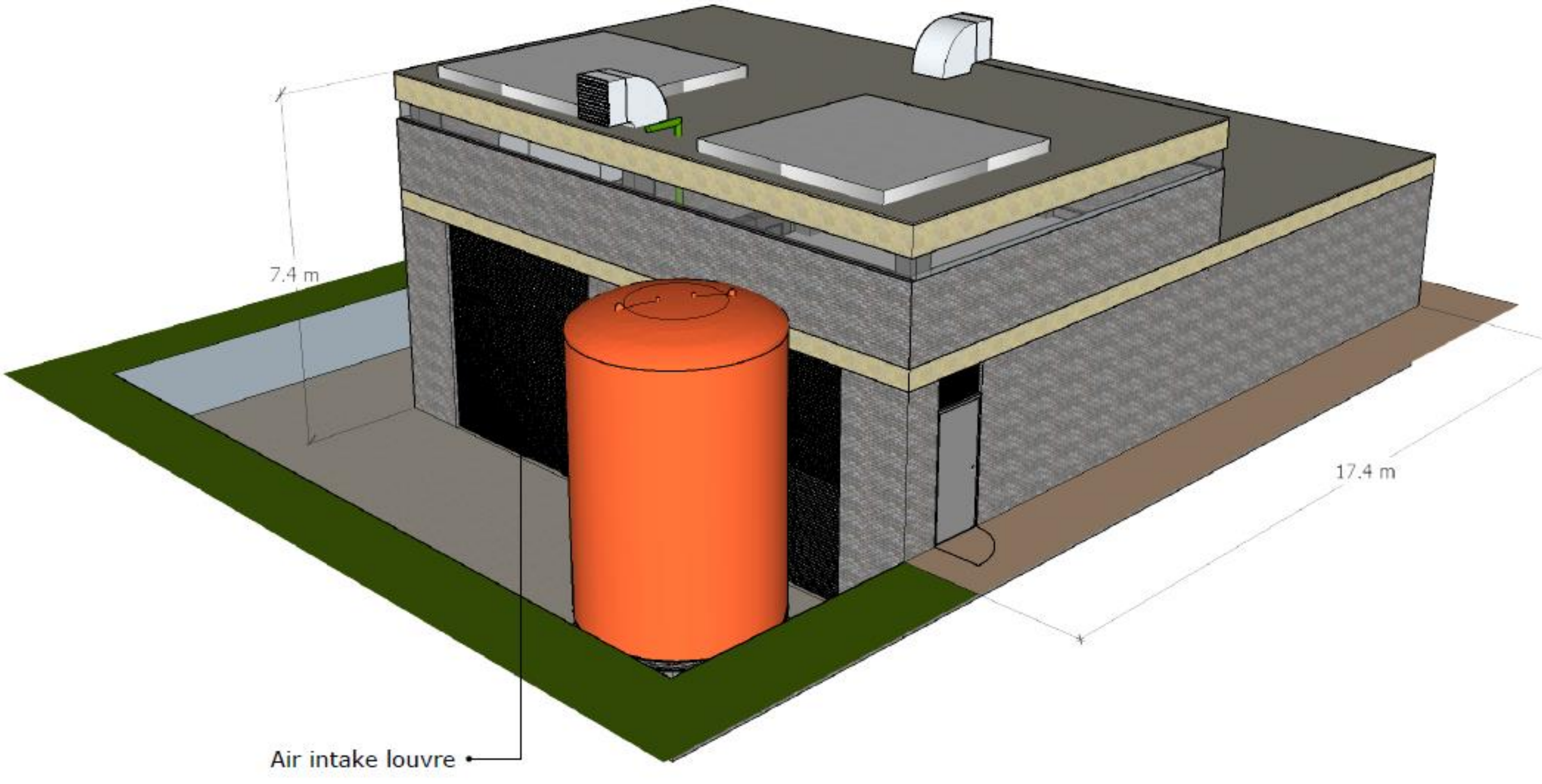

Figure 2: Energy centre - external view

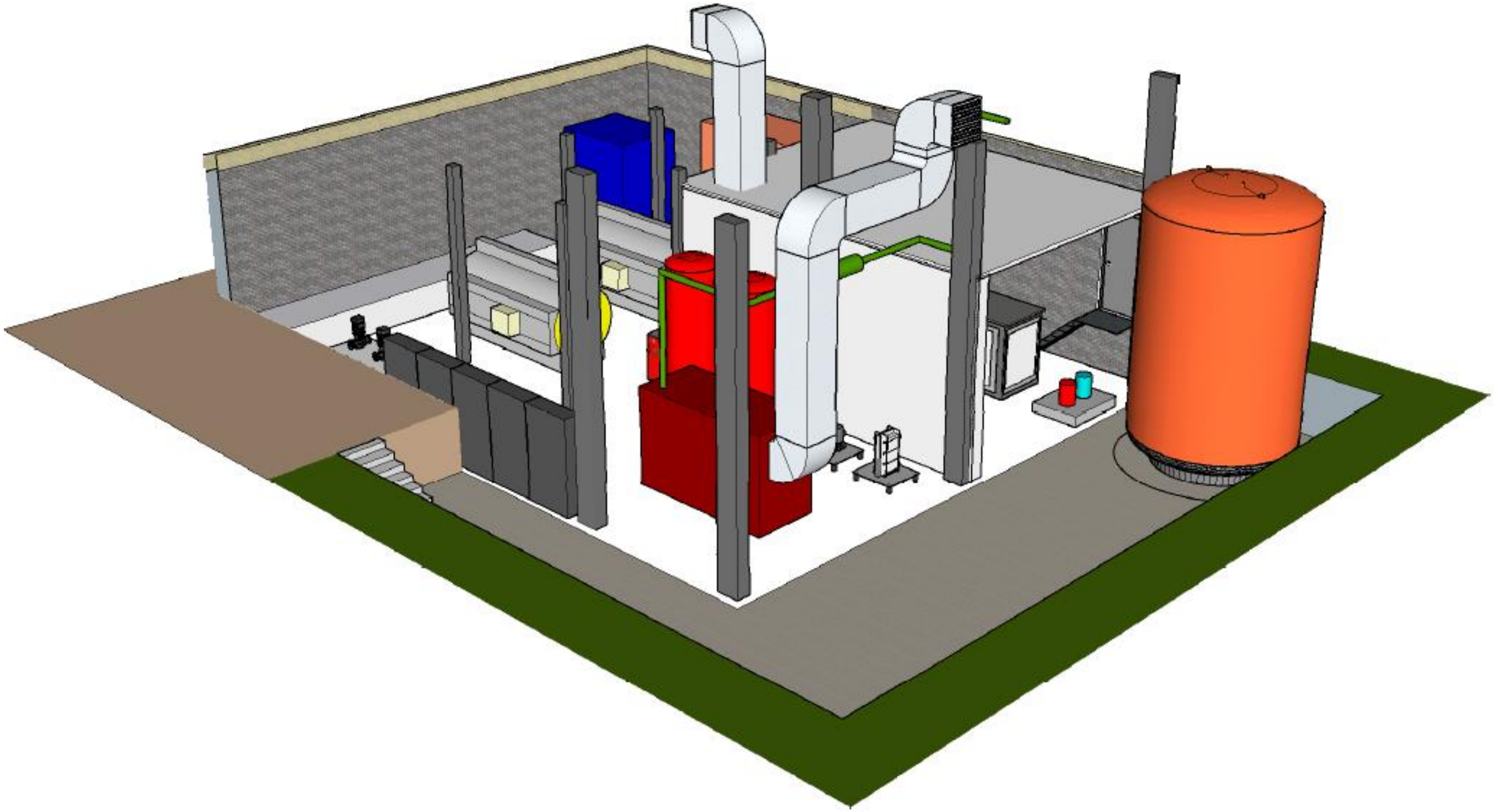

Figure 3: Energy centre – internal view

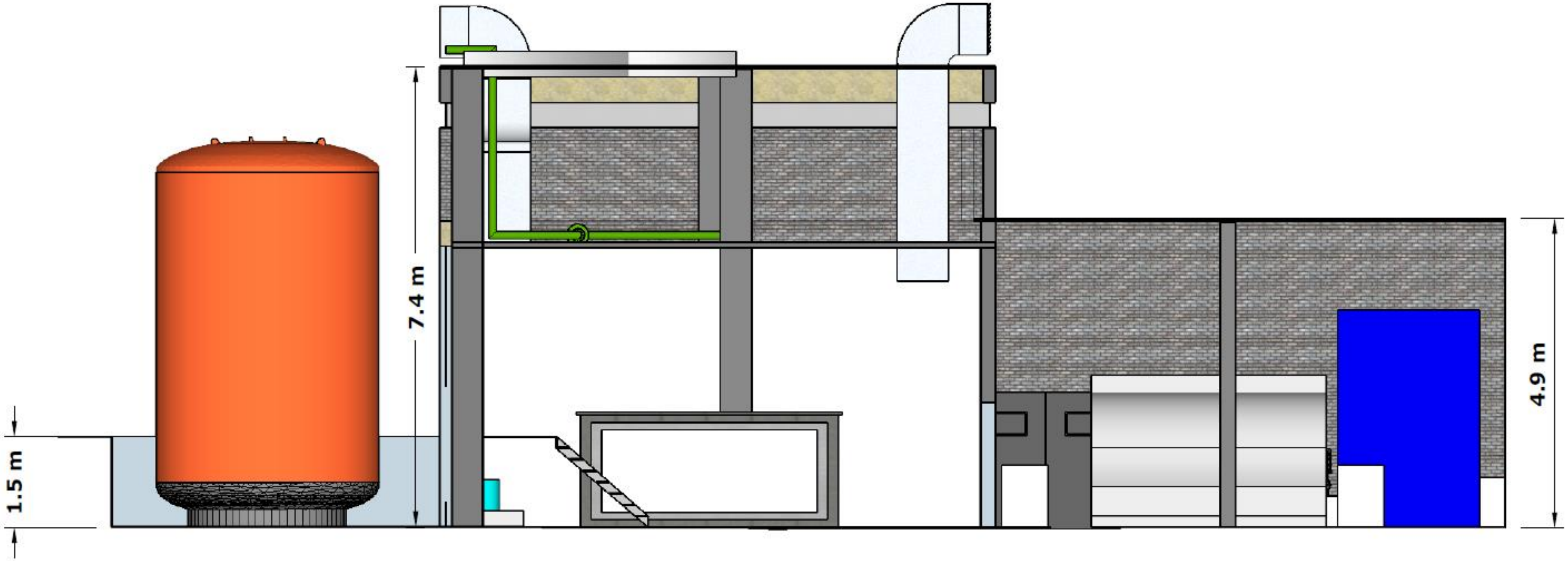

Figure 4: Energy centre – internal view elevation

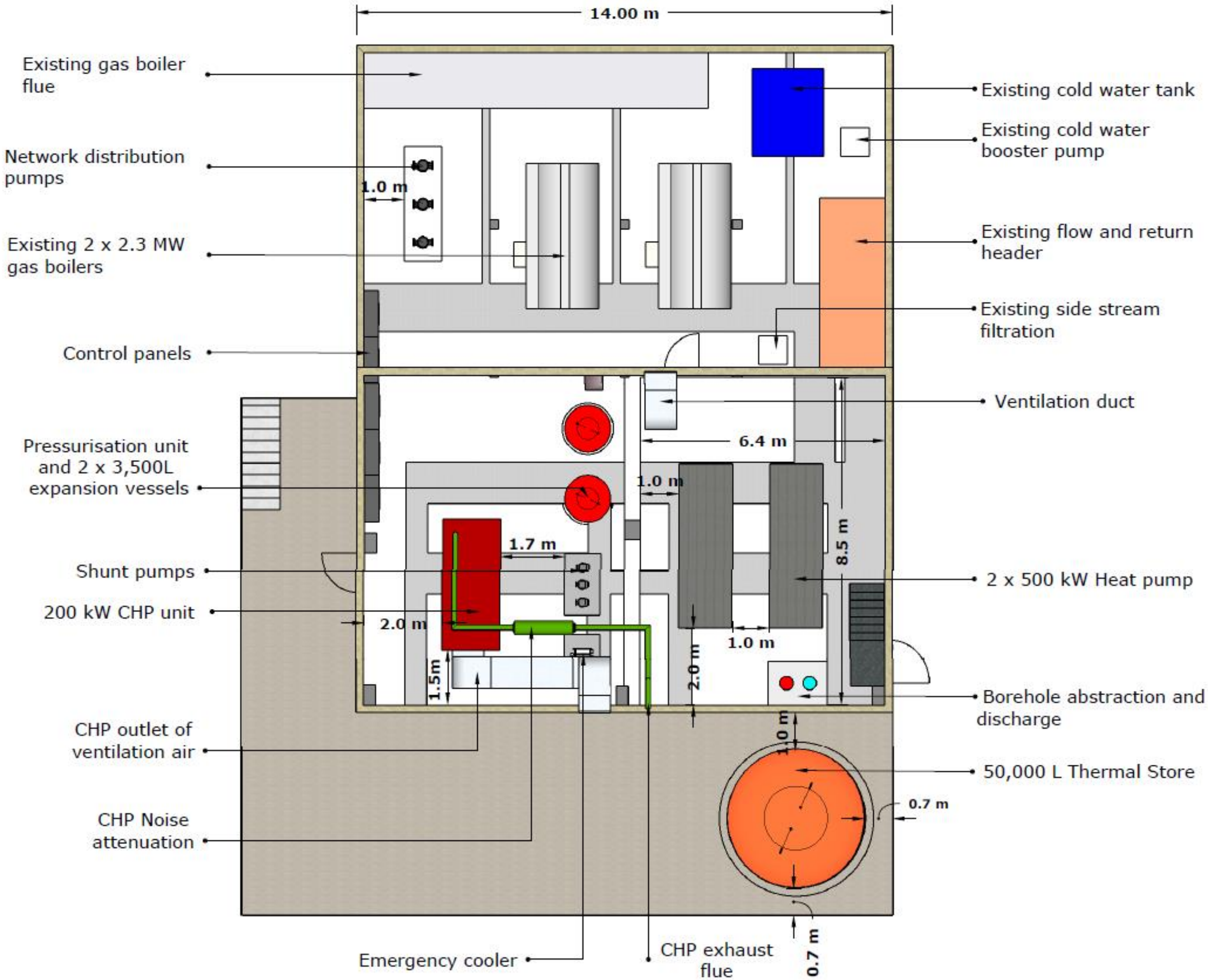

Figure 5: Energy centre – ground floor

2.3 Heat Generation

2.3.1 GSHPs

The ground source heat pumps will be packaged units connected within the energy centre to two main circuits; the abstraction and discharge water source circuit and the primary heating circuit.

The heat pump operates by running a low-temperature, low pressure refrigerant fluid through a heat exchanger to extract heat from the borehole water. The refrigerant fluid 'absorbs' the heat and boils at low temperature with the resulting gas being compressed to increase the temperature, the gas is then passed through another heat exchanger, where it condenses, releasing its latent heat to the primary heating circuit.

The heat pump refrigerant circuit will be hermetically sealed and subject to the F-gas directive and the working fluid will be a Low Global Warming Potential refrigerant.

The borehole water is sufficiently clean and free from bacterial growth to allow a direct connection to the heat exchanger. An inline strainer will be included on the abstraction circuit to remove any large particles. On the heat pump heat exchanger a differential pressure switch has been included to monitor the pressure drop across the heat exchanger to provide early warning of heat exchanger fouling.

The heat pump capacity will be limited based on the network demand and the flow rate of water pumped from the abstraction wells and returned to the wells to recharge the source. Consideration has also been given to the optimum balance between heat generation capacity, capital cost, maintenance costs and physical size.

A detailed sizing exercise has been undertaken using SEL's heat pump and thermal store sizing tool. The tool analyses the hourly network heat demand, network losses, water source temperature, heat pump capacity and modulation and thermal store size on an hourly basis for a full year taking into account hourly, daily and seasonal variation as well as peak and off peak electricity tariffs. Following this exercise, a 1,000 kW capacity heat pump system, comprising 2 x 500 kW heat pumps has been selected, combined with a 200 kW CHP plant.

The heat pump sizing strategy includes two smaller heat pumps rather than one large heat pump to improve the ability of the plant to modulate during periods of low demand. This sizing strategy also allows the additional flexibility in operation of the scheme in periods of scheduled maintenance and resilience in the event of heat pump failure.

2.3.2 Gas CHP

The proposed gas CHP plant is a reciprocating, spark ignition gas engine fitted with exhaust gas heat exchangers. The engine is directly coupled to a synchronous electricity generator, co-producing heat (from the exhaust gas heat exchanger and engine cooling circuits) and electrical power (from the generator). The unit will be a packaged plant which includes a noise reducing canopy enclosing the engine, generator, heat exchangers, and ancillary equipment.

The gas CHP plant will have a capacity of 200 kWe / 252 kWth, sized to meet the electricity demand of 1 x 500 kW GSHP plant. The CHP will only run when the heat pump is operational and will modulate to provide the required electricity output to meet the demand of the heat pump. If the combined heat output from the CHP plant and the heat pump is greater than the network demand, then the gas CHP will not operate. There will be no electricity export from the energy centre.

An emergency cooler may be required for the CHP. A plate heat exchanger on the incoming borehole water will be used to provide the emergency cooling. As the controls of the CHP only allow operation during heat pump operation, there will always be a supply of cooling water when required.

Maintenance requirements

The CHP plant would be due for replacement after a lifetime of 15 years, at which point it would be replaced with a heat pump. The CHP plant would be installed in the location next to the existing energy centre windows, which would be replaced with a removable louvre panelled wall to ensure ease of plant maintenance and replacement.

2.3.3 Gas Boilers

The 2 x 2.3 MW existing gas boilers will be retained to provide peak and reserve heating capacity. The retained gas boilers capacity allows for an n+1 strategy, so that failure of any single heat generation equipment would still result in the network peak demand being supplied.

2.4 Ventilation Design

Heat Pumps

The heat pumps will be installed within their own designated room within the energy centre. The heat pump room will be mechanically ventilated in accordance to EN 378 which includes the requirement for emergency ventilation in the event of a refrigerant leak. Commonly used refrigerants (except R-717) are heavier than air and so care should be taken to avoid stagnant pockets of heavy refrigerant vapours, by proper location of ventilation inlet and exhaust openings. Refrigerants and their combinations with oils, water or other substances, can affect the system chemically and physically and can potentially endanger persons, property and the environment when escaping from the refrigerating system. Refrigerants shall be selected with due regard to their potential influence on the global environment (ODP, GWP) as well as their possible effects on the local environment.

