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1 Site Information

1.1 Site Location Plan and Context

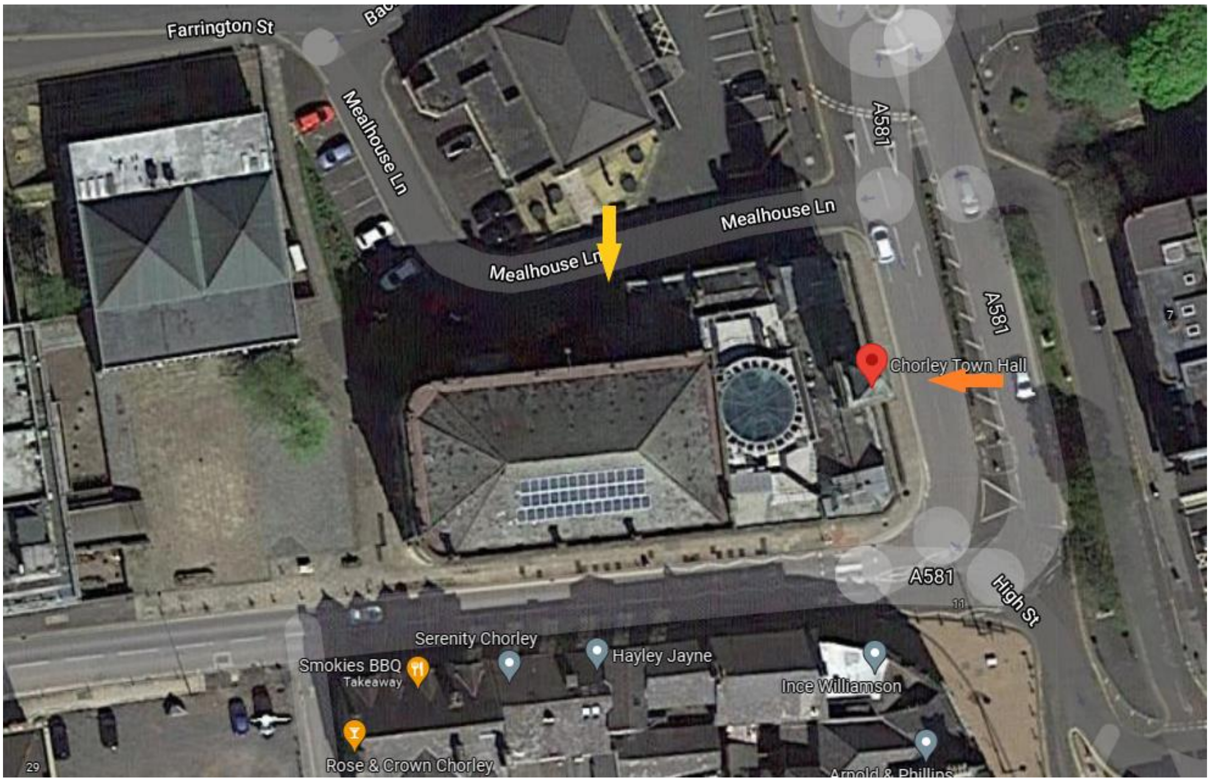


Figure 1 – Chorley Town Hall (photos denote street view positions).

Figure 2 – Town Hall main entrance.

Figure 3 – Town Hall entrance to basement from Mealhouse Ln.

1.2 Introduction

A site energy audit has been undertaken, with the principal objective being to support an application for the Public Sector Decarbonisation Scheme (PSDS).

The existing building and services have been examined, along with baseline information such as energy consumption, DEC and drawings.

Opportunities for eligible decarbonisation technologies have been identified and the likely level of energy and carbon savings quantified. A traffic-light system has been used to summarise for each initiative:

- **Ineligible / not viable or cost effective**
- **Viable but with concerns**
- **Good viability**

1.3 Site description

1.3.1 Overview

The site is a Town Hall in Chorley constructed in 1879 and refurbished in 2005.

The building is formed of three floors, a basement and a full-height atrium/hall. In addition to the building the site contains a car park.

Wall construction is stone. Part of the roof is pitched and a solar PV array is present on the southern area of the pitched roof.

1.3.2 Information for Salix form Step 2 'Building Details'

Building Name or Number*	Chorley Town Hall
UPRN (Unique Property Reference number)	200004064422
Display Energy Certificate Rating (DEC)	C – 52 (2018)
Building Age (Years)	142
Postcode (buildings must be on the same site)*	PR7 1DP
Building Type*	Town Hall
Gross Internal Area (m^2)*	Basement: 1083.51 Ground Floor: 1083.51 (approx.) First Floor: 1093.45 Second Floor: 353.87
Number of Floors	3
Existing Annual Fossil Fuel Use (kWh p.a.)*	237,363
Existing Annual Electricity Use (kWh p.a.)	203,111.7
MPRN (Gas Meter Number) - if applicable	5363309
MPAN (Electricity Meter Number)	1600000024702
Peak heat loss - pre improvements (kW)	249.49
Peak heat loss - post improvements* (kW)	249.49
Existing total cooling load - if applicable (kW)	N/A

1.4 Site Services Summary

The site is served heating via gas-fired boilers in a central boilerhouse, serving radiators via a wet vented gravity-pressurised system. Domestic Hot Water (DHW) is generated by an electric water heater in a separate plantroom in the basement.

The building is naturally ventilated throughout.

Comfort cooling to parts of the building is provided by five outdoor DX air-conditioning units which are located at either side of the basement entrance from Mealhouse Ln, plus two on the flat roof.

1.5 Gas supply

Incoming low pressure gas passes through a single fiscal meter located in a small room adjacent to the boilerhouse, before branching to serve the boilers.

