Metropolitan Police Service
Bexleyheath Police Station Zero Carbon Report

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hamilton ARCHITECTS

Quality Information

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Contents

1. Executive Summary

The existing gas-fired boilers of Bexleyheath Police Station have reached the end of their economic life and are now due replacement. On-site surveys and record information have identified that the existing gas-fired boilers are now in their 13th year of service. Operational requirements of the building have meant that these boilers are available for use 24 hours a day, 365 days a year, resulting in runhours which may be 1.5-2 times greater than a standard installation. CIBSE Guide M suggests an economic life for the installed plant of 15-20 years; however this is based on typical installations with standard runhours. When factoring the extended runhours of Bexleyheath's boilers, the 'equivalent operational runhours' age of the boilers may be closer to 26 years for reference against CIBSE Guide M, which would place these at the end of their operational life.

Options have been explored for replacing this plant with new, with proposals including like-for-like replacement of the existing gas-fired boiler plant and associated equipment and also proposals for decarbonising the heating system by replacing the existing gas-fired heating plant with electric heat pumps.

Thermal modelling software and a review of gas meter records covering the past five years have been used to establish the anticipated heating demand of the building, which has demonstrated that the existing heating plant capacity of 951 kW could be reduced to 400 kW. By using a green energy tariff for electricity with an effective carbon factor of zero due to the use of renewable energy sources, the carbon emissions associated with the heat pump heating system become zero, therefore decarbonising Bexleyheath's heating system, saving approximately 124 tonnes of carbon dioxide per annum based on current carbon emissions.

A study has also been carried out into options for upgrading the existing thermal envelope of Bexleyheath Police Station, which has concluded that the most viable option is to install triple glazing to all windows of the building. Thermal modelling has indicated that this measure could reduce the required heating plant capacity for the building by almost 7% and yield 11% savings heating energy. Given this modest saving, it has been deemed that fabric improvements are not the most cost effective option to be pursued. Analysis has also indicated that whilst the heat pump solution can reduce carbon emissions to zero, the SCOPs achieved cannot fully overcome the difference between electricity and gas unit prices, with the heat pump solution resulting in a 9.6% fuel running cost increase based on current prices. As future electricity and gas prices change, there is a possibility that the 'spark gap' will reduce (difference between gas and electricity prices) bringing the heat pump running costs down relative to gas-fired plant. This analysis does not include ongoing maintenance costs, which may be less for the heat pump solution.

The report also includes proposals for installing electric vehicle charging points in the car park of Bexleyheath Police Station to effectively decarbonise the vehicle fleet associated with operations at the station. Lighting upgrades from existing fluorescent luminaires to LED technology with automatic controls have also been proposed in order to improve energy efficiency and reduce carbon emissions associated with the lighting installation. The implications of installing EV charging and electric heat pumps to serve the building's heating system has been studied and proposals are included for upgrades to the building's electricity supplies and electrical infrastructure to support this.

2. Introduction

Hamilton Architects were appointed in April to carry out a Net Zero Carbon Feasibility for Bexleyheath Police Station. The building was constructed in the mid 1990's and the fabric is generally original with double glazed metal framed windows, original clay brick, zinc cladding and a combination of flat and standing seam roofs.

3. Existing Heating System

Bexleyheath Police Station is currently heated using gas-fired low temperature hot water (LTHW) boiler plant located in a ground floor plant room within the building.

Within the boiler plant room there are three boilers:

- 1nr Remeha P420/8 sectional forced draught boiler, Riello dual fuel burner – rated output 390 kW
- 1nr Remeha Gas 310 ECO atmospheric gas fired boiler – rated output 395 kW
- 1nr Remeha Gas 210 ECO PRO – 160 atmospheric gas fired boiler – rated output 166 kW

This gives a total installed LTHW boiler heating capacity of 951 kW. It has been reported that the building includes a 112 kWth combined heat and power (CHP) unit and whilst a flue from this unit was visible during the survey, access was unable to be provided to review the CHP installation. It is assumed that the boiler installation has been sized to suitably operate and meet the building demand in absence of operation of the CHP unit.

Existing Bexleyheath LTHW dual fuel boiler

Limited record information is available of the original design and as such it is not known how much of the installed heating capacity was originally intended as 'spare' capacity over and above the anticipated maximum demand of the building, however it is typical of an installation such as this that there is a minimum of 20% spare capacity, which would suggest a design heating capacity in the region of 793 kW and 159 kW as 20% spare. It is also reported that the smaller 166 kW boiler is a 'summer' boiler, used to operate to serve the domestic hot water (DHW) calorifier without having to operate the larger duty boilers which are well in excess of the DHW primary heating demand.

Based on information received and review of the installations, the existing LTHW system appears to have been designed to operate with a boiler flow temperature of 80°C and a flow and return temperature drop (delta T) of 20°C, ie. 80/60°C F/R. The boiler's primary circulation system was observed to operate at a gauge pressure of 1.6-2.0 bar.

Whilst it is evident that much of the boiler plant dates from the original installation over 25 years ago in the mid 1990's, manufacturer data from the nameplates of the boilers indicate that the original boiler plant was installed in 2009 as such the boiler plant has been in operation for 13 years. The boiler plant appears to have been well maintained over its operational life. As stated in CIBSE Guide M (2014) 'Maintenance engineering and management', the indicated economic life expectancy of boilers such as those installed in Bexleyheath is 20 years, whilst the life expectancy of the dual fuel forced draught burner is 15 years. CIBSE Guide M's economic life is defined as 'the estimated number of years until that item no longer represents the least expensive method of performing its function'. This will come from a combination of factors such as loss of efficiency, material wear & tear / deterioration, increased servicing requirements, need for replacement components, reduced availability of spares and implications of equipment breakdowns or service downtime. The CIBSE Guide M economic life will assume a standardised set of conditions, and in particular typical runhours, which may be expected of a standard installation such as an office or school which may have usage to support nominal '9am – 5pm' operation. A key distinction for Bexleyheath Police Station is that there is operation of some of the building for 24 hours a day, 365 days a year. It is estimated that this will result in plant runhours which may be 1.5-2 times as many as a typical installation. When factoring this in for Bexleyheath, the 'equivalent operational runhours' age of the boilers may be closer to 26 years for reference against CIBSE Guide M, which would place these at the end of their operational life.

Existing boiler indicating year of manufacture 2009

The LTHW system comprises a primary LTHW loop around the boilers, with each boiler featuring a dedicated shunt pump. From the primary loop, several secondary distribution circuits are taken, divided into several separate zones / functions:

- Variable temperature north
- Variable temperature south
- Constant temperature (general)
- Constant temperature serving primary domestic hot water (calorifier)

The domestic hot water system comprising of two calorifiers also included a DHW return pump on the secondary circulation system.

The majority of circulation pumps within the plant room appear to predate the existing boilers and perhaps date back to the original installation in mid 1990's. It appears that replacements have been made to pumps on a case-by-case basis, perhaps has reactive maintenance requirements demand, with several pumps installed as recently as 2020. One pump had been removed from service and the pipework capped off on the LTHW circuit serving the DHW calorifier, leaving a single duty pump here without a standby pump.

Existing secondary LTHW pumps (left), showing nameplate of one of the existing pumps (right)

Image of a more recent replacement pump installed in 2020

Within the building, heat is delivered to spaces primarily by radiators / fan convectors, with air heating via a ventilation system serving the custody suite.

Domestic hot water (DHW) for the building is generated centrally within the boiler plant room using two 700 litre calorifiers. Record information for these calorifiers was not available at the time of survey. For the purpose of further analysis, it is assumed that the calorifiers offer 30 minute recovery to a storage temperature of 60°C, which would require a heat input of 82 kW each, or 164 kW total, which would align with the size of the Boiler 3 'summer boiler' capacity. Anecdotal reports indicate that one of these calorifiers has been isolated as demand can be met by a single calorifier.

Domestic hot water calorifiers

The following is a summary of the CIBSE Guide M economic life expectancy of other equipment forming part of the existing boiler plant room installation at Bexleyheath, which demonstrate that the majority of the installation, installed over 25 years ago, has reached the end its economic life:

Equipment	CIBSE Guide M Economic Life (Years)	Estimated Plant Age (Years)	Status
Boilers	20	13	End of economic life when considering the 'equivalent operational runhours' age of the boilers may be closer to 26 years
Burners	15	13	End of economic life when considering the 'equivalent operational runhours' age of the burners may be closer to 26 years
Flues	30-40	27	End of economic life when considering the 'equivalent operational runhours' age of the flues may be closer to 52 years
Steel Pipework	25-35	27	End of economic life range reached
Valves	25	27	End of economic life
Circulation Pumps	20	2-27	Majority of pumps at end of economic life, particularly when factoring for 'equivalent operational runhours'
DHW Calorifier	20	27	End of economic life
BMS Motor Control Centre / Outstation	10-15	27	End of economic life

Within the boiler plant room, all equipment appears to date back to the original mid 1990's installation with the exception of the following:

- Boilers
- General maintenance replacements, including planned preventative maintenance consumable item replacement.
- Reactive maintenance replacements – this was observed to include several pumps

4. Like-for-like Heating Plant Replacement

The scope of this report includes a review of the feasibility and options for a ‘like-for-like’ replacement of the existing LTHW boiler plant, which would see the existing gas-fired boilers replaced with similar gas-fired boilers and the replacement of other existing ancillary equipment such as pumps, pressurisation unit, expansion vessels, flues, pipelines, valves and other ancillaries.

The scope of this work for the main boiler plant is summarised as follows:

- Enabling works such as site setup & opening up access routes for removal & delivery of equipment to/from plant room.
- Measurement of existing site LTHW system parameters including temperatures, pressures, flow rates etc.
- Measurement of existing site DHW system parameters.
- Strip out existing boilers, pumps, feed and expansion tank.
- Up to the plant room boundary, strip out existing pipework, flues, valves, ancillaries and supports.
- Modify existing concrete plant bases to suit proposed new equipment. Apply robust paint finish to floor.
- Supply & installation of new ultra-low NOx, efficient gas-fired boilers & burners to match existing heating capacity and operating parameters.
- Supply & installation of new boiler flues, including flue rising through upwards building (subject to flue specialist verification).
- Supply & installation of new gas pipework and associated valves, gas controls and ancillaries. Reconnection of oil supply to dual fuel boiler.
- Supply & installation of circulation pumps.
- Supply & installation of new pressurisation system and connection to mains water supply.
- Supply & installation of new LTHW pipework, valves and ancillaries.
- Supply & installation all thermal insulation & robust cladding finish.
- Supply & installation of BMS outstation and motor control centre.
- Electrical works associated with mechanical installations, to include new power supplies, controls wiring and lighting modification to suit new plant configuration.
- Commissioning & setting to work of all of the above.
- Provision of training, demonstrations, record drawings and operation and maintenance manuals.

4.1 Estimated Costs

Estimated costs for these elements of work are included in the Outline Cost Plan found in the appendices of this report and summarised in the Conclusion.

5. Whole Building Approach to Decarbonisation

5.1 Introduction

Dramatic reductions of carbon dioxide (CO2) and other greenhouse gas emissions are required to prevent damaging impacts of Climate Change. This requires an energy transition from high carbon intensity fuels to low or zero carbon energy systems.

Decarbonisation is the strategy employed to achieve a reduction in fossil fuels that have high carbon factors by increasing the use of low carbon energy sources and renewable energy technologies. This feasibility study aims to provide a road map to inform the Metropolitan Police's decision making process and their investment planning programme in meeting their low carbon heat aspiration.

The road map to heat decarbonisation has reviewed options for the replacement of the existing fossil fuel (gas-fired) heating plant with new technologies such as heat pumps and renewable energy systems.

When considering replacement technologies such as heat pumps, it is important that this is reviewed in a context wider than simply replacing the existing building's fossil fuel boilers with a matching capacity of heat pumps or other renewable energy systems. This is important for a variety of reasons, including the saving in heating energy that can be gained via long life passive measures such as fabric upgrades; the additional capital cost of replacement technologies relative to traditional fossil fuel options; and ensuring that the replacement technologies can operate with the best possible efficiency by closely matching capacity to demand.

5.2 Context

5.2.1 UK / World response to Carbon Targets

Energy policy in the UK is the responsibility of the Department for Business, Energy and Industrial Strategy (BEIS). Although there are numerous regulators for specific parts of the energy sector, much of the energy market is regulated by OFGEM.

Historically, parts of energy generation, transportation, and supply were run by the public sector. Most of the market is now privatised; generation and supply are competitive, and transportation through networks is regulated as the operators are monopolies.

The Government and OFGEM continue to regulate the market for customers and deliver policy to meet the Government's aims on energy.

The energy policy of successive Governments has centred around three objectives of security, affordability, and decarbonisation. Last year, the Conference of Parties [CoP 26] took place in the UK, where 196 countries plus representations from the European Union discussed and supported the United Nations Climate change convention. Commitments to reducing carbon emissions have been restated and reinforced.

5.2.2 Climate Change Act

The Climate Change Act 2008 established long term statutory targets for the UK to achieve an 80% reduction in greenhouse gas emissions by 2050 against a 1990 baseline. In 2019, the target was changed to at least a 100% reduction of greenhouse gas emissions relative to 1990, otherwise known as a net zero target.

5.2.3 The 2050 NZC targets

The UK is set to vigorously pursue ambitious targets to reduce Greenhouse Gas Emissions (GHGs) to 'net-zero' by 2050, ending the UK's contribution to global warming within 30 years. To ensure parity Scotland will need to set a net-zero GHG target for 2045 and Wales will need to target a 95% reduction by 2050 relative to 1990 base levels.

A net-zero GHG target for 2050 will deliver on the commitment that the UK made by signing the Paris Climate Agreement. It is achievable with known technologies, alongside improvements in people's lives, and within the expected economic cost that Parliament accepted when it legislated the existing 2050 target for an 80% reduction from 1990. This is only possible if clear, stable, and well-designed policies to reduce emissions further are introduced across the economy without delay, as current policy is insufficient for even the existing targets.

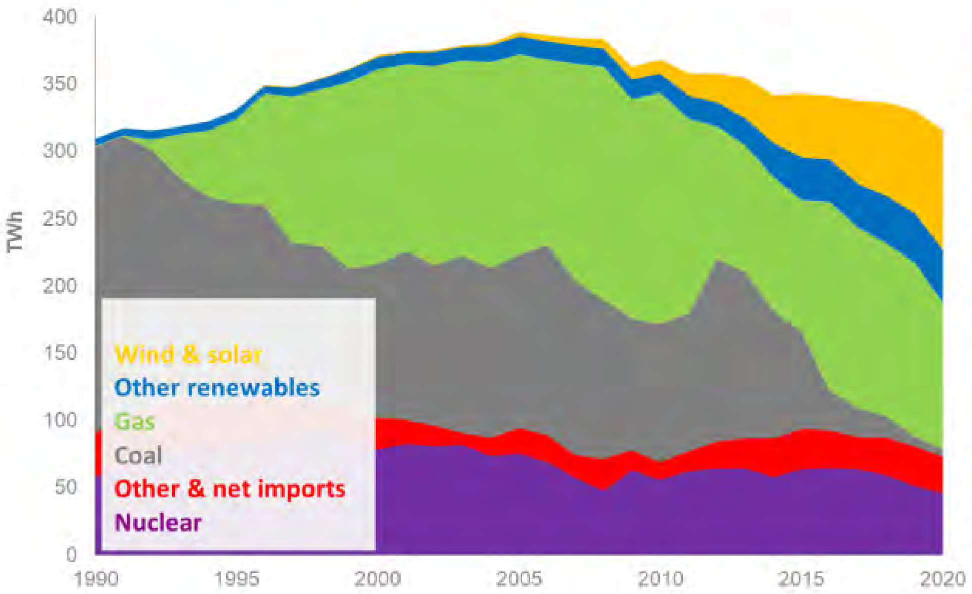
A net-zero GHG target for 2050 would respond to the latest climate science and fully meet the UK's obligations under the Paris Climate Agreement, and fundamentally goes beyond the reduction needed globally to hold the expected rise in global average temperature to well below 2°C and beyond the Paris Agreement's goal to achieve a balance between global sources and sinks of greenhouse gas emissions in the second half of the century.