Main Plant Room

The rest of the energy centre will have natural ventilation provided by fresh air louvres. By the gas boilers there are existing louvres that will remain unchanged. At the CHP side of the building, the current window will be replaced with a louvre that provides sufficient free space for the required air intake of the CHP and for heat dissipation within the plant room.

2.5 Thermal Storage

Thermal storage has been included to maximise the proportion of heat that can be provided from the heat pumps and gas CHP plant, and to reduce the use of the peak and reserve gas boilers. The thermal storage comprises a large cylindrical, insulated water tank which will be connected in parallel with the GSHP and gas CHP so that a proportion of low carbon heat is always used to charge the thermal stores when they are below full capacity. The thermal store design will maximise the stratification of the stored volume. The thermal store will be of circa 3.5 m diameter and 7 m height and will provide 50 m^3 of storage.

2.6 Flues

Gas boiler

The existing gas boiler flue will be retained with the gas boilers. The flue passes underground from the energy centre to a riser located in Cornish House; this riser terminates approximately 58 m above the energy centre.

CHP plant

It is not possible to combine the gas boiler flues and the gas CHP flue due to the higher operating pressure of the gas CHP exhaust. Therefore, the gas CHP exhaust will terminate at the top of the energy centre building.

The local topography and buildings will impact heavily on the emissions dispersion, in particular Cornish House and Molesworth House which are adjacent to the energy centre. The exhaust will be directed away from the windows of any nearby dwellings, to avoid local residents being impacted by emissions from the gas CHP plant (the approximate distance from the proposed gas

CHP exhaust to either building is 14 m). However, depending on the results of emissions dispersion modelling, a flue dispersion system could be installed which will be designed to dilute the flue gases to less than 1% CO_2, 5ppm NOx and 50 ppm CO as per IGEM UP/10. This would be achieved by drawing fresh air into an inlet louvre pulled in by a fan which is integrated within the flue ductwork. This fresh air dilutes the flue gases from the CHP plant exhaust before being expelled through a discharge louvre, the flue gases would be diluted to approximately 10 parts air to 1 part flue gas and would be safe for horizontal discharge. Flue dilution systems are only permitted for boilers with a gross thermal input of 6 MW (as per the Clean Air Act Memorandum) but the gas boiler capacity proposed within the concept design is below this limit.

2.7 Variable Speed Pumps

The design utilises variable speed pumps in a multi-pump arrangement (3 pumps – 2 x duty and 1 x standby). They will be controlled to maintain a minimum pressure difference at specific locations using index differential pressure sensors within the network. The pump set will be sequenced, and speed controlled (on a demand basis) to maintain a differential pressure that is influenced by the pressure independent control valves controlling heat demand to ensure heat demands are satisfied and flow rates are minimised.

The benefits of the variable speed function will be realised as peak flow rate conditions will typically only occur for brief periods during a heating season, with average demands being much lower.

2.8 Ancillary Equipment

All balance of plant such as pressurisation, expansion and water treatment are designed with redundancy so that failure of any one item will not prevent the plant from generating and distributing heat to the network. The total volume of the network plus the thermal store is circa 65,000 litres. The expansion vessels have been sized to allow for thermal expansion from 45°C to 70°C.

2.9 Utilities Connections

Electricity

An upgraded electricity connection will be required at the energy centre to meet the 500 kVA requirements for the site. A budget quote was requested from UK Power Networks (UKPN) but was not received at the time of writing. For this assessment a budget quote received by Buro Happold in the Pre-Feasibility Report (2021) of £113,000 + VAT from UKPN was used.

Gas

The existing gas connection at the energy centre will be sufficient to supply the proposed heating system.

Water and Drainage

An existing mains water supply and drainage connection is available at the energy centre.

2.10 Metering

All metering will be specified with suitable accuracy class in accordance with the Measurement Instrumentation Directive to satisfy the utility requirements for the purchase of gas, water and electricity for the energy centre and MID Class 2 for all heat meters.

