# Liverpool City Region Combined Authority Heat Decarbonisation Plans

## Building Level Heat Decarbonisation and Energy Efficiency Report

## Pier Head Ticket Office
Merseytravel

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**Glossary of Terms**

| | |
|---|---|
| A | Amp |
| AC | Air Conditioning |
| ACH | Air Changes per Hour |
| ASHP | Air source heat pump |
| BEMS | Building Energy Management System |
| CIBSE | Chartered Institute of Building Services Engineers |
| CT | Constant Temperature |
| CT | Current transformer |
| $CO_2$ | Carbon Dioxide |
| CWS | Cold Water Service |
| DHN | District Heat Network |
| DHW | Domestic Hot Water |
| GSHP | Ground Source Heat Pump |
| HDP | Heat Decarbonisation Plan |
| HVAC | Heating, Ventilation and Air Conditioning |
| kVA | Kilovolt Ampere |
| LED | Light Emitting Diode |
| LTHW | Low Temperature Hot Water (for Heating) |
| LV | Low voltage |
| MCCB | Moulded case circuit breaker |
| MID | Measuring Instruments Directive |
| MPAN | Meter Point Access Number |
| MPRN | Meter Point Reference Number |
| PSDS | Public Sector Decarbonisation Scheme |
| PPA | Power Purchase Agreement |
| PV | Photovoltaic |
| POU | Point of Use |
| SP | SPManweb |
| SCOP | Seasonal Coefficient of Performance |
| TP&N | Three Phase and Neutral |
| TRV | Thermostatic Radiator Valve |
| VT | Variable Temperature |
| WSHP | Water Source Heat Pump |

# Executive Summary

A site energy audit has been undertaken for Pier Head Ticket Office in support of a Heat Decarbonisation and Energy Efficiency Plan funded by Salix Finance Ltd under the Low Carbon Skills Fund Scheme for LCRCA. The existing building and services have been examined, along with baseline information such as energy consumption records, Display Energy Certificate (DEC) and drawings, where available.

The site has a baseline CO2 emissions of 218 tonnes p.a. ranking it 4 of 18 buildings in LCRCA and 15 in the wider LCRCA portfolio considered.

Opportunities for eligible decarbonisation technologies have been identified in the categories of energy use reduction, energy efficiency, low carbon heat and renewables, following the energy hierarchy recommended by Salix. The following opportunities to decarbonise the building have been identified:

| | Technology | Proposed | Reason |
|---|---|---|---|
| Energy Use Reduction | Resetting of time clocks and temperatures | Yes | A simple way to reduce energy usage in lieu or advance of BEMS |
| | Building Energy Management System (BEMS) | Yes | Existing controls offer only basic control options and no off-site access. The addition of a BEMS is proposed as part of the heat pump upgrade. |
| | Metering and Monitoring | Yes | Existing metering should be reviewed and optimised per technology to increase energy management and efficiency |
| Energy Eff... | Building Fabric | No | No feasible improvements to the building fabric identified |
| | Variable Speed Drives | Yes | VSDs should be considered in the design of the new decarbonisation solution for heat distribution and air handling. |
| | LED Lighting | Yes | The lighting can be upgraded to LED, giving a significant savings on the electricity consumption |
| Low Carbon Heat | ASHP | Yes | ASHP system of circa 85kW$_{th}$ recommended as the core heat decarbonisation strategy. Sufficient rooftop space identified and highlighted in the appendix. |
| | GSHP | No | Site exhibits sufficiency economy of scale to justify capital cost of infrastructure and is above a viable aquifer, but no space identified for borehole installation |
| | WSHP | No | The site is on the bank of river Mersey. A WSHP would provide an efficiency advantage over ASHP; without the need for bulky external heat rejection plant on a space-constrained and sensitive site. It would potentially reduce the necessary electricity supply upgrades compared to an ASHP. This is a bespoke solution in which technical challenges would need to be overcome, with pipework run from the building to the river and either a civil works installation to abstract/inject water or a submerged heat exchanger array. A feasibility study should be undertaken to establish the technical viability of the proposals including modelling of the water source, establish the necessary consents/permissions and their likely outcomes, and undertake an options appraisal to compare to the ASHP |
| | Thermal Store | Yes | Alongside a heat pump, facilitates demand peak-shaving and time-shifting to maximise the use of intermittent electricity generation from solar PV and/or a flexi grid connection tariff resulting in reduced operating emissions and cost |
| | DHN | Yes | District heating is a way to address the decarbonisation of buildings and has been investigated for the area in conjunction with the Council. The site is thought to fall in the scope of the Heat Network Zoning Pilot Project, whose findings are expected later this year and should be consulted before determining a pathway. |
| | Heat Recovery | No | No significant or suitable sources of waste heat have been identified in the vicinity |
| Renewables | Solar Photovoltaic (PV) | Yes | Flat rooftop space for solar PV of circa 108 kW$_p$ has been identified. This should be utilised to maximise access to low-carbon, price-stable electricity, particularly considering the additional electrical loads proposed |
| | Electrical Storage | Yes | Power storage should be considered in with the expansion of the solar PV system and the power production profile in relationship to expected use. Purchase to off peak cheaper power could also be an option to support battery storage |
| | Solar Thermal | No | The site DHW arrangement does not lend itself too solar thermal. |

A WSHP from the River Mersey should be fully explored as the optimum heat supply decarbonisation solution. A simple analysis indicates it could provide a favourable lifecycle business case over ASHP. We have shown an ASHP solution as readily demonstrable (but potentially sub-optimal) pathway. A feasibility study should be undertaken to establish the technical viability of the proposals including modelling of the water source, establish the necessary consents/permissions and their likely outcomes, and undertake an options appraisal to compare to the ASHP.

The building's boilers have been assessed as end of life, thus meeting eligibility for grant funding under the previous round of Public Sector Decarbonisation Scheme (and likely to remain a key criterion for future rounds).

The building exhibits straightforward potential for heat pump conversion for space heating, albeit a new heat distribution system is proposed. Point-of-use electric water heaters will be retained as they are appropriate to usage and offer no decarbonisation opportunity.

The site incoming electrical supply will need to be ungraded to support the decarbonisation proposals, which has been accounted for in the cost estimation.

The likely level of energy and carbon savings has been quantified for each measure, along with budget cost estimates and an indication of operational cost impact. The lifetime $CO_2$ savings over 30 years have been estimated in line with Salix guidelines, along with the cost per tonne $CO_2$ abated estimated. It should be noted that different technologies have different persistence factors i.e., lifetimes and therefore capital replacement cycles. Capital replacement cycles have not been considered in this analysis and should be considered at business case level along with maintenance costs.

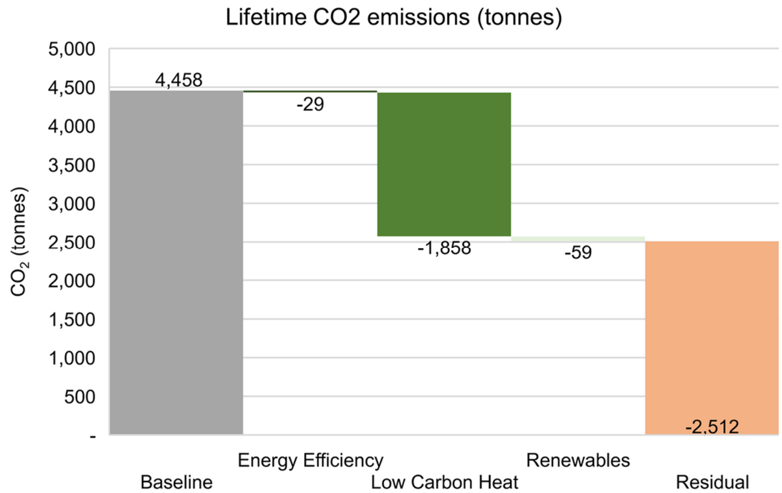
For Pier Head Ticket Office the total capital cost of the proposals is estimated at £341,586 and will deliver 46% lifetime $CO_2$ saving on the baseline of 4,239 tonnes $CO_2$ at a marginal abatement cost of £121 per tonne $CO_2$. This means that each tonne of carbon saved costs £121.

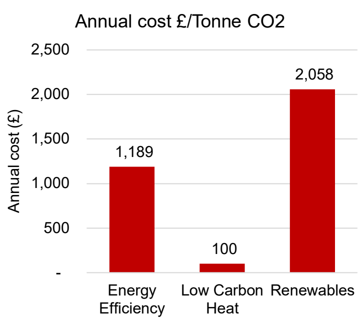
| Decarbonisation Measure Category | LED lighting | ASHP | Solar PV | TOTAL |
|---|---|---|---|---|
| Cost Estimate (£) | £34,000 | £185,387 | £122,199 | £341,586 |
| Annual Cost Impact (£) | -£13,143 | £10,262 | -£27,773 | -£30,654 |
| Annual Energy Savings (kWh) | 37,551 | 349,643 | 79,350 | 466,544 |
| Annual Carbon Saving (tCO2e) | 6 | 71 | 12 | 88 |
| Payback (Years) | 3 | N/A | 4 | 11 |
| Cost £/Tonne CO2 | £1,189 | £100 | £2,058 | £176 |
| Lifetime Cost Impact | -£294,574 | £390,621 | -£502,682 | -£406,635 |
| Lifetime Energy Saving (kWh) | 938,783 | 6,992,861 | 1,785,375 | 9,717,018 |
| Lifetime Carbon Saving (tCO2e) | 29 | 1,858 | 59 | 1,946 |

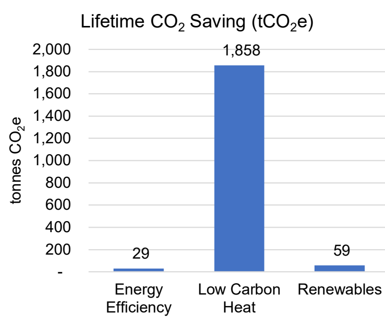
The following table shows the impact associated with each proposed measure.

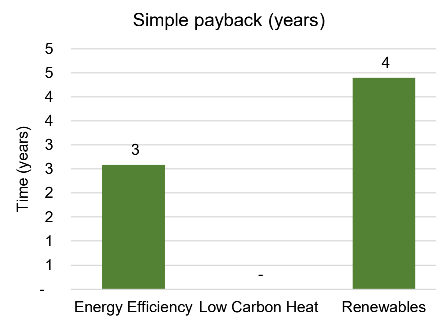
- Note – Annual costs shown as a <u>negative</u> – net cost saving. A positive figure represents an increase in cost.

The following charts show the lifetime $CO_2$ emissions after proposals in each stage of the energy hierarchy, along with a dashboard of metrics cost per tonne $CO_2$, lifetime $CO_2$ emissions saving and simple payback.



# 1 Introduction

This Building Level Heat Decarbonisation and Energy Efficiency Report has been prepared for the site. However, it also informs a wider heat decarbonisation plan for the Local Authority and a portfolio-level plan for Liverpool City Region Combined Authority and Merseytravel. It was funded by Low Carbon Skills Fund (LCSF) and follows its guidance accordingly.

This plan has been produced following a successful Low Carbon Skills Fund (LCSF) bid to assess potential decarbonisation options and will support the organisation in identifying and prioritising the investment required to deliver on reduction targets for the carbon emissions within its responsibility.

The scope of carbon emissions include:
**Scope 1:** emissions generated locally from fossil fuels, included in the scope of this work.
**Scope 2:** indirect emissions generated elsewhere related to the local consumption of electricity and heat, also included in the scope of this work.
**Scope 3** emissions are those that are not produced and are not the result of activities from assets owned or controlled by the client such as purchased goods and services and are therefore outside the scope of this work.

## 1.1 Approach

The HDP methodology included consultation with the Council, collection of desktop data and site survey. Energy conservation measures have been identified and outline feasibility explored, with any issues highlighted to be concluded. Capital cost estimates have been made, based on benchmarks for similar projects.