The House of Commons in 2019 made a UK Declaration to the Climate Emergency compelling the government to act. Subsequently April 2021 the UK set the world's most ambitious Climate Change target to cut emissions by 78% by 2035 compared to 1990 levels. This forms part of the 6th carbon budget and incorporates the UK's share of international aviation and shipping emissions, bringing the UK more than 75% of the way to NZC by 2050. With this in mind, there is an industry drive in all sectors to decarbonise by 2050.

5.2.4 Influence of the Green Grid

The ongoing decarbonisation of the electricity grid and the increase in renewable technologies is expected to lower the carbon factor of electricity to a value closer to that of natural gas. The clean grid is seen as a pivotal factor in the cultural use of fossil and petroleum fuels as they are large contributors of nitrous oxides (NOx) and other particulates. It is anticipated that dependency on these fuels will substantially reduce and that clean electricity will be used to provide heating through heat pump and fuel cell technologies.

The introduction of electric vehicles will increase the demand upon the electrical grid but will reduce air pollution and improve air quality within our towns and cities.



National Grid fuel mix, UK Energy in Brief 2021

5.3 Proposed Fabric Upgrades & Rationale

The building was constructed in the mid 1990's and the fabric is generally original with double glazed metal framed windows, original clay brick, zinc cladding and a combination of flat and standing seam roofs.

It was felt the most effective potential improvement to the building fabric would be the replacement of the existing double glazed windows with new triple glazed aluminium framed windows and this has been considered, as an option, as part of the thermal modelling outputs. The existing windows are generally in good condition. The provision of the new windows will increase the thermal performance of the building and also have some benefits to thermal comfort levels in the station.

5.4 Mechanical Services Improvements

Replacement of the existing fossil fuel heating system is discussed in further detail in the next section of the report. This section looks at other potential improvements to the current mechanical services installations to yield energy and carbon saving opportunities. These currently sit outside of the scope of this report, but further investigations around these proposals are recommended in a future phase of works or under within the scope of other investigations.

5.4.1 Review of secondary LTHW heating distribution hydraulics

It has been observed during building survey that the LTHW return temperature to the boiler is elevated above the design return temperature. The efficiency of gas boilers is improved when the design return temperature, or as close to this as possible, can be consistently returned to the boiler.

When considering alternative heating systems such as heat pumps, the return temperature becomes even more important as the return temperature will have a direct impact on the coefficient of performance (COP) of the heat pump, its measure of efficiency. The efficiency of a heat pump tends to more sensitive to elevated return temperatures than gas-fired boilers. When considering the retrofit of a heat pump to replace gas-fired boiler plant, it would be considered vital that the hydraulic arrangement of the associated LTHW distribution system is optimised.

Many older LTHW distribution circuits, such as that which is in Bexleyheath, include hydraulic elements such as 3-port diverting valves, low loss headers and fixed speed pumps. These elements can act to redirect LTHW flow water back to the return, resulting in elevated return temperatures, particularly during periods of low heating demand.

It is suggested that further investigation and optimisation of the heating system hydraulics is carried out to yield efficiency improvements, regardless of final heating plant selection.

5.4.2 Review zoning, periods of operation and control of heating systems

The existing mechanical installations for the heating system include the following zoning measures:

- Systems split based on the elevation of the building (north and south circuits)
- Variable temperature weather compensation of radiator LTHW circuits
- BMS time schedule controlling operation of zones

The provisions already in place are good but there is an opportunity to improve on these.

- It is important that the activation of various systems is linked to demand to that circuits are not activated when not required. This could mean verifying time schedules to ensure that match periods of occupancy. Consideration could be given to local ‘overtime’ switches to activate heating outside of normal operating hours.
- Verification of variable temperature weather compensation on radiator / fan convector circuits to establish if there are any opportunities to further reduce the required flow & return temperatures.
- Review opportunities for introducing weather compensation to the AHU ‘constant temperature’ circuits.
- Consider the use of combined ‘dynamic balancing’ thermostatic radiator valves which provide regular thermostatic control of radiators, along with the ability to control to the fixed design flow rate regardless of changes in differential pressure in the system. This will prevent elevated flows through radiators (and therefore elevated return temperatures) when adjacent radiators on the same circuit close.

5.4.3 Review building ventilation

The existing building is currently predominantly naturally ventilated using manually operated windows. Whilst this method of ventilation is effective and doesn’t have any associated fan energy, there is also no possibility for heat recovery.

Consideration could be given into further feasibility of a heat recovery ventilation system in order to recover heat from exhausted stale air to use in heating up incoming fresh air, thereby recovering up to 80-85% of the energy and significantly reducing the ventilation heating loads.

5.4.4 Heat metering

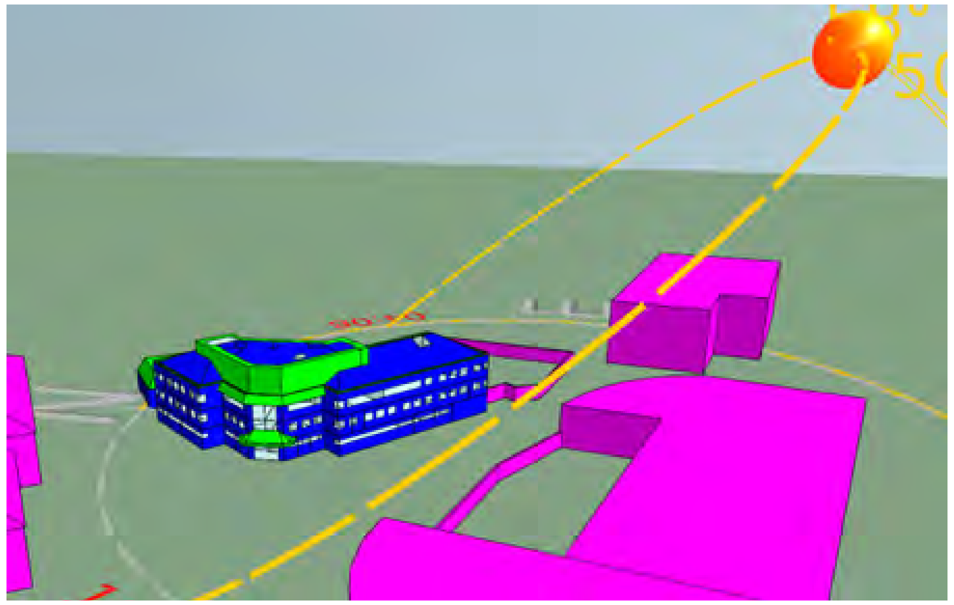
Gas meter records are useful for generating a picture of how the existing heating system operates at a coarse macro level. Consideration could be given to adding heat metering of individual heat circuits, such as the various secondary LTHW circuits of Bexleyheath, to help provide enhanced definition of the operation of the heating system. Such metering could be temporarily or permanently installed, although for maximum benefit it should be installed during peak winter conditions when the heating system is operating close to maximum capacity – dependent upon the timing of future works on the heating system of Bexleyheath, this may be of limited benefit for the purposes of informing this design.

6. Thermal Modelling

6.1 Introduction

A software thermal model of Bexleyheath Police Station has been produced to better understand and analyse the thermal and energy characteristics of the building and permit various energy saving measures to be tested to assess their impact.

IES Virtual Environment 2021 has been used to produce the thermal model. This software is CIBSE AM11 'Building Performance Modelling' compliant and the model has been built according to the principles of this guidance. The image below presents an illustration of how the building is represented within the software.



IES thermal modelling representation of Bexleyheath Police Station

6.2 Model Inputs

6.2.1 Geometry

Record floor plans, Autodesk Revit models and site survey information has been used to produce a geometrically accurate representation of the building within the software, including building features such as external buildings and walls which may have a solar shading effect on the building.

The virtual model of the building shares the same approximate dimensions as the actual building for everything from room dimensions, floor to floor heights to window sizes.

The software model is set in the same context as the actual building and is set to be located in London, with the building's orientation on the site set relative to true north. This is important, as the thermal model can accurately model the interaction of the sun and solar heat gains day to day and season by season. The previous image includes a sun path diagram showing the path the sun takes relative to building on a given day, in this case mid-May.

6.2.2 Building Fabric

Unfortunately record information relating to building fabric thermal performance is not available. Assumptions have been on the thermal fabric performance based on typical construction practices at the time the building was built and using best estimate from what was viewed during the survey.

Two separate thermal models have been produced, one to capture the existing building as it is assumed to be now, and a further model to analyse the effects of the architectural fabric improvements discussed in further detail in the Building Fabric Upgrades section of this report.

The following table indicates the thermal parameters which have been applied to the model for the current building and the proposed building following fabric upgrades.

Exposed Element	Existing Building	Proposed Fabric Improvement Option
	U-Value (W/m²K)	
Roofs	0.25	0.25
External walls	0.45	0.45
Exposed floors and ground floors	0.45	0.45
Windows	2.8	0.8
Rooflights	2.20	2.20
Pedestrian doors	2.20	2.20
Windows g-value	0.50	0.35
Air permeability ($m^3/h/m^2$ @ 50Pa)	10.0	10.0

6.2.3 Location and Weather File

The thermal model is located London Heathrow within the software as the closest standard location, which sets the latitude and longitude parameters for the building which will have a bearing on the solar exposure of the building.

Within the software, the weather file to be used for the analyses has been set to a London Test Reference Year (TRY), which was developed to represent hour by hour weather conditions over a standardised year, based upon many years' worth of past weather information recorded at a nearby London weather station. The weather file contains data on external air temperature and humidity, wind speed and direction, solar irradiation, cloud cover etc.

6.2.4 Internal Design Criteria

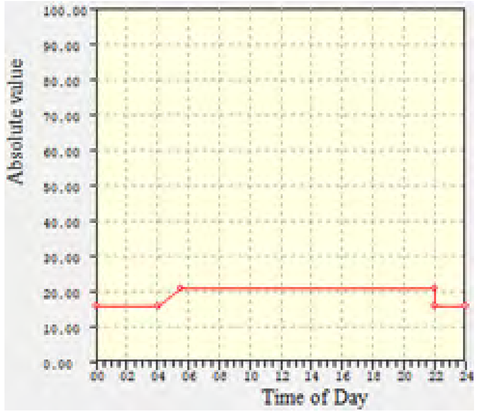
The following parameters are based upon other recent analyses, information available from surveys and standard industry guidance.

6.2.4.1 Internal Design Temperatures

Area/ Room	Min Winter Temperature °C	Max Summer Temperature °C
Offices Areas, Meeting Rooms	21	25
Circulation Areas, WCs	18	Uncontrolled
Stores	18	Uncontrolled
Risers, Plant Areas	Uncontrolled	Uncontrolled

Variation Profile

The following profile has been adopted to simulate the activation of the heating in various areas of the building according to a time schedule. Activation and deactivation times have been derived from changes in load recorded on historical gas meter half hourly readings, indicating activation and deactivation of the heating system. The below example shows the profile for office areas, indicating a 16°C minimum setback temperature, although under most conditions the room temperature would not fall to this level following heating system deactivation.



6.2.4.2 Fresh Air

Parameter	Minimum Flow	Notes
Fresh Air	12 l/s/person	No heat recovery applied to reflect existing building Assumed capacity varies according to changes in occupancy level, as occupants manually operate windows to suit requirements.

Variation Profile

The variation profile for fresh air follows a modulating pattern tracking the building occupancy, using a modulating value within the software, where a value of 1.0 denotes maximum ventilation supply and 0.0 denotes no ventilation. The system will provide 12 l/s/person based on the total number of people in a room at a given time according to the variation profiles shown in the next sub-section.

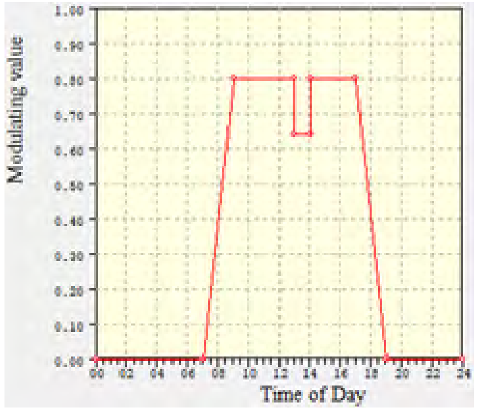
6.2.4.3 Internal Heat Gains

Parameter	Heat Gain	Notes
People (Office / Meeting Areas)	80 W/person (sensible) 50 W/person (latent) Floorplate density 24m²/person	Floorplate density is elevated (from 10 m²/person) to take account of the average occupancy when factoring in meeting areas and other portions of the office spaces such as kitchenettes, reprographics areas which do not have seated occupants and some diversity in day-to-day occupancy levels
Equipment (Office / Meeting Areas)	150 W/person	Allowance of average for computer, monitors, printers etc.
Lighting (Offices & General Areas)	8 W/m²	Mixture of fitting types

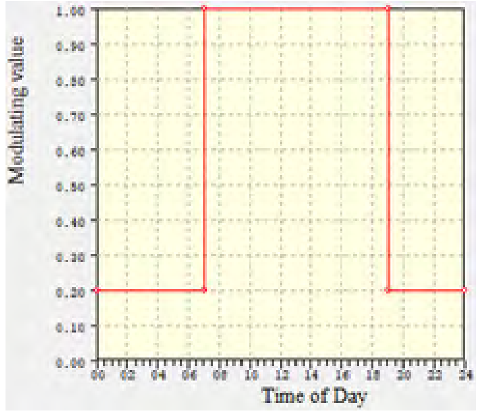
When seeking to calibrate the thermal model against historical gas loads, it was noted that the internal heat gains had a significant bearing on the annualised gas loads calculated by the thermal model. The figures noted above were found to be good figures to be applied across the various areas to have the thermal model co-ordinate well with the historical gas load figures.