2.10.1 Heat

The energy centre will have five heat ultrasonic heat meters to allow accurate monitoring of heat network operation. The following heat meters are required:

- 1 x heat meter to measure heat supplied from the energy centre to the network
- 2 x heat meters for heat generated by the water source heat pumps (one meter installed on each heat pump)
- 1 x heat meter for combined heat generated by the existing 2 x 2.3 MW reserve gas boilers
- 1 x heat meter for heat generated by the gas CHP plant

The ultrasonic flow sensors measure flow and return temperatures and flow rates and the multi-function meters will calculate the heat energy exported. The heat meters will provide output signals (via mbus) for instantaneous measurements and cumulative measure of flow and energy. Data from all meters will be imported into the control system and used for control and monitoring of system performance.

2.10.2 Gas

The existing gas meter will be used as the overall gas consumption meter, which will output cumulative values. The main gas meter will be monitored and will allow network performance to be assessed.

A separate sub-meter will be installed to measure the gas consumption by the CHP plant. The meter will output cumulative values and will allow performance assessment and control of the gas CHP plant.

2.10.3 Water

Water meters will be installed to determine the cumulative use by each of the system pressurisation units, water treatment plant and the overall incoming mains water to the energy centre. All data will be collected by the control system.

2.10.4 Electricity

The energy centre will include a number of electrical sub-meters as follows:

- 2 x electricity sub-meters for energy consumption from each heat pump compressor
- 2 x electricity sub-meters for energy consumption from each heat pump shunt pump
- 2 x electricity sub-meters for energy consumption from each abstraction pump

2.11 Energy Centre Controls

The control system will prioritise and optimise the supply of heat to the network from the GSHPs and thermal stores all year round; peak and reserve gas boilers will be used to supply heat in the case that the GSHPs are not available, or if heat demand is greater than the combined GSHP and thermal store discharge. In cold weather and peak demand situations, the gas boilers will be used to raise the flow temperature to the heat network for short periods.

The gas CHP plant will be operated to provide electricity to one of the heat pumps. It shall only run when the heat demand of the network is large enough to utilise the heat from the CHP plant as well as the heat pumps. There is no electricity export from the energy centre.

The control system shall optimise the operation of all plant and equipment to deliver the lowest operational cost whilst maintaining the CO_2 content of heat generated below the maximum agreed level. The control system will calculate the cost of electricity from the gas CHP plant, and the gas CHP plant will only run if the cost of produced electricity is less than the cost of imported electricity.

The network distribution pumps will be controlled to maintain differential pressure conditions at the index points of the network. Pressurisation plant, water treatment plant, filters and ancillary equipment will all be monitored by the Control

System. Data from the thermal substations and energy network will be used by the Control System to generate control information that will optimise the production and distribution of heat to the network.

3 GROUND WATER ABSTRACTION AND RECHARGE

3.1 Boreholes

The GSHP system is required to be non-consumptive. Water is abstracted from the chalk aquifer via boreholes and pumped to the heat pump with the energy centre to extract heat. The water is then injected back into the same horizon via the recharge boreholes, as per Figure 6. The depth of the abstraction boreholes is expected to be circa 130 m - based on the existing borehole at the Wyndham Estate.

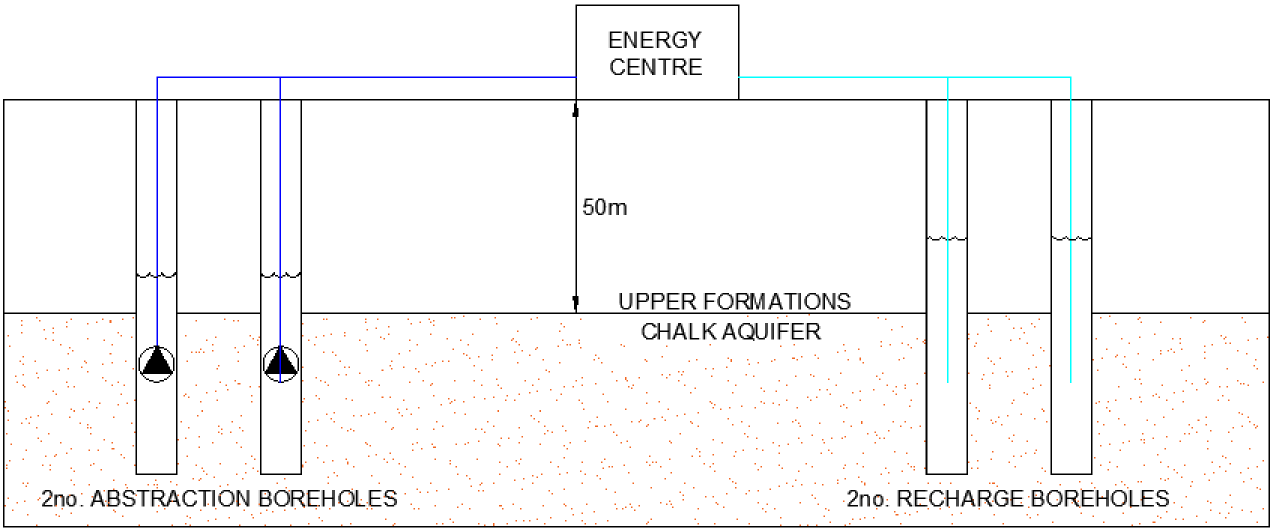

Figure 6: Ground water abstraction and recharge arrangement

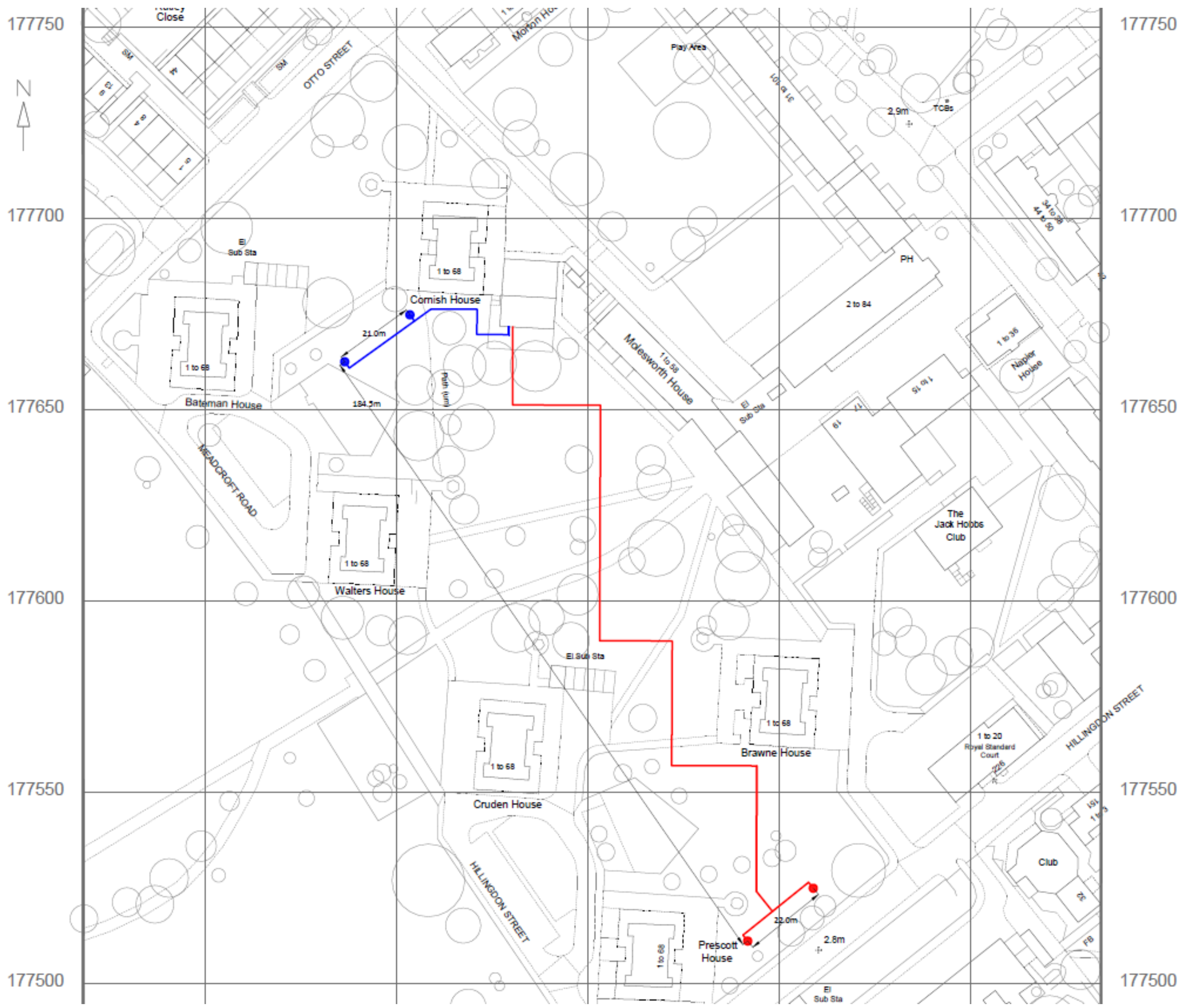

Figure 7: Borehole locations

Assessment of the data available from the existing abstraction boreholes located at other LBS sites indicates that a yield of 19.5 l/s per bore / well has been achieved.

To meet the peak heat extraction required for the GSHPs, and assuming a maximum delta T of 10°C, it is concluded that a bore field comprising 2 x abstraction boreholes and 2 x recharge boreholes would be required; the recharge boreholes would be located at a distance of circa 185m from the abstraction site, as at other sites.

Each of the boreholes will have a circa 1.2 m x 1.5 m x 1.2 m height subterranean chamber to house the well head, delivery pipe and associated electrical and controls equipment. The abstraction borehole arrangement includes a submersible pump below the water level to pump the water to the recharge wells via the heat pumps in the energy centre. The submersible pump will be sized to deliver the peak 19.5 l/s from the source water level to the recharge boreholes via the heat pump heat exchanger in the energy centre; the water level at the maximum pumping rate needs to be confirmed via further assessment and pump testing a trial well but, using available information, it is estimated that a 15 kW pump with a head of 40 m would be suitable. The cross section for each of these borehole types is shown in Figure 8.

3.2 Local Borehole Data

The assumptions used in this assessment are based on existing data from several London Borough of Southwark heat pump schemes. Table 3 shows the details from these boreholes and their proximity to the proposed borefield.

Table 3: Local borehole data

Borehole name	Distance from proposed borefield, m	Depth, m	Abstraction flow rate, l/s
Consort	~3,300	90	19.5
Wyndham	~520	130	19.5
Newington	~1,030	110	19.5

3.3 Abstraction and Recharge Network

The abstraction and recharge boreholes will connect to the energy centre via an underground pipe network. The network consists of individual delivery pipes from each borehole, connecting to a main pipe which in turn connects to the heat pump system in the energy centre. Typically, the underground pipework will be HDPE plastic which will change to stainless steel when it enters the energy centre. Pipework will run in trenches typically at a depth of circa 600 mm and enter the bore hole well head chamber at this depth through the well head chamber wall. The trench will also include power and communications cables for the abstraction pump.