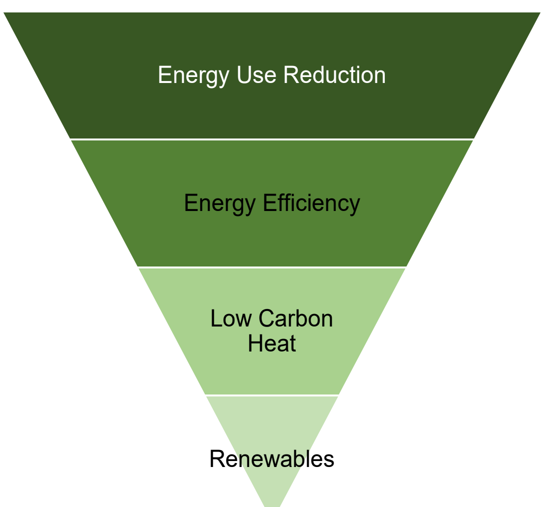
This plan has been developed based on the review of the energy consumption and carbon footprint of building/buildings, desktop data as well as site surveys to assess the opportunities and constraints, the condition of the building fabric, existing heating systems and existing domestic hot water systems.

The structure of the report is as follows:

- Introduction and description of site
- Consideration of unique constraints and opportunities
- Consideration of decarbonisation measures in context
- Decarbonisation proposals
- Concept designs
- Techno-economic implications

## 1.2 Prioritisation of Opportunities using the Energy Hierarchy

The proposals within this plan have been based on the energy hierarchy shown below.




**Energy use reduction** measures target energy wastage and inefficient practices via simple steps such as resetting of time clocks and temperatures, upgrading systems controls and good energy housekeeping by staff, students, visitors, and contractor.

**Energy efficiency** step includes material improvements to building fabric and services equipment, such as fitting variable speed pumps or “two port” control of mechanical services, as well as building fabric improvements.

**Low carbon heat** option primarily considers the use of heat pumps to switch fossil fuel to electricity – preferably from onsite renewables, or a dedicated renewable PPA, or as a backstop from the grid. District heating is also considered where viable.

**Renewables** should be implemented where possible on site. Given the potential increase of overall electrical demand due to electrification of heat, onsite renewable electricity generation projects can reduce the impact on local and national electrical infrastructure and the need for reinforcement.

## 1.3 Grant and Energy Efficiency Opportunities

Efforts have been made across this report to identify opportunities for different funding routes. Those that would be deemed energy efficiency e.g., LED lighting and those that would potentially qualify for future rounds of Public Sector Decarbonisation Funding (PSDS) with one strict criterion – the building in scope has end of life boiler (s). Energy efficiency schemes in a building with no end-of-life boiler, will be required to be funded by internal capital resources as they would not qualify (under the current criteria) for public sector grant funding.

## 1.4 Public Sector Decarbonisation Scheme - Projects for Grant Funding Opportunity (PSDS)

At the time of writing this statement, the current PSDS funding round was phase 3b (closed). No further funding rounds have been announced yet. Therefore, it is with best endeavours that those opportunities are presented.

PSDS is a grant funding process for public sector buildings. The funding pays for decarbonisation of buildings that are emitting scope one direct emissions, that occur through the burning of fossil fuels derived from boilers that are deemed end of life. Removal of boilers that are **not** currently end of life and are being replaced with low carbon heating, would not be deemed compliant with the existing scheme, which targets old inefficient plant. End of life (or near end of life) is determined by a technically competent person along with reference to CIBSE guide M. In this document, if heating plant is deemed end of life, then there is an opportunity to apply for funding. The next window will be expected to open in September 2023.

The PSDS project development process targets peak heat loss from the fabric, and in this document, opportunities for insulation of the fabric will have been identified, where possible. Insulating the building better, reduces peak heat loss and therefore the heating demand of a building and sizing of the low carbon heating system. There has been a systematic process followed to build up the Peak heat loss values and the opportunities to reduce where possible. These are identified where applicable.

PSDS grants are currently paid on the total lifetime tonnes of (scope 1) carbon emissions saved according to the persistence factor of the technology. Fabric improvements are deemed a passive measure with a long lifetime for have a high factor. Interventions with lower factors e.g., variable speed drives, need replacing over a short life cycle and have a lower persistence factor.

There are many different types of intervention with the PSDS scheme and the limit to funding is at £325 pounds per lifetime tonne saved of direct emissions (scope 1). If the totality of fabric and low carbon heating projects in a scheme is less than £325/ lifetime tonne, there is the opportunity to look at electricity saving measures, which carry no grant support, unless they save scope 1 emissions. For instance, PV and LED save indirect scope 2 emissions, which are not grant funded, but can be used to take the total capital costs to over £325 lifetime tonne. If projects exceed £325 lifetime tonnes, then adding project to this, increases what is called the client 'match funding element'.

Outputs for application criteria that are mandatory for PSDS, can be found throughout this document, including building and meter details along with descriptions of the current building fabric and services. In addition, those measures that are proposed to reduce peak heat loss (before and after, through calculation) and any proposed low carbon heating measure. Whilst the low carbon system heating capacity has been estimated, details of potentially suitable equipment have also been proposed.  Estimated costs of interventions have been derived from similar projects, however, quotes of technically competent estimates from a QS will be needed in any bid as evidence.

This document can be used as evidence, for a PSDS application, if the building qualifies under the criteria for PSDS funding.

# 2 Site Description

## 2.1 Overview

Pier Head Ticket Office is a modern riverside ferry ticket office, also housing a café and restaurant.Description

| Information Category | Value |
|---|---|
| Building Name or Number | Pier Head Ticket Office |
| Site Address | George's Dock Gates, Pier Head, Liverpool, L3 1BY |
| UPRN (Unique Property Reference number) | 38318842 |
| Display Energy Certificate Rating (DEC) | No DEC available |
| Building Age (Years) | 13 |
| Gross Internal Area ($m^2$) | 3,028 |
| Number of Floors | 2 |
| Existing Annual Fossil Fuel Use (kWh p.a.) (2021/22) | 683,977 |
| Existing Annual Electricity Use (kWh p.a.) (2021/22) | 625,855 |
| MPRN (Gas Meter Number) – if applicable | 9159362203 |
| MPAN (Electricity Meter Number) | 1300060086781 |

## 2.2 Baseline Energy and $CO_2$ Emissions

Data was provided by the Council from 2021/2022 to baseline emissions and energy. The baseline annual consumption and $CO_2$ emissions for the site are shown below.

| Energy type | Annual Consumption (kWh) | $CO_2$ emissions (tonnes) |
|---|---|---|
| Electricity | 625,855 | 87.5 |
| Gas | 683,977 | 129.4 |

There is no DEC rating for the building. Therefore, comparisons between typical and actual use to look at overall performance against benchmark figures were not possible.

LCRCA should consider producing DEC's for all of its buildings, even if they are not publicly accessible to and this will help the monitoring of energy efficiency, on a year-on-year basis. Average DEC score could also be calculated as a measure weighted across space and energy consumption. This would then give a performance metric (KPI), which would be used for reporting purpose.

All publicly accessible buildings over 250m2 require an up-to-date DEC certificate reviewed every year. Although not technically needed, it is worth reviewing whether a DEC could be carried out as good practice as the information they give is valuable to visibility of overall performance, especially in the context of a business case for investment and with-it performance improvement. Use of the Sigma MT system would also help break down elements of use through more submetering. Team Sigma can generate an energy rating that would allow them to review and compare the site in operation and assist with carbon budgeting and improvement opportunities.

DEC certificates are also able to give recommendations for the occupier to progress and reduce building energy use.

| | |
|---|---|
| **DEC Certificate in date** | N/A |
| **DEC Lodgement Date** | N/A |
| **DEC recommendations found with the certificate?** | N/A |

#### 2.2.1 DEC Recommendations for Energy Efficiency

There were no recommendations given as there is no DEC Certificate

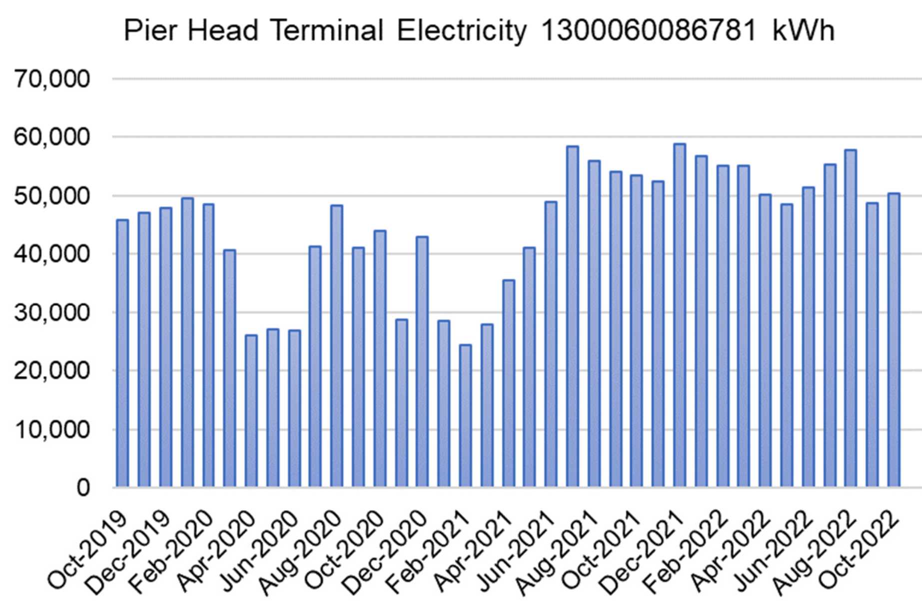
## 2.3 Energy Consumption Profiles

Utility information has been provided by Merseytravel for a 3-year period and it set out below.

### 2.3.1 Electricity Consumption

Electricity Consumption Profile Year April 2019 – March 2022. The pattern of consumption is had increased significantly since 2019 and is up 31% on the baseline year. The profile of electricity shows much higher peaks, with lower use in the 2 lockdown periods, which perhaps explains that. A more detailed use of energy across this site should be developed with sub metering and analysis of being the key.

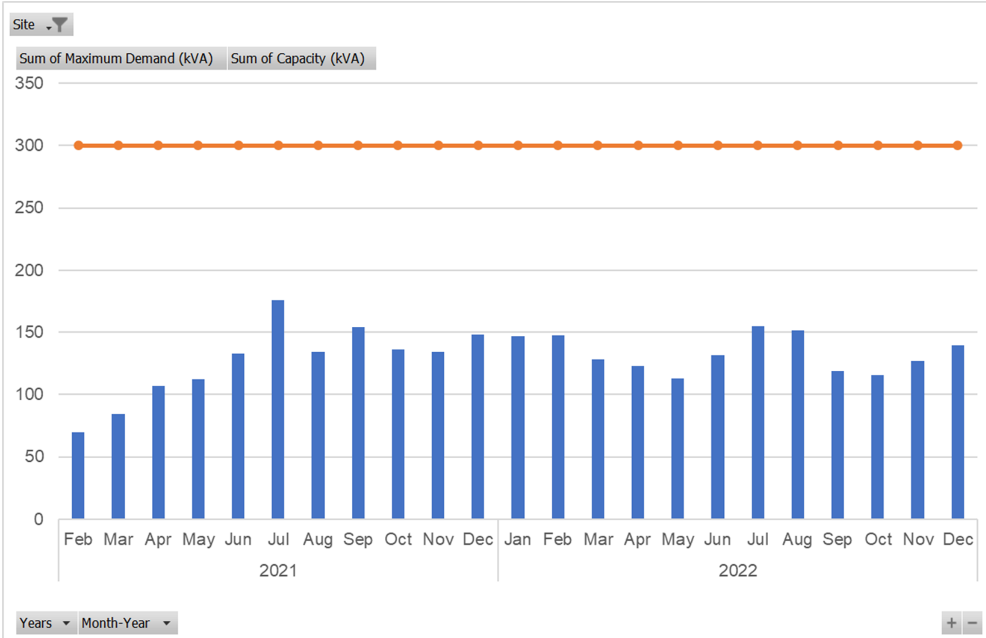
| | Annual Utility Consumption (kWH) | | | | |
|---|---|---|---|---|---|
| **Building** | **Utility** | **2019-2020** | **2020-2021** | **2021-2022** | **Difference from Baseline Year (%)** |
| Pier Head Terminal | Electricity | 490,323 | 490,592 | 643,862 | 31% |




Electricity consumption by month over the past 3 years (2019 – 2022)

### 2.3.2 Electricity Maximum Demand Profile

Max demand profile was available for this site and is shown below along with the allowed capacity. It can be seen from the graph, that maximum demand is well below the allowable capacity. It is recommended that this be reviewed in line with this report's recommendations and electrical infrastructure intentions. Capacity is a chargeable item on the electricity bill. Therefore, the occupier is paying for capacity per kVA it currently doesn't utilise but is still a cost every month.