Variation Profile

The variation profile for internal gains uses a modulating value within the software, where a value of 1.0 denotes 100% of the heat gain is applied and 0.0 denotes 0% of the heat gain applied. Due to the higher level of variability of gains related to occupancy and occupant use of electrical equipment causing heat gains, these profiles tend to follow a pattern of increasing in the morning as more people arrive to the office and declining in the evening as people leave the office, with a brief dip around lunchtime as some occupants leave the building. It is acknowledged that these profiles are not a perfect match for the operation of the building (eg. there is a level of occupancy overnight), but the profiles have been found to be approximately representative as part of the wider thermal model during calibration of the thermal model results against historic gas load information.



Occupancy and equipment modulation profile



Lighting modulation profile

6.2.4.4 External Design Temperatures

For the purposes of dynamic calculations, the external temperatures applied to the model are contained within the weather file described above. For static calculations, where the building is analysed at a single point in time with a given external temperature, the following temperature has been used. It is noted that the MOPAC design guide lists a winter design external temperature of -1°C. The below temperature has been selected to give more of a worst-case figure which is still realistic and appears to match quite well with existing heating capacities.

	Design Winter Temperature °C
External	-2.5 (saturated)

6.3 Static Heating Loads

Static heating load calculations are used to determine the heating loads of the building for a single point in time, typically under a peak winter condition when the external temperature is at a given design external temperature. The thermal models have been used to calculate static heating loads for Bexleyheath Police Station under two scenarios:

1. Existing fabric
2. Proposed fabric improvement option (as discussed in previous sections)

For the purposes of static heating loads, the models are set up to assume that there are no beneficial internal heat gains or solar gains, as this would be reflective of a potential worst case where the building is unoccupied at night during mid-winter and is required to deliver design internal conditions for the start of a working day.

For true static calculations, it is assumed that the model is in a steady state, whereby the internal and external temperatures do not change. This yields a steady state static heating load.

Most buildings do not behave in a steady state however and even if the external temperature is assumed to remain constant, the internal temperature may change due to heating being turned on to suit a temperature for occupied hours of a working day and then turned off when the building is no longer occupied. In this intermittent heating scenario, the power of the heating system needs to be greater in order to heat up the building. The software applies a factor to the steady state heating load to take account for this, with magnitude dependent upon the thermal response times of the building and how intermittent the heating actually is.

The overall building heating load which the heating plant is required to meet typically comes from a combination of the following for most buildings:

- Offsetting fabric heat losses
- Offsetting fresh air ventilation heat losses / warming incoming fresh air
- Heating of domestic hot water

Bexleyheath Police Station generates domestic hot water using the low temperature hot water (LTHW) heating system served by the existing gas-fired boiler plant. As noted in the Existing Heating System section of this report, it has been estimated that the design DHW heating load is 164 kW based upon a 30 minute reheat of the existing calorifiers.

The ventilation heat load has been calculated within the thermal model for the design winter condition. This load takes into account the design external and internal temperatures and the fresh air ventilation rate based on the space occupancy and stated rate of ventilation per person.

6.3.1 Existing Fabric

Static heating load calculations using IES Virtual Environment 2021 have yielded the following results for the existing building:

Scenario	Fabric Heating Load (kW)
Steady state	204
Intermittent heating (6am to 7pm heating)	310

As this table indicates, by extending the duration of operation of the heating system towards the 24hr steady state, the fabric heating load reduces. It also shows how sensitive the overall heating load requirement is to the level of intermittent operation.

By adding the above fabric heating loads to the domestic hot water heating load of 164 kW, gives the overall heating load to be met by the heating plant:

Scenario	Total Heating Load (kW)
Steady state	368
Intermittent heating (6am to 7pm heating)	474

The above figures would indicate that the existing gas-fired boiler heating capacity of 951 kW (plus availability of a further 112 kW from the CHP system) is oversized for the building. The figures also demonstrate the significance of the domestic hot water load on the building – in a steady state scenario the DHW load equates to 45% of the over design heating load, 35% when considering the intermittent heating scenario.

6.3.2 Proposed Fabric Improvement Option

Static heating load calculations using IES Virtual Environment 2021 have yielded the following results for the proposed fabric improvement option:

Scenario	Fabric Heating Load (kW)
Steady state	188
Intermittent heating (6am to 7pm heating)	289

6.3.3 Proposed Fabric Improvement Review

By comparing the fabric heat loads for the existing building with the fabric loads for the proposed fabric improvement option illustrates the reduction in heating plant capacity which could be expected following the proposed fabric improvements:

Scenario	Fabric Improvement Heating Load Reduction (kW)
Steady state	16 (8%)
Intermittent heating (6am to 7pm heating)	21 (7%)

A reduction in plant capacity of the magnitude indicated above would not yield a particularly significant capital saving on plant for a replacement gas-fired plant scenario; however given the higher capital cost of alternative decarbonised plant such as heat pumps, this becomes more significant.

To help put the magnitude of the potential heat load reduction into some perspective, if the objective was simply to reduce the capacity of the proposed heating plant, as discussed above if the accepted duration of operation of the heating plant was extended from say 6am – 7pm towards longer operation, the results indicate that a heating plant load reduction of up to 100 kW (33%) could be achieved. This is not to say that the duration of operation of the heating system would need to be extended at all times – the adoption of optimum start control from the BMS would permit the controls system to automatically dictate the start time of the heating system to ensure that the desired design temperature is reached for a given time.

Based upon a consideration of the reduction of plant heating capacity alone, the fabric improvements do not yield a sufficiently high impact to warrant further consideration. The following sections will consider the fabric improvements impact on ongoing heating energy use.

6.4 Dynamic Heating Analysis

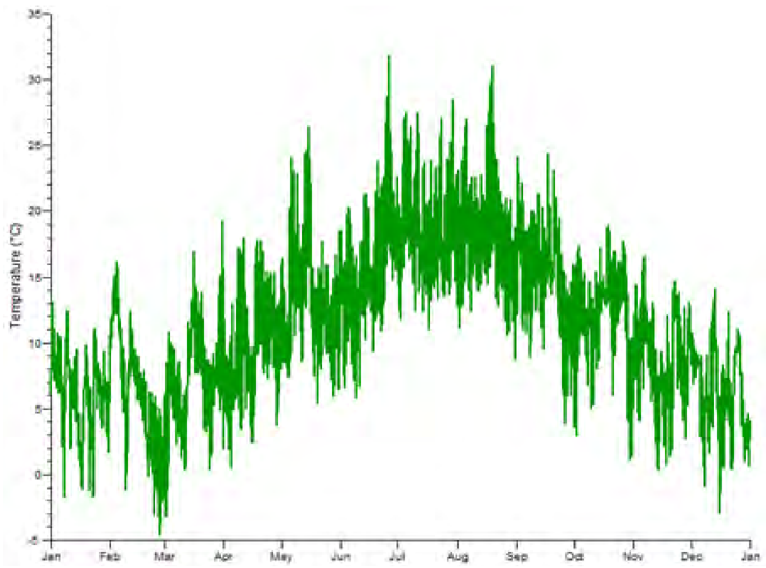
The previous section discussed static heating loads as a means to determine heating plant capacity; however, in order to analyse the performance of the system over time, particularly in relation to reviewing energy consumption and carbon emissions, requires a dynamic thermal model, also referred to as an energy or carbon model.

Using the input parameters already described, the following dynamic thermal models have been produced using IES Virtual Environment 2021:

- Existing fabric
- Proposed fabric improvement option (as discussed in previous sections)

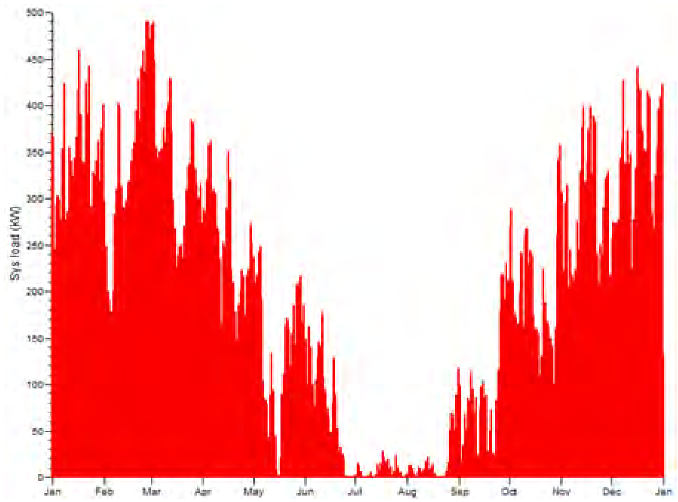
For the purposes of boiler energy and carbon emissions calculations, the existing gas-fired boiler plant is assumed to have an efficiency of 90%.

The following chart illustrates the variation of external air temperature over the course of a year using the London Test Reference Year. This temperature applies to calculations within the model which leads to the boiler heat load, energy use and carbon emissions.



6.4.1 Existing Fabric Dynamic Thermal Modelling Results

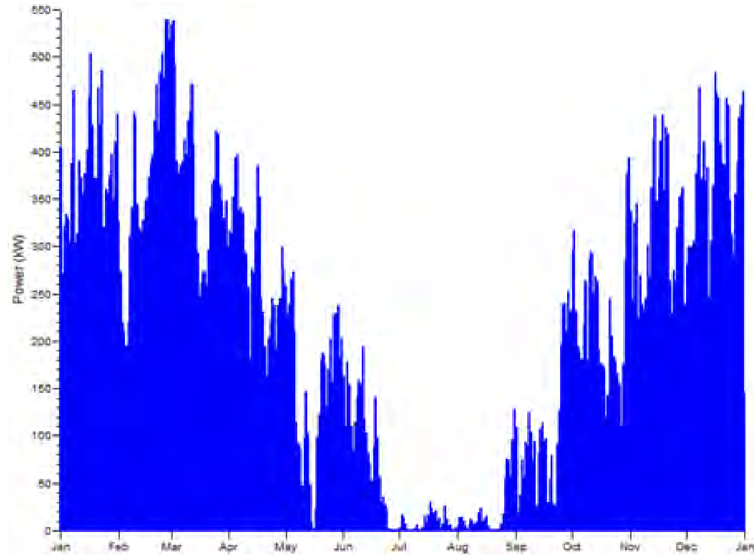
The following chart demonstrates the variation of the boiler load on an hour-by-hour basis over the course one year, excluding domestic hot water, derived from the dynamic thermal model. The table following shows the heating energy used on a month-by-month basis.



Month	Heating Energy Used (MWh)
Jan	52.5414
Feb	44.8922
Mar	44.3504
Apr	27.8082
May	12.4144
Jun	5.3236
Jul	0.5509
Aug	1.3528
Sep	7.6810
Oct	22.5416
Nov	39.5025
Dec	52.2181
Summed total	311.1771

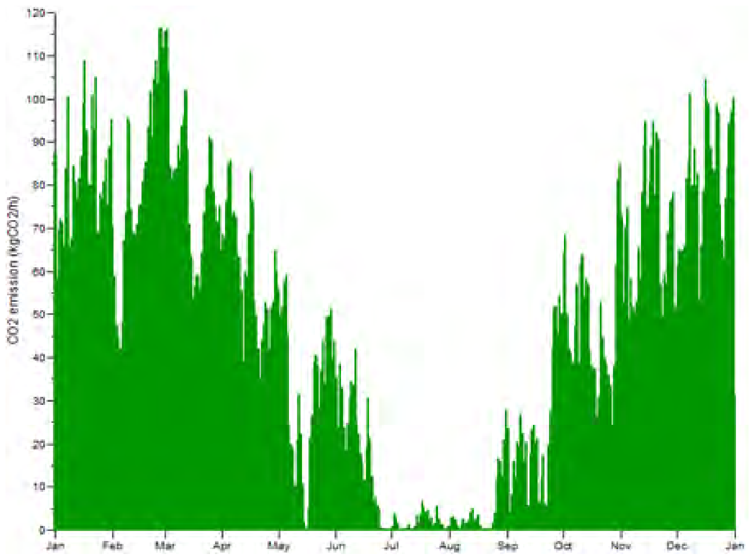
As can be seen from the graph, the heating load is most pronounced during the winter months and drops away to zero during the winter months when external temperatures rise and the heating system is no longer called upon. The chart shows a peak boiler load of approximately 500 kW in this scenario; however further analysis indicates that this is due to the thermal model attempting to heat spaces to design temperatures within a short time, resulting in a more elevated heating load.

The gas load yields a similar trend to the heating load, but the figures are larger due to the efficiency of the boiler – for every 70 kW produced by the boiler, 100 kW of gas needs to be provided. The annual gas loads are indicated below.



Month	Gas Used (MWh)
Jan	57.7378
Feb	49.3321
Mar	48.7367
Apr	30.5585
May	13.6422
Jun	5.8502
Jul	0.6054
Aug	1.4866
Sep	8.4407
Oct	24.7710
Nov	43.4093
Dec	57.3826
Summed total	341.9529

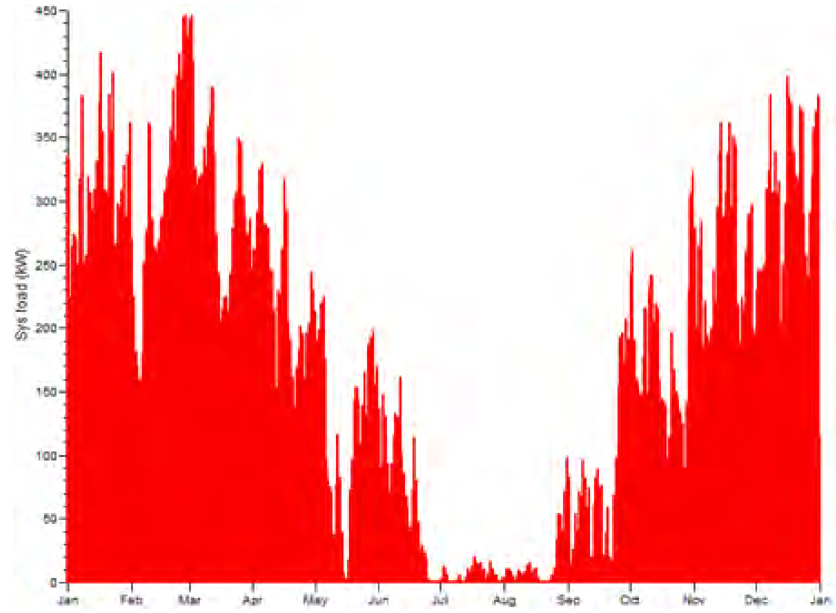
The carbon emissions from the heating plant, is as indicated below and directly correlates with the heating and gas loads.