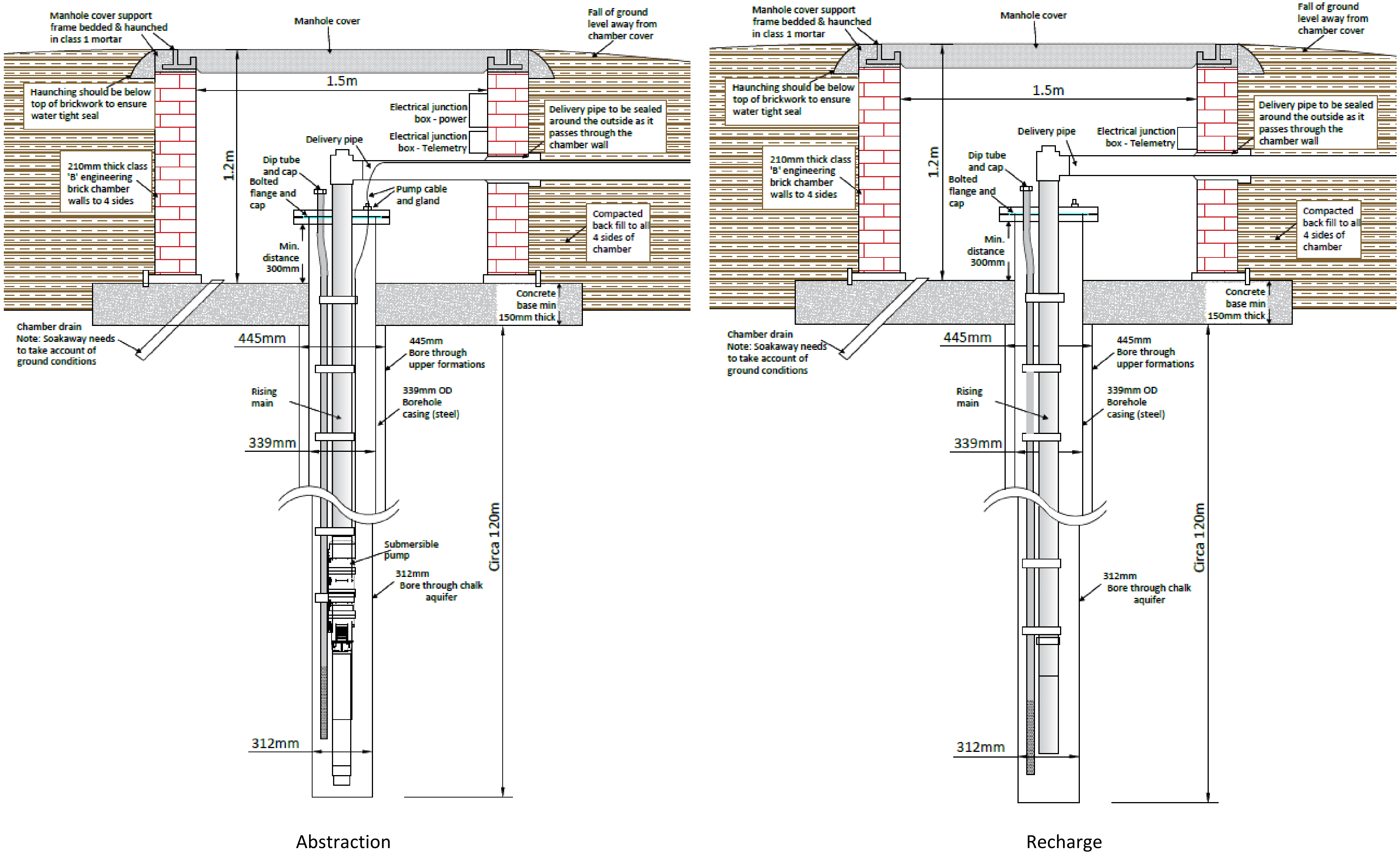

Figure 8: Borehole cross sections

4 HEAT NETWORK

The existing network will be retained for this project.

4.1 Operating Conditions

A detailed assessment of the existing network has been undertaken and the proposed operating conditions reflect the optimal network efficiency. To effectively serve the connected buildings, the heat network will operate with variable temperature conditions.

4.1.1 Primary Network Temperatures

Heat pumps have a performance which is significantly impacted by the temperature conditions of the network and, to maintain efficient performance, network flow and return temperatures should be as low as possible. The primary heat network will provide heat to the connecting buildings via plate heat exchangers with a primary flow temperature of up to 70°C at peak conditions and 60°C for off peak and summer conditions.

4.1.2 Secondary Systems / Building Heating System Temperatures

The secondary heating systems within the buildings are being replaced and will be designed to reduce building heating system temperatures in accordance with CIBSE / ADE CP1. This will result in lower average return temperatures, which will increase the efficiency of the network and the heat generation plant. Target secondary side temperatures are 55°C flow and 35°C return, in line with the latest building regulations. Key considerations for the secondary side heating designs are to allow for low temperatures while maintaining flowrates that can be effectively controlled - this means a ΔT across the emitters of 20°C maximum would be optimal.

4.1.3 Operating Pressure

The site topography does not have much variation, therefore, the static pressure from natural ground variation is minimal. However, there are some buildings which have direct connections to the primary network and this is where the largest height difference over the network occurs. The maximum height difference between the lowest point on the network and the highest point is circa 10m - this gives a static pressure requirement of circa 1 barg.

The pumping pressure defines the maximum operating pressure required to generate enough head to deliver sufficient flow rate to all buildings. Hydraulic modelling was carried out to assess how the pressure in the network will vary throughout the year - the maximum pressure differential was calculated to be 1.5 barg. The results are summarised in Section 4.3.

4.2 Network Route

Figure 9 shows the existing heat network route (green), the proposed location of the abstraction (red) and recharge(blue) boreholes and the proposed route of the associated borehole pipework to connect to the energy centre.

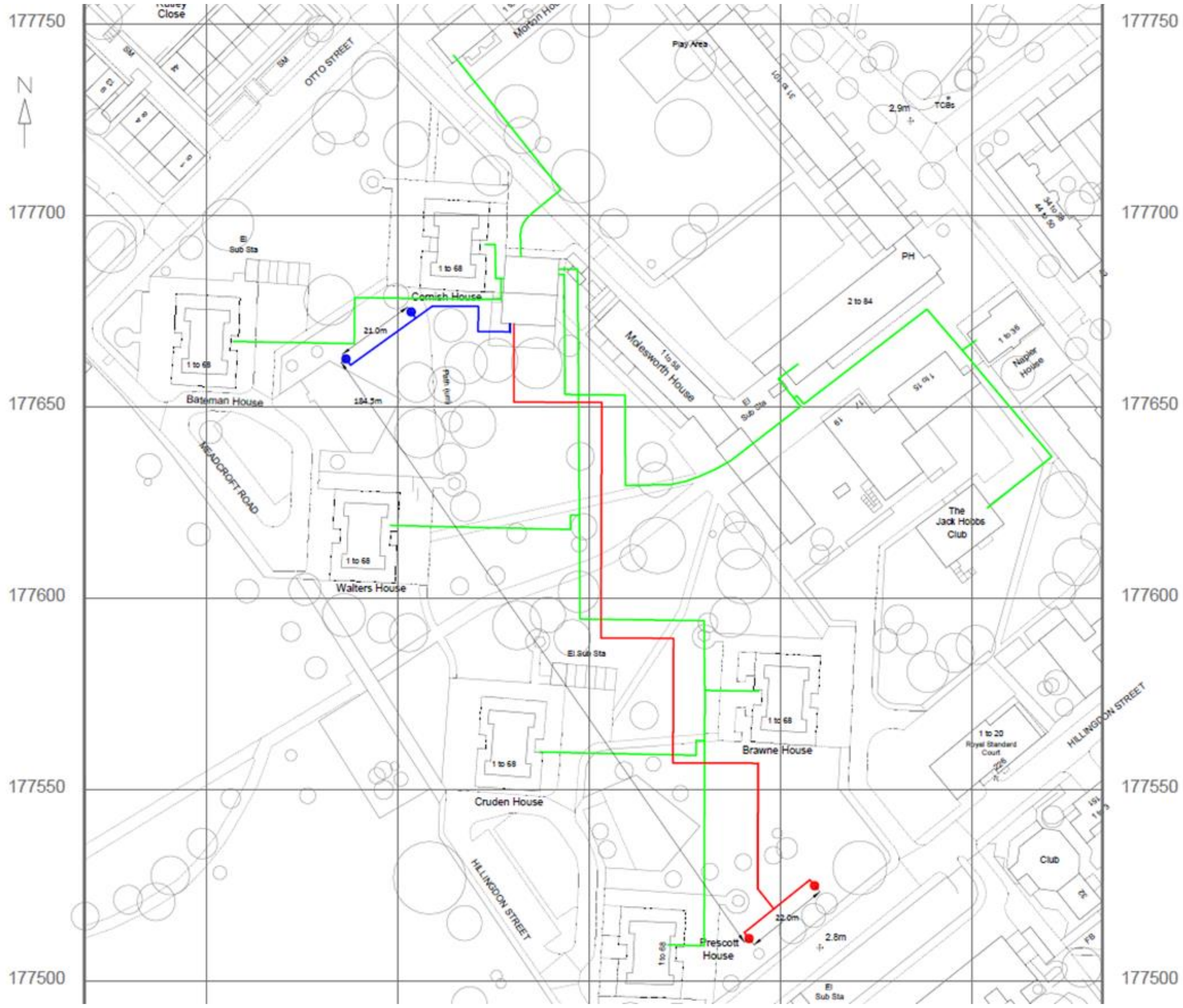

Figure 9: Network and borehole pipework route (extract from drawing S2278-SEL-HN-ZZ-DR-Y-4001)

4.3 Network Simulation

Fluidit heat network modelling software was used to determine the characteristics and sizing for each part of the network to confirm the network pump operation and expected network heat losses. The software allows for scenarios to be modelled to determine pipe characteristics, velocity and flow temperatures. Energy centre pumping requirements are also considered to ensure that the optimum pipe size is selected. Figure 10 illustrates an example output from the software, displaying pipe velocity under diversified load conditions.