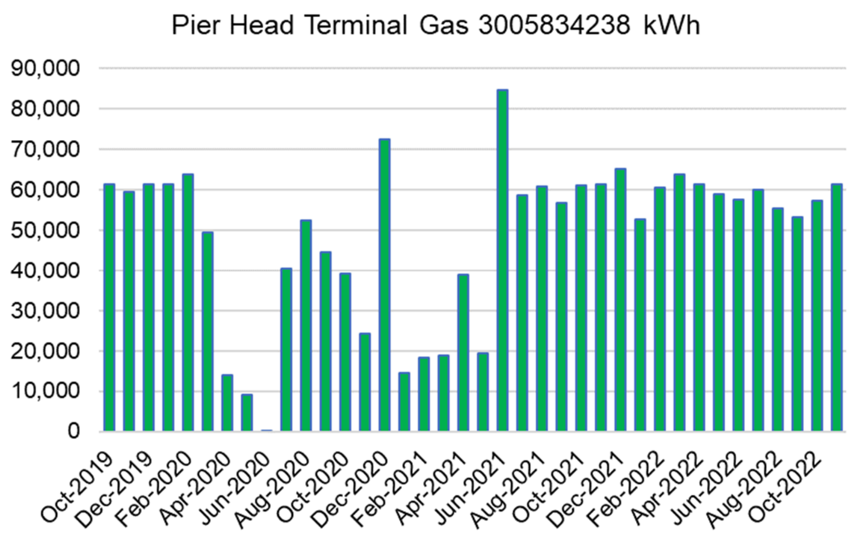



| Site | Pier Head Terminal | |
|---|---|---|
| **Row Labels** | **Sum of Maximum Demand (kVA)** | **Sum of Capacity (kVA)** |
| **2021** | **1387.3** | **3300** |
| Feb | 69.4 | 300 |
| Mar | 84.5 | 300 |
| Apr | 107 | 300 |
| May | 112.1 | 300 |
| Jun | 133 | 300 |
| Jul | 175.9 | 300 |
| Aug | 133.9 | 300 |
| Sep | 153.7 | 300 |
| Oct | 135.8 | 300 |
| Nov | 133.9 | 300 |
| Dec | 148.1 | 300 |
| **2022** | **1596.5** | **3600** |
| Jan | 146.6 | 300 |
| Feb | 147.4 | 300 |
| Mar | 128.4 | 300 |
| Apr | 122.8 | 300 |
| May | 113 | 300 |
| Jun | 131.7 | 300 |
| Jul | 154.8 | 300 |
| Aug | 151.2 | 300 |
| Sep | 119.1 | 300 |
| Oct | 115.2 | 300 |
| Nov | 126.6 | 300 |
| Dec | 139.7 | 300 |
| **Grand Total** | **2983.8** | **6900** |

### 2.3.3 Gas Consumption

Gas consumption has fluctuated over the past 3 years, with the pre pandemic usage levels being similar to post pandemic levels. However, the flat profile between the summer and winter months perhaps indicates a lack of control and this definitely needs investigating further. The key piece being that gas consumption is 37% higher than was compared with the baseline year.

| | Annual Utility Consumption (kWH) | | | | |
|---|---|---|---|---|---|
| Building | Utility | 2019-2020 | 2020-2021 | 2021-2022 | Difference from Baseline Year (%) |
| Pier Head Terminal | Gas | 518,353 | 506,892 | 711,005 | 37% |

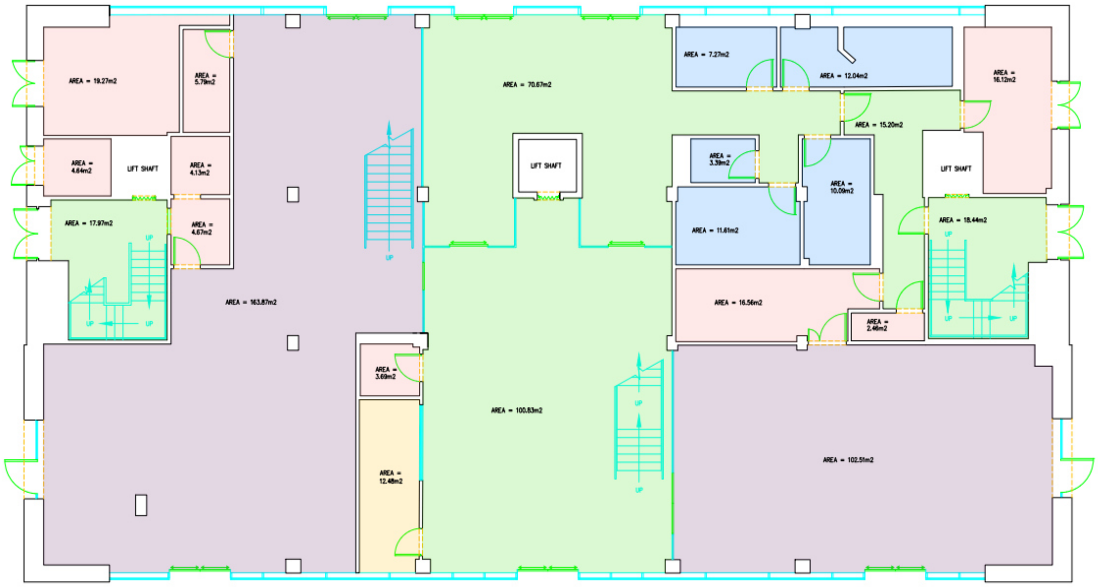



Gas consumption by month over the past 3 years (2019 – 2022)

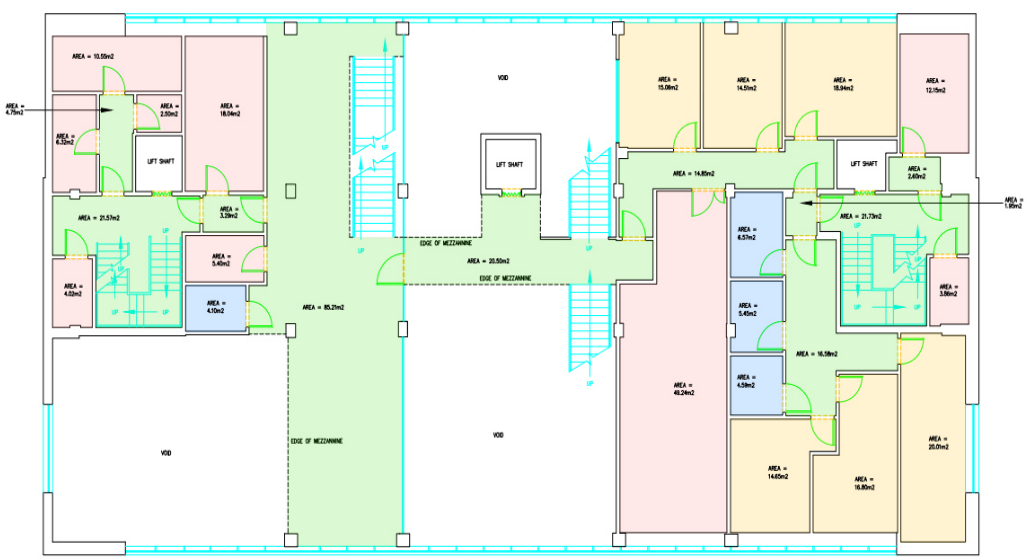
## 2.4 Site Plan and Images


**Aerial view Pier head ticket office**

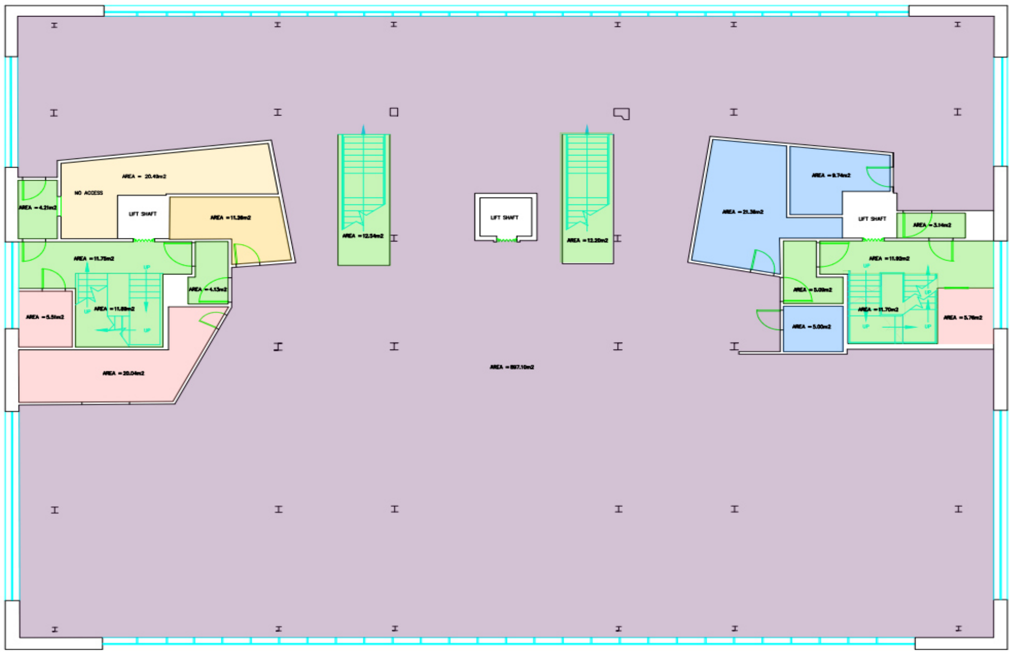

**Pier head ticket office front view**



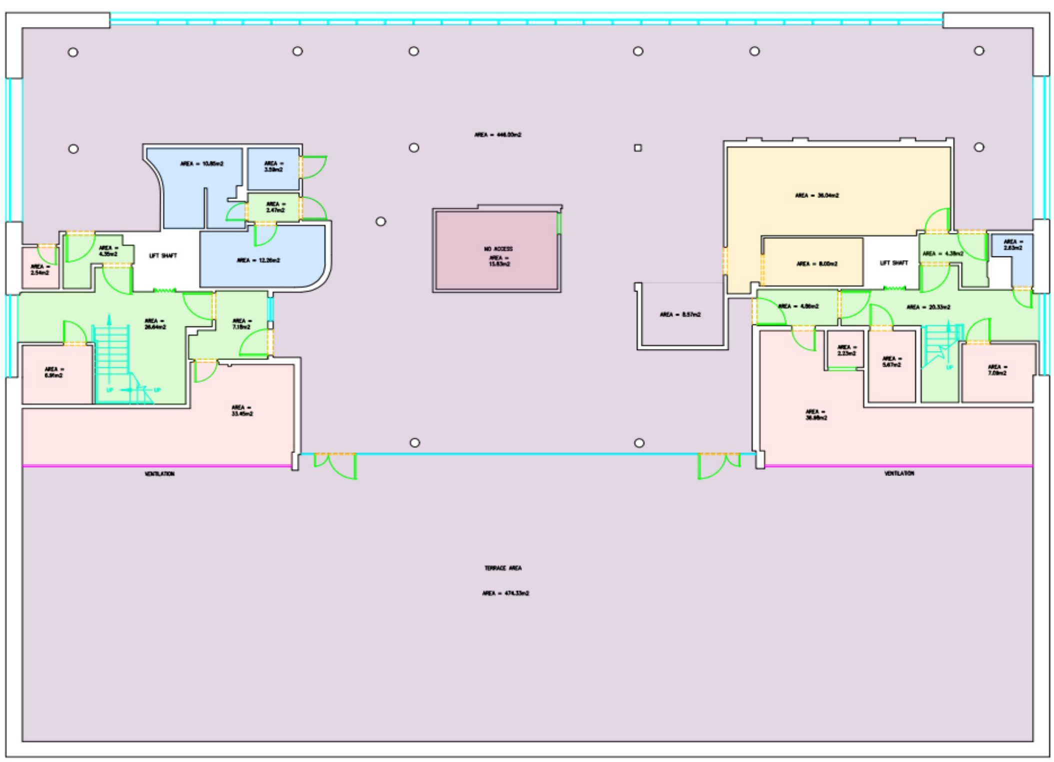
Ground Floor Plan



Mezzanine Floor Plan



Second Floor Plan



Third Floor

## 2.5 Incoming Energy Utilities

### 2.5.1 Electricity

Pier head ticket office has an existing CT metered supply with a maximum demand (MD) capacity currently set at around 300kVA. The highest monthly load recorded to date is 147 kVA. This gives a head room of 153kVA. This head room is over 50% of the declared amount and as such each month a financial charge is levied against this value. It would be advised to assess if this amount of spare capacity is really necessary as it could be negotiated with SP Manweb, and some capacity released back onto the network for additional loads in the near vicinity. This would reduce the monthly charges to Pier head Ticket office and potentially allow other load centres nearby to have additional capacity added without any network reinforcement costs.