Month	Heating Carbon Emissions (kgCO_2)
Jan	11,719
Feb	10,013
Mar	9,892
Apr	6,202
May	2,769
Jun	1,187
Jul	123
Aug	302
Sep	1,713
Oct	5,028
Nov	8,811
Dec	11,647
Summed total	69,406

6.4.2 Proposed Fabric Improvement Option Dynamic Thermal Modelling Results

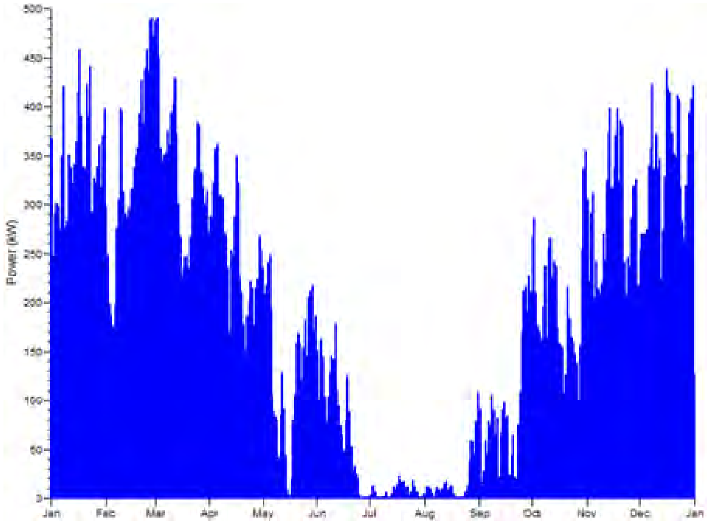
The following chart demonstrates the variation of the boiler load on an hour-by-hour basis over the course one year, excluding domestic hot water, derived from the dynamic thermal model. The table following shows the heating energy used on a month-by-month basis for the fabric improvement option including the existing fabric results for comparison.



Month	Heating Energy Used (MWh)	
	Existing Fabric	Fabric Improvement Option
Jan	52.5414	46.4372
Feb	44.8922	39.8652
Mar	44.3504	39.9714
Apr	27.8082	25.3231
May	12.4144	11.3753
Jun	5.3236	5.0611
Jul	0.5509	0.5108
Aug	1.3528	1.1665
Sep	7.6810	6.7174
Oct	22.5416	19.7968
Nov	39.5025	34.7752
Dec	52.2181	46.0100
Summed total	311.1771 (Base case)	277.0101 (Base - 11.0%)

With reference to the heating energy used table, it can be seen that the fabric improvements indicate an 11% improvement in energy consumption required to heat the building for one year.

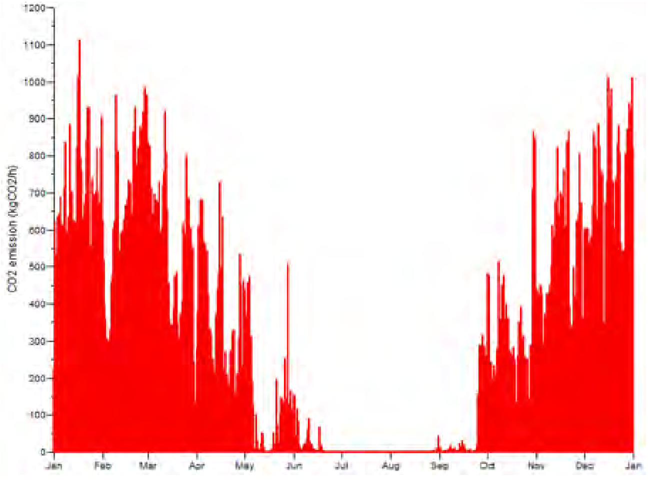
The gas load yields a similar trend to the heating load, but the figures are larger due to the efficiency of the boiler – for every 90 kW produced by the boiler, 100 kW of gas needs to be provided. The annual gas loads are indicated below.



Month	Gas Used (MWh)	
	Existing Fabric	Fabric Improvement Option
Jan	57.7378	51.0298
Feb	49.3321	43.8079
Mar	48.7367	43.9246
Apr	30.5585	27.8276
May	13.6422	12.5004
Jun	5.8502	5.5617
Jul	0.6054	0.5613
Aug	1.4866	1.2819
Sep	8.4407	7.3817
Oct	24.7710	21.7547
Nov	43.4093	38.2145
Dec	57.3826	50.5605
Summed total	341.9529 (Base case)	304.4066 (Base - 11.0%)

With reference to the gas energy used table, it can be seen that the fabric improvements indicate an 11% improvement in gas consumption required to heat the building for one year.

The carbon emissions from the heating plant, is as indicated below and directly correlates with the heating load. The table shows the carbon emissions on a month-by-month basis for the fabric improvement option including the existing fabric results for comparison.



Month	Heating Carbon Emissions ($kgCO_2$)	
	Existing Fabric	Fabric Improvement Option
Jan	11,719	10,358
Feb	10,013	8,892
Mar	9,892	8,915
Apr	6,202	5,648
May	2,769	2,537
Jun	1,187	1,129
Jul	123	114
Aug	302	260
Sep	1,713	1,498
Oct	5,028	4,416
Nov	8,811	7,756
Dec	11,647	10,262
Summed total	69,406 (Base case)	61,785 (Base - 11.0%)

With reference to the table above, it can be seen that the fabric improvements also indicate an 11% improvement in carbon emissions resulting from heating the building for one year.

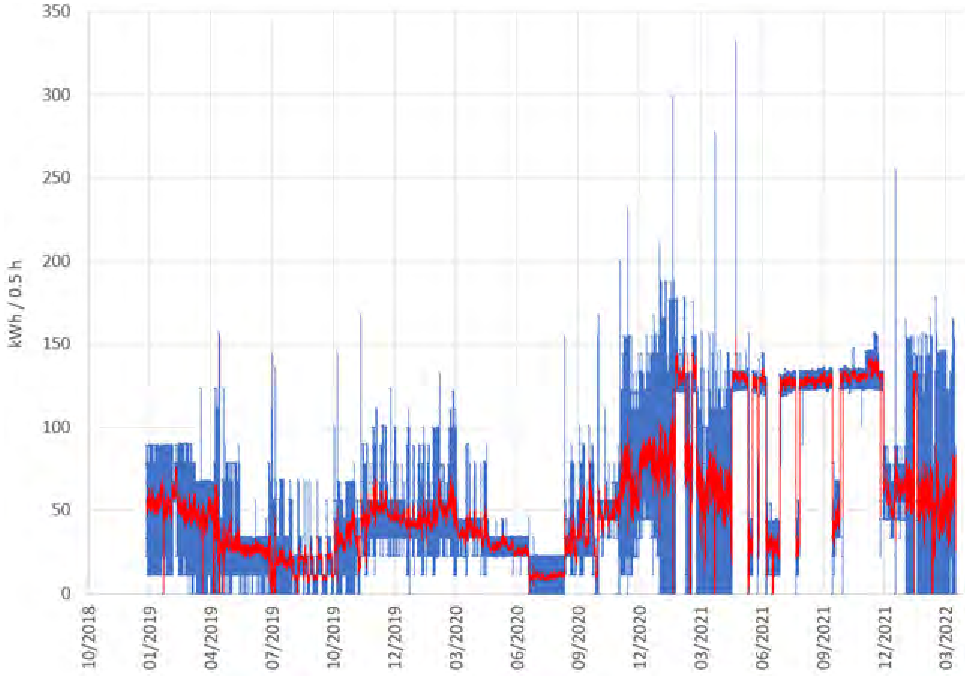
7. Gas Meter Reading Analysis

Gas meter readings, taken over a period over three years between January 2019 and March 2022, at half hour intervals, have been provided by the Metropolitan Police for the main meter at Bexleyheath Police Station for further analysis. This meter MPRN for this site is reported to be 525039808.

The chart below indicates the raw meter reading figures in blue, with the red trend graph added to help indicate the moving average over the course of 5 hour periods.

To assess an approximate indication of the gas load in kW at any given time, this is obtained by doubling the kWh / 0.5 h figures recorded by the meter. This yields an average power for the period of 30 minutes –due to minute-by-minute variations not shown within the resolution of the figures, it is likely that instantaneous peak gas loads may be slightly higher.

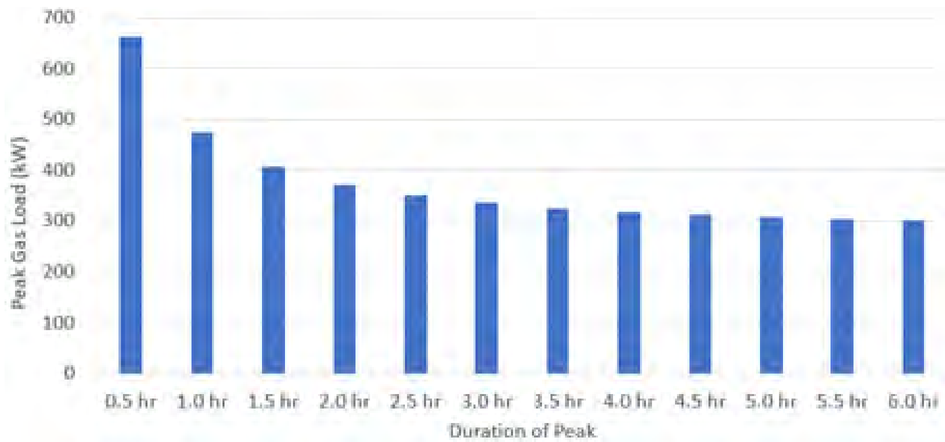
A further important consideration when interpreting the gas loads is that whilst the predominant loads on this gas meter is the gas-fired boiler plant, there is also a connection taken from this meter to serve the CHP unit. No separate submetering of this CHP supply was available, so it is not possible to differentiate boiler loads from CHP loads, however it is anticipated that CHP loads can be approximated as heating load as a worst case due to its small size relative to the boilers, even though it is used to generate electricity and its thermal efficiency is much less than the gas-fired boiler plant. This would represent a worst case as some of the gas energy interpreted as generating heat will actually be used to generate electricity.



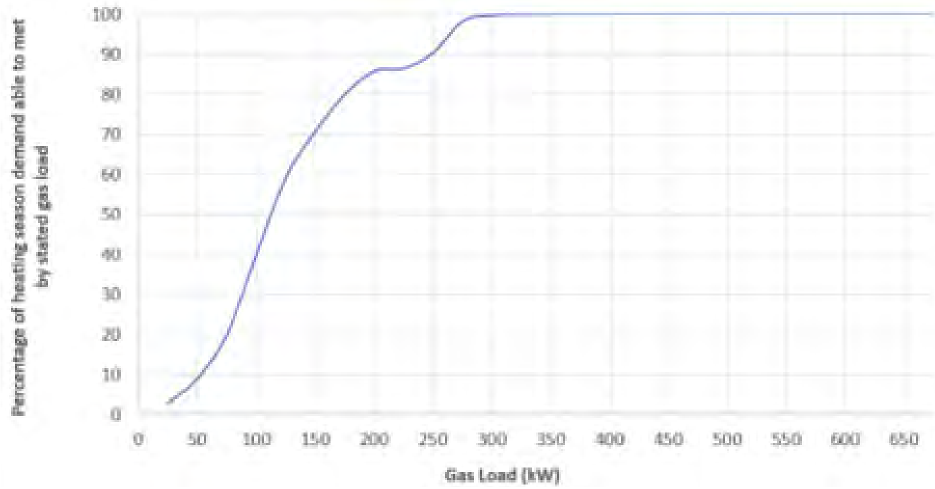
As indicated in the graph above, it can be seen that the gas loads generally follow the same seasonal variation indicated by heat loads of the dynamic thermal models, being higher in winter and lower in summer; however this pattern is not as pronounced as some other sites. The all-year-round domestic hot water load will lead to a reasonably consistent domestic hot water 'base load' throughout the year, working to make seasonal variations a little more subtle. The graph also shows an incongruous region between mid-May and mid-December 2021 where the gas consumption was persistently elevated above where it would be expected – it is not known the explanation for this, but it could be something like a persistent high domestic hot water demand or leak, enhanced ventilation or something related to CHP unit operation if this is operated as electrically led with excess heat rejection.

A peak half-hourly gas load of approximately 332 kW is recorded, occurring in mid-May 2021 – this is equivalent to a peak instantaneous load of 664 kW at this time, which sits well below the maximum installed boiler capacity of 951 kW. It is also noted that this peak occurred during the incongruous region of persistently elevated gas load.

As the graph also indicates, peaks in gas usage are generally short lived and the moving average is significantly lower than the peak loads. The graph below illustrates this – it shows the peak gas load sustained for the given time period. For example, the half hour peak load is 664 kW, however the peak gas load sustained over a period of 3 hours is just 336 kW. By looking at longer time intervals such as this, and in particular where this graph starts to level off, gives a good indication of the true peak gas demand for the building. This method also removes the effect of short-lived one-off events such as, for example, a purge of the gas lines or firing of all boilers during maintenance activities, that isn't reflective of the true building demand.



Another means of analysing the figures is to look at the proportion of the heating load (during the heating season October to April inclusive) that can be met by a given gas load. A chart illustrating this, taken directly from the gas load figures for Bexleyheath, is presented below.



Graphs such as this do not typically indicate an inflection point and it is believed that this relates to the incongruous region of persistently high gas usage identified between mid-May and mid-December 2021.

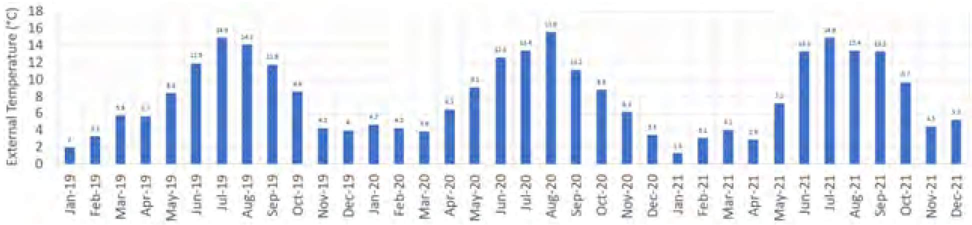
Based on this analysis:

- a 300 kW gas load can support the building for 99.0% of the time
- a 350 kW gas load can support the building for 99.9% of the time
- a 425 kW gas load can support the building for 99.99% of the time

Given that 0.01% of the peak loads may be due to not heating events such as maintenance, it may be acceptable to consider that a gas load of 350 kW, covering 99.9% of the heating season may be appropriate to analyse further as a design gas load for the boiler plant.

For the purposes of identifying a peak boiler load from the peak gas load, an efficiency of 90% is assumed, which would be typical for boilers of the age and kind installed at Bexleyheath. Based on this assumption, the peak boiler load to address 99.9% of the demand is assumed to be 315 kW. Note that this includes the domestic hot water.

To complete this analysis, it is required to put the gas meter records for Bexleyheath into the context of the weather experienced during this period. The Met Office hold this record data for a variety of locations across the UK. Data for London Heathrow is presented below for the same 3 year period which the Bexleyheath gas loads relate to.



From the above graph, it can be seen that the lowest air temperature experienced in the area close to Bexleyheath in the past 5 years was 0.6°C in February 2018.

The lowest temperature of 1.3°C is higher than the design winter temperature used for static thermal modelling, which was -2.5°C. By extrapolating the previously analysed boiler load of 315 kW from a minimum experienced external temperature of 1.3°C to -2.5°C design external leads to boiler load of approximately 375 kW being indicated by gas meter figures to meet 99.9% of the heating demand for Bexleyheath (with no further margins applied) under winter design conditions. This represents a worst case approximation, as the above has extrapolated the entire boiler load to adjust for external temperature, however in reality the domestic hot water load is unaffected by external ambient temperature for gas-fired boiler installations.