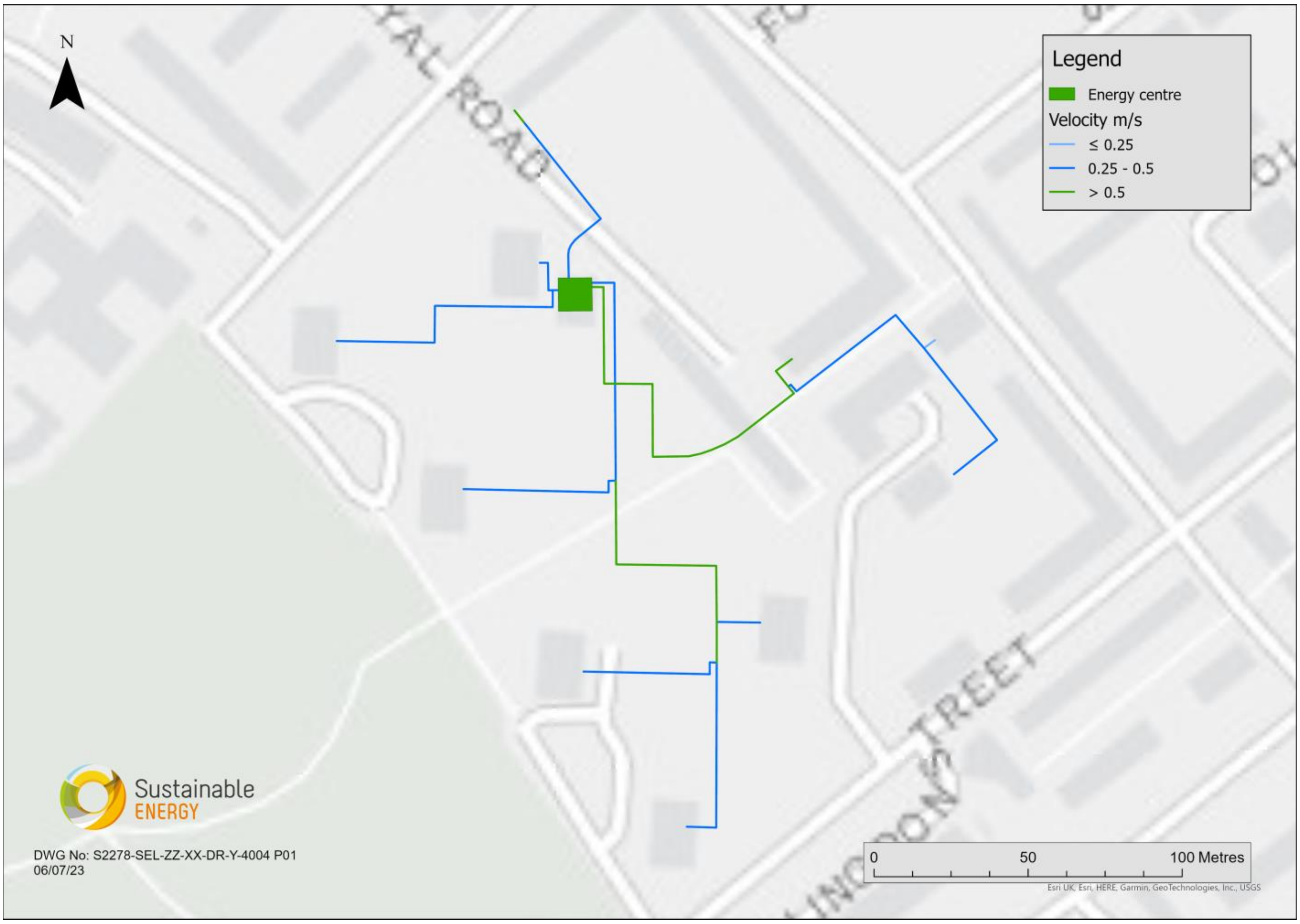

Figure 10: Example of pipe velocity under diversified load conditions

The results of the network modelling exercise conclude that the installed pipework is oversized for the proposed operating conditions.

5 BUILDING CONNECTIONS

Details of the buildings connected to the existing Brandon heat network are shown in Table 4 – this summarises the existing connection/secondary side system and the proposed changes to the building/secondary side system for compatibility with the low carbon heating plant and lower network temperatures.

The connecting buildings are predominantly housing blocks, plus two non-residential buildings - Brandon Library and the Jack Hobbs Community Centre. Maddock Way, Molesworth House and Brandon Library share a substation and form a single network connection.

Table 4: Brandon Estate network connections

Ref	Building name	Substation name	Current connection details	Changes to connections
1	Bateman House	Bateman	• Hydraulic break via a plate heat exchanger, to separate the primary and secondary networks • Secondary hot water pipework serves the hot water tanks in each dwelling and the space heating pipework flows directly through to the radiators in each dwelling (no HIU)	• Upgrade all flats to direct HIU connections with instantaneous DHW • Upgrade radiators and pipework within flats • Connect HIUs to current DHW flow and return pipework • Modify DHW riser to isolate three port valve into fully open position • Upgrade secondary side pump to variable speed • Decommission existing SH riser pipework
2	Brawne House	Brawne		
4	Cornish House	Cornish		
5	Cruden House	Cruden		
7	Morton House	Morton		
9	Prescott House	Prescott		
10	Walters House	Walters		
3	Cooks Road	No substation	• Network supplies the dwellings directly with no hydraulic separation	• Upgrade all flats to indirect HIUs • Upgrade radiators and pipework within flats
6	Maddock Way	Maddock Way	• Hydraulic break via two plate heat exchangers to separate the primary and secondary networks • Substation serves both housing blocks and the library • Secondary hot water pipework serves the hot water tanks within each dwelling and the space heating pipework flows directly through to the radiators in the dwellings • Secondary pipework supplies the library directly with no additional hydraulic separation	• Upgrade all flats to direct HIU connections with instantaneous DHW • Upgrade radiators and pipework within flats • Connect HIUs to current DHW flow and return pipework • Modify DHW riser to isolate three port valve into fully open position • Upgrade secondary side pump to variable speed • Decommission existing SH riser pipework
6	Molesworth House			
11	Brandon Library			
8	Napier House	Napier	• There insufficient space within the plant room for a substation which means there is no hydraulic separation and the primary network directly supplies the dwellings	• Upgrade all flats to indirect HIUs • Upgrade radiators and pipework within flats
12	Jack Hobbs Community Centre	No substation	• Network supplies the building directly with no hydraulic separation	• Upgrade to include a substation • Isolate mixing leg on secondary side • Upgrade pump to variable speed control

5.1 Plantroom Modifications

The substations within the existing plant rooms are being retained with some modifications. In all buildings there is a DHW circuit and a space heating circuit - the space heating circuit splits into multiple risers to feed different properties, whereas there is only one DHW riser per building.

To reduce the secondary side network losses the existing space heating risers are to be decommissioned. As the current DHW riser feeds all properties in each building, this will be repurposed as a secondary heating riser to supply all HIUs within each building. Extracts of the riser modifications P&IDs for the different substation types (direct, single PHEX or multiple PHEX) are shown below in Figure 11, Figure 12 and Figure 13.

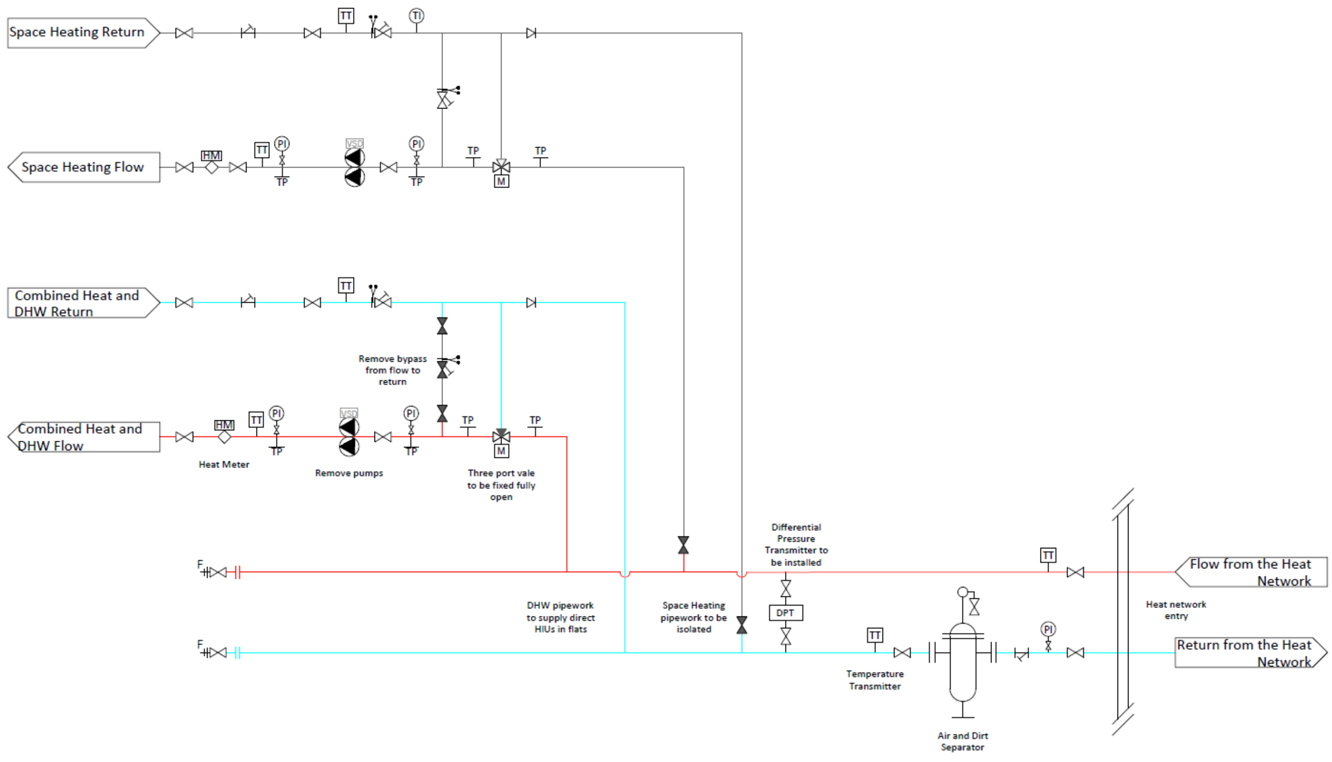

Figure 11: Proposed riser pipework modifications for direct connections (extract from drawing S2278-SEL-PP-XX-DR-Y-7001)

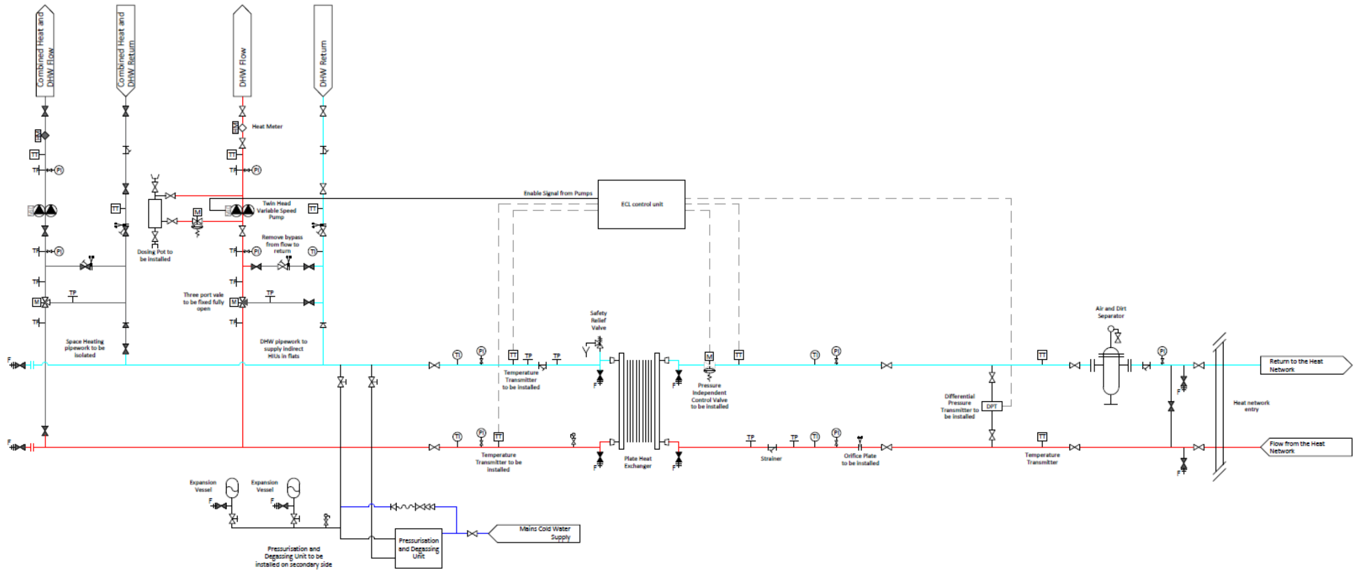

Figure 12: Proposed riser pipework modifications for single PHEX substation connections (extract from drawing S2278-SEL-PP-XX-DR-Y-7002)