### 2.5.2 Gas

There is an incoming mains gas supply to serve the existing boilers. It is DN50 and 40m$^3$/h which is adequate for the existing gas boilers. No other significant gas users were identified on site.

### 2.5.3 Metering and Submetering

There are main gas and electric meters onsite both with electronic signalling with the functionality to report readings however it was identified that there was no submetering to assess the contribution of heating and hot water and what the energy difference was between the two supplies.

## 2.6 Building Services

### 2.6.1 Space Heating

Space heating is generated by three Remeha Quinta 65 units each producing 61kW on an 80C60C circuit feeding a common header, which supplies the AHU's run around coils and heat emitters as well as the Envirotec overdoor curtain from the common header and distribution pumps.

The system consists of the three boilers, pressurisation unit and expansion vessels with shunt pump and distribution pump sets. The pumps and associated equipment appear in good working order.

The distribution pipes and primary pipework appear in good order and are all well insulated however the heat emitters and overdoor curtain are in poor condition and should look to be upgraded in due course.

The boilers are 15 years of age and have reached end of life as identified in CIBSE Guide M life expectancy tables and should be replaced.

### 2.6.2 Domestic Hot Water

Direct hot water is currently provided by point of use electric heaters as well as a dedicated gas fired Andrew's water heater of 275 litre capacity and rated at 24kW providing all of sites DHW demand.

### 2.6.3 Ventilation

The building is mechanically ventilated and consists of three air handling units (AHU's) each with a run around coil from the LTHW CT circuit. There is also a dedicated toilet extract system for site. The AHU's supply tempered air to all spaces as well as extract.

### 2.6.4 Cooling

The site has a dedicated VRF system installed for heating and cooling purposes. There appears to be smaller split DX units with external condensers installed as a later addition to original design. These units are under local control to provided additional thermal comfort.

### 2.6.5 Central Plant

The following plant is currently used to provide space heating, and flow temperature is assumed to be circa 80ºC based on the observed system design and equipment typology.

| Space Heating | | | | | |
|---|---|---|---|---|---|
| Type | Output (kW) | Model | Age | Quantity | Total Output (kW) |
| Gas fired | 61 | Remeha 65 | 15 | 3 | 183 |

## 2.7 Building Fabric

The building fabric consists of insulated stone and block wall construction, flat insulated concrete roof construction and double glazed windows.

Fabric materials and thermal performances has been calculated using data obtained from a non-intrusive site survey and known thermal properties of the materials. This has been checked with reference to historic building regulations. An intrusive survey will be required to confirm materials and thicknesses with greater certainty.

Peak heat loss is a vital element of determining the changes to a heating system during a proposed retrofit as this calculation determines the size of the new heating system peak capacity. In this case, the peak heat loss as shown in the table below has been determined by modelling the thermal transmittances through these fabric elements at an external winter design temperature of -4ºC. This does not include thermal bridging or additional capacity requirements such as safety margin or cold-start margin, which would typically be added in the design stage to the simple heat loss to determine a design peak.

| **Building Fabric** | **Existing** | |
|---|---|---|
| | **U-value (W/m$^2$K)** | **Peak heat loss (kW)** |
| External walls | 0.22 | 7 |
| Roof | 0.25 | 6 |
| Windows | 2.2 | 26 |
| Floor | 0.25 | 8 |
| Ventilation and Infiltration | | 91 |
| **Peak heat loss (excluding warm-up factor, resilience, and margins)** | | **138 kW** |

## 2.8 Lighting

The lighting to the building has a mix of linear fluorescent, and compact fluorescent lamp sources. A small number of areas have been relit using modern LED lamp sources. The fluorescent and compact fluorescent light sources we would recommend be replaced by modern low energy LED lamp sources. These lamp technologies are now being phased out in favour of more energy efficient LED lamp sources. Whilst they would provide the illumination required for the spaces their energy consumption is more than modern expectations.

The remaining percentage of non-led luminaires, if replaced would reduce the lighting load down again to an efficient low energy level. This would then achieve the most efficient type of light source being utilised.

| Lighting technology | Lamp quantity |
|---|---|
| Fluorescent tubes | 40 |

## 2.9 Local Site Resources, Opportunities and Constraints

### 2.9.1 Constraint – Listing Status

The site is not listed and therefore no rectrictions apply to the changes that can economically be made to building fabric, structure, and layout.

### 2.9.2 Opportunities – External Space for New Heat Pump Plant

While space is not abundant, there is potential space for a rooftop sited heat pump highlighted in the appendix.

### 2.9.3 Local Site Resources – Water Bodies for WSHP

The site is nearby the banks of the River Mersey which is suitable as a heat source for a Water Source Heat Pump (WSHP). This technology could also be leveraged for high-efficiency cooling in summer.

However, these all pose technical challenges. A submerged closed-loop array in the River Mersey would be the most straightforward option but would require a study of the river's capacity to provide the heat, necessary permissions, and expensive underground pipework.

It would also require liaison and necessary permissions e.g., from the Environmental Agency. A feasibility study should be undertaken to establish the technical viability of the proposals including modelling of the water source, establish the necessary consents/permissions and their likely outcomes, and undertake an options appraisal to compare to the ASHP. Section **Error! Reference source not found.** summarises the additional considerations and provides an indicative cost/benefit exercise.

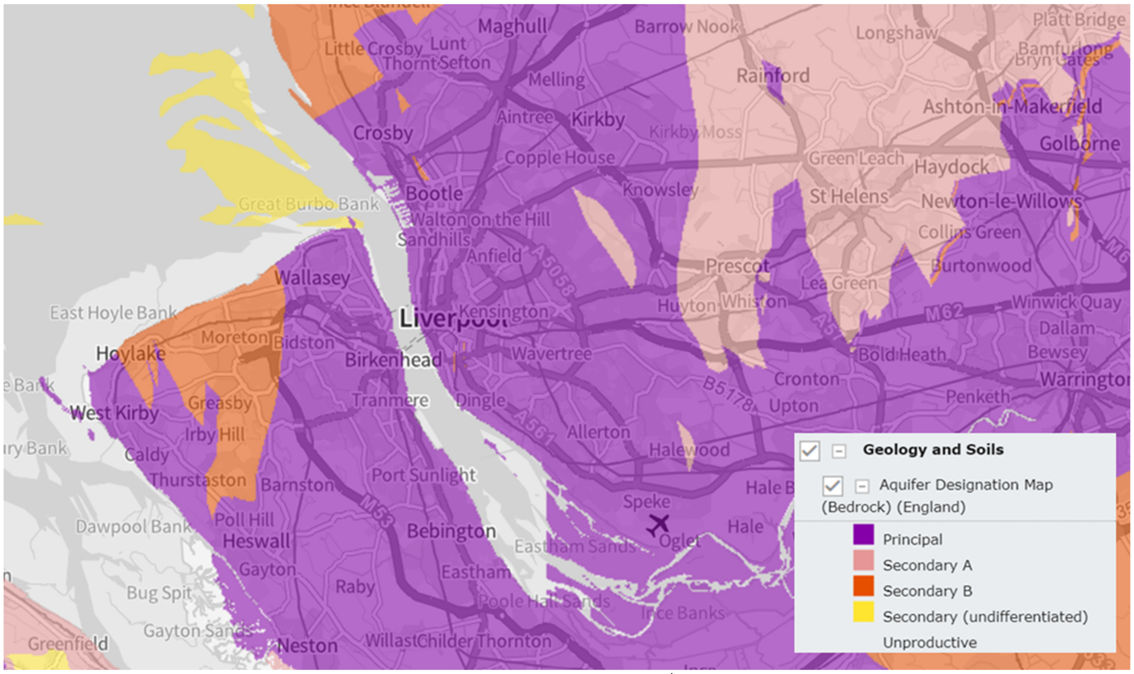
### 2.9.4 Local Site Resources – Aquifer Potential for Open Loop GSHP

The site lies in a region of principal bedrock aquifer according to the DEFRA MAGIC map, an extract from which is shown below. This means there is potential for a productive aquifer to be accessed below the site, which could be used in an open-loop GSHP system. For an open-loop GSHP scheme, a pair of boreholes are required for abstraction and injection, separated horizontally by a recommended distance of at least 50m to avoid feedback over the operational life. The site is big enough to facilitate this.

A GSHP would provide an efficiency advantage over ASHP. The capital cost uplift of the boreholes has a fixed minimum and therefore requires a certain threshold size of site to create a positive business case, which this site may well meet. The other factor that can create an advantage for GSHP is the requirement for comfort cooling.

Site specific considerations such as the likely yield of the aquifer at this location and risk factors such as depth and below ground risk would need to be assessed by a geological consultant. It would also require liaison and necessary permissions e.g., from the Environmental Agency.

Our recommendation is that open-loop GSHP be explored for the site. However due to the lack of space available for installation of boreholes, we have opted to prioritise a more viable ASHP alternative for the heat decarbonisation plan.




DEFRA MAGIC map[1]

### 2.9.5 External Space for Closed Loop GSHP

As per above section, there is insufficient space for a feasible vertical GSHP array. The space required for a closed loop horizontal GSHP is greater still, so this has also been discounted as unfeasible.

### 2.9.6 District Heat Networks

District heating is a way to address the decarbonisation of buildings and has been investigated for the area in conjunction with the Council and the opportunity has been outlined below.

Liverpool City Region Combined Authority (LCRCA) and Liverpool City Council (LCC) are working jointly with BEIS to support their Heat Network Zoning Pilot Project. Both LCRCA and LCC have adopted Net Zero Carbon targets in response to climate change, and the decarbonisation of heat through the development of heat networks is an important part of the solution. As an example, the LCC Net Zero Carbon strategy targets the connection of 70,000 buildings to heat networks by the year 2030.

There are existing heat networks at Paddington Village, The University of Liverpool, Royal Liverpool Hospital and under construction at the Docks (Merseyheat) which could all be expanded.

The BEIS Heat Network Zoning Pilot Project provides an opportunity to use Liverpool as a case study to help identify and overcome the challenges of accelerating the development of heat networks. It is hoped that this pilot project will lead to nationally available tools and processes that can identify viable heat network zones and support the development of legislation that will help heat networks to provide affordable low carbon solutions to customers across the UK.

The authors have consulted with the technical consultants undertaking the Heat Network Zoning Pilot Project, who at the time of writing were not in a position to share information of discuss specific site opportunities. However, they did advise that most of buildings in the LCRCA portfolio East of the Mersey were likely to be within a Heat Network Zone, and thus exhibit potential for future DHN connection.

It is recommended that the initial outcomes of the Heat Zoning Pilot Project, expected later this year, are taken into consideration in determining the potential for DHN connection. However, it should be borne in mind that such opportunities take many years of development.