7.1 Comparison of gas records with dynamic modelling

In order to calibrate the dynamic thermal model for Bexleyheath Police Station and give a degree of confidence in the analyses of results from this, a comparison of the historical gas records with the gas load information produced from the thermal model has been carried out.

The table below indicates monthly gas loads from historical record information, in this case gas bill information, and those derived from the dynamic thermal model for the existing building. The gas bill figures for 2019 have been used as this is anticipated be the most representative of typical operation of the building. As the dynamic thermal model covers space heating and ventilation heating, but not domestic hot water, a heating allowance has been made for the gas load associated with an industry typical 10 litres per day per building occupant, with a delivery efficiency of 50%, which is again reasonably typical of a system such as this.

Month	Gas Used (MWh)	
	Gas Billing Records (2019)	Dynamic Thermal Model (Existing Building) + DHW
Jan	81,836	80,66
Feb	73,700	70.03
Mar	69,384	71.66
Apr	54,442	52.74
May	42,756	36.56
Jun	38,035	28.03
Jul	27,645	23.53
Aug	23,477	24.41
Sep	22,922	30.62
Oct	48,387	47.69
Nov	57,556	65.59
Dec	75,367	80.30
Summed total	615,509	611.76

As can be seen from the table, the annual totals tally reasonably closely as well as month by month figures.

8. Proposed Low Carbon Heating System

8.1 Decarbonisation Options

When considering heating decarbonisation solutions for Bexleyheath, at the outset, several options were reviewed:

1. Electric heat pumps
2. Direct electric heaters
3. Variable refrigerant flow (VRF / VRV) direct expansion systems
4. Biofuel boilers / CHP
5. Connection to District Energy Network

Of the above, the electric heat pump option was deemed the most favourable and so passed to further technical analysis. The other options did not progress to further review for the following reasons.

Direct electric heaters

- Effective coefficient of performance (COP) of 1 as 1 kW of electric energy becomes 1 kW of heat energy. This is significantly less than other heat pump options which have COPs of at least 2, even under the least favourable conditions. This low COP would result in higher running costs and larger electrical infrastructure requirements.
- Significant additional refit works required to replace existing radiators, trench heaters and heating coils throughout the whole building.
- Covered electric heaters can lead to heightened fire hazards.
- Significant electrical works to provide supplies to units throughout the building.

VRF systems

- Some in depth analysis, including thermal modelling of COPs, was carried out into this option before ruling it out.
- Due to the heat capacity required for the building, an extensive number of separate systems would be required due to limitations in the maximum capacity of VRF systems, especially when considering that it is desirable to operate on the refrigerant R32 to have less sensitivity to potential F-Gas phase down of the typical R410A.
- Whilst this VRF system itself offers reasonable COPs and the ability to both heat and cool the building, recovering heat in the case of a 3-pipe / 4-pipe system, significant works would be required to fit units throughout the building.
- VRF indoor units are not suitable for every space in the building requiring heating, such as WC's, showers, stores and the custody suite. When factoring in that these areas may be heated by electric panel heaters with a COP of 1, the SCOP for the overall system could be reduced to below 2.
- Refrigerant pipe length and height change limitations add complications to finding suitable external plant locations for outdoor units.
- Significant electrical works to provide supplies to units throughout the building.
- Future replacement of units may require significant works throughout the building.

Biofuel boilers / biofuel combined heat and power

- These systems tend to have elevated nitrous oxide (NOx) emissions which exceed NOx emission guidance set out in the London Environment Strategy, London Plan Air Quality Positive and the London Borough of Hammersmith and Fulham Air Quality Plan for the Air Quality Management Area (AQMA). Biofuel boilers have higher NOx emissions than equivalent ultra-low and low NOx gas boilers.
- The efficiency of boiler plant tends to be lower than equivalent gas-fired boilers. This can be offset in part by using biofuel combined heat & power for suitable applications.
- Additional on site fuel storage would be required to store sufficient supplies of biofuel, which would be subject to various environmental and technical requirements.
- Fuel would need to be delivered to the site by delivery vehicles.

Connection to District Energy Network

- No District Energy Networks (DEN) are currently available in the vicinity of Bexleyheath Police Station.

Given the above noted obstacles for alternative decarbonisation options, heat pumps have been recommended as the preferred decarbonisation method. Below are several advantages of this approach.

- Aligns well with ongoing plans to decarbonise the electricity grid. No carbon generation at the point of use.
- A reasonably good efficiency / coefficient of performance (COP) can be achieved.
- Ability to connect to existing chilled water system as a heat source, helping to improve the effective COP and recycle heat which would otherwise be rejected to atmosphere back into the building.
- Existing heat distribution system and heat emitters can be retained and reused.
- Centralised plant in a dedicated plant area permits maintenance of the system without requiring access into office areas.
- Centralised plant limits the extent of works areas and associated mechanical and electrical infrastructure.
- Fed with mains electricity, so no transport fuel deliveries required to site.
- Running cost is comparable and perhaps slightly less than equivalent gas-fired plant. This is subject to variances in electricity and gas unit costs and efficiency levels achieved by plant.
- Can use non-HFC refrigerants and therefore not subject to future F-Gas phasedown.

8.2 Proposed Heat Pump System

8.2.1 Proposed Capacity

To understand the thermal dynamics of the existing building, an IES Virtual Environment 2021 software model of the building has been produced as described in a previous section of this report. This, and an analysis of the existing gas loads also described in a previous section, has helped to inform the required heat pump capacity. The static thermal modelling has suggested a required heating capacity of 453 kW based upon an extended operation profile of the heating system, decreasing to 352 kW when the system is permitted to run 24 hours during peak winter conditions. The analysis of the historical gas loads from the past 5 years has indicated that a heating capacity of 375 kW would be appropriate to meet 99.9% of the heating requirements based on current operation.

Based on the above, 300 kW has been selected as the existing building's space heating requirement, with a further 100 kW assumed for domestic hot water generation, bring this to a total of 400 kW. Further onsite metering analysis would be desirable to differentiate the space heating and domestic hot water loads from one another. The existing building in its current form without further fabric upgrades represents a 'worst case' (largest heating plant size) for the selection of heating plant. As indicated in the section of the report which analysed the static heating loads, modelling has indicated that the proposed fabric upgrades could see a reduction of this heating capacity by approximately 21 kW. As this is a modest 7% reduction for what is quite extensive works on the building to perform the fabric upgrades, it is proposed to based the heat pump installation size on the existing fabric requirement, prior to any fabric upgrades.

In order to provide some spare capacity in the system for the purposes of future building development, to provide resilience in the system in the event of equipment failure and to make allowance for some of the uncertainties surrounding assumptions made, a 25% additional margin is proposed, which would yield a total heating space heating load of 375 kW and domestic hot water load of 125 kW for the selection of heat pump plant.

8.2.2 Equipment Selection

When looking at options for heat pumps, the primary options are:

- Air source
- Ground source
- Water source

Large scale air source heat pump installation, Denmark. Image courtesy of Solid Energy.

The various pros and cons of these options were reviewed in conjunction with dialogue with heat pump specialists and current best practice guidance of implementation of heat pumps. In order to limit the extent of immediate enabling works required to facilitate the adoption of heat pumps for Bexleyheath, solutions which can support flow and return temperatures of up to 80/60°C flow/return for the LTHW system were selected. This would mean that the existing secondary side LTHW heating distribution system could be retained and in particular the existing heat emitters such as radiators, trench heaters and heating coils can be retained.

IIt is anticipated that emitters and pipework will have a degree of design oversizing, illustrated by the existing boiler capacity being 951 kW compared with gas records indicating a maximum demand of closer to 375 kW. Assuming a design margin of oversizing of 20% which may be typical, this would mean that a system based on 80/60°C LTHW F/R could be able to meet the design loads, net of the extra margin, using a 73/53°C LTHW F/R or perhaps even lower depending upon the exact heat emission exponents of the heat emitters in the building. An opportunity also exists for replacement of the existing building heat emitters to operate on lower design flow and return temperatures in order to maximise the COP of the heat pump installation. It has been determined that the disruption which would be required to replace all heat emitters throughout the building to further lower LTHW flow and return temperatures as part of these works, and the resulting widespread interruption to critical operations, would not be acceptable. It is suggested that emitter replacements are instead carried out as part of any future phased refit works which may be required to suit operational requirements. For this reason, a 'high temperature' heat pump has been selected to suit the existing building heat emitters.

The LTHW flow and return temperatures are pivotal in determining the efficiency, or coefficient of performance (COP), of the heat pump, with heat pump COP increasing (efficiency) with lowering flow temperatures. As such it is important that the existing LTHW system should be able to operate on the lowest possible flow temperatures. Further investigation into the existing system is suggested in order to optimise the hydraulics and controls in order to maximise COPs and therefore lower running costs, without the need for extensive disruption of replacing all heat emitters.

Based on preliminary equipment selections provided by heat pump specialist, it was noted that at elevated flow and return temperatures of 80/60°C, the performance of ground source heat pumps was only marginally better (3%) than that of air source heat pumps. Typically, ground source heat pumps will have a better COP due to heating exchange with the ground, which typically has a relatively stable ambient temperature of 8-12°C compared with air which varies from perhaps -2°C to 30°C over the course of a year. Heat pump performance is a function of the temperatures on the heat source and heat load and so there will be times of the year where an air source heat pump is more efficient that a ground source heat pump, although this typically occurs in spring through to autumn when the building's heating loads are reduced from winter peaks.

Given the significant addition expense of a ground source heat pump system due to the need for boreholes, and associated risks such as environmental planning and achieving the require thermal performance from boreholes, it was decided to rule ground source heat pumps out at this point.

Given that the heating plant for Bexleyheath includes for domestic hot water and in order to maximise opportunities for future reduction in LTHW space heating system flow and return temperatures, we recommend decoupling the domestic hot water generation from the space heating. DHW generation will always demand elevated temperatures from the heat pump system. If DHW is incorporated in the overall system, it will demand that the heat pump continues to generate water at higher temperatures, and therefore lower COPs, regardless of what the space heating system flow and return temperatures are.

We consulted with several heat pump specialists / manufacturers in order to provide technical selections for the heat pumps.

The COPs from the different manufacturers appeared to be quite similar, despite that their systems used different approaches and different refrigerants from ammonia to hydrocarbons in their heat pump technology. The following information therefore applies equally to each solution, however it became apparent during research that having such large ammonia plant in the proposed location would require an ammonia risk survey to be completed and a strong likelihood of additional plant required to deal with potential ammonia leaks.

As such, proposals are based upon the alternative multistage hydrocarbon heat pump solution, although other solutions (such as carbon dioxide based systems) could be explored further in future.

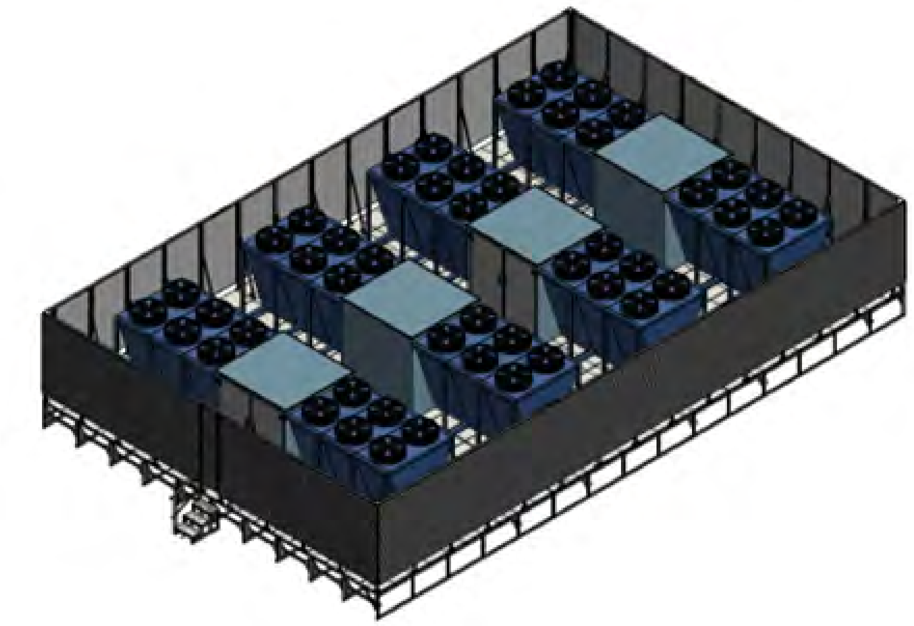
The proposed make up of the plant would be as follows:

- 3nr close coupled air source heat pumps, 150 kW each (at -2°C)
- Minimum 2m3 thermal stores
- 1nr domestic hot water specific heat pump and buffer vessel matched to building DHW demand

It is proposed that the air source heat pumps will be located on an external raised gantry adjacent to the existing plant roof within the car park. This approach offers several significant advantages:

- Proximity of plant to existing plant room for onward distribution.
- Creates a plant space where no suitable space exists at roof level, with minimal impact on existing operations.
- Permits car parking to be retained beneath.
- Reduced impact on planning considerations including reduced visibility and noise.
- Good air circulation for heat exchange.
- Aids phasing of works whilst minimising disruption to operations.
- Ease of access for installation and maintenance.
- Reduced risk from flammable refrigerants.

The below image shows an external platform with 4nr large capacity air source heat pumps to illustrate what this plant compound may look like. The specialists have been briefed on providing air source heat pumps within a similar installation structure on a raised gantry above parking spaces in the car park within the station compound.



It is planned that the air source heat pumps would be open to external air as this is necessary for their operation, with the existing boiler plant room used to house thermal stores and distribution plant including pumps etc. Thermal stores are included to limit equipment starts to extend their lifespan and reliability and also allow provision for short term boosts in the overall output from the system above the total capacity of the heat pumps alone.

The ASHP for DHW generation is anticipated to be enclosed within the existing boiler plantroom, with free air connections via louvres and a ducted discharge to outside for this to function.

Domestic hot water air source heat pump system

8.2.3 Heat Pump System Performance

Based upon equipment selections and the anticipated operating conditions, the following seasonal coefficients of performance (SCOPs) per EN 14825 / EN 14511 have been calculated:

Space heating SCOP 2.68
DHW generation SCOP 4.30

8.3 Estimated Costs

Estimated costs for this element of work is included in the Outline Cost Plan found in the appendices of this report and summarised in the Conclusion.