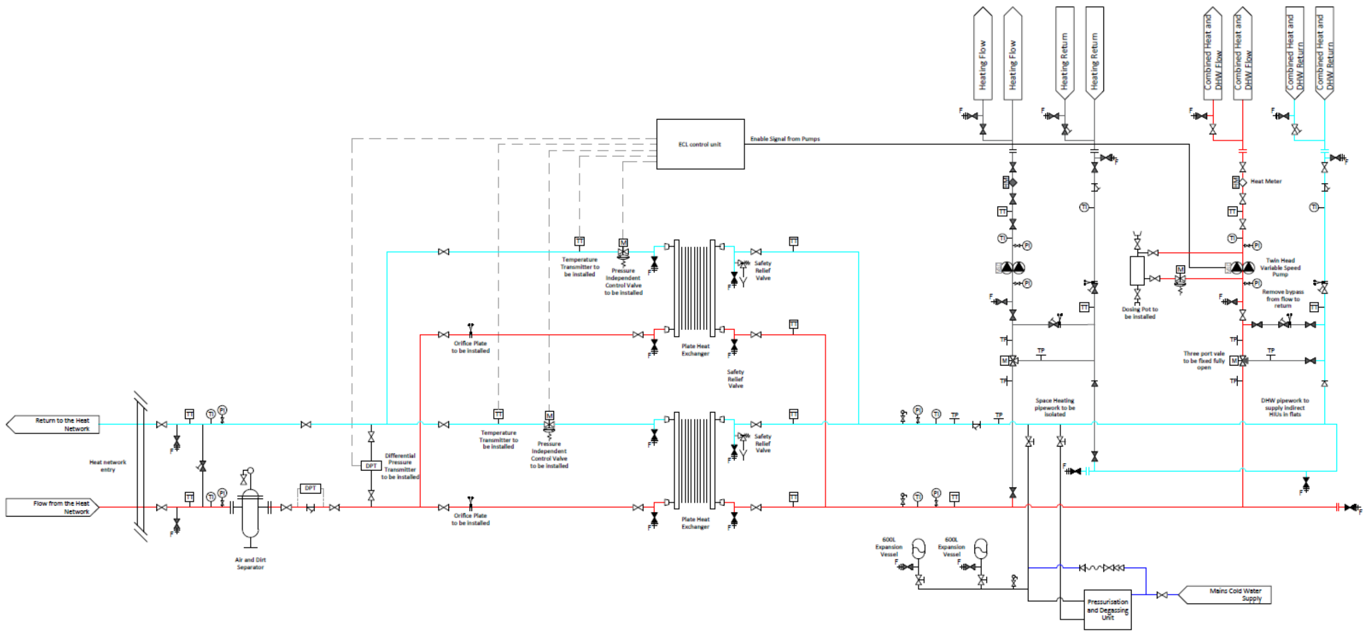

Figure 13: Proposed riser pipework modifications for dual PHEX substation connections (S2278-SEL-PP-XX-DR-Y-7003)

For the direct connections to the network, the mixing leg on the current DHW riser 3-port valve will be fixed fully open and the pumps removed. A differential pressure transmitter will be included to communicate with the energy centre to ensure sufficient pressure is available at the building.

For the connections with a heat exchanger, regardless of the number of PHEXs, the following changes are required:

On the primary side of the heat exchanger:

- a pressure independent control valve is to be installed to control the network flow
- with commissioning orifice plates with a means of flow measurement and test points

On the secondary side of the heat exchanger:

- Flow and return temperature transmitters are to be included

- Riser modifications - on the mixing leg of the current DHW riser, 3-port valve will be fixed open
- A variable speed pump will be installed in place of the current pump
- A chemical treatment dosing pot is to be installed across the pump
- Pressurisation and degassing unit to be installed

5.2 Residential Connections

For buildings with an existing substation, heating will be provided to the flats using a direct connection HIU. For buildings without an existing substation, heating will be provided by an indirect HIU connection, via an extra plate heat exchanger. Both types of HIU include a plate heat exchanger for instantaneous domestic hot water, pressure independent/differential pressure control valves and a heat meter. The key functional features for direct and indirect HIU connections are shown in the simplified schematics in Figure 14 and Figure 17.

HIUs are comparable in size to a domestic combination boiler and are usually wall hung. The hot water is best provided via an instantaneous PHE with a suitable means to ensure the network side of the plate is controlled, to ensure satisfactory hot water supply response to dwelling taps whilst minimising the supply pipework heat losses during standby periods.

The utilities required for the HIU within each flat are typically:

- 240 V spur connection
- 15 mm mains cold water service (MCWS) connection

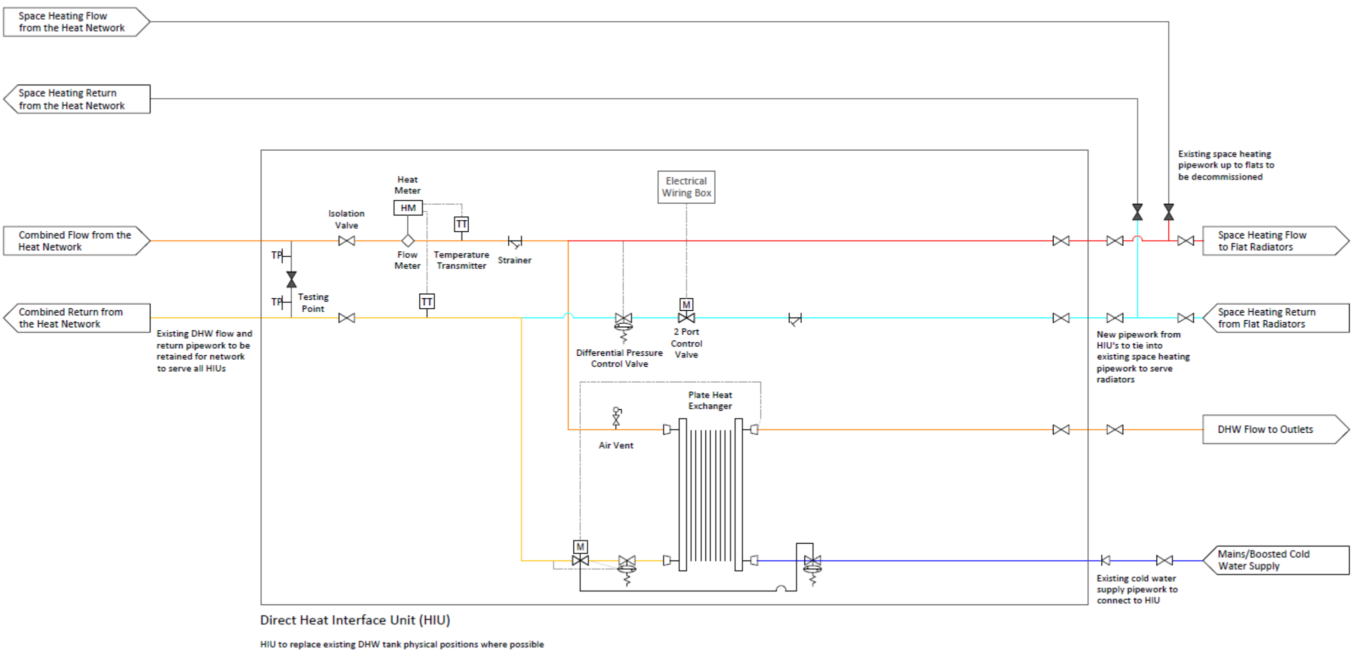

Figure 14: Example of typical direct connection domestic HIU connection (extract from drawing S2278-SEL-FP-XX-DR-Y-7001)

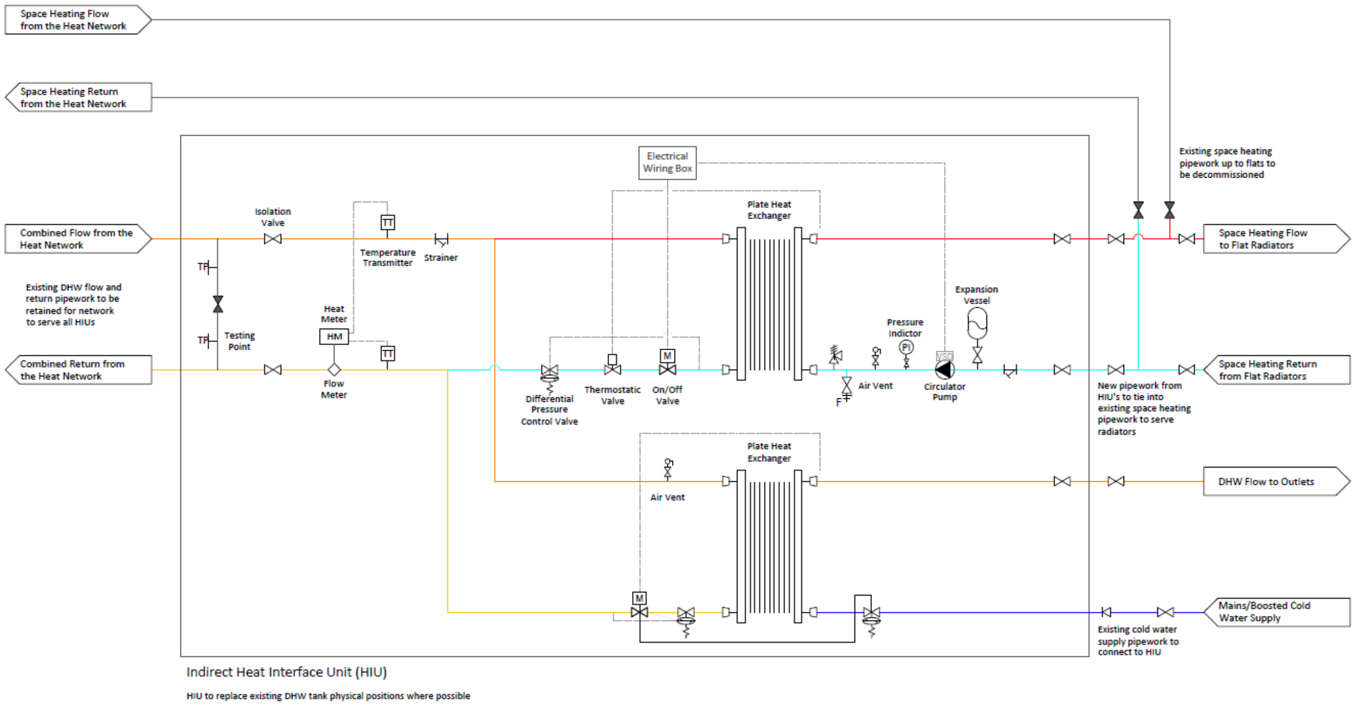

Figure 15: Example of typical indirect connection domestic HIU connection (extract from drawing S2278-SEL-FP-XX-DR-Y-7002)

5.2.1 Typical HIU Design

The typical design of an HIU is shown in Figure 16, Figure 17 and Figure 18. Connection to the HIU can be made on either the top or bottom of the HIU, as shown in Figure 17.