[1] Source: Aquifer Designation Dataset for England and Wales, published by: British Geological Survey (BGS), Last updated: 23 February 2023

Should DHN connection not provide a viable pathway (for instance the timescale too long), an onsite ASHP could still be progressed, with DHN compatibility considered in the design. Note however this could be detrimental to future DHN economics and viability. Key design considerations are operating temperatures and pressures, space, and hydraulic provision in the plantroom for future connection e.g., spare flanges on the headers.

### 2.9.7 Renewable- Roof Space for Solar Power

There is availability of suitable roof space for the installation of solar. For further detail please see section 3.3. It is recommended that solar Photovoltaic (PV) be prioritised over solar thermal as the site DHW arrangement does not lend itself to the latter.

## 2.10 Heat supply decarbonisation options appraisal

An ASHP has been proposed as a feasible heat decarbonisation technology. However, considering the local resources available an alternative option has been identified which may offer a better decarbonisation solution, but requires additional considerations to demonstrate feasibility, as indicated in the table below.

| Heating Technology Options Appraisal Table | | Additional Considerations (to be addressed in detailed feasibility study) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Heating Technology** | **Is it feasible?** | **Achievable in PSDS Timeframe?** | **PSDS single (SY) / multi (MY)** | **Structural Survey** | **Plant Space** | **Noise** | **Availability of land** | **Geological Study** | **Below ground risk assessment** | **Environmental Permit** | **Maintenance Ease** | **Capex Cost Benefits** | **Running Costs Benefits** | **3rd Party Sub Metering** |
| ASHP | Y | Y | SY | Y | Y | Y | | | | | Y | Y | Y | |
| GSHP | N | | | | | | | | | | | | | |
| WSHP | Y | Y | MY | Y | Y | | Y | Y | Y | Y | N | N | Y | |
| DHN | N | | | | | | | | | | | | | |

To give an idea of the potential cost/benefit, a high level undiscounted cashflow estimation over the 7-year period to 2030 has been made, using the assumption of a 30% uplift in capex over an equivalently sized ASHP scheme, providing a COP uplift from c2.5 to 4.0 and assuming an energy price inflation at 5%.

| | **Item** | **2024** | **2025** | **2026** | **2027** | **2028** | **2029** | **2030** | **Cumulative** |
|---|---|---|---|---|---|---|---|---|---|
| **ASHP** | Capital Costs (£) | £ 185,387 | | | | | | | |
| | Additional Electricity (kWh p.a.) | 197,538 | 197,538 | 197,538 | 197,538 | 197,538 | 197,538 | 197,538 | 1,382,769 |
| | Cost of Electricity (£) | £ 57,286 | £ 60,150 | £ 63,158 | £ 66,316 | £ 69,632 | £ 73,113 | £ 76,769 | £ 466,424 |
| | | | | | | | | | |
| **GSHP** | Capital Costs (£) | £ - | | | | | | | £ - |
| | Additional Electricity (kWh p.a.) | - | - | - | - | - | - | - | - |
| | Cost of Electricity (£) | £ - | £ - | £ - | £ - | £ - | £ - | £ - | £ - |
| | | | | | | | | | |
| **WSHP** | Capital Costs (£) | £ 241,003 | | | | | | | £ 241,003 |
| | Additional Electricity (kWh p.a.) | 129,882 | 129,882 | 129,882 | 129,882 | 129,882 | 129,882 | 129,882 | 909,171 |
| | Cost of Electricity (£) | £ 37,666 | £ 39,549 | £ 41,526 | £ 43,603 | £ 45,783 | £ 48,072 | £ 50,476 | £ 306,674 |

Capex uplift is offset by running cost benefits over the period. The additional benefits such as further $CO_2$ reduction, noise, comfort cooling etc have not been costed in this analysis.

| **Heat Type** | **Capex** | **Capex Uplift** | **Cumulative Running Costs (2030)** | **Difference Running Costs** | **Difference in Energy (kW)** |
|---|---|---|---|---|---|
| ASHP | £ 185,387 | £ - | £ 466,424 | | - |
| GSHP | £ - | £ - | £ - | £ - | - |
| WSHP | £ 241,003 | £ 55,616 | £ 306,674 | -£ 159,750 | - 473,598 |

# 3 Measures Considered

## 3.1 Energy Efficiency

### 3.1.1 Building Fabric Upgrade

The building fabric materials and performance has been calculated with data obtained from a non-intrusive site survey and cross referenced with historic building regulations. An intrusive survey will be required to confirm this with greater certainty.

Any technically feasible upgrades to the building fabric will not be economically sound due to the already high performance of the fabric, meaning improvements would yield a diminished return on investment. Double-glazing is already in place which cannot economically be improved upon until the end of its life.
Prop_Fabric_Des
As it stands, the peak base heat loss of the building will remain at 117 kW, from which a heat supply decarbonisation plan will be considered with addition of margins for thermal bridging and cold-start requirements.

| | |
|---|---|
| **Proposed fabric upgrades** | No feasible upgrades have been identified. |

A heat supply decarbonisation plan will be built to meet this peak loss in addition to margins for thermal bridging and cold-start requirements.

### 3.1.2 Lighting

There is an opportunity to replace the remaining existing light fittings with LED equivalent to deliver a reduction to electricity consumption. To further assist the reduction of consumed energy, modern automatic lighting controls can be installed to turn off lighting in un-occupied areas.

The table below summarises the potential savings from these upgrades. In the absence of sub metered electrical data we have estimated the lighting demand based on lamp-counts as a share of total annual electricity demand, and the percentage energy use reduction available in switching from incumbent lighting technologies to LED equivalents.

| **Lighting** | | | |
|---|---|---|---|
| Current Electricity Consumption | | Demand Saving from LED upgrades | |
| Percentage of total electrical demand | Lighting demand (kWh/annum) | Percentage improvement | (kWh/annum) |
| 20% | 125,171 | 30% | 37,551 |

## 3.2 Low Carbon Heat

This section considers the fossil-fuel fired heat supply system and considers the potential to upgrade it to a lower-carbon source.

### 3.2.1 Heat Supply Type

The existing gas fired boiler system can be decarbonised through replacement by a heat pump. The principal rationale is replacement of fossil fuel with electricity preferably from onsite renewables or from the electricity grid, the $CO_2$ content of which is reducing year-on-year. See Appendix C for more detail on the technology including why heat pumps offer $CO_2$ emissions reduction over gas boilers. Whilst $CO_2$ emissions are the main deriver, any replacement of local combustion by heat pumps will create an air quality improvement. The proposals will also improve internal comfort and system controllability.

### 3.2.2 Heat Distribution System

It is proposed that the heat pump serve the space heating and DHW systems with the new system replacing the current ad hoc POU units to ensure best efficiencies are being realised.

The building considered exhibits heat pump conversion potential in a relatively straightforward manner; however, the distribution pipework and heat emitters are recommended for replacement. Additionally, new POU units and new distribution pipework and taps be where identified are recommended, along with new heater batteries for the AHU's and heat emitters across site.

### 3.2.3 System Operating Temperature

We advocate that at a reduction in design temperature from 80ºC be sought through design of the decarbonised solution, to improve heat pump efficiency. Stored DHW is a consideration for the central system due to the current system design so as to allow a straight forward exchange of systems, a flow temperature of 70ºC ought to be achievable. We would also advise that the heat pump system be designed to allow for zonal control to allow space heating for permanently occupied spaces instead of full building heating.

For resilience we would advise multiple units to meet the peak and consider multi-compressor units for additional capacity. The heat connection should be facilitated via a plate heat exchanger and a new thermal store to smooth demand and reduce heat pump capacity needed.

### 3.2.4 Heat Pump Proposal

An ASHP is proposed (see section 2.9 for discussion around alternatives). We have identified a suitable location for a existing rooftop plant room sited heat pump solution, highlighted in the Appendix. sited externally located heat pump solution, highlighted in the Appendix. Section **Error! Reference source not found.** below provides more detail about the concept design.

The sizing of the heat pump accounts for the estimated heat loss, plus allowances for thermal bridging, cold-start margin (i.e., to raise the building's temperature not just maintain it) and any additional safety factors.

| **Heat Pump** | | | |
|---|---|---|---|
| Type | To Serve | Total capacity (kW) | Assumed realistic SCoP |
| ASHP | Space Heating and DHW | 85 | 2.77 |

## 3.3 Renewable Energy Generation

There isn't an existing PV installation on site.

A new rooftop PV installation can reduce reliance on grid electricity to reduce the carbon intensity of low carbon technology electricity consumption. In conjunction with the thermal store, the ASHP can maximise use of PV generation where there is not concurrent heat demand.

See the table below for calculations toward feasible capacity. Annual generation has been estimated using simple rules of thumb. New solar PV installations in these areas are subject to roof loading at the design stage.

| **Solar Photovoltaics:** | | |
|---|---|---|
| **Pierhead Tickets** | | **Unit** |
| Inclination: degrees from horizontal | 0 | **º** |
| Orientation: degrees from South | 10 | **º** |
| KWh per KWp for site at orientation above | 738 | **Kk** |
| Shading factor | 1 | |
| 1 SF (1.00 assumes nil shading) | | |
| Maximum potential available roof area | 870.00 | **m²** |
| Percentage for available roof area chosen | 75% | |
| Roof area available for PV | 652.5 | **m²** |
| Typical panel area | 1.94 | **m²** |
| Number of panels selected | 336 | |
| Output of each panel | 320 | **Wp** |
| Installed capacity of PV system | 107.52 | **kWp** |
| Estimated annual output | 79,350 | **kWh/ann** |

# 4 Summary of Proposals

The proposals for Heat Decarbonisation of the site are shown in the table below:

| | Technology | Proposed | Reason |
|---|---|---|---|
| Energy Use Reduction | Resetting of time clocks and temperatures | Yes | A simple way to reduce energy usage in lieu or advance of BEMS |
| | Building Energy Management System (BEMS) | Yes | Existing controls offer only basic control options and no off-site access. The addition of a BEMS is proposed as part of the heat pump upgrade. |
| | Metering and Monitoring | Yes | Existing metering should be reviewed and optimised per technology to increase energy management and efficiency |
| Energy Eff.. | Building Fabric | No | No feasible improvements to the building fabric identified |
| | Variable Speed Drives | Yes | VSDs should be considered in the design of the new decarbonisation solution for heat distribution and air handling. |
| | LED Lighting | Yes | The lighting can be upgraded to LED, giving a significant savings on the electricity consumption |
| Low Carbon Heat | ASHP | Yes | ASHP system of circa 85kW$_{th}$ recommended as the core heat decarbonisation strategy. Sufficient rooftop space identified and highlighted in the appendix. |
| | GSHP | No | Site exhibits sufficiency economy of scale to justify capital cost of infrastructure and is above a viable aquifer, but no space identified for borehole installation |
| | WSHP | No | The site borders the Mersey. There is opportunity for a water-source heat pump (WSHP) system of either closed or open-loop design. Efficiency would be greater than ASHP, but upfront costs and risk are generally higher. We recommended this option be explored, but ASHP is proposed for the purposes of this plan. |
| | Thermal Store | Yes | Alongside a heat pump, facilitates demand peak-shaving and time-shifting to maximise the use of intermittent electricity generation from solar PV and/or a flexi grid connection tariff resulting in reduced operating emissions and cost |
| | DHN | Yes | District heating is a way to address the decarbonisation of buildings and has been investigated for the area in conjunction with the Council. The site is thought to fall in the scope of the Heat Network Zoning Pilot Project, whose findings are expected later this year and should be consulted before determining a pathway. |
| | Heat Recovery | No | No significant or suitable sources of waste heat have been identified in the vicinity |
| Renewables | Solar Photovoltaic (PV) | Yes | Flat rooftop space for solar PV of circa 108 kW$_p$ has been identified. This should be utilised to maximise access to low-carbon, price-stable electricity, particularly considering the additional electrical loads proposed |
| | Electrical Storage | Yes | Power storage should be considered in with the expansion of the solar PV system and the power production profile in relationship to expected use. Purchase to off peak cheaper power could also be an option to support battery storage |
| | Solar Thermal | No | The site DHW arrangement does not lend itself too solar thermal. |

# 5 Concept Designs

This section details the high-level concept design proposals, including changes to the site mechanical and electrical services to implement decarbonisation.