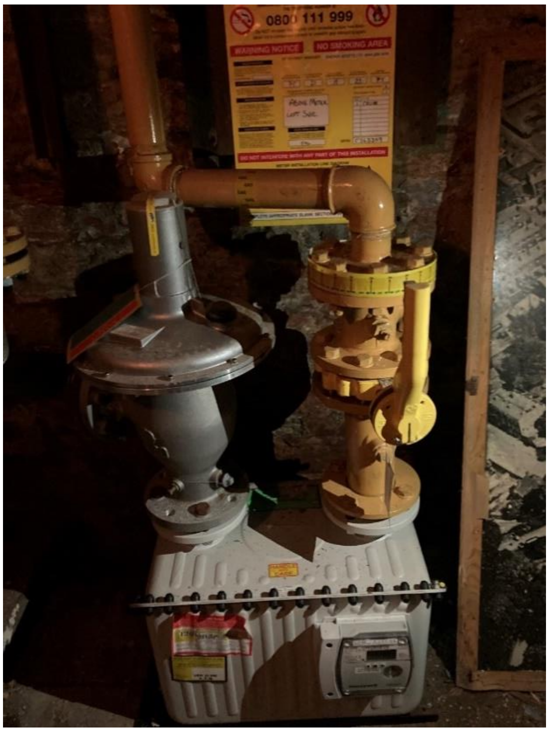


Figure 4 – Gas meter arrangement, 2" (DN50) pipework.

1.6 Heating System

1.6.1 System Descrtiption

The site is heated via central gas-fired boilers serving radiators and fan-convectors via a a wet vented gravity-pressurised system in steel pipework.

The gas boilers do not serve a Domestic Hot Water (DHW) load, which is generated by an electric water heater.

The boilerhouse is located in the basement. It is compact with little space internally to accommodate new equipment.

There are a total of three operational De Dietrich boilers serving a common 4" (DN100) header via duty/standby pumps and a mixing valve. The original system consisted of four boilers but one of the boilers has not been functioning for roughly a year. From the header, a circuit with boiler circulating pumps is present.

The boilers are flued into a 12" (DN300) common flue header and stack which exits the basement side wall and runs up the external face of the building.

Figure 5 – Gas-fired boilers in the plantroom.

Figure 6 – Domestic Hot Water (DHW) system.

A separate wall-hung gas-fired boiler system supplies heat to a certain area of the building believed to be the Extension, via a wet independently-pressurised system.

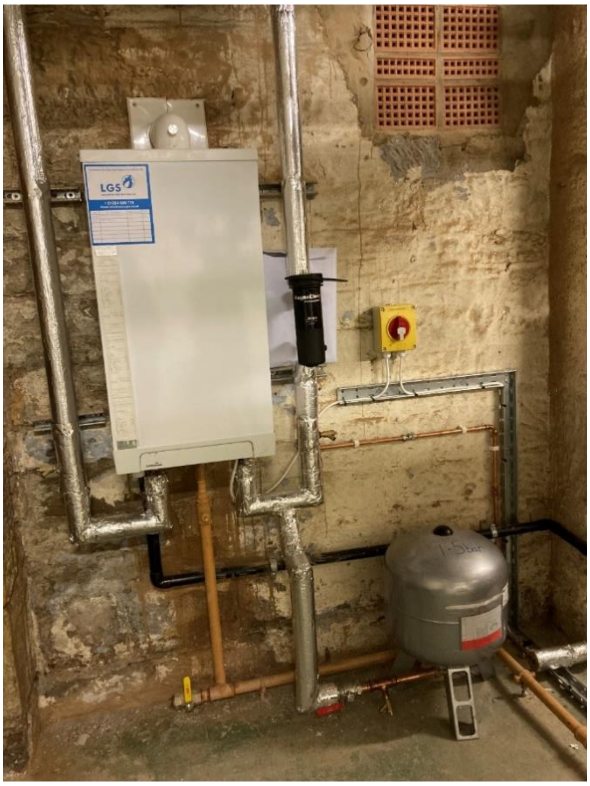


Figure 7 – Separate gas-fired boiler system.

Control is via a simple panel incorporating weather compensator with night set back and time clocks for zones. There was no BMS present. The operating temperatures of the system were not displayed, however according to the weather compensator it could be expected to be c.73°C at -5°C outside temperature and c.55°C at +5°C.

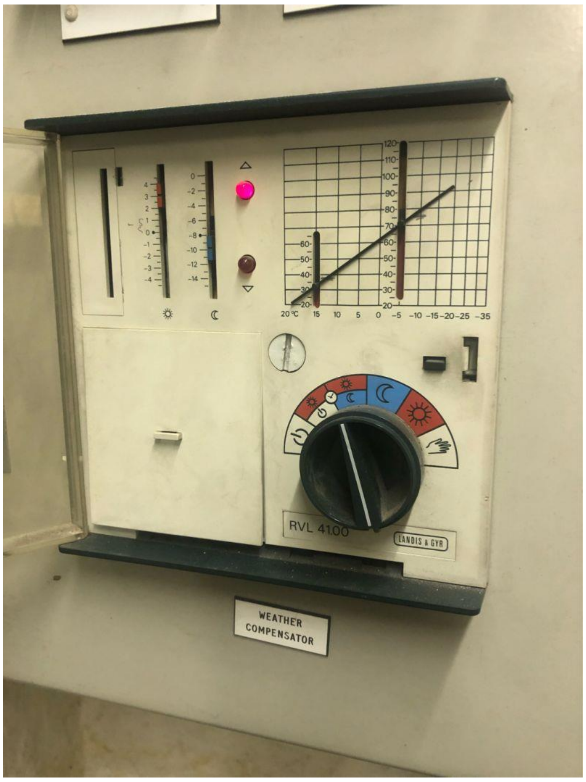


Figure 8 - Weather Compensator

Condition appraisal is generally acceptable. Minimal corrosion was observed. Insulation was in good order with exception of a few points as shown in the picture below. Whilst the boilers appear well maintained, at 33 years old they reached end of useful life, which according to CIBSE Guide M is 25 years.