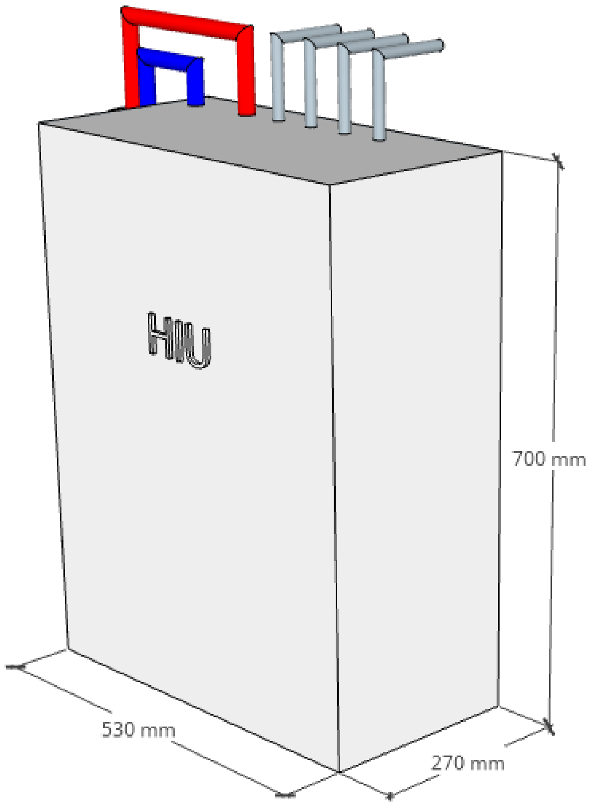

Figure 16: Typical HIU dimensions

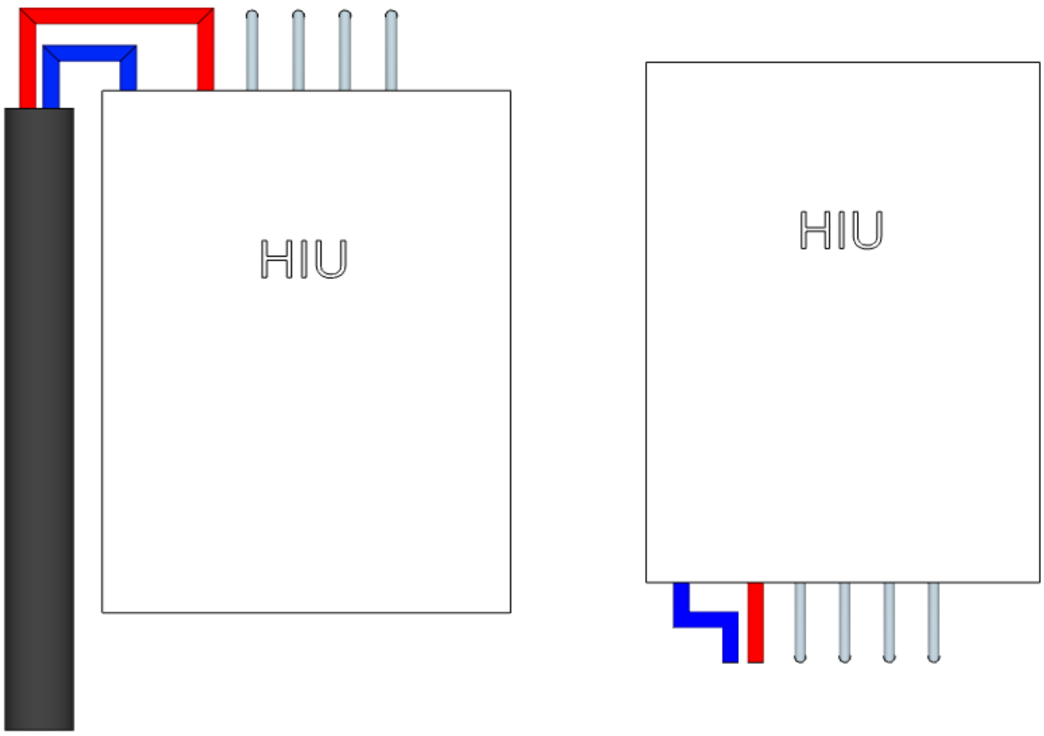

Figure 17: Connection to the HIU

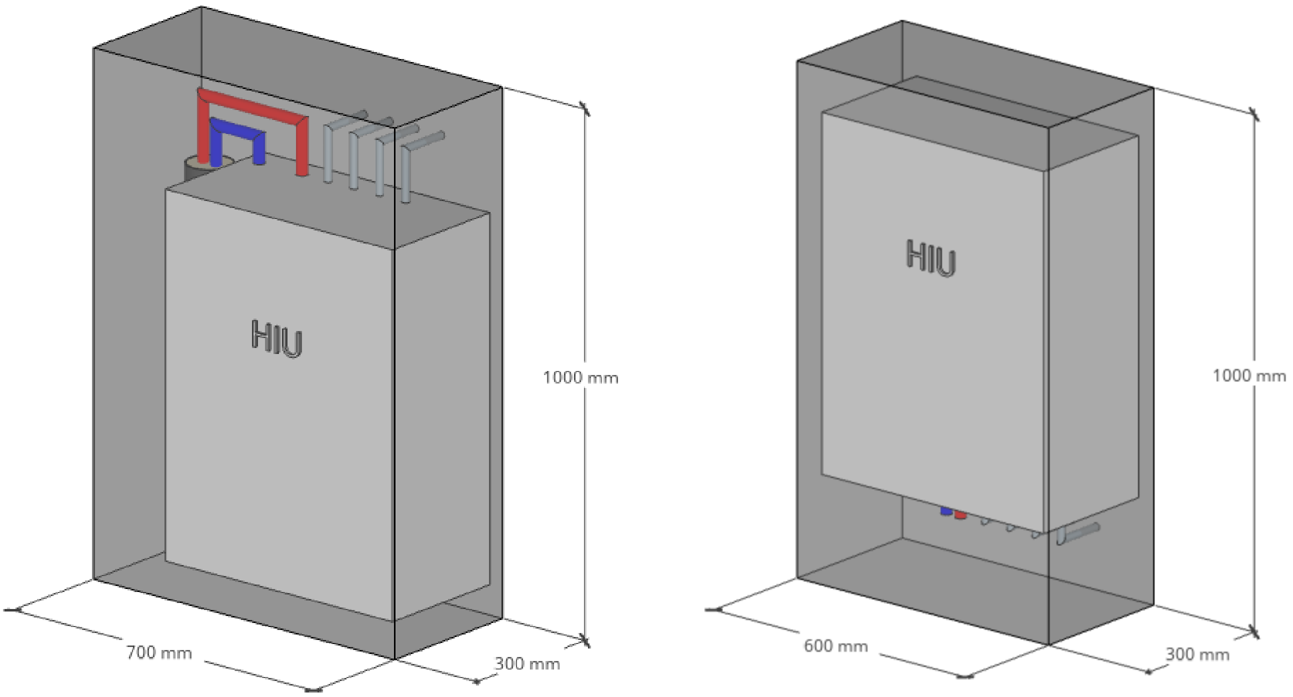

Figure 18: Typical minimum enclosure sizes

HIUs are normally installed within an enclosure. The HIU must be easily accessible and the enclosure must be fully opening to enable the front of the HIU to be removed. The minimum free space in front of the HIU is 600 mm, as shown in Figure 18.

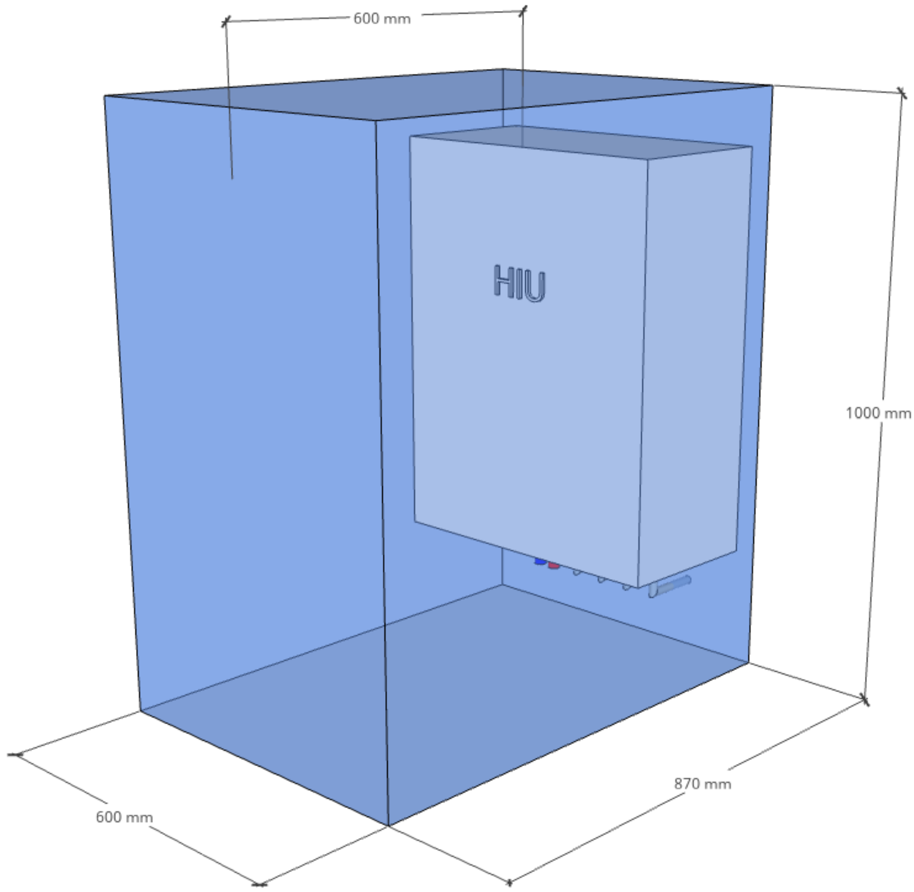

Figure 19: HIU minimum access requirements

5.2.2 Flat General Arrangements

It is proposed that HIUs are positioned such that they replace the existing hot water tanks where possible, or otherwise located in an internal cupboard. The internal space heating pipe work will be upgraded and modified to connect to the HIU. The heat supply will come from the existing DHW flow and return risers.

An example of a modified dwelling is shown below in Figure 20.