## 5.1 Mechanical Services

The mechanical services are the only users of gas in Pier Head Ticket Office, in the form of gas fired boilers and water heaters. Omitting the gas from the building by providing electrically generated hot water for heating is required to decarbonise the building.

Peak heat demand = 109kW

There have been no fabric improvements identified at Pier Head Ticket Office.

Heat losses are directly linked to air change rate (ACH), which has been assumed at 1 ACH due to the age of the building and the windows. A high temperature ASHP solution to meet the heating demands of the building is recommended, removing the need for gas & enabling the building to decarbonise. The survey reports and as fitted drawings from Pier Head Ticket Office show a mixture of heat emitters, including radiators, AHUs, and AC units. A thermal store will be included to enable peak demands to be met without oversizing the ASHP equipment. To retain the existing emitters within the building, the ASHPs will be required to produce system operating temperatures of 70/50 oc. The DHW in the building is partially served by point of use water heaters and 1No gas fired water heater. Running the ASHPs at a higher temperature will allow for the ASHP, and thermal store to also serve the buildings DHW, in the areas that are not currently served by point of use heaters (POU).

Proposed Air Source Heat Pump Solution

- 2no. Mitsubishi ASHP units, operating on R32, nominal heating capacity 42.6kW at -5oC, model CAHV-P500YB-HPB with a SCOP 2.77, with dimensions of 1.978m (W) x 1.71m (H) x 0.759m (W) and weight 526kg.
- 2,000 litres of thermal storage located within the existing plantroom.
- Distribution pumps, pressurisation units, controls etc. located in existing plantroom.

As this option considers the gas plant to be removed, there will be available space in the plantroom for locating additional plant, such as the thermal store.

The renewable heating solution for this site will benefit from the installation of a new BEMS system.

The new system will provide the ability to remotely control and monitor the new heat pump units. It is proposed that the BEMS system be established as a component of designing and commissioning the system. Refer to section 5.3.

## 5.2 Electrical Services

Pier head ticket office has an existing CT metered supply with a maximum demand (MD) capacity currently set at around 300kVA. The highest monthly load recorded to date is 147 kVA. This gives a head room of 153kVA.

The proposal is to install several Air Source Heat Pumps to decarbonise the gas fired boilers. The estimated additional electrical load derived from the proposals of the above services will be in the order of 81kVA. This additional load can be accommodated with the spare capacity currently available on site.

New cabling would be installed from the existing distribution boards and terminated into the new ASHPs. An allowance has been made to install additional distribution equipment if required to distribute the circuits. This aspect will be further detailed in the next phase of design development.

Refer to Appendix E for the electrical schematic. A new proposed PV array (107kWp) would be installed and cabled back from high level and the associated inverters and system protective (G99) relays installed adjacent the new switchgear initially. The output from the inverters would be cabled to a protected connection points on the new panel boards/ existing switchgear. The PV array location would require a structural assessment prior to installation. The above proposals are subject to agreement with Scottish Power for the interconnection and facilitation of the new PV installation.

## 5.3 Building Energy Management System and Metering

### 5.3.1 Building Energy Management System

The new proposed heat pumps and ancillary pumps should be integrated with a new BEMS system along with a new controls gateway to a centralised command station and headend unit. This will be linked with the existing. individual local BMS used for individual building supervisory monitoring and control. These should be upgraded if required to facilitate all new requirements and the feedback to a centralised system.

Supervisory control within the individual plantrooms and any additional plant room equipment should be provided via an industry best-practice BEMS system, which will be programmed to enable and disable equipment based on a timeclock, trimming pump motors, operating control valves, external signal, or manual user input, along with the following capabilities:

- Operate under an optimum efficiency tracking strategy based on site demand.
- Modulate the thermal stores' charging and discharging.
- Modulate the supply and distribution pumps associated with the new heat pump infrastructure and/or existing systems if undertaking a phased approach
- Provide monitoring and control interface with the various pumps & associated sensors.
- Provide weather compensation.
- Provide capacity feedback to the BEMS panel and alarm output signals where required from the heat pumps, thermal stores, ventilation systems, gas guard units and related ancillaries
- Facilitate monitoring of individual space thermal comfort levels recording space temperatures, humidity and
- CO/CO2 levels and link back to zonal control valves to facilitate better control of heat distribution through buildings.
- Monitor and control valves, actuators associated with the new heat pump network.
- Link all new LED lighting to the new front end where possible to allow for full control of lighting onsite from a central control with time clock
- Provide dashboard overview and navigable menus with data export functionality, for the system operator with 12-month tracking and logging of information.

### 5.3.2 Metering

- Link all main services metering on site, (Electric and Water, gas where it could not be fully removed) to personalised dashboard.
- Metering onsite should include, as part of the new BEMS commission, to allow for individual building sub metering of all services including DHW, CWS, Solar PV and heating from new HP's. This will allow better understanding of building usage and operation.
- All metering to be MID compliant sub-metering with open protocol integration.
- All metering should have a standalone battery system back-up regarding power loss but also the main controller will have sim integration in the event of the local area network loss so that data can be retrieved and logged via mobile networks ensuring consistency and resilience.

# 6 Cost Estimates, Energy and $CO_2$ Savings

A high-level techno-economic analysis has been undertaken following guidance issued by Salix Finance[2] for carbon emissions factors and technology persistence factors.

Based on the decarbonisation measures proposed the table below outlines the energy, carbon, and cost analysis[3] for the site.

| Decarbonisation Measure Category | LED lighting | ASHP | Solar PV | TOTAL |
|---|---|---|---|---|
| Cost Estimate (£) | £34,000 | £185,387 | £122,199 | £341,586 |
| Annual Cost Impact (£) | -£13,143 | £10,262 | -£27,773 | -£30,654 |
| Annual Energy Savings (kWh) | 37,551 | 349,643 | 79,350 | 466,544 |
| Annual Carbon Saving (tCO2e) | 6 | 71 | 12 | 88 |
| Payback (Years) | 3 | N/A | 4 | 11 |
| Cost £/Tonne CO2 | £1,189 | £100 | £2,058 | £176 |
| Lifetime Cost Impact | -£294,574 | £390,621 | -£502,682 | -£406,635 |
| Lifetime Energy Saving (kWh) | 938,783 | 6,992,861 | 1,785,375 | 9,717,018 |
| Lifetime Carbon Saving (tCO2e) | 29 | 1,858 | 59 | 1,946 |

- Note - Annual costs shown as a negative – net cost saving. A positive figure represents an increased cost

## 6.1 Modelling Assumptions

For energy, $CO_2$, operating cost, and lifecycle cost comparisons, in all cases we assess a baseline (some people call this a business-as-usual or counterfactual) case, and then assess each scenario against it.

**Reference year**
Year 1 of the Lifetime model. Assumed to be 2024 to determine appropriate $CO_2$ emissions factors.

**Energy tariffs**
The following assumptions were made, based on advice from the client.

| Tariff (£) | |
|---|---|
| Gas | 0.085 |
| Electricity | 0.29 |

**Annual $CO_2$ Emissions**
Annual $CO_2$ emissions give a snapshot of a single Reference Year (2024, based on Government Green Book carbon factors, table 1 and 2b), calculated by applying carbon emissions factors (see below) to annual forecasts for electricity and gas usage (kWh per annum).

| Carbon Factor (kg$CO_2$e/kWh) | |
|---|---|
| Gas | 0.183 |
| Electricity | 0.149 |

[2] https://www.salixfinance.co.uk/P3LCSF_Resources
[3] Note on modelling conventions and assumptions: a negative cost number indicates a saving. Lifetime is governed by Salix persistence factors. Future costs are undiscounted. Energy tariffs modelled flat (no escalation). Lifetime Cost Impact is upfront capital plus lifetime energy saving. All cost estimates are exclusive of VAT.

**Lifetime**
A simple model has been undertaken to forecast the $CO_2$ emissions and cost over the lifetime of the decarbonisation measures. These lifetime (or 'persistence factor') of each measure is prescribed by Salix**[4] varying between 22.5 and 30 years as a reflection of how long the technology could be expected to make savings before needing replacement. The baseline model Lifetime is 30 years.

**Lifetime cost impact**
Lifetime cost impact is the sum of capital cost and the undiscounted annual energy savings (or increases) over the Lifetime. Assumptions: No energy tariff forecast. No inflation. No operational costs other than energy costs (e.g., maintenance). No degradation factors for plant output or efficiency. No plant replacement costs: at the end of the asset lifetime, we have assumed the technology ceases operation.

**Lifetime $CO_2$ emissions**
Sum of the annual CO2 emissions over the Lifetime. Note forward forecast of $CO_2$ emissions factors changes each year. Hence annual $CO_2$ emissions (or savings) is not constant throughout the Lifetime. Source: Treasury Green Book: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal
Notes: Electricity 'Grid Average' figures used throughout.

**Cost per tonne $CO_2$**
Also known as marginal abatement cost, this is the capital cost estimate divided Lifetime $CO_2$ emissions saving.

## 6.2 Cost Estimation Methodology

Budget cost estimates for the decarbonisation works have been compiled using benchmarks derived from recent similar projects. The table below schedules the benchmarks used. Heat pump costs have been estimated as marginal costs over like-for-like replacement.

| Building Name | Metric | Utility (note metric is applied to savings) | Benchmark (standard building) | Benchmark (Listed Building) |
|---|---|---|---|---|
| Fabric Roof/loft | £/kWh | GAS | £1.22 | £1.83 |
| Fabric Windows Secondary | £/kWh | GAS | £1.93 | £2.89 |
| Fabric Windows New Double G | £/kWh | GAS | £5.03 | £7.54 |
| Fabric (Walls) | £/kWh | GAS | £2.18 | £3.28 |
| Boiler Upgrade | £/kWh | GAS | £193.60 | £290.40 |
| Heat pump (GAS SAVING) | £/kWth | ELEC | £2,035.00 | £3,052.50 |
| Solar PV Power | £/kWh | ELEC | £1,540.00 | £2,310.00 |

In addition, the following costs were estimated as 'extra-over' the benchmarks.

| Electrical upgrade | Lighting upgrade |
|---|---|
| £ 27,000 | £ 34,000 |

[4] Source: Phase 3 Public Sector Decarbonisation Scheme (PSDS) Guidance (Updated 15th September 2021)

# 7 Risks

A risk register outlining current identified risks has been developed and is shown below. Please note that the risk register is a live document and requires to be regularly reviewed and updated throughout the project with new risks added if necessary.