Decarbonisation potential: Y

The heating system could be decarbonised using an Air Source Heat Pump (ASHP) system, either in hybrid with the existing gas boilers or as full-capacity

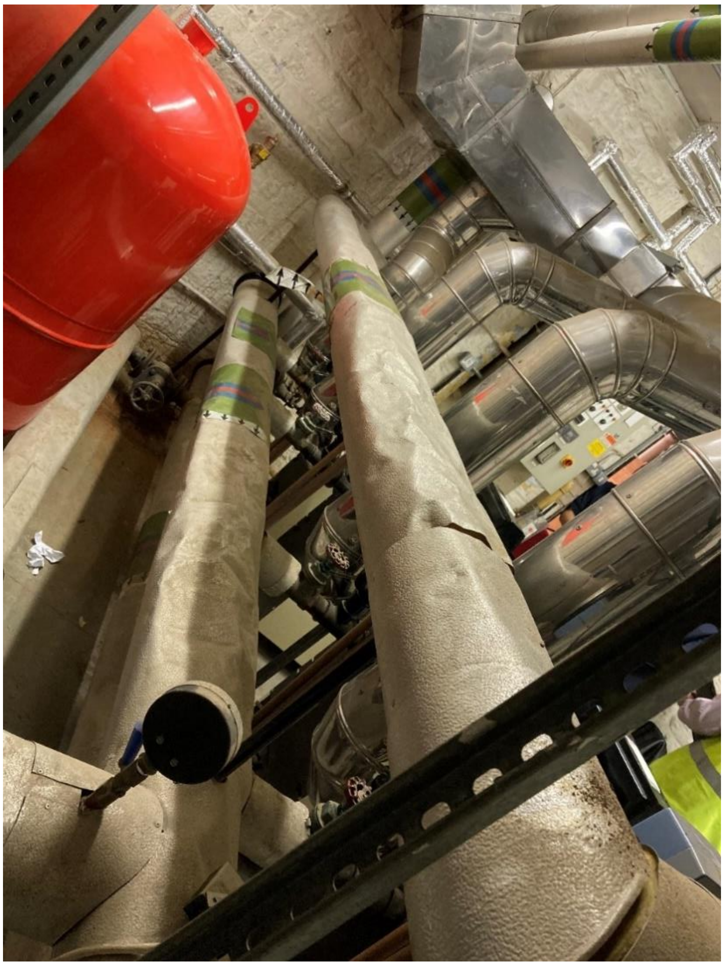


Figure 9 – Pipework insulation.

1.6.2 Schematic arrangement

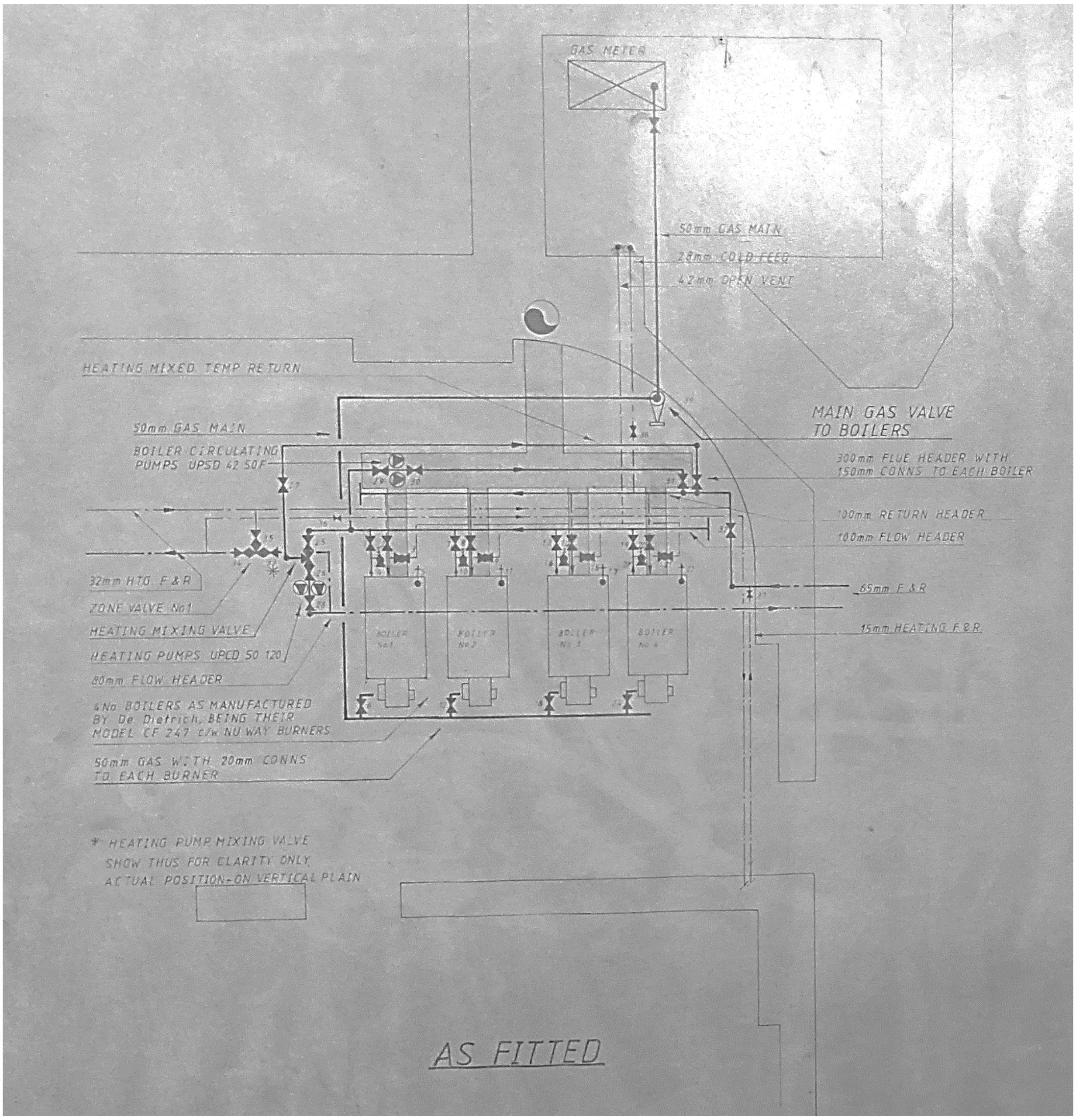


Figure 10 – Schematic arrangement and layout

1.6.3 Boilers specs

Main Boilers

Make	De Dietrich
Model	CF247
Age of system* (years)	33
Boiler type	Sectional cast iron
Indicative life (years, CIBSE Guide M)	25
Can boilers be categorised 'End of life'?	**Yes**
Output load per unit* (kW)	65 (estimate)
Number of duty units*	3 (originally 4 but 1 is out of commission)
Total output load (kW)	195 (260)
Current Seasonal Efficiency* (%)	75% (est)