8.4 Impact on building running costs & carbon emissions

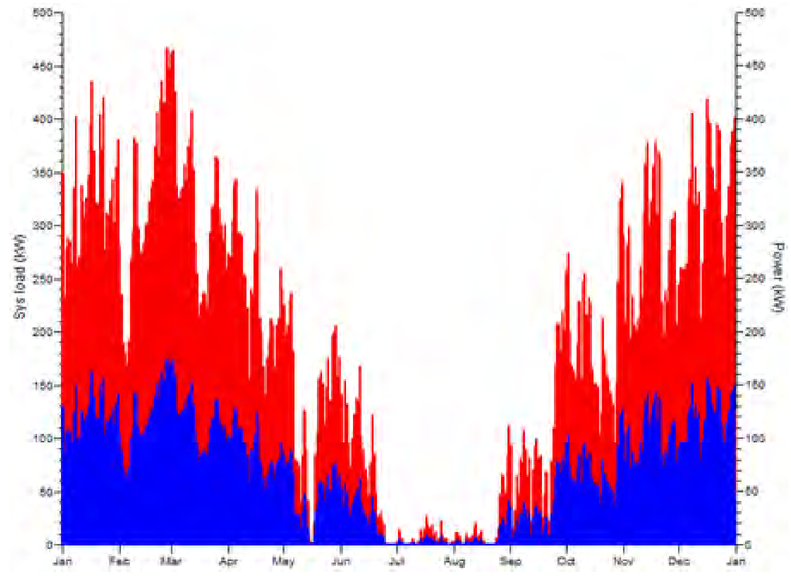
For the purposes of reviewing the running costs and carbon emissions resulting from adoption of heat pumps to decarbonise the existing gas-fired LTHW heating system of Bexleyheath, the following parameters have been applied:

- LTHW operating temperatures 70/50°C flow / return
- SCOP as noted in previous section
- Gas & electricity costs as advised in spreadsheet provided by the Metropolitan Police's Environment Advisor (Energy and Carbon Management), via email on 14/02/2022. This varies with year and the calculation follows this annual figure – for the purpose of a 2022 comparison, the 2022 figures are quoted as:
  - o Electricity 19.42 p/kWh
  - o Gas 5.01 p/kWh
- Carbon factors, taken from BEIS 2021 figures (updated January 2022):
  - o Electricity 0.21233 kgCO2/kWh
  - o Gas *0.20297 kgCO2/kWh

The Metropolitan Police have confirmed that they have committed to procuring their electricity on a guaranteed green tariff, which derives all of their electricity from certified renewable sources, resulting in an effective carbon factor of 0 kgCO2/kWh. For the purposes of reference, information is presented for carbon emissions based upon the current BEIS 2021 electricity carbon factor.

8.4.1 Running Costs

Running costs for the existing gas-fired boiler and the proposed heat pump system are based upon dynamic thermal modelling results for energy used over the course of one year and as such are based upon the various assumptions applied to the model as outlined elsewhere. The heat pump energy usage profile is presented below for the existing Bexleyheath building fabric option (space heating only, no domestic hot water) – the red portion represents heat energy delivered, whilst the blue port represents the associated electrical input energy.



The following table shows a comparison of the heating energy used for four different scenarios, based on space heating only (no domestic hot water):

1. Existing building fabric, existing gas-fired boiler, based on thermal model results to ensure representative comparison
2. Proposed building fabric improvements, existing gas-fired boiler, based on thermal modelling results
3. Existing building fabric with new heat pump system applied, based on thermal modelling results

Month	Heating Energy Used (MWh)		
	1. Existing Fabric, Gas	2. Improved Fabric, Gas	3. Existing Fabric, Electricity (HP)
Jan	57.7378	51.0298	18.6249
Feb	49.3321	43.8079	15.9134
Mar	48.7367	43.9246	15.7213
Apr	30.5585	27.8276	9.8575
May	13.6422	12.5004	4.4007
Jun	5.8502	5.5617	1.8871
Jul	0.6054	0.5613	0.1953
Aug	1.4866	1.2819	0.4795
Sep	8.4407	7.3817	2.7228
Oct	24.7710	21.7547	7.9905
Nov	43.4093	38.2145	14.0028
Dec	57.3826	50.5605	18.5103
Summed total	341.9529 (Base case)	304.4066 (Base - 11.0%)	110.3061 (Base - 11.0%)

Adding assumed domestic hot water usage of 10 litres / building occupant / day over the course of the year, these figures become:

	Heating Energy Used (MWh)		
	1. Existing Fabric, Gas	2. Improved Fabric, Gas	3. Existing Fabric, Electricity (HP)
Annual	611.76 (Base case)	574.21 (Base - 6.1%)	173.05 (Base - 71.7%)

Based upon the gas & electricity unit costs quoted for 2022, this yields the following annual costs:

	Heating Energy Used (MWh)		
	Existing Fabric, Gas	Improved Fabric, Gas	Existing Fabric, Electricity (HP)
Annual Cost	£30,649 (Base case)	£28,768 (Base - 6.1%)	£33,606 (Base + 9.6%)

8.4.2 Carbon Emissions

As with the running costs analysis, carbon emissions for the existing gas-fired boiler and the proposed heat pump system are based upon dynamic thermal modelling results over the course of one year and as such are based upon the various assumptions applied to the model as outlined elsewhere.

The following table shows a comparison of the carbon emissions for three different scenarios based on space heating only (no domestic hot water):

1. Existing building fabric, existing gas-fired boiler, based on thermal model results to ensure representative comparison
2. Proposed building fabric improvements, existing gas-fired boiler, based on thermal modelling results
3. Existing building fabric with new heat pump system applied, based on thermal modelling results, BEIS 2021 carbon factor applied
4. Existing building fabric with new heat pump system applied, based on thermal modelling results, green energy tariff carbon factor 0 applied

Month	Heating Carbon Emissions ($kgCO_2$)			
	1. Existing Fabric, Gas Boilers	2. Improved Fabric, Gas Boilers	3. Existing Fabric, Heat Pumps (BEIS carbon factor)	4. Existing Fabric, Heat Pumps (green tariff carbon factor)
Jan	11,719	10,358	3,780	0
Feb	10,013	8,892	3,230	0
Mar	9,892	8,915	3,191	0
Apr	6,202	5,648	2,001	0
May	2,769	2,537	893	0
Jun	1,187	1,129	383	0
Jul	123	114	40	0
Aug	302	260	97	0
Sep	1,713	1,498	553	0
Oct	5,028	4,416	1,622	0
Nov	8,811	7,756	2,842	0
Dec	11,647	10,262	3,757	0
Summed total	69,406 (Base case)	61,785 (Base - 11.0%)	22,389 (Base - 67.7%)	0 (Base - 100%)

Adding assumed domestic hot water usage of 10 litres / building occupant / day over the course of the year, these figures become:

	Heating Carbon Emissions ($kgCO_2$)			
	1. Existing Fabric, Gas Boilers	2. Improved Fabric, Gas Boilers	3. Existing Fabric, Heat Pumps (BEIS carbon factor)	4. Existing Fabric, Heat Pumps (green tariff carbon factor)
Summed total	124,169 (Base case)	116,547 (Base - 6.1%)	36,744 (Base - 70.4%)	0 (Base - 100%)

As can be seen from this table, by replacing the existing gas-fired boiler plant with heat pump heating plant, served by a green energy tariff with guaranteed renewable electricity, the carbon emissions for heating Bexleyheath Police Station can be reduced to zero, saving approximately 124 tonnes of carbon dioxide per annum carbon emissions and decarbonising the existing heating system.

The proposed installation includes energy meters to provide a full auditable record of energy use and carbon emissions associated with the new heat pump installation. These records shall provide separate energy and carbon records for space heating separate and domestic hot water.

9. Energy Efficient Lighting

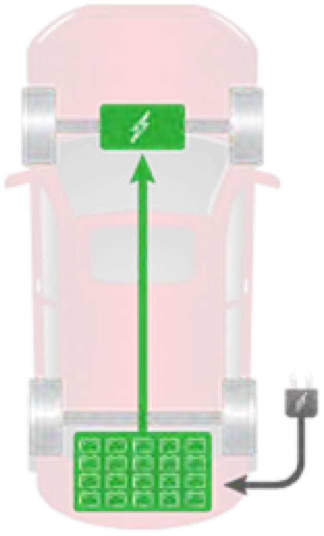
The existing building's general lighting installation comprises a mixture of types of fluorescent luminaires and is nearing the end of its life, is inefficient and in a dilapidated condition. Issues include: missing or failed lamps, missing louvres or diffusers and no automatic controls.

Significant advancements in lighting technology have been made since the original installation, which serve to improve the energy efficiency and quality of lighting, which, in addition to the further energy savings associated with simple automatic controls such as presence or absence detection, assist to make significant carbon emissions reductions associated with the building's lighting system.

It is therefore our recommendation that the existing lighting installation be replaced in its entirety with a new installation comprising LED luminaires and automatic controls.

10. Electrical Vehicle Charging

This report investigates feasibility of providing a network of electric vehicle (EV) charging points throughout the parking area.



Battery Electric Vehicle Arrangement

Typical 2 x 7kW EV Charger Station

This report is based on the following EV charger provision and is based on the current site layout:

7kW Trickle Chargers (AC)	42 No
22kW Fast Chargers (AC)	6 No
50kW Rapid Chargers (DC)	5 No
Total	53 No

Based on the above the total connected load for the above EV charges will be 676kW.

While diversity can be applied to most electrical systems the current electrical regulations (BS7671) and UK Power Networks (UKPN) Engineering Design Standard EDS – 08-5050 stipulate that, for the purposes of assessing Maximum Demand (MD), no diversity should be applied to EV charging loads. Diversity may however be applied to the customers own distribution system.

If a charging Load Management System (LMS) is provided to control and manage the vehicle charging it may be possible, subject to agreement with the Distribution Network Operator (DNO), to apply diversity to the load in order to reduce the required MD. It should be noted that a LMS can only control AC chargers and the larger DC chargers would not be controlled by the LMS.

UKPN provide tables of diversity for multiple charger installations in EDS – 08-5050, however these are only applicable if an acceptable Control and Monitoring system is provided.

For the purposes of this study we have assumed that a LMS will be provided and that the diversity figures will apply and we have interpolated these figures from EDS-08-5050.

In order to agree the additional Maximum Demand the proposals will require it is essential that there is early engagement with UKPN to negotiate an agreed diversity and MD to avoid undue costs and charges.

Further to the above, it is appreciated that EV charging points create significant disturbance to the mains supply, in the form of Harmonics, and it would be a requirement for any connection that a Harmonics Study be carried out and the appropriate harmonic filtration be provided.

A Harmonics Study will assess the likely Total Harmonic Distortion (THD) of the proposed installation and provide an indication of the required level of Harmonic Filtration to be applied to the installation to satisfy the DNO in order to achieve a connection agreement.

The THD can be managed by the provision of Dynamic Harmonic Filters. These can be located within the main LV switchboard where they will filter out the harmonics created by the EV chargers before they reach the DNO network.

Typical large scale Harmonic filter

Illustration of the effect of Harmonic Filtration

In addition to the capital costs associated with the installation of EV charging points there will be ongoing management charges for monitoring the chargers and the Load Management system together with annual maintenance charges to maintain and repair the EV outlets and these are based on the number of EV outlets installed. Estimates of these costs have been included within the costing section of this report.

In order to support the proposed EV charging installation it will be necessary to provide additional electrical capacity and a distribution network for the chargers. This will require the provision of a new main LV switchboards and distribution feeder pillars across the site and this is discussed further in the electrical Infrastructure section of this report.

11. Electrical Infrastructure

This section of the report deals with the electrical supply capacity and distribution arrangements as part of the proposed decarbonisation works including the provision of heat pumps and EV charging points discussed elsewhere.

The proposed Heat Pumps and EV charging points will impose a significant additional electrical load on the existing electrical infrastructure including the existing Distribution Network Operators (DNO) electrical network and site distribution. This meter MPAN for this site is reported to be 1200010169328.

We have been unable to establish the existing site Maximum Import Capacity (MIC) however it is clear that the MIC and associated infrastructure will need to be upgraded to support the proposals.

Based on the current decarbonisation proposals the anticipated additional electrical loads to connected are as follows:

Air Source Heat Pumps	250kW Connected Load
EV Charging	676kW Connected Load

Air Source Heat Pumps (ASHP)
The total connected load for the proposed ASHP is 250kW made up of 6 No. ASHP's of equal rating for space heating together with 2 No. ASHP's for DHW. Applying normal diversity these units will have an anticipated After Diversity Maximum Demand (ADMD) of approx. 200kVA

Electric Vehicle Charging Points
The total connected load for the proposed EV Charging Points is 676kW. Applying diversity as follows we estimate the MD for the EV charging points, after diversity is applied to be 600kVA.

Rapid EV Chargers (DC)	1.0 (No diversity)
Fast EV Chargers (AC)	0.75
Trickle EV Chargers (AC)	0.75

Taking the Heat Pumps and EV Charging together, after applying diversity, the proposed additional load for MD purposes has been assessed as a total additional ADMD of 800kVA.

There is an existing PV array on the station room comprising 72 No panels. Using a conservative allowance of 300w per panel this will contribute 21.6kW to the site load.

The current contracted Maximum Import Capacity (MIC) for the premises is 225kVA and the Maximum Demand (MD) is currently recorded as 175kVA (2019-2020) therefore the MIC would need to be upgraded to 1000kVA to cater for the proposed additional electrical load. The generator currently on site would need supplemented by an 800kVA to meet the increased demands and a suitable location for the fuel storage would need to be investigated.

12. Proposed Pathway & Programme

It is proposed that the existing boiler is kept operational during the works. The new heat pumps can be installed without any impact on the existing boiler. There will be an ongoing requirement for a site compound and some craneage, but these aspects can be limited both in terms of working hours (craneage being carried out at weekends) and by limiting the size of compound being utilised by the contractor with materials arriving on a 'just in time' basis.

It is proposed that the construction period is 40 weeks.

Final connections (and associated shutdown to allow this to occur) needs to be carefully planned and will be weather dependant.

See Appendix D for Programme.

13. Location for Plant

See Appendix A for images of optional locations of large-scale air source heat pump in¬stallation.

14. Planning Implications

With the proposed inclusion of a new plant platform elevated above the eastern car park planning permission will be required for the works. This will include acoustic screening to the air source heat pump equipment
The visuals in Appendix A demonstrate how the proposed plant would appear and we are confident that such a proposals would be approved further to an appropriate application to London Borough of Bexley.
Issues which will have to be addressed will include:

- Acoustic report indicating background noise levels and demonstrating that the screening will effectively silence nay noise form the proposed heat pumps.
- Elevations and sections that indicate the platform in context to demon¬strate that the proposals have minimal impact to neighbouring properties
- 3D visuals that demonstrate that the proposals are in keeping with the architecture for the building
-

Additional or alternative plant locations could include the upper flat roof of the main building. This would also include acoustic screening to the plant. The enclosure will be set back from the roof perimeter so that it would be largely unseen from ground level. Visuals of this proposal are also included in Appendix A

15. Project Costings

See Appendix c

16. Conclusions

The existing gas-fired boilers of Bexleyheath Police Station have reached the end of their economic life and are now due replacement. On-site surveys and record information have identified that the existing gas-fired boilers are now in their 13th year of service. Operational requirements of the building have meant that these boilers are available for use 24 hours a day, 365 days a year, resulting in runhours which may be 1.5-2 times greater than a standard installation. CIBSE Guide M suggests an economic life for the installed plant of 15-20 years; however this is based on typical installations with standard runhours. When factoring the extended runhours of Bexleyheath's boilers, the 'equivalent operational runhours' age of the boilers may be closer to 26 years for reference against CIBSE Guide M, which would place these at the end of their operational life.