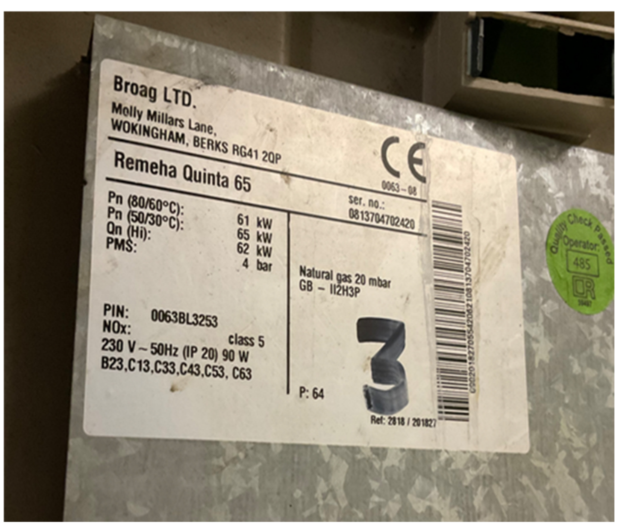
| Probability (P) | Impact () |
|---|---|
| 1 - Very unlikely | 1 - Minor: minimal loss, delay, inconvenience |
| 2 - Unlikely | 2 - Moderate: minor loss, delay, inconvenience |
| 3 - Fairly likely | 3 - Significant: significant loss, delay, inconvenience |
| 4 - Likely | 4 - Substantial: major impact on project and objectives |
| 5 - Very likely | 5 - Catastrophic: critical impact on project objectives |

| Risk identification | | | | | Current status | Risk analysis | | | | Risk mitigation | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ref | Date Raised | Category | Risk Description | Consequence | | P | I | Rating | Risk owner | Required action | Action owner | Date action required by |
| 1 | | Construction | Construction operations damage existing buildings / structures | Health & safety risk, impact on service delivery, works ordered to stop, cost, delay | | 2 | 2 | 4 | Contractor | Works to be executed in accordance with approved logistics plan. | Contractor | |
| 2 | | Construction | Abnormal ground / site conditions, services, obstructions etc discovered during construction | Programme delay | | 2 | 3 | 6 | Contractor | Undertake surveys during design completion. Ensure works are executed in accordance with surveys that have been undertaken. Undertake further surveys / investigations if necessary | Contractor | |
| 3 | | Construction | Existing services damaged | Injury, disruption to service delivery, programme delay | | 2 | 3 | 6 | Contractor | Undertake surveys during design completion. Ensure works are executed in accordance with surveys that have been undertaken. Undertake further surveys / investigations if necessary | Contractor | |
| 4 | | Construction | Building services interrupted by construction | Impact on service delivery. Costs incurred, programme delay | | 2 | 3 | 6 | Contractor | Maximise isolation of services & undertaking works out of hours. Undertake surveys during design completion. Ensure works are executed in accordance with surveys that have been undertaken. Undertake further surveys / investigations if necessary | Contractor | |

# Appendix A – Building Survey Photos


Aerial view Pier head ticket office

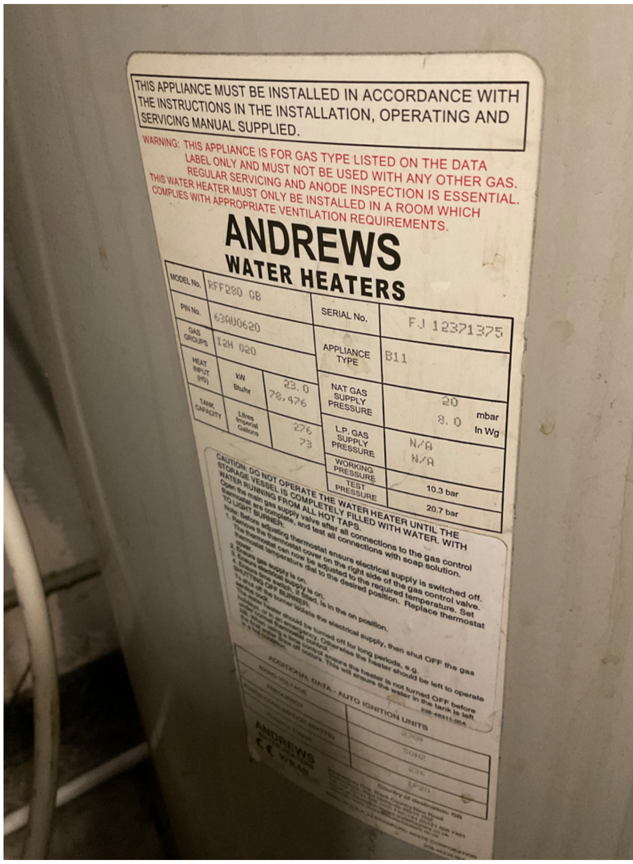

Pier head ticket office front view




Gas fired boiler


Internal glazing


Heating system distribution pumps




Gas fired water heater

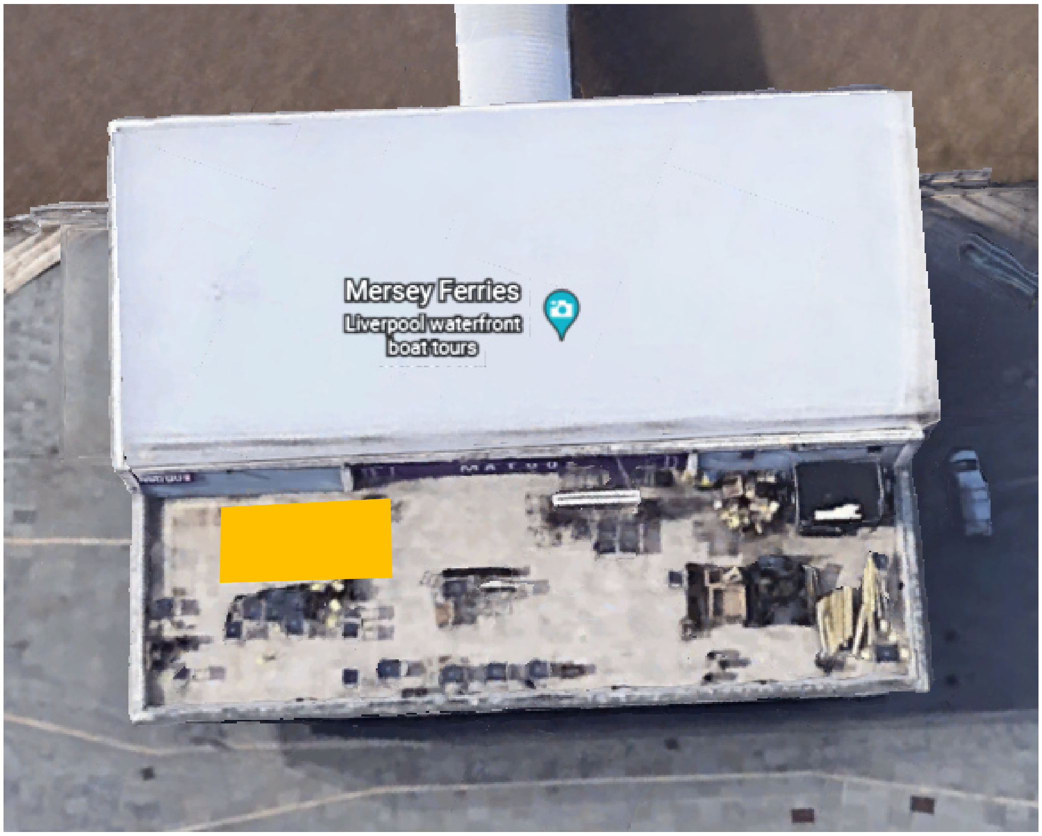

Air handling unit


Heat recovery AHU

Air conditioning unit - Ceiling mounted cassette


VRV System

Fan coil unit with swirl diffusers




**Potential locations for ASHP.**

# Appendix B – Solar PV Potential


**Rooftop areas suitable for solar PV, subject to structural survey.**

# Appendix C – Technologies Considered

## 7.1 Energy Use Reduction

### 7.1.1 Passive Infrared (PIR) Sensor

Using passive infrared sensors, a PIR light is activated when detects sources of heat and remains off the remainder of the time. Therefore, there is no waste of electricity in unoccupied rooms.

### 7.1.2 Resetting of Time Clocks and Temperatures

It is important to set the appropriate system temperatures and to ensure that plant is timeclock controlled. This way the plant is not run unnecessarily and there is no waste of energy.

### 7.1.3 LED Lighting

Light-emitting diodes (LEDs) are devices that convert electric energy into light of a single colour. Due to “cold” light generation technology, most of the energy is delivered in the visible spectrum and therefore there is no energy wastage due to non-light producing heat.

## 7.2 Energy Efficiency

The following energy efficiency measures have been analysed and their suitability considered for the building.

### 7.2.1 Building Energy Management Systems

Building Energy Management Systems (BEMS) monitor and control services such as heating, ventilation, and air-conditioning, ensuring the building operates at optimum levels of efficiency and removing wasted energy usage and associated costs. The optimal level of efficiency could be achieved by continuously maintaining the correct balance between operating requirements, external and internal environmental conditions, and energy usage. BEMs control upgrade may include additional sensor points, resetting of time clocks, use of temperature compensation, additional metering, and improved plant sequencing.

### 7.2.2 Building Fabric

Building fabric improvements are key to the decarbonisation of buildings and achieving net-zero carbon, as they can significantly reduce the energy demand of buildings. Therefore, where possible a ‘fabric first’ approach should be explored before considering changes to any electrical or mechanical building services systems. This approach ensures that the performance of the components and materials that make up the building fabric are optimised. This will result in a reduction in thermal losses, energy use and carbon emissions, thereby potentially reducing the scope of required electrical and mechanical works and associated capital and operational costs. Cavity wall insulation survey should be carried out to assess the current insulation properties of the buildings where applicable.

### 7.2.3 Insulation

Insulation covers are removable and can be added later to improve the thermal insulation properties for valves, flanges, and pipework. They offer an effective and convenient solution to reduce heat losses and lower energy bills.

### 7.2.4 Variable Speed Drives

Variable Speed Drives (VSDs) vary the speed of a normally fixed speed motor. In HVAC systems, they are used primarily to control fans in variable air volume systems instead of other devices such as inlet vanes, pumps, and discharge dampers. Variable speed drives provide effective speed control of AC motors by manipulating voltage and frequency. Controlling the speed of a motor provides users with improved process control, reduced wear on machines, increased power factor and energy savings.

### 7.2.5 Field Control

Field control improvements may include replacement of three-port with two-port control valves, resizing coils for lower water side operating temperatures and eliminating bypasses and low loss headers.

## 7.3 Low Carbon Technology

The following low carbon technologies have been analysed and their suitability considered for the building.

### 7.3.1 Air Source Heat Pump

Air Source Heat Pumps (ASHPs), or alternatively air-to-water heat pumps, works by extracting heat from the external air and transferring it to space heating and/or domestic hot water (DHW) systems via a vapour compression cycle. ASHPs are powered by electricity, eliminating the need for fossil fuel consumption, and they are typically located externally to the buildings they serve.

To achieve optimum operating efficiencies, ASHPs flow temperatures are generally limited to 45°C which, when compared to a conventional boiler system flow temperature of approximately 80°C, means that radiators will present lower surface temperature, and therefore reduced heat output. To compensate for this, larger radiators to achieve the same heat output of a boiler system are generally required.

In addition, recovery times for DHW cylinders should be taken into consideration. Where hot water usage is relatively low, it is practicable to install instantaneous electric water heaters. Alternatively, a water-to-water heat pump should be considered to boost the DHW flow temperature to the desired figure.

Another important factor to be considered is that ASHPs are generally required to be installed externally and therefore noise impact has to be considered.

### 7.3.2 Ground Source Heat Pump

Ground Source Heat Pumps (GSHPs) use the relatively constant year-round temperature below ground to reject or extract heat and supply cooling or heating via a refrigeration cycle to the end-user.

Even when the ground temperature is lower than the air temperature, it is more predictable and does not vary significantly, which makes GSHP system design more robust and with more consistent Coefficient of Performances (COPs).

GSHPs can have either an open loop system, using groundwater such as a river or borehole to an aquifer, or a closed loop system, consisting of pipework buried within the ground. Most GSHPs are powered by electricity but some systems can use waste heat or fossil fuel to power the compressors.

COPs of circa 3.6-4.5 are achievable provided correct application and system design are in place.

Similar to ASHPs, to maximise operating efficiencies, a lower flow temperature of approximately 35-50°C for the heating system is generally used.

### 7.3.3 Water Source Heat Pump

Water Source Heat Pumps (WSHPs) use similar technology as ASHPs and GSHPs. The only difference relies on the method by which they extract heat from the environment, which, in this case, is from a body of water. WSHPs are usually more efficient than ASHPs or GSHPs due to the greater heat transfer efficiency with water.

WSHPs can have either an open loop or a closed loop system.

In a closed loop system, sealed pipes with fluid are submerged into the water and, as the fluid flows within the pipes, it extracts heat from the body of water. In this case, the fluid within the system does not come into contact with the body of water.

In an open loop system, a pump circulates water to extract its heat before discharging it back into the source. This system is usually more efficient when compared to a closed loop system, but consent might be required from the Environment Agency.

### 7.3.4 Solar Thermal

Considering that ASHPs operation is less efficient when coupled with DHW supply due to the requirement of higher flow temperatures, the performance of the heat pump system could be further optimised by supplementing the DHW generation through solar thermal collectors.

The two main types of solar thermal technology are flat panel and evacuated tube, the latter tending to present a higher efficiency in terms of kilowatt output per square meter (kW/m$^2$).