Extension Boilers

Make	Intergas
Model	Rapid 32
Age of system* (years)	0
Boiler type	Wall-hung
Indicative life (years, CIBSE Guide M)	20
Can boilers be categorised 'End of life'?	**No**
Output load per unit* (kW)	32
Number of duty units*	1
Total output load (kW)	32
Current Seasonal Efficiency* (%)	85 *(est)%

1.6.4 Main pump specs

Description	No. Off	Manufacturer	Model	DOM/Age	Capacity	Comments
Distribution pumps	2	Grundfos	Magna D50-120F		800W	

1.6.5 Balance of plant specs for Extension system

Description	No. Off	Manufacturer	Model	DOM/Age	Capacity	Comments
Expansion vessel	1	Zilmet	130 CAL-PRO		500L	Precharge 2.5bar, Pmax 6bar, Tmax - 10/99ºC
Pressurisation unit	1	Mikrofill	Mikrofill 3	2016		Power supply 230V, Max inlet pressure 5bar
Expansion vessel	1	Flamco	Airfix P	2020	35L	Precharge 2.7bar, Pmax 10bar, Tmax - 10/100ºC

1.6.6 Domestic hot water generation

The DHW for the building is supplied via the following unit located in the boilerhouse:

Description	No. Off	Manufacturer	Model	DOM/Age	Capacity	Comments
Electric immersion	1	Brodex	Direct 20	2005	250L	6kW

Upgrade potential: No. Due to higher temps required and additional pipework to feed the DHW it is not proposed to integrate it to the ASHP scheme.

1.7 Cooling System:

Description	No. Off	Manufacturer	Model	DOM/Age	Capacity	Comments
R410A DX Mr Slim	3	Mitsubishi	PUHZ-P125YHA	2008/2016		
R407C DX Mr Slim	1	Mitsubishi	PU-P5YGAA	2004		
R407C DX Mr Slim	1	Mitsubishi	PUH-PV3GAA			
DX Mr Slim	2	Mitsubishi	TBC	TBC		Located on roof

Upgrade potential: N. Split DX units are not viable to integrate into a heat pump solution.

Figure 11 – Air-conditioning units.

1.8 Electrical System:

1.8.1 General

The current site electrical infrastructure date is unknown. The site appears to have a substation in the basement with external doors accessed from Mealhouse Lane. It was not accessible. The electricity supply capacity is not known.

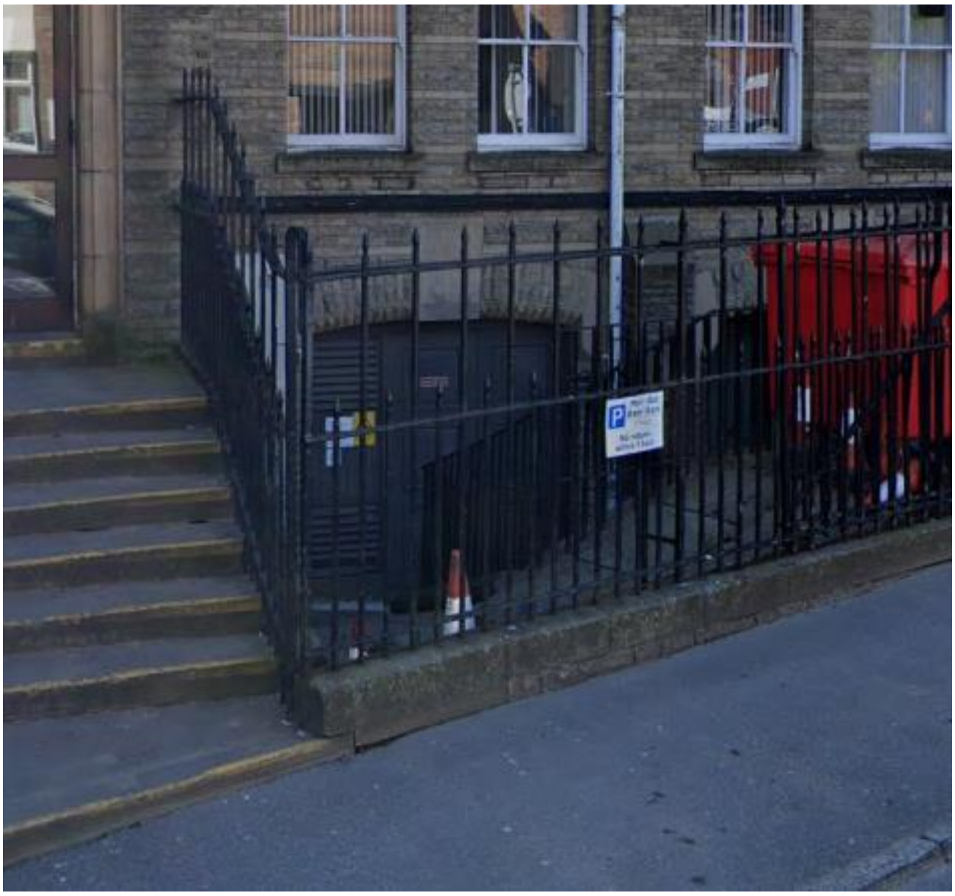


Figure 12 – Substation doors.

1.8.2 Solar PV system

A Solar Photovoltaic (PV) system is aleady present on site, comprising a total of 40 panels on the South facing pitched roof of the Lancastrian Room. The rated output of the system is unknown but an estimate based on number of panels, orientation and solar irradiance shows this could potentially be between 9 – 13 kWp. The age of the system is unkown. There does not appear to be any remaining suitable roof area availabe, hence we have concluded that there is no additional PV that can be recommended for the site.

Expansion potential: No

1.9 Building Fabric

1.9.1 Walls

The wall construction of the building is 19^{th} Century solid stone. It is presumed to have a U-value of 2 W/m^2K.

Insulation potential: N

1.9.2 Roof Construction

The roofs are pitched, of timber structure and covered with a traditional tile roof cover. The pitched roof over the easternmost part of the building running N-S was accessed via a hatch. It was found to be laid with c300mm rockwool type insulation.

It was not possible to access the roof above the Lancastrian, which apparently requires rope access. It is assumed uninsulated.

Upgrade potential: N

Figure 13 – Roof insulation.

1.9.3 Window Construction

Approximately 50% of windows are double glazed. The remainder have some secondary glazing.

Insulation potential: N

1.10 Lighting

The lighting is predominantly:

- Fluorescent 600x600mm quad tube T8 throughout the offices / meeting rooms.
- T12 strip 1200mm in the basement
- Compact Fluorescent (CFL) and T12 in the circulation spaces
- CFL, halogen and LED mix in the atrium and Lancastrian room

Description	Wattage	Number (approx.)
Quad 600x600 18w T8 HF	76	154
Single 1200mm 36w T8 HF	38	TBC
Twin 1200mm 36w T8 HF	75	14
CFL Twin	TBC	57
Halogen	TBC	20
LED	TBC	TBC

Updrage potential: yes with LED fittings

2 Site Energy Consumption

2.1 Gas

Annual gas consumption in 2020 is cited at 237,363 kWh p.a.

Annual gas cost is £504,681.21.

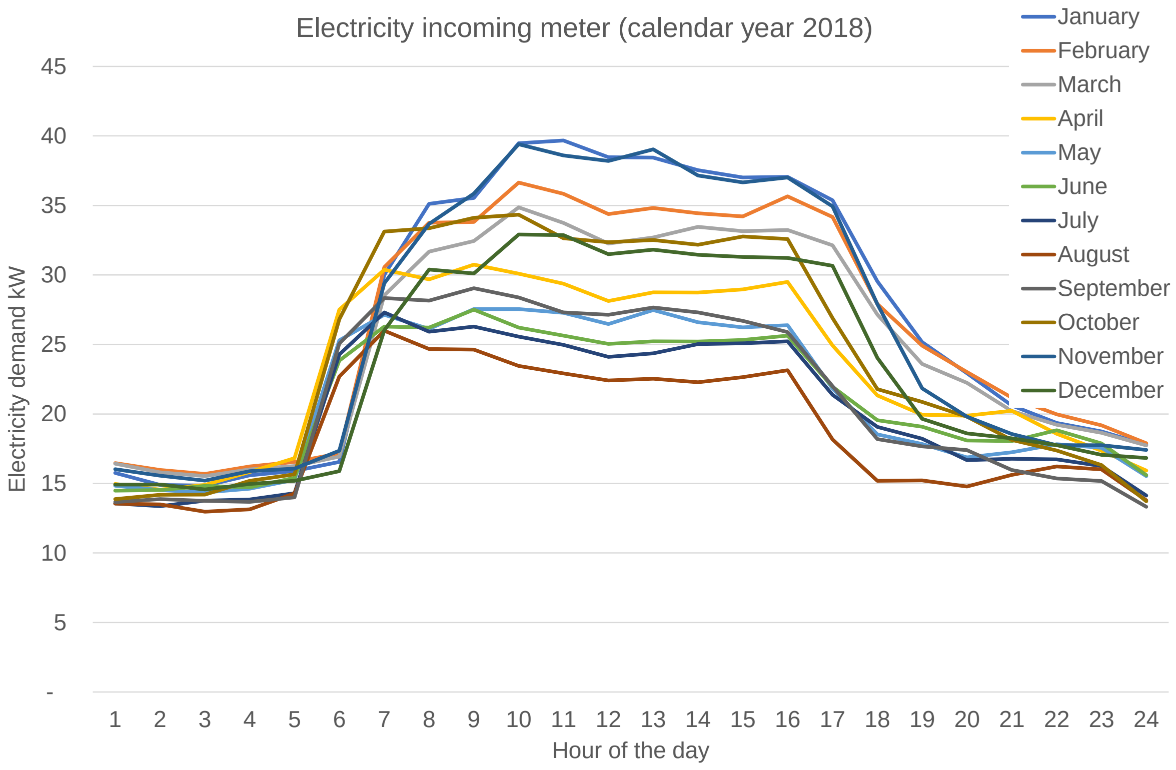
The derived gas unit tariff is 2.13 p/kWh.

2.2 Electricity

Half-hourly data for 2019 was provided. Annual electricity consumption 2019 was 203,111.7 kWh p.a.

Annual electricity cost is £2,242,353.17.

The derived electricity unit tariff is 11.04 p/kWh



The graph above indicates that peak site electrical load occurs around midday, with an increase in load in the winter months. This reflects an increased lighting demand, and potentially auxiliary heating (several portable electric heaters were observed on the walk-round). The chart possibly also displays offset demand by Solar PV generation which has a greater effect in summer.

Maximum site load over any half hour period has been calculated at **37.8 kW**

2.3 Peak heat loss calculation

Based on Salix Heat Loss tool v1.0; full calculation and assumptions given in Appendices

Peak heat demand = **249.49 kW**

Note this is similar to the overall installed boiler capacity. It is highly sensitive to air change rate, which has been assumed at 0.5ach/hour. This may actually be high if the windows are usually closed, as was typically the case on our visit.

3 Assessment of Potential Decarbonisation Options

3.1 Whole Building Approach

Based on the information available from the DEC certificate and collected on site during the survey, a number of opportunities to reduce the energy and heat demand on site have been examined:

- **Glazing**. Double glazing is present throughout.
- **Loft insulation.** 300mm loft insulation throughout.
- **Lighting**. LED lighting upgrade is proposed.
- **Low Carbon Heating System**. Several options have been considered and a recommendation made as set out below.

3.2 Low Carbon Heating System

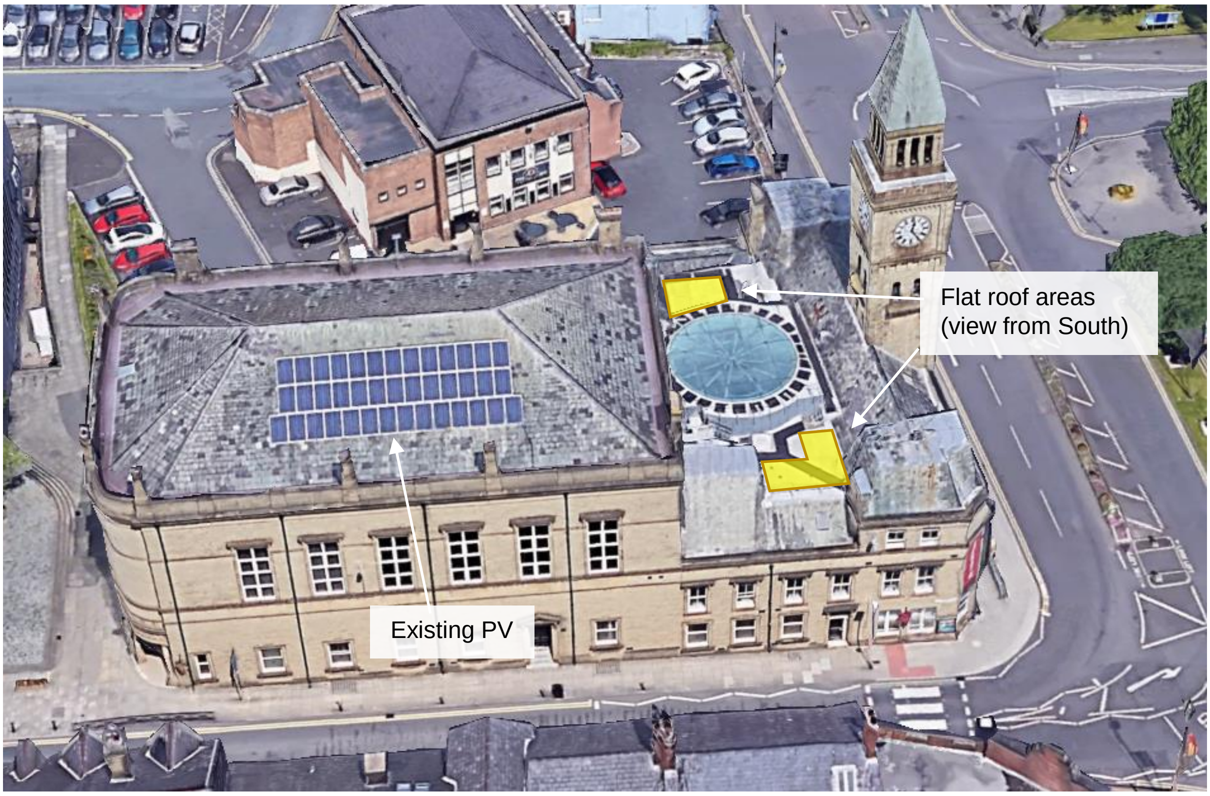
3.2.1 Technology Options Considered

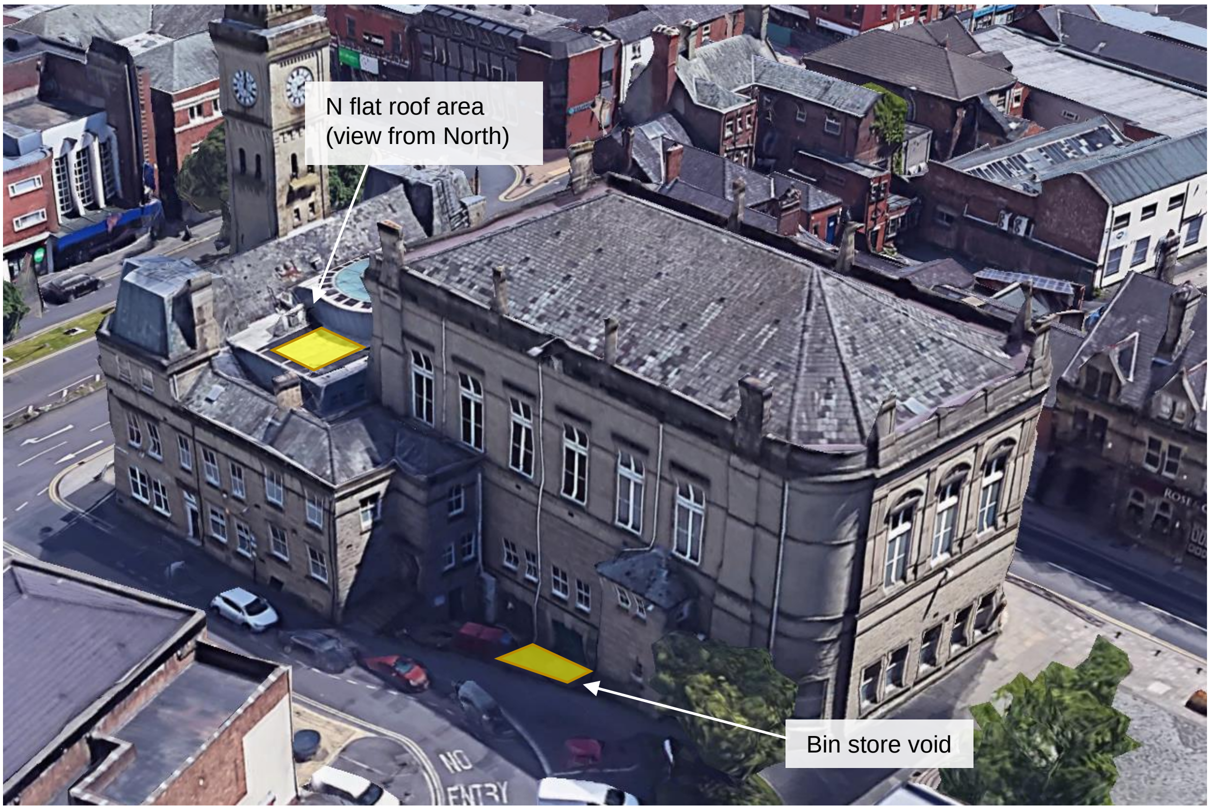
Air Source Heat pumps (ASHP) have been identified as a suitable low carbon heating technology. Biomass heating has been discounted on the grounds of air quality and plant space. Ground Source Heat pumps have been discounted on the grounds of lack of available opportunity.

3.2.1.1 Site considerations

The limiting factor for ASHP conversion is external plant space, which is at a particular premium on this site. Two areas have been identified:

1. Flat roof areas to the North and South of the central skylight. Two separate areas are available, each of approximately 5 x 5m. They are bounded by hand guardrails. This route is favoured, although cranage would be required to place plant. Services route to the basement needs identified. Visual impact from street level must be considered.
2. Basement level void where bin store is located off Mealhouse Lane. This area is in currently in use by bins also used for acces to the basement and the electrical substation. There is no other viable obvious place for the bins and hence this area is not considered viable.
3. An option raised on site was to use adjacent car parks. However we consider this unviable, on account of additional costs that would be caused by a permanent enclosure, street works, trenching and re-instatement, road closures and long-term loss of car-park spaces.


Flat roof areas
(view from South)
Existing PV


N flat roof area
(view from North)
Bin store void

The existing boiler room has no significant potential for additional plant. External space is at a premium, with a identified as the most viable spot for new plant.

The heating system currently operates with a winter ‘set point’ of circa 70°C flow temperature; weather compensation is used to lower the heating flow temperature in mild weather. No fabric improvements are proposed, and hence whilst it may be possible through operational trial to reduce this slightly (i.e. by say 5°C), the nature of existing heat emitters – predominantly radiators – are such that it cannot be significantly lowered. Redesign/renewal of the heat emitters is considered cost-prohibitive for this scheme. It should be noted anecdotally that some parts of the building struggle to achieve comfort on winter, and several auxiliary heaters were noted.

DHW is currently generated by electric immersion in a storage tank. This is not co-located in the boiler room, being some 15m away within the basement level. It is not proposed to integrate DHW supply into heat pump proposals via new calorifiers.

The following two options have been considered for ASHP integration:

1. Integrated hybrid system with lead ASHP plus modern condensing gas boilers for peak lopping (winter addition).
2. Complete gas replacement with a high temperature solution: either an ASHP with multi stage compression, or ASHP plus WSHP in series with integral buffers to provide high temperature output.

There are advantages and disadvantages to both approaches, which are explored in more detail below:

3.2.1.2 Option 1: ‘Hybrid’ – ASHP with New Gas Boilers

This option allows the baseload to be supplied by the heat pump, and the peak loads or additional loads in winter to be supplied by the gas boilers. The heat pump will raise the water temperature to a nominal 60°C before, if the external temperature justifies it, feeding into a boiler which would raise the temperature to the desired level.

Under this option, the new gas boilers would be sized to allow for additional heat requirements. The current end of life boilers would be replaced by rack mounted units, to provide peak lopping and a small amount of redundancy in the event of a heat pump being out of service.

As this option involves replacing the boilers, this option also gives a reduced risk to the system if for any reason the heat pump experienced a fault. In this scenario, the gas boilers would take over the primary heating and there would be no break in heat supply to the site.

Benefits:

1. This approach allows for less capacity to be installed for the heat pump element. Experience has identified that sizing the heat pump based on a nominal 50% of the installed boiler capacity provides 80 to 85% of the annual consumption, once the BMS is upgraded to the new regime. This only leads to a 12% reduction in CO_2 savings over the life of the heat pump.
2. Adopting this approach reduces capital cost, and allows existing distribution and heat emitters to be retained, as flow temperatures similar to those existing can be regenerated with the boilers used for top up during the coldest periods only.
3. Using a hybrid system reduces the additional electrical kVa requirements for the site, which leads to lower electrical upgrade costs, and less cost impact from the DNO. In some cases, these costs can be excessive and render the projects non-viable from a financial viewpoint.
4. Any hybrid system, which essentially uses a dual fuel approach, also provides a larger degree of redundancy, should one of the fuel sources be interrupted.
5. It may be considered that the solution does not truly correlate to decarbonisation, as there is still an element of fossil fuel technology included in the proposed solution. However, carbon savings are only minimally affected, and considerable carbon savings are achieved using hybrid systems.

Risks:

6. The BMS and system controls need to ensure that the heat pump is selected as the main heating source, and that the boilers are held off, in order to ensure that expected CO_2 savings are delivered. However, with established design process and thermal store integration, along with BMS modifications, this can easily be achieved.
7. It may be considered that the solution does not truly correlate to decarbonisation, as there is still an element of fossil fuel technology included in the proposed solution. However, carbon savings are only minimally affected, and considerable carbon savings are achieved using hybrid systems.

3.2.1.3 Option 2: Replace gas plant with High Temperature Heat Pumps

For this option, the gas plant would be removed, and the heat required by the system would solely be supplied by the heat pump. This requires two stage compression within the heat pump to generate the high flow temperatures required for the system.

Due to space constraints, we do not consider it viable to provide the full heating load via ASHP.

3.2.2 Scope of Recommended Option

Due to increased cost and space requirements of option 2, and the inherent risk caused by not having a redundancy measure in place, it is suggested that option 1 is the most suitable and feasible solution. We propose that a Hybrid ASHP solution be incorporated.

Review of basic scope of preferred option:

- Nominal 200kW ASHP, currently based on 2 x Hidros LZT 1202 HA XL heat pumps. The ASHP needs to be placed outside and has dimensions of circa 4.0m (L) x 1.1m (W) x 1.8m (H).
- 5,000 litres of thermal storage, located within the basement boiler room
- New gas-fired boiler plant to produce minimum of 350kW, currently identified as 4 x Remeha Quinta 90kW rack mounted condensing boilers.
- Balance of plant, as required.

Schematically, the return from the heat distribution system would be routed via the heat pump, which would then feed the gas boilers and a thermal store. Removal of the existing boilers units and replacement with smaller rack mounted units will free up some space in the plantroom.

The site currently operates on 4 x 85kW + 1 x 32kW (nominal) boilers, giving a current capacity of 372kW nominal. The heat pumps have been sized to provide a nominal load of 200kW, with a further 360kW of condensing boilers, giving a post upgrade capacity of 560kW. We will conduct further analysis at design stage to ensure capacity is sufficient for the site requirements.

The preferred location for the ASHPs is one on each flat roof either side of the skylight. As each unit weighs approximately 1 ton, a structural assessment would be necessary. The location is directly above the existing boiler room, and the current flue route provides a pipework route as the flues are likely to be consolidated.

As the existing boiler room is reasonably compact, we believe the proposed thermal stores would be best accomodated outside it. There is an empty room directly adjacent to the boiler room.

3.2.3 Additional Measures

On top of the heat pump solution, additional measures have been considered.

3.2.3.1 Thermal Batteries

There is also the potential to use thermal batteries as a heat store and charge these up overnight using low cost electricity. The battery uses a phase change material which melts as it absorbs thermal energy during the night, and then when the heat is required, the material freezes and releases the heat into the system. The downside of this technology is that it will increase the project cost dramatically and requires a large footprint to be able to offer the heat required by the system. For this reason, thermal batteries have not been proposed as part of this solution, however, could be installed in the future to further decrease the electricity consumption.

3.2.3.2 Thermal Store

A thermal store is recommended with the use of heat pumps to provide a constant load output for and to prevent any fluctuations in demand reducing the efficiency of the heat pump. Heat pumps work best when they are running for a prolonged period, unlike gas which can regulate itself quickly to the heat demand. The thermal store acts as a buffer between the system heat demand and the heat pump. Overnight the heat pump would heat both the pool and the thermal store, so they act as the heat store. This allows the heat pump to run most efficiently as it is not constantly trying to increase or decrease its' output. It is estimated that including a thermal store would save up to 3% on the annual kWh consumption.

3.2.3.3 Plant Room Upgrades

It is proposed to integrate the two heating circuits into one heat source. It would be sensible to assess the controls and pumping arrangements at design stage. Currently there are several 3-port valves and fixed-speed pumps which could be optimised.

3.2.3.4 Control Strategy

The Low Carbon Heating solution for will benefit from the installation of a new BEMS system. This system will provide the ability to remotely control and monitor the new ASHP pump system and the existing boilers. It is proposed the BEMS system be established as a component of designing and commissioning the system. The system will then be monitored as part of the M & V strategy set out in section 4 of this document.

3.2.3.5 System Feasibility Salix Application 3.3

We have surveyed the building and completed a heat loss calculation using the Salix fabric tool, as shown in section 2.3. Using this as peak building heat load, allows us to size the heat pumps and auxiliary gas boiler plant to meet this demand, including required redundancy in the system.

This provides a robust assessment of the building demand based on real time data, and we confirm that our selection of equipment meets the heating requirement for the site.

a. Is the building fabric suitable for the proposed heat pump measure?		Yes
b. Will the new system be supplying space heating, DHW or both?		Space heating
c. Have heat emitters been sized for the flow temperature(s) set out?		Yes
d. Have the cost of replacing emitters been included within the application?		N/A
f. Have schematics been drawn for the design of the new system, including flow and return temperatures? If so please include in supporting info.		Not at this stage
g. Is a thermal store included within this design?		Yes
a. All systems - Have you provided a specification for the chosen heat pump to confirm the Seasonal Coefficient of Performance (SCOP) for the given flow temperatures/operating conditions?	SCOP = 3.2	

3.2.3.6 Assessment of Current Electrical Infrastructure

The current site electrical infrastructure is of unknown age. The maximum electrical load over any half hour period has been identified as 37.8 kW.

The heat pumps selected each have a total input power of 47kW. Based on a power factor of 0.8 for ASHPs, this provides a kVa equivalent of nominally 58.75 kVa, which exceeds the current maximum supply capacity for the site, when combined with current maximum load, based on HHD analysis.

It isn't clear at this stage whether the site has its own separate electrical supply, or whether there is a dedicated sub-station at the overall site already, although this appears to be the case. This may help to improve the situation, and may allow electrical strengthening costs to be reduced.

3.3 Summary of anticipated Energy Savings

The following has been estimated based on the assumptions stated above:

Baseline	**Gas**		**Electricity**	
	237,363	kWh p.a.	203,112	kWh p.a.

Decarbonisation Solution	**Gas**		**Electricity**	
	kWh p.a. Saving	**% savings**	**kWh p.a. Saving**	**% savings**
Air Source Heat Pump	135,296.91	80%	- 42,280.28	-21%
LED Lighting	-	0%	32,498	16%
Total	**135,296.91**	**80%**	**- 9,782.28**	**-5%**

4 Appendix A – Additional Drawings and Information

Building Thermal Capacity Calculator ΣUA (V1.0)

As applicable, please use the average u value calculator on the following tab if the building fabric is made up of multiple elements.

	Average U-value (W/m²K)	Area (m²)
Roof	1.80	1204.78
Roof Lights		0.00
External Wall	1.77	1749.38
Windows	2.60	583.13
Doors	1.00	0.00
Floor	1.50	1204.78

Building Thermal Capacity	8,588	W/K

Notes:

1. Please see the "Average U-value Calculator" tab for help calculating average U values of building types made up of several elements. For example if you have sections of roof with different U-values.

2. Typical average U-Values can be found in CIBSE guidance documents.

Salix Peak Building Heat Loss Calculation Tool (V1.0)

The thermal capacity of the building is based on each part of the building fabric, and is calculated on the following worksheet. The ventilation heat loss per kelvin is based on the air changes per hour (ventilation rate) and the building volume. Please select the internal setpoint temperature and external design temperature in order to compute the Building Peak Heat Loss.
White cells are where information needs to be inputted and pale green cells show the calculation result.

	Value	Unit	Additional Information	
Building Thermal Capacity ΣUA	8,588	W/K		
Volume of Space to be Heated by Heat Pump	*10,843.02*	m^3	*Estimate based on envelope geometry*	Evidence should be provided
Air Changes per Hour	*0.50*	ACH	*Natural ventilation however glazed area relatively small*	Please provide reasoning for value selected.
Ventilation Loss	1,807	W/K		
Heat Loss Coefficient	10,395	W/K		
U'	10	kW/K		
Winter Internal Setpoint Temperature	*21.00*	°C	*Set for internal comfort*	The internal and external temperature should be specific to the site requirements and location. Outdoor design temperatures are typically between -6°C and -3°C.
Winter Outdoor Design Temperature	*-3.00*	°C	*CIBSE Guide A*	
Peak Building Heat Loss	**249.49**	kW		

Notes:

1. This calculation provides only an estimation of the peak building heat loss. This can be used to estimate the heating system capacity required to match this heat loss and heat the building.
2. The heat output of a heat pump depends on its operating conditions - A heat pump operating at a flow temperature of 55 degC and external air temperature of -3 degC will not be able to deliver the same amount of heat load as if the same heat pump is operated at a flow temperature of 35 degC and external air temperature of -3 degC . Lower flow temperatures will allow the heat pump to deliver more heat as long as the heat emitters are correctly sized for that flow temperatures. The manufacturers specification and your system design have to be cross referenced with the calculated peak heat loss above to correctly size your heat pump.
3. Peak Building Heat Loss calculation based on fabric losses only - i.e. DHW loads are not included in this calculation tool