Options have been explored for replacing this plant with new, with proposals including like-for-like replacement of the existing gas-fired boiler plant and associated equipment and also proposals for decarbonising the heating system by replacing the existing gas-fired heating plant with electric heat pumps.

Thermal modelling software and a review of gas meter records covering the past five years have been used to establish the anticipated heating demand of the building, which has demonstrated that the existing heating plant capacity of 951 kW could be reduced to 400 kW. By using a green energy tariff for electricity with an effective carbon factor of zero due to the use of renewable energy sources, the carbon emissions associated with the heat pump heating system become zero, therefore decarbonising Bexleyheath's heating system, saving approximately 124 tonnes of carbon dioxide per annum based on current carbon emissions.

A study has also been carried out into options for upgrading the existing thermal envelope of Bexleyheath Police Station, which has concluded that the most viable option is to install triple glazing to all windows of the building. Thermal modelling has indicated that this measure could reduce the required heating plant capacity for the building by almost 7% and yield 11% savings heating energy. Given this modest saving, it has been deemed that fabric improvements are not the most cost effective option to be pursued. Analysis has also indicated that whilst the heat pump solution can reduce carbon emissions to zero, the SCOPs achieved cannot fully overcome the difference between electricity and gas unit prices, with the heat pump solution resulting in a 9.6% fuel running cost increase based on current prices. As future electricity and gas prices change, there is a possibility that the 'spark gap' will reduce (difference between gas and electricity prices) bringing the heat pump running costs down relative to gas-fired plant.

This analysis does not include ongoing maintenance costs, which may be less for the heat pump solution.

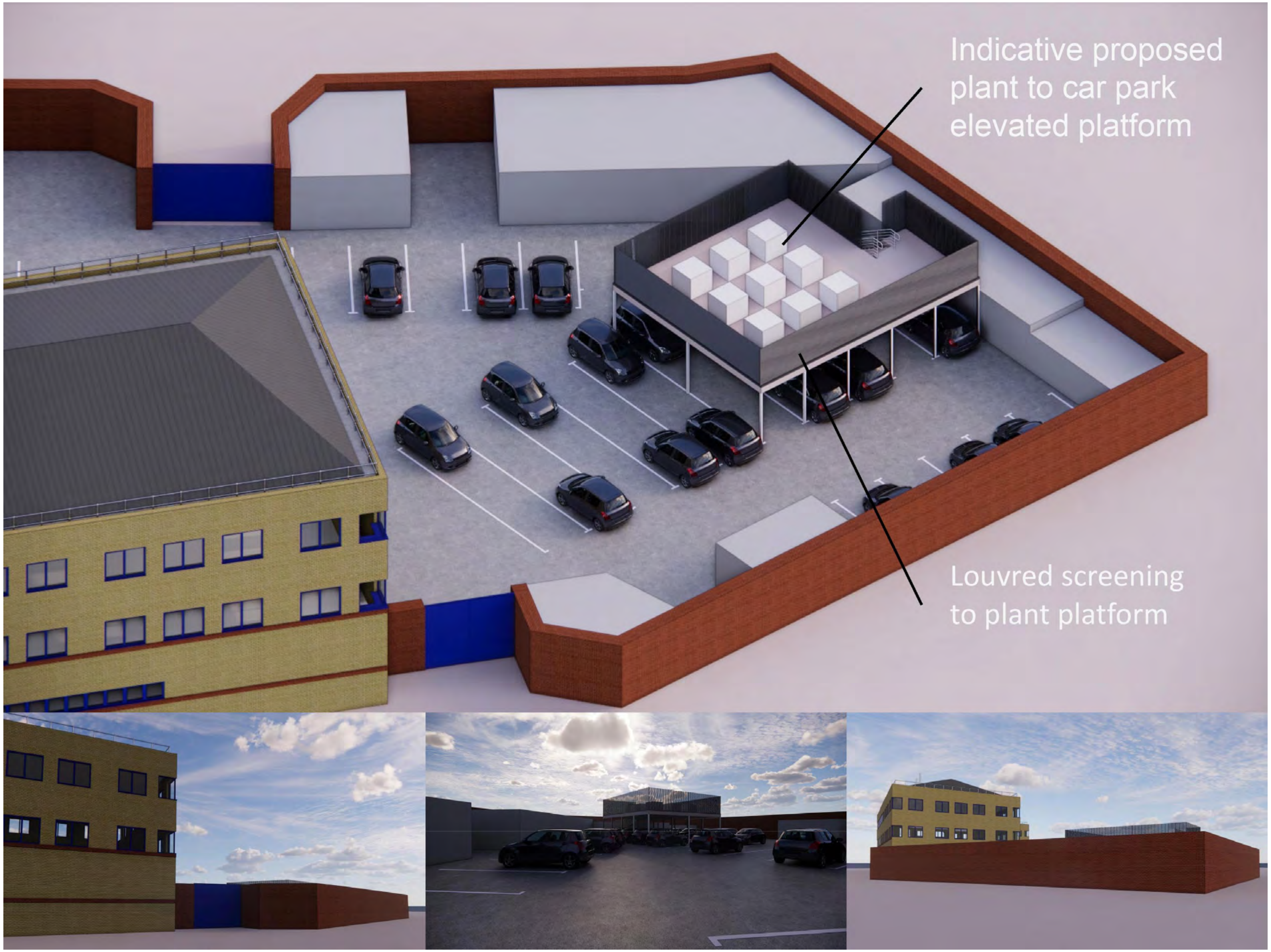
The report also includes proposals for installing electric vehicle charging points in the car park of Bexleyheath Police Station to effectively decarbonise the vehicle fleet associated with operations at the station. Lighting upgrades from existing fluorescent luminaires to LED technology with automatic controls have also been proposed in order to improve energy efficiency and reduce carbon emissions associated with the lighting installation. The implications of installing EV charging and electric heat pumps to serve the building's heating system has been studied and proposals are included for upgrades to the building's electricity supplies and electrical infrastructure to support this.

The implications of installing EV charging and electric heat pumps to serve the building's heating system has been studied and proposals are included for upgrades to the building's electricity supplies and electrical infrastructure to support this.

17. Appendices

a. **Proposed Plant 3D views**
b. **Heat Pump Information**
c. **~~Costings~~**
d. **Programme**
e. **Risk register**

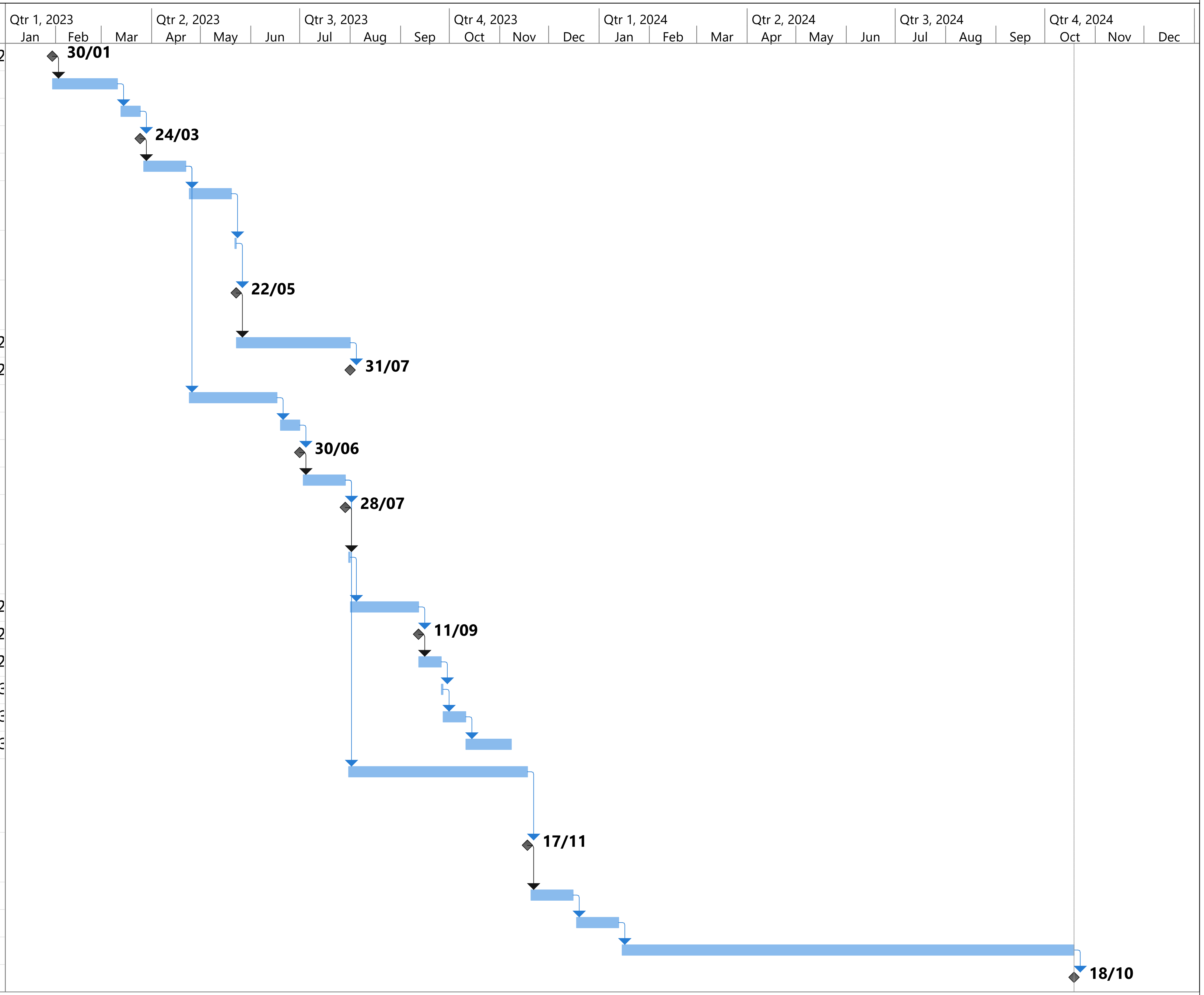
Appendix a. Proposed Plant 3D views



Appendix d. Programme

Bexleyheath PS Zero Carbon Feasibility Study
Design and Construction Programme
Ver 1.0 26/04/22

ID		Task Mode	Task Name	Duration	Start	Finish
1			Approval to proceed	0 days	Mon 30/01/2	Mon 30/01/2
2			Stage 2 design	6 wks	Mon 30/01/2	Fri 10/03/23
3			Stage 2 costs	2 wks	Mon 13/03/2	Fri 24/03/23
4			Stage 2 report	0 days	Fri 24/03/23	Fri 24/03/23
5			Approval period	4 wks	Mon 27/03/2	Fri 21/04/23
6			Community Consultation	4 wks	Mon 24/04/23	Fri 19/05/23
7			Planning Pre Application Meeting	1 day	Mon 22/05/23	Mon 22/05/23
8			Planning Application submitted	0 days	Mon 22/05/23	Mon 22/05/23
9			Planning Process	10 wks	Tue 23/05/2:	Mon 31/07/2
10			Planning Approval	0 days	Mon 31/07/2	Mon 31/07/2
11			Stage 3 design	8 wks	Mon 24/04/2	Fri 16/06/23
12			Stage 3 costs	2 wks	Mon 19/06/2	Fri 30/06/23
13			Stage 3 report	0 days	Fri 30/06/23	Fri 30/06/23
14			Approval period	4 wks	Mon 03/07/2	Fri 28/07/23
15			Issue Tender pack to MPS Procurement	0 days	Fri 28/07/23	Fri 28/07/23
16			Tenders issued to Framework	1 day?	Mon 31/07/23	Mon 31/07/23
17			Tender period	6 wks	Tue 01/08/2:	Mon 11/09/2
18			Tenders returned	0 days	Mon 11/09/2	Mon 11/09/2
19			Tender assessment	2 wks	Tue 12/09/2:	Mon 25/09/2
20			Contractor interviews	1 day	Tue 26/09/2:	Tue 26/09/2:
21			Tender report	2 wks	Wed 27/09/2	Tue 10/10/2:
22			Approval	4 wks	Wed 11/10/2	Tue 07/11/2:
23			Stage 4 designs with contractor involved in later stages	16 wks	Mon 31/07/23	Fri 17/11/23
24			Contract cost and programme fixed	0 days	Fri 17/11/23	Fri 17/11/23
25			Approval	4 wks	Mon 20/11/2	Fri 15/12/23
26			Mobilisation	4 wks	Mon 18/12/2	Fri 12/01/24
27			Construction works	40 wks	Mon 15/01/2	Fri 18/10/24
28			COMPLETION	0 days	Fri 18/10/24	Fri 18/10/24



Project: Bexleyheath Zero Carbo
Date: Tue 26/04/22

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

Appendix e. Risk Register

Risk Register
Site: **Bexleyheath Zero Carbon Conversion**

Date Issued: 26th April 2022
Version: 1.2 September 2022

Risk Identification: CLIENT HELD			Risk Analysis			Risk Mitigation	Review Date	Notes	
Risk Type	Risk Description	Risk Impact Commentary	Likelihood	Impact	Stage 1 Risk Score				
SITE									
Bexleyheath	Disruption to existing parking arrangements due to anticipated site compound.	Reduction in parked cars on site. Impact on the delivery of refurbishment works.	3	4	12	Offsite parking arrangements made. Discussion with contractor regarding minimising site compound impact.	Mid Stage 2.		
CLIENT									
Risk	Changes in key MPS stakeholders	New stakeholders unfamiliar with scheme	2	3	6	Limit changes to stakeholders, Construction Leads to be briefed on each other's projects	Stage 5.		
Risk	Brief Change/sign off	Change to brief may result in delay	4	3	12	Limit revisions to brief.	Mid Stage 2.		
Risk	Design changes	Further changes to design by client	2	4	8	Control design change early in stage 2	Mid Stage 2.		
Risk	Insufficient budget availability	If the budget is insufficient, the brief may not be met.	3	4	12	Designs altered to meet the existing funding levels. Derogations from brief agreed with Client at Stage 2.	Commencement Stage 2.		
Risk	No M+E As built information		1	4	4	Provide the necessary building M+E As built information. Access now provided to SharePoint information.	Mid Stage 2.		
Risk	Availability of current Asbestos Survey & Report and identification of significant clarifications or exclusions in such.	Potential delay to design in respect of additional intrusive surveys. Discovery of ACM's during utilisation causing delay and additional costs.	1	3	3	Agree to a mechanical design that incorporates a floor by floor installation process. Plant Rooms reviewed at stage 2.	Stage 5.		
Risk	Disruption to occupants and operation of site during construction greater than anticipated.	Potential extension of delay for extended out of hours, weekend working or increase decant provisions.	3	4	12	Early MPS engagement to identify feasibility of occupation and operation during construction.	Stage 5.		
Risk	Feasibility of MPS design guides in respect of BREEAM 'very good' as applied to major refurbishments.	Design requirements to achieve BREEAM target increases costs beyond current Budget allocations.	1	4	4	Early MPS engagement regards feasibility and confirmation of any derogations.	Mid Stage 2.		
Risk	Feasibility of MPS design guides in respect of Sustainability targets as applied to major refurbishments.	Design requirements to achieve Sustainability targets increases costs beyond current Budget allocations.	1	4	12	This is the whole purpose of this project	Mid Stage 2.		
Risk	Existing Drawings assumed with inaccuracies	Design may become incompliant / delay	1	4	4	Obtain up to date As builts in stage 2	Stage 2		
Risk	Refrigerants in Heat Pumps can be highly flammable	May lead to more expensive screening dependant on location	2	4	8	Where possible loacte away from buildings and / or perimter in stage 2 designs			

Risk Identification: CLIENT HELD			Risk Analysis			Factored Risk Cost	Risk Mitigation	Review Date	Notes
Risk Type	Risk Description	Risk Impact Commentary	Likelihood	Impact	Stage 1 Risk Score	(£)			
DESIGN									
Risk	M&E Input - Late or failure to liaise	Delay to design / abortive work	3	4	12	M&E consultant input provided at Stage 2.	Mid Stage 2		
Risk	Structural Design / Review	Delay to design / abortive work	2	3	6	Continued dialogue with Structural Engineers. Structural checks required.	Mid Stage 2.		
Risk	Unknown occupancy levels.	Delay to design / abortive work	1	4	4	MET to determine staff numbers. Occupancy numbers provided at stage 2.	Mid Stage 2.		
Risk	No M+E As built information	Delay to design / abortive work	1	4	4	Provide the necessary building M+E As built information. As built M&E info obtained through SharePoint files.	Mid Stage 2.		
Risk	Restrictive space within the mechanical plant rooms and service risers	Additional or larger plant spaces maybe required which will have an effect on the floor layouts.	3	4	12	Agree to a mechanical design that incorporates a floor by floor installation process. Plant Rooms reviewed at stage 2.	Mid Stage 2.		
Risk	Unknown equipment within ceiling void	abortive work/change in M&E design	4	2	8	Inspect ceiling void at stage 2	Mid Stage 2.		
Risk	Structural as built information unavailable	Incorrect assumptions may be made regarding existing structure or internal partitions which may require additional support or mean new layout is unachievable	2	4	8	Provide as built information or provide full access to the building and structure. Check at stage 2.	Mid Stage 2.		
Risk	Original structural design information has not be made available	Structure may be incapable of supporting additional load	2	4	8	Structural condition survey to be carredi out at stage 2 if required.	Mid Stage 2.		
Risk	Insufficient capacity of existing incoming services, including phasing of continuous occupation and construction.	Existing incoming services infrastructure incapable of supporting proposed loads for maintaining existing loads for continuous occupation and construction loads resulting in potential delays or increase generator provision.	2	4	8	Confirmation of existing loads, proposed loads and suitability of existing infrastructure. To be checked at stage 2.	Mid Stage 2.		
Risk	Availability of current Conditional Survey & Report and identification of significant clarifications or exclusions in such.	Potential delay to design in respect of additional unforeseen conditional survey works.	2	4	8	Confirm most current Conditional Survey. Visual condition survey carried out.	Mid Stage 2.		
Risk	Working / amending services / vertical runs via Secure Areas	Safety security, potential delays,	1	4	4	To be taken into account in detailed design stage 2 onwards.	Mid Stage 2.		
Risk	Existing Drawings assumed with inaccuracies	Design may become incompliant	2	4	8	Check survey to be carried out in stage 2	Mid Stage 2.		
Risk	Existing Drawings assumed with inaccuracies	Design may become incompliant	2	4	8	Check survey to be carried out in stage 2			
PLANNING									
Risk	Any external alterations that may require planning consent	Potential delay to the programme or refusal.	3	4	12	Planning likely to be required for Plant platform in carpark	Mid Stage 2.		
Risk	No dialogue with an Approved Inspector to discuss scheme compliance with BS9999 or a Fire Engineered solution.		1	4	4	Early dialogue with an Approved Inspector. Consultation required.	Mid Stage 2.		
Risk	Onerous planning conditions.	Unforeseen additional design considerations to be undertaken in order to discharge conditions may result in potential delay and increase in costs.	2	5	10	Early dialogue with a Planning Officer. Planning will likely be required.	Mid Stage 2.		
Risk	Local conditions imposed in respect of out of hours and/or weekend working.	Potential extension to the programme.	2	5	10	Early dialogue with a Planning Officer. Planning will likely to be required.	Mid Stage 2.		
Risk	Carbon Tax- Failure to achieve GLA 35% carbon reduction	Potential to affect cost plan and exceed budget	1	5	5	This is the purpose fo this exercise so is unlikely to occur.	Mid Stage 2.		
FINANCIAL									
Risk	The Risk of the Scheme budget not being achieved.	Reduced scheme requirements and scope of works.	4	4	16	Early cost plan development. stage 2 costs prepared.	Mid Stage 2.		
Risk	MPS Specification not delivered	Reduced Spec due to budget pressure	3	4	12	stage 2 review required and budget confirmed	Mid Stage 2.		
Risk	Market conditions change more than current inflation or cost indices forecast.	Delay due to reduced scheme and/or value engineering required.	4	4	16	Early cost plan development and monitoring of cost fluctuations. Stage 2 costs prepared.	Mid Stage 2.		

Risk	Supply Chain Logistics	Microchip shortage / Transportation delays leading to additional costs	3	5	15	Specification of UK manufactured plant. Extended lead in times have been factored into the programme.	Mid Stage 2.		
Risk	Electricity Supply Upgrade	Increase in costs due to length of travel to suitable infrastructure and obstacles (such as major roads requiring thrust boring etc)	2	5	10	Early consultation and application to UKPN to determine this at an early stage	Mid Stage 2.		
Risk	Fuel price Increases	Rising Capital costs due to fuel price increases	3	5	15	Stage 2 review and close monitoring of RICS cost indices	Mid Stage 2.		
Risk Identification: CLIENT HELD			**Risk Analysis**			**Factored Risk Cost**	**Risk Mitigation**	**Review Date**	**Notes**
Risk Type	**Risk Description**	**Risk Impact Commentary**	**Likelihood**	**Impact**	**Stage 1 Risk Score**				
PROCUREMENT									
Risk	Construction inflation during the procurement period	Inflationary pressures will put pressure on the budget	4	4	16	Include construction inflation within the Stage 2 Cost Plan	End of Stage 2		
Risk	Uncertainty over future tendering environment	Possible cost pressures put on the budget	3	5	15	Review prior to tender	End of Stage 2		
Risk	Procurement strategy not yet decided	Recommend utilising MPS Lot 1 Framework Contractors and PCSA	2	4	8	Allow within budget for D&B costs/traditional procurement method. Contractor appointed based on Open Book Management.	End of Stage 2		
Risk	Market flooded with work especially on subcontractors	Potential effect to Contract Programme and Quality of Work	4	4	16	Early engagement with contractors and subcontractors	Mid Stage 2.		
Risk	Inappropriate choice of Procurement Route	Potential to cause contractual issues and delays	4	4	16	Careful consideration of the procurement route and potential use of Framework.	Mid Stage 2.		
Risk	Labour costs going up	Potential effect to budget	4	4	16	Use of Framework may mitigate costs	Mid Stage 2.		
CONSTRUCTION									
Risk	Loss of Power	Potential to delay project and affect critical areas	1	4	4	MPS should have their own Station Generators and UPS in place and Contractors to have their own independent ones separate from MPS. 28 days notice required for electrics change-over affecting Custody Suite agreed with MPS	Mid Stage 2.		
Risk	Conflict at interface between construction works and occupants of building (including visitors).	Injuries or death, reputational damage, litigation	2	5	10	Phasing / Decant strategy developed in liaison with MPS. Segregation of access routes wherever possible paying particular attention to visitors. Restrict noisy / disruptive operations during key times. Restrict movement of plant and materials during key times. Consider use of external hoists to reduce internal material movements. Ensure all operatives are aware of sensitive nature client operations and requirement to stop works if requested.	Mid Stage 2.		
Risk	Site Security / Unauthorised access gained onto site.	Injuries or death, reputational damage, litigation	3	5	15	Hoarding to secure works area. Site security controls (scaffold alarms / CCTV / controlled turnstiles / security guard).	Mid Stage 2.		
Risk	Unplanned interruption to existing services including mechanical, electrical, fire, data, telecoms.	Injuries or death, reputational damage, litigation, disruption to client operations	2	5	10	Phasing / Decant strategy to be developed which addresses requirements to maintain live services to occupied areas of accommodation. Contingency arrangements to be developed.	Mid Stage 2.		
HANDOVER									
Risk	Final project does not meet the brief.	If the brief is not continually monitored, scope creep could occur leading to ongoing design changes on site.	3	4	12	Design freeze at end of stage 2. Avoid scope creep by implementing change control process.	End Stage 2.		
Risk	Handover delayed	Issues on site cause delays to the programme, causing delays to the handover of the building.	2	4	8	Monitor progress against programme through the construction process. Ensure the original programme is robust and correct. Allow programme float if necessary.	During Stage 5		
Risk	Incomplete or delayed As Built Drawings & OM Manuals	May delay handover if not completed on time.	2	4	8	Ensure O&M manuals are developed in a timely manner. Issue Building User Manual and hold training and familiarisation workshops prior to handover.	During Stage 5		
HEALTH & SAFETY									
Risk	Previously unidentified hazardous materials identified	Potential extra cost / delay	2	4	8		Mid Stage 2.		
Risk	Conflict between construction access / site setup and client access.	Injuries or death, reputational damage, litigation, disruption to client operations	2	5	10	Site Logistics Plan developed in consultation with all parties ensuring key routes are kept clear. Contractor to develop & maintain traffic management plan. Segregated vehicular / pedestrian routes established. Restrict contractor delivery times. Limit volume of materials which can be stored on site.	Mid Stage 2.		
Risk	Conflict at interface between construction works and occupants of building (including visitors).	Injuries or death, reputational damage, litigation	2	5	10	Phasing / Decant strategy developed in liaison with MPS. Segregation of access routes wherever possible paying particular attention to visitors. Restrict noisy / disruptive operations during key times. Restrict movement of plant and materials during key times. Consider use of external hoists to reduce internal material movements. Ensure all operatives are aware of sensitive nature client operations and requirement to stop works if requested.	Mid Stage 2.		
Risk	Works compromise existing emergency procedures for building.	Injuries or death, reputational damage, litigation	2	5	10	Contractor to maintain Fire Risk Assessment and Emergency Plan for duration of works. Contractor to maintain fire segregation between construction works and occupied areas. Liaison with MPS to ensure client Emergency Procedures / Fire Risk Assessment remain current.	Mid Stage 2.		
Risk	Site Security / Unauthorised access gained onto site.	Injuries or death, reputational damage, litigation	2	5	10	Hoarding to secure works area. Site security controls (scaffold alarms / CCTV / controlled turnstiles / security guard).	Mid Stage 2.		
Risk	Striking underground services / tanks.	Injuries or death, reputational damage, litigation, disruption to client operations	1	5	10	We can provide mains record drawings and As Built information as a result of our work on current contracts	Mid Stage 2.		

Risk Type	Risk Description	Risk Impact Commentary	Likelihood	Impact	Risk Score	Factored Risk Cost (£)	Risk Mitigation	Review Date	Notes
Risk	Unplanned interruption to existing services including mechanical, electrical, fire, data, telecoms.	Injuries or death, reputational damage, litigation, disruption to client operations	2	5	10	Shutdowns strategy to be developed which addresses requirements to maintain live services to occupied areas of accommodation. Contingency arrangements to be developed.	Mid Stage 2.		
Risk	Uncontrolled collapse during demolition works.	Injuries or death, reputational damage, litigation, disruption to client operations	1	5	5	Structural Surveys to be completed in advance of works commencing in order that loading elements can be identified. Temporary works to be appropriately designed and correctly installed, used, checked and maintained during the works.	Mid Stage 2.		
Risk	Fall of persons / objects from height.	Injuries or death, reputational damage, litigation	2	5	10	Suitable protection and protective screening to be provided. Safety clearance zones established with additional overhead safeguards to be incorporated in vulnerable areas.	Mid Stage 2.		
Risk	Lifting operation outside confines of site compound.	Injuries or death, reputational damage, litigation	1	5	5	Contractor to develop lifting plan. Safety clearance zones to be established. Appropriate road closure license to be sought if lifting operations on highway required. No lifting operation over occupied accommodation.	Mid Stage 2.		
Risk	Exposure to non-ionising radiation from radio antennas.	Ill health, reputational damage, litigation	2	4	8	MPS to provide information if radio antennas are in vicinity of proposed works in order that personal risk can be assessed. Contractor to ensure risks are communicated to workforce.	Mid Stage 2.		
OTHERS (cross check against PESTLE headings, i.e. Political, Economic, Social, Legal, Environmental)									
Risk	Major Incident	Potential access / communication restricted	2	5	10	MPS to provide guidance	Mid Stage 2.		
Risk	Temporary plant required to facilitate permanent plant replacement	Location for temporary plant required	4	4	16	Location to be established and duration to be confirmed	Mid Stage 2.		
					Total Factored Risk Cost	0			

Risk Identification: CLIENT HELD | Risk Analysis

Scale	Likelihood	Description
1	Negligible (VL)	Rare, no realistic chance of occurrence
2	Low (L)	Could occur, but unlikely
3	Medium (M)	Possible
4	High (H)	Likely
5	Very High (VH)	Almost certain

Key Terms

Risk No.: Unique identifying reference number assigned to each risk
Risk Description: A brief narrative of the risk and its cause(s)
Risk Impact: Brief narrative of the impact if the risk is realised
Likelihood: The probability that the risk will be realised (on a scale of 1-5)
Impact: The severity of the impact if the risk is realised (on a scale of 1-5)
Risk Score: Product of Likelihood x Impact
Risk Owner: The person nominated to monitor the risk and its triggers
Mitigation: Brief narrative of the actions planned to reduce the likelihood of the risk occuring and/or the impact if it does
Planned Completion Date: The date by when the mitigation action(s) should be completed
Action Owner: The person or organisation responsible for carrying out the mitigation action(s)

Scale	Impact	Impact Categories / Description: Delivery of Corporate Objectives	Confidence & Satisfaction	Financial	Community & Staff Safety
1	Insignificant (VL)	No discernable impact on delivery of corporate objectives	No discernable impact on service delivery / reputation	Negligible impacts on budget / efficiency	No injury
2	Minor (L)	Minor effects on delivery of corporate objectives	Impact on service delivery / reputation is of little or no concern to stakeholders	Minimal impacts on budget / efficiency	First aid injury
3	Moderate (M)	Noticeable effects on delivery of corporate objectives	Impact on service delivery / reputation is relevant and noticeable to stakeholders	Limited impacts on budget / efficiency	Lost time injury (3 days off)
4	Major (H)	Delivery of several corporate objectives compromised	Major impact on service delivery / reputation	Major impacts on budget / efficiency	Major injury
5	Catastrophic (VH)	Wholesale failure in delivery of corporate objectives	Catastrophic impact on service delivery / reputation	Beyond budget capacity / unworkable	Death

LIKELIHOOD					
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	3	3	4	5
	1	2	3	4	5

IMPACT

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