Solar thermal systems are generally more viable when used in buildings with reasonably high levels and regular consumption of DHW.

### 7.3.5 Electric Boilers

Electric boilers that are powered by renewable sources can provide useful low carbon heat. If sized at less than 10% of the anticipated annual heat demand and controlled to deal with short peak demand periods, they can provide a low cost, flexible heat input.

#### 7.3.6 Thermal Batteries

Thermal batteries can be used to store heat when it is available until a time when it is required. They can be charged 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 typically increases the project cost dramatically and requires a large footprint to be able to offer the heat required by the system.

#### 7.3.7 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 the thermal store, so it acts 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.

## 7.4 Renewables

The following renewable options have been analysed and their suitability considered for the building.

#### 7.4.1 Solar Electric (Photovoltaic)

Photovoltaic (PV) cells are semi-conducting materials constructed in panels that convert sunlight into DC electricity. They can be fitted in an array on roofs, walls, or integrated into the building fabric. They are typically installed facing South or Southeast to maximise exposure and therefore their energy output.
Several PV cell technologies are available in a range of efficiency rates and capital costs. Conversion efficiencies from solar to electrical energy usually vary between 7% and 22% and are cell type dependant.
Typically, each PV panel has dimensions in the region of 0.5 to 1.5 $m^2$ with peak output of circa 70 to 350 Watts.
When proposed with heat pump systems, PV panels offset the heat pump electricity consumption.

#### 7.4.2 Battery Storage

Battery storage systems allow energy to be captured when it is readily available and stored until it is required. These systems are typically integrated with renewable energy systems, as they obviate the requirement for matching energy consumption loads with energy generation.
This technology not only streamlines the process of energy generation via localised consumption such as reduction in transmission losses, but also enables the viability of renewable systems to geographical areas that are not linked to the national grid.

#### 7.4.3 Biomass

Biomass is a renewable energy source generated from burning plants, wood, and other organic matter. As it burns, it releases $CO_2$, but the emissions are considerably less when compared to fossil fuels. In addition, when the fuel is wood based, the amount of carbon dioxide emitted is said to be equal to that absorbed during the growth of a tree.
Biomass heating systems, therefore, burn wood pellets, chips, or logs to power central heating and hot water boilers.
Biomass boilers can be slow to heat up and slow to cool down and for this reason a buffer vessel is usually required to allow for heat up and cool down periods. Furthermore, most biomass boilers need to operate at temperatures higher than 60°C to avoid condensation and consequent corrosion due to the moisture content of the organic materials used.

## 7.5 Energy Networks

Energy networks consist of a centralised source delivering heating or cooling to a number of buildings. They are one of the most cost-effective ways of reducing carbon emissions from heating and cooling, and their efficiency and carbon-saving potential increase as they expand and connect to each other.
Three energy network options are described below.

#### 7.5.1 Ambient Loop Network

An ambient loop network consists of a two-pipe system circulating water at the temperature of waste heat recovery sources, with heat pumps and thermal storage located at each building or cluster of buildings, each of which would be served by a hot network.

#### 7.5.2 Low Temperature Network

In this case, the network comprises a two-stage temperature lift. It is similar to the ambient loop network, except for the fact that additional heat pump(s) and thermal storage carry out the first stage temperature lift at the energy source(s).

#### 7.5.3 4th Generation Hot Network

A 4th generation hot network consists of a single stage temperature lift at the energy source(s) using heat pump(s) and thermal storage, with heat distribution at the temperatures required for the buildings.

## 7.6 Off-site Connections

Connection to existing adjacent heat networks to reduce carbon emissions from heating and cooling, as energy networks efficiency and carbon-saving potential increase as they expand and connect to each other.

## 7.7 Heat Recovery

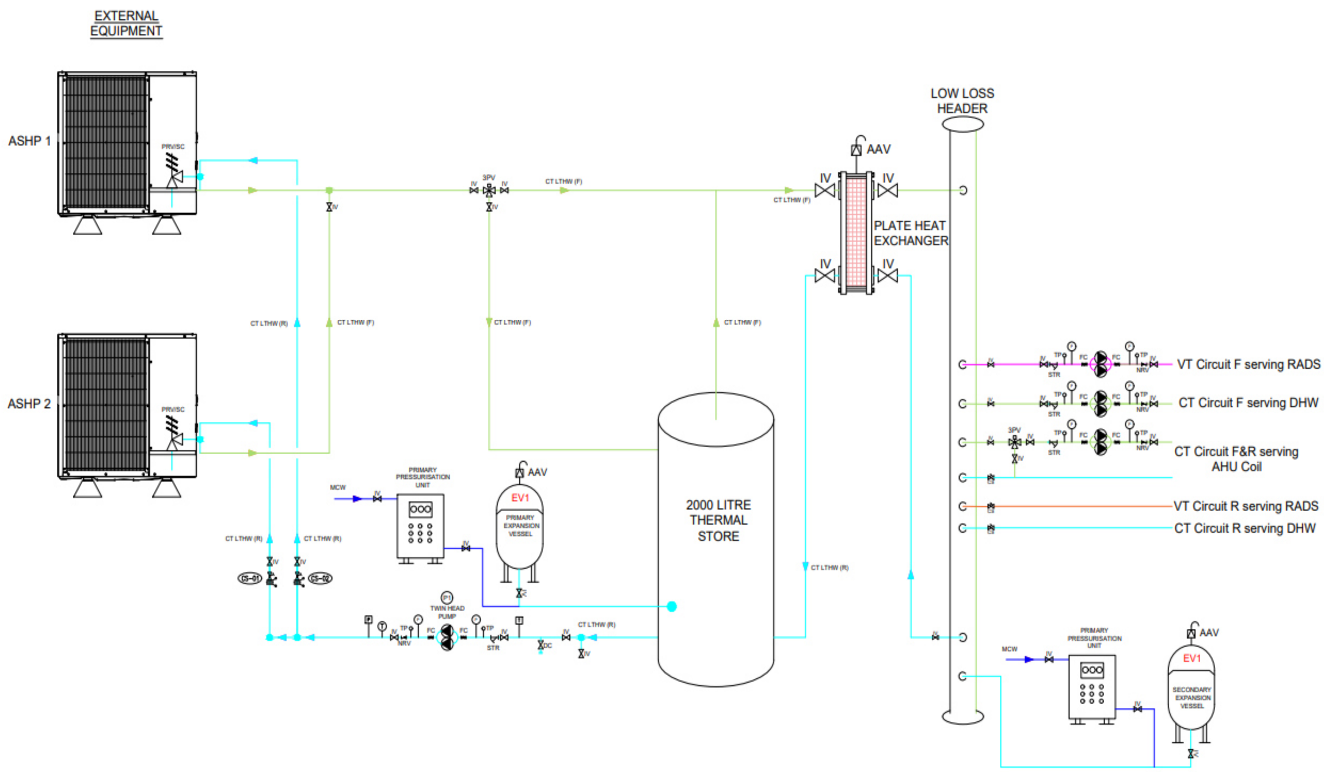
Heat recovery is the use of waste heat from a process to be used in another process. There are many sources of waste heat such as heat recovery from cooling systems and sewers.

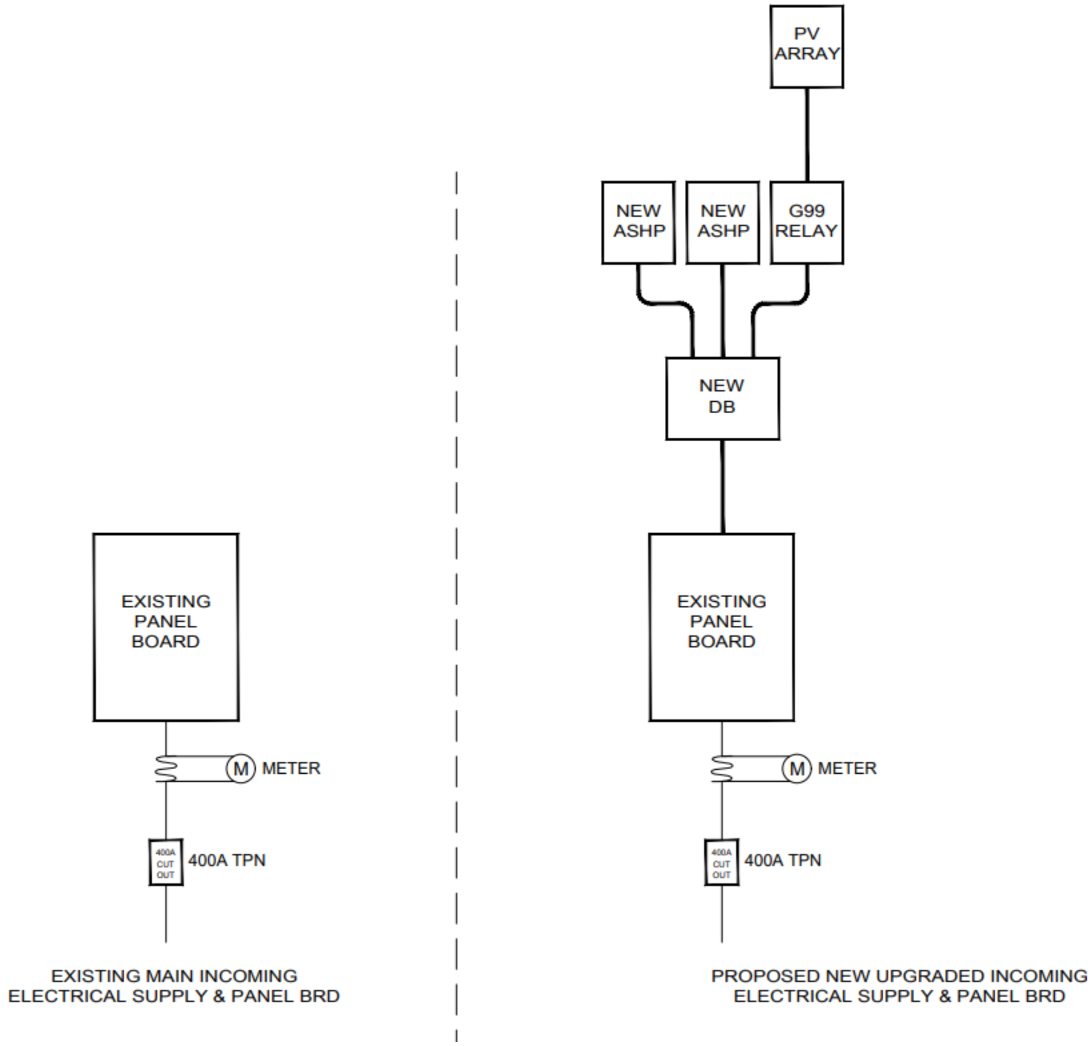
# Appendix D – Schedule of Assumptions

| Global model assumptions | | |
|---|---|---|
| **Tariff (£)** | | |
| Gas tariff | 0.1076 | Rolling 6-month average from April to Sep 22 |
| Electricity tariff | 0.35 | Rolling 6-month average from April to Sep 22 |
| **Carbon Factors (kg CO2e/kWh)** | | |
| Gas | 0.183 | |
| Electricity | 0.149 | |
| **Building Fabric** | | |
| Preheat margin | 25% | |
| Thermal Bridging addition to fabric loss | 20% | |
| External design temperature (°C) | -4.0 | |
| **Domestic Hot Water (°C)** | | |
| DHW storage temperature | 65 | |
| Cold water inlet temperature | 10 | |
| DHW storage ΔT | 55 | |

# Appendix E – Concept Design Schematics

## PIER HEAD TICKET OFFICE
## PROPOSED HEATING SCHEMATIC




PV ARRAY
NEW ASHP
NEW ASHP
G99 RELAY
NEW DB
EXISTING PANEL BOARD
M METER
400A CUT OUT
400A TPN
EXISTING MAIN INCOMING ELECTRICAL SUPPLY & PANEL BRD
EXISTING PANEL BOARD
M METER
400A CUT OUT
400A TPN
PROPOSED NEW UPGRADED INCOMING ELECTRICAL SUPPLY & PANEL BRD