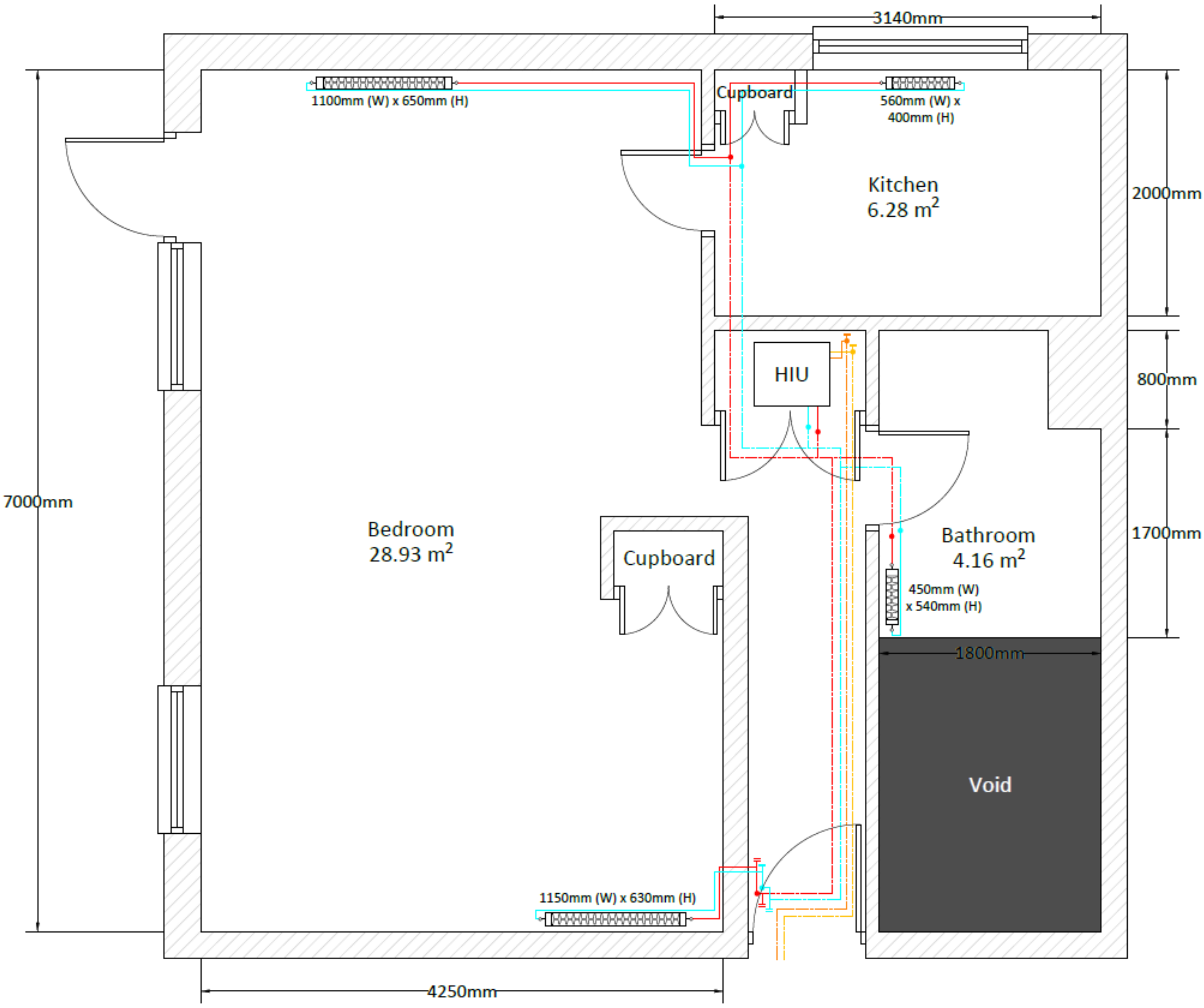

Figure 20: Example of HIU, pipework and radiators layout within a flat

5.2.3 Radiator Design

New radiators and associated pipe work are required for all flats. Updated building regulations require all significant refurbishments to include heat emitters that are compatible with low temperature heating systems. The key temperature considerations for the radiator design include:

- Must be suitable for low temperature heating: 55°C supply, 35°C return
- Average radiator temperature: (55 + 35) / 2 = 45°C
- Room temperature: air to radiator average temperature ΔT: 25°C
- Apply ΔT factor to radiator sizing (e.g., typical radiator sized for ΔT 50 will be de-rated by 50 %)

Key flow rate considerations for radiator design include:

- Flow control and commissioning of radiators is essential to maintain performance
- Requires pre-settable dynamic flow controlled TRVs

Key return temperature considerations for radiator design include:

- To ensure return temperatures are maintained, radiators should be top entry, bottom exit (see Figure 21 left)
- Alternatives available with bottom connections with internal pipe to top entry (see Figure 21 right)

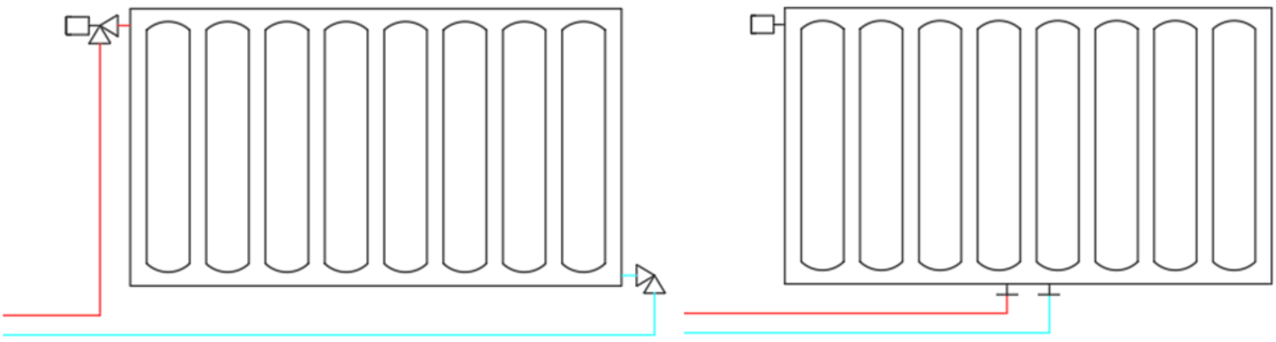

Figure 21: Connection options for low temperature radiators

5.3 Non-residential Connections

The non-domestic buildings will connect to the heat network via a heat substation. The substation includes heat exchangers, control valves and heat metering and will be maintained by the network operator. The substation can include one or more plate heat exchangers (PHEs) (one shown in the example in **Error! Reference source not found.**), depending on the size, turn-down and redundancy required for each building. The key functional features are shown in the simplified schematic in Figure 22 (drawing no. S2278-SEL-PP-XX-DR-Y-7004).

The substation package will include:

- Supplier heat meter to measure the heat usage on the primary side of the connection
- Two-port differential pressure control of the supply flowrate and temperatures across the heat exchanger. Control valves can either be a single PICV or a DPCV with a separate two-port control valve
- Plate heat exchanger (PHE) where the district heat is transferred to the customer secondary side network. PHEs will be specified with a maximum 3°C approach temperature across the return lines and a maximum 80kPa pressure drop on the secondary side of the heat exchanger
- Means of flow measurement and test points on primary and secondary sides for commissioning purposes
- Filtration to protect the plate heat exchangers and valves from fouling
- Flushing, filling and draining details for chemical flushing of all pipework on the primary and secondary side
- Pressure relief, control and instrumentation to allow the supplier to control and monitor the supply of heat

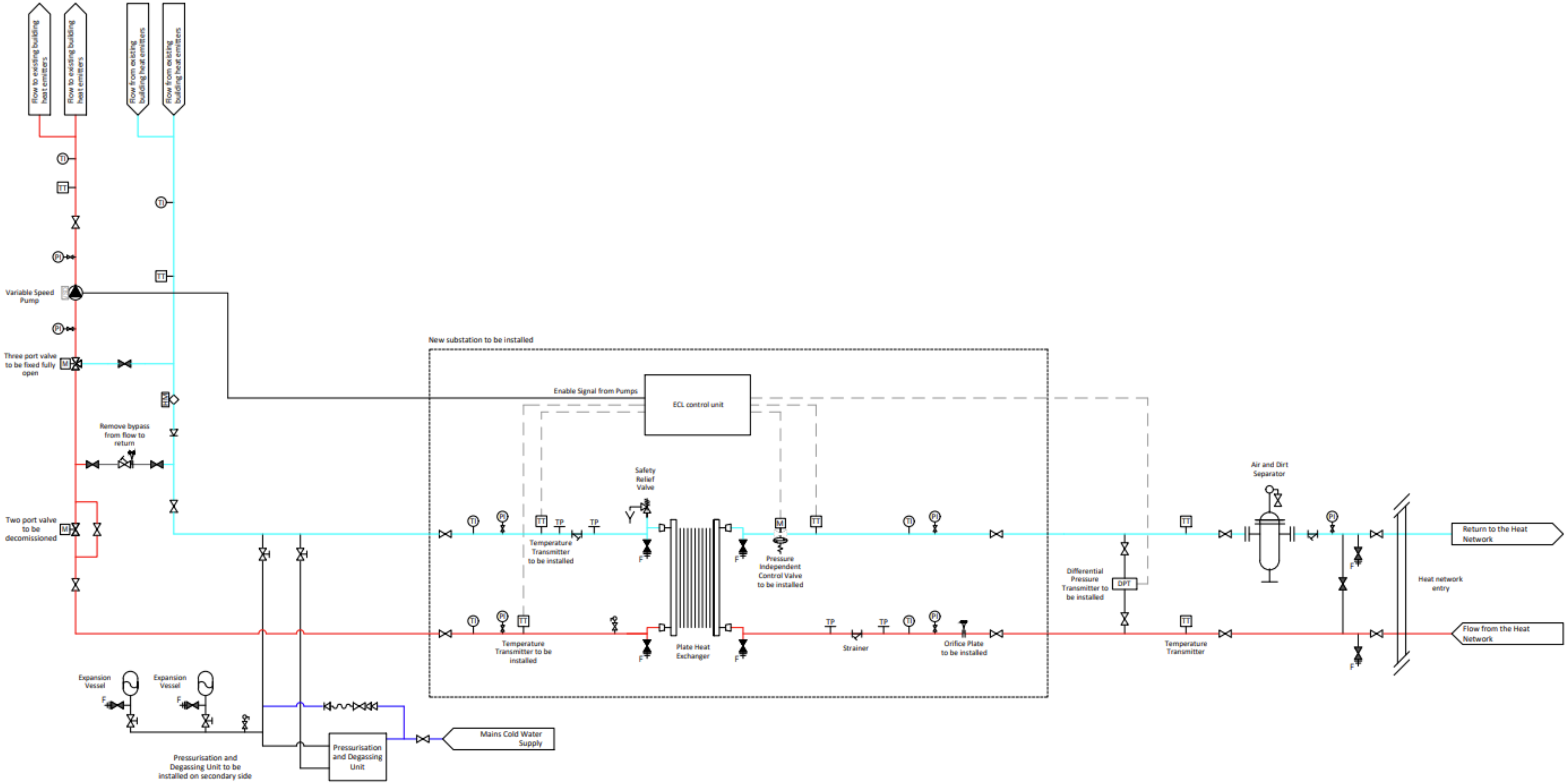

Figure 22: Example of typical substation for non-residential connection (extract from drawing S2278-SEL-PP-XX-DR-Y-7004)