St Pancras Site Heat Decarbonisation Milestone 2 Report

The British Library

Milestone 2 Report
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Quality information

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Revision History

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1. Executive Summary

AECOM were appointed to develop a Heat Decarbonisation Plan (HDP) for the British Library St. Pancras Site. This study was to evaluate a sustainable means for the site to "get off gas" and will lead to the application for Public Sector Decarbonisation Funding.

This report forms the output for Milestone 2, Decisions and Design. A short (max 4 pages) summary of the recommendations will follow. Milestone 3, Funding Application, are to follow this report.

This report details out the proposed intervention measures, summarised below[1]:

Intervention Measure	Capital Budget	Emissions Reduction (TCO_2)
IM07 – Hybrid ASHP with Gas Boilers	£2,182,315	13,034
IM09 - Hybrid ASHP with Electric Boilers	+£1,820,907[2]	13,976
IM11 - Chiller waste heat recovery	£992,261	3,694
IM27 – Ultrasonic humidification	£780,419	5,800
IM28 – BMS Upgrades	£432,900	1,232
IM30 – Photo Voltaics	£606,216	87
IM38 – Catering equipment electrification	+£167,700[3]	1,096
Energy Management Systems (mandatory to include energy monitoring to pursue grant funding)	£296,365	-

All IMs above are viable to be taken forward in some context. IM16 flow temperature reduction has been removed as works have already been carried out.

Key next steps are set out below:

- Review and agree which options are to be taken forward into Milestone 3 and for PSDS funding
- Develop long term capital funding plan for works not taken forward for an immediate PSDS application
- Potential to engage with Somers Town Heat Network and allow them access to BL land for the installation of a larger scale ASHP solution which would serve BL and form a decarbonisation solution for the Somers Town Heat Network.
- Decide on how to progress with IM7 or 9.

Key risks prior to mitigation are set out below:

Risk	Owner
Electrical capacity for Boilers	British Library
Electrical capacity for ASHP	British Library
Electrical capacity for WWHP	British Library
Electrical capacity for humidification	British Library
Control process changes lead to adverse conditions for the collection	British Library

[1] Fabric interventions were excluded from the original scope. IMs focused on gas usage only.
[2] Additional cost above and beyond IM7 due to the electric boilers and need for diesel generator
[3] Additional cost over installing a gas based catering refit

2. Introduction

2.1 Project Aims

AECOM have been appointed to develop a Heat Decarbonisation Plan (HDP) for the British Library St. Pancras Site. This study was to evaluate a sustainable means for the site to "get off gas" and will lead to the application for Public Sector Decarbonisation Funding if applicable.

Milestone 1; Feasibility has been issued, and the original 'blue sky' option list reduced to 7 options. Following the conclusion of this assessment, the main outcomes were identified;

- Business as Usual presents the lowest CapEx and TotEx option to the site but this is not compliant with the client's goals of achieving net zero.
- The Partial Degasification options presents the best balance between whole life cycle cost and carbon savings when looking at NPV and SNPV (NPV plus the social impact of carbon reduction). This option does not meet British Library's target of full degasification.
- The Full Degasification option presents best value of the options that eliminates gas from St.Pancras
- PSDS grant impact has not currently been assessed and would support Full Degasification (PSDS) or Full Degasification (Extras)

The report findings were presented to the British Library client team on 3rd May 2024. The client decision was to progress the following IMs as part of the AECOM Milestone 2 package of design development;

IM07 – Hybrid ASHP with Gas Boilers

IM09 - Hybrid ASHP with Electric Boilers

IM11 - Chiller waste heat recovery

IM16 – LTHW heating system temperature reduction

IM27 – Ultrasonic humidification

IM28 – BMS Upgrades

IM30 – Photo Voltaics

IM38 – Catering equipment electrification

The scope of this report has been taken from the original Invitation to Tender, and is listed below;

Design: *Develop the preferred option to RIBA design Stage 2 (at a block diagram level, sufficient for a PSDS and/or GHNF funding application). To include the interface with existing building services. Estimate the financial and carbon impacts (capital cost, running costs, operational carbon savings, embodied carbon). Using future carbon factors, model progress towards net zero over time. We anticipate this stage requiring at least a further two site visits, to liaise with our buildings services team.*

This report forms the output for Milestone 2, Design, taking the agreed options to RIBA stage 2 level of detail as sufficient for funding applications for further consideration. Milestone 3, Funding Application, is to follow this report.

2.2 General Matters

2.2.1 Additional Professional Advice

The following additional professional input is required at the next design stage.

2.2.1.1 Structural Engineering

The structural suitability of allocated roof spaces for Air Source Heat Pumps needs to be analysed for IM7 & IM9.

2.2.1.2 Construction Design & Management

A Principal Designer should be appointed as required by the Construction Design & Management Regulations

2.2.1.3 Planning Consultant

A Planning Consultant should be appointed for initial reviews of the proposals to comment on likely planning authority concerns for those items which will attract planning interest.

- IM7 & IM9: ASHP's located at roof level.
- IM30: Photovoltaic installation at roof level.

2.2.2 Procurement

The procurement of the agreed works needs to be considered at this stage and may be dependent on funding streams (where PSDS funding is likely to create specific deadlines).

The works can be procured via traditional methods (full consultant design, tender process, and then contractor's duties - production of installation drawings and installation, testing & commissioning & setting to work, and record information & training).

An alternative approach is the design & build process (outline consultant design, tender process, and then contractor's duties – RIBA stage 4 detailed design, production of installation drawings and installation, testing & commissioning & setting to work, and record information & training).

Previous discussions noted in the Milestone 1 report inform this matter, in addition AECOM will provide a note on the impact of funding based on client discussions after the issue of this report.

2.3 Existing Installation

The systems providing heating and cooling for the building installed during the original construction have largely been retained, but with some modifications, particularly the removal of some of the original heat reclaim facilities, and replacement of the original gas boilers.

Most of the site is served from Air Handling Units (AHU's) providing filtered, heated, cooled and humidified air to control the temperature and humidity of the space served. The majority of the AHU's are in the basements, with some minor additional AHU plantrooms at upper levels.

The AHU's are served from cooling plant, heating plant & steam generation plant (for humidification) located in the basement, and the energy use of the cooling system (electricity) and the heating & steam systems (primarily gas) are the prime energy uses in the building and the focus of most of the intervention measures proposed.

2.3.1 Cooling Installation

The primary chilled water service is fed from 3 No. original chillers at basement B1 level & discharging waste heat to 3 No. cooling towers located at the level 5 roof, each cooling tower dedicated to a specific chiller. Additional chillers 4 & 5 link into Chiller 2 and Chiller 3 condenser water circuits respectively. Each condenser water circuit has a pair of run & standby pumps (P/44/P1-P6)

There are primary chilled water circuit pumps (P/52/P1-P3) which circulate through the chillers, and secondary chilled water circulation serves separate zone distribution as follows:

- P/56/P1&P2 – BML Secondary Circuit No 1
- P/57/P1&P2 - BML Secondary Circuit No 2

- P/58/P1&P2 – SRL Secondary
- P/59/P1&P2 – Meeting Rooms
- P/60/P1&P2 – Zone 9
- P/61/P1&P2 – Zone 8
- P/62/P1&P2 – Zone 7

A number of ancillary chilled services are installed to serve specific locations, in most cases via a plate heat exchanger (BLCC chillers and dry coolers, Kings Library packaged chiller, Kings Library auxiliary cooling chillers, UGF Bookstacks chiller and air cooled condenser, Philatelic Strongroom chiller). There is also an ice storage system noted in some records but the veracity of this is being investigated – it is not believed to be in use.

2.3.2 Heating installation

3 No 630kW gas-fired boilers with primary circulation pumps (P02/P1 & P02/P2) located in the basement plantroom serve a primary circulation loop designated 'LPHW pre-heat' via a pair of pumps (P06/P1 & P06/02) connecting to heat exchangers (Plant 91/HE1 & HE2) which serve the secondary heating circuit – this is known as the 'Heat Reclaim Circuit' (HRC) because when installed it had number of heat sources apart from the boiler source. A pair of HRC pumps (P85/P1 & P85/P2) provide the circulation within the basement plantroom, and from the headers of this circuit a number of tertiary pumps serve the local circuits as follows:

- P/76/P1&P2 – BML Secondary Circuit 1 - Basement Bookstacks
- P/77/P1&P2 - BML Secondary Circuit 2
- P/78/P1&P2 – SRL
- P/79/P1&P2 – Meeting Room
- P/81/P1&P2 – Zone 9
- P/82/P1&P2 – Zone 8
- P/80/P1&P2 – Zone 7

The Heat Reclaim Circuit (HRC) originally received heat input from sources other than the gas boiler system, and these are believed to have been as follows (from record drawings and asset register):

- Thermal Storage System served by heat pumps drawing heat from the chiller condenser water circuits (Heat Pumps Plant 72/HP1, HP2 & HP3, Thermal Storage Tank 71, heat exchangers 89/PHE1 & PHE2, pumps 73/P1 & P2, & 86/P1 & P2), now removed
- Electrode boilers system to top up thermal stores (Boilers 21, Plate Heat exchangers 023, pumps 87 & 22), now removed
- An additional boiler circuit which 'topped up' the HRC circuit by direct connection into the HRC circuit, (original boiler 3) believed to have been removed during latest boiler replacement (TBC)
- A plate heat exchanger (plant 90/HE2) repurposed to reclaim heat from the steam system (this was originally a part of the thermal store system) current status to be confirmed (but assumed that it will not be available because if IM27 Ultrasonic Humidification proceeds the steam system heat will not be available)
- Appendix A includes a simplified schematic of the current Heating System, and indicates the additional heat reclaim systems that were originally installed. In conclusion, the system is now run from the 3 gas boilers, newly installed in about 2010.

Operating Hours

The majority of the storage and library areas are 24 hour running to maintain consistent conditions for the sensitive stored items.

Operating temperatures

- primary gas boiler circuit operates at 80 deg C flow, 60 deg C return

- secondary heating circuits operate at 50 deg C flow, 30 deg C return

2.3.3 Domestic Hot Water Installation

The Hot Water Service, previously fed entirely from a gas-fired HWS generator, is now served primarily by solar thermal, with roof mounted solar hot water collector, and a storage tank & pumps at basement. The gas heated hot water generator now just provides the top up to the system to maintain supply at the required temperatures.

2.3.4 Steam Installation

2 No gas-fired steam generators serve the humidification system. Each unit is rated at 1084 kg/hr at 6.9 bar, and the plant is located at basement level. The steam serves approximately 19 humidifiers within Air Handling Units (AHU's).

There are a number of local electric humidifiers in remote plantrooms, not fed from the central steam system.

2.3.5 Electrical Installation

The electrical infrastructure has dual High Voltage (HV) supplies derived from the UKPN network located within either the Midland Road or Ossulston Street sub-stations located at Basement 1 level. As these HV supplies are from diverse HV circuits it has eliminated the necessity for a Life safety generator. The British Library substations of which there are six (numbered 1 to 5 and "Package Substation") are dual fed by HV supplies from either Midland Road and Ossulston Street UKPN HV sub-stations or from British Library substations. The British Library sub-stations are also located at Basement 1 level.

Substation No. 1 consists of: -

2 No. HV supplies (1 from Midland Road, 1 from Ossulston Road)

4 No. HV/LV transformers (S1/T1, S1/T2, S1/T3 & S1/T4)

Each transformer supplies their respective LV switch board (LVS1S1, LVS2S1, LVS3S1 & LVS4S1).

Each of the switch boards are bus-coupled together to add another level of resilience.

2 No. additional HV supplies originates from Sub Station No.1. One supply supports the Package Sub-station transformer (PS/T1) and the other supported the now decommissioned Electro Boiler No.2.

Substation No. 2 consists of: -

4 No. HV (11kV) supplies (2 from Midland Road, 2 from Ossulston Road)

4 No. HV/LV (11kV/400V) transformers (S2/T1, S2/T2, S2/T3 & S2/T4)

3 No. HV/LV (11kV/3.3kV) transformers (CH1/2, CH2/2, CH3/2)

Each of the HV switch boards are bus-coupled together to add another level of resilience.

Each transformer supplies their respective LV switch board (LVS1S2, LVS2S2, LVS3S2 & LVS4S2).

Each of the LV switch boards are bus-coupled together to add another level of resilience.

2 No. additional HV supplies originates from Sub Station No.2. One supply supports the Package Sub-station transformer (PS/T2) and the other provides the alternative HV supply to Substation No.4.

Substation No. 3 consists of: -

2 No. HV (11kV) supplies (1 from Midland Road, 1 from Ossulston Road)

4 No. HV/LV (11kV/400V) transformers (S3/T1, S3/T2, S3/T3 & S3/T4)

Each of the HV switch boards are bus-coupled together to add another level of resilience.

Each transformer supplies their respective LV switch board (LVS1S3, LVS2S3, LVS3S3 & LVS4S3).

Each of the LV switch boards are bus-coupled together to add another level of resilience.

An additional HV supply originates from Sub Station No.3. This supply supports Sub-station No.4 and provides an alternative HV supply to Substation No.4.

Substation No. 4 consists of: -

2 No. HV (11kV) supplies (2 from Ossulston Road)

2 No. HV (11kV) supplies (1 from Substation No. 2, 1 from Substation No. 3)

4 No. HV/LV (11kV/400V) transformers (S4/T1, S4/T2, S4/T3 & S4/T4)

Each of the HV switch boards are bus-coupled together to add another level of resilience.

Each transformer supplies their respective LV switch board (LVS1S4, LVS2S4, LVS3S4 & LVS4S4).

Each of the LV switch boards are bus-coupled together to add another level of resilience.

Substation No. 5 consists of: -

2 No. HV (11kV) supplies (1 from Midland Road, 1 from Ossulston Road)

4 No. HV/LV (11kV/400V) transformers (S5/T1, S5/T2, S5/T3 & S5/T4)

Each of the HV switch boards are bus-coupled together to add another level of resilience.

Each transformer supplies their respective LV switch board (LVS1S5, LVS2S5, LVS3S5 & LVS4S5).

Each of the LV switch boards are bus-coupled together to add another level of resilience.

Package Substation consists of: -

2 No. HV (11kV) supplies (1 from Substation No. 1, 1 from Substation No. 2)

4 No. HV/LV (11kV/400V) transformers (S5/T1, S5/T2, S5/T3 & S5/T4)

Each transformer supplies their respective LV switch board (LVPSS1 & LVPSS2).

Each of the LV switch boards are bus-coupled together to add another level of resilience.

3. Intervention Measures Summary

The summary of intervention measures, as published in the Milestone 1 presentation is as follows:

Intervention	Description	Impact
IM7	• Install 3no. new 630kW gas boilers • Install new array of 445kW ASHPs • Install 10m3 thermal store for ASHPs	Reduces reliance of gas by electrifying a large portion of the LTHW heating demand. >90% of LTHW heat from ASHPs
IM9	• Install 3no. new 630kW electric boilers • Install new array of 445kW ASHPs • Install 10m3 thermal store for ASHPs	>90% of LTHW heat from ASHPs. Residual LTHW heat from new electric boilers
IM11	• Install 420kW WWHP linked to existing chillers • Install 30m3 thermal store for ASHPs	Recovers ~20% of the LTHW heat from the waste rejected by the chiller system
IM16	• Change set point on BMS to control flow temp to 60ºC • Change AHU coils (duct mounted) • Replace limited number of radiators	Reduces unwanted heat loss by 6%. Necessary to optimise IM7, 9 and 11. Supports connection to future heat network
IM27	• Ultra Sonic Humidification replacement of current steam lance system (duct mounted)	Enables a 90% energy demand reduction over the steam system.
IM30	• Photo Voltaics	To be modelled
IM38	• Catering Electrification	Allows for elimination of gas use on site

In addition we have included intervention measure IM28 – BMS Upgrades, at the client's request

4. Concept Designs

For each of the intervention measures proposed, the following sections provide more detail on the intended effects, what works must be physically carried out, what plant & equipment will be needed, controls changes, and a brief commentary on whether PSDS funding can be applied for.

Note that these are written so that each of the sections can be read independently, so where similar aims are intended some parts will repeat.

4.1 IM7 Partial Air Source Heat Pumps with Gas Boilers

4.1.1 Introduction

4.1.1.1 Intended Effects

The proposal is to provide the majority of the building heating needs from Air Source Heat Pumps (ASHP) which are electrically driven, to provide two carbon emissions improvements:

- To use the ASHP refrigeration cycle to produce approximately 2.7W of heating for each 1kW of electricity used at design conditions – the ratio of input to output is known as the 'Coefficient of Performance' (CoP) and varies between makes and models of ASHP, and also varies dependent on external temperatures and required output temperatures, with ESEER (European Seasonal Energy Efficiency Ratio - effectively an 'annual' CoP) used to allow for external temperature variations. Deciding system water temperatures and equipment selection will be key to optimising energy savings.

- To transfer the majority of the heating energy source to electrical power in place of the existing gas energy source, taking advantage of the ongoing decarbonisation of the National Grid electricity supply.

The 445kW capacity of the ASHP installation may appear very low in comparison to the existing 1890kW gas boiler installation – this is for two main reasons:

- The actual heating demand of the building varies continuously, principally in response to external temperature, and rarely approaches the installed boiler capacity, and for the majority of the time is less than the output of a single gas boiler.

- Installation of ASHP's matching the boiler capacity would involve excessive cost and excessive use of the available roof areas (with associated planning and structural risk)

An assessment has been carried out at the previous stage to determine the most effective ASHP capacity, determined as 445kW, and this is calculated to satisfy 90% of the annual building heating energy demand.

The ASHP's need, like most major plant, to run for a reasonable period of time to achieve their peak efficiency and reliability – rapid stops and starts cause unnecessary wear and tear. Therefore, to minimise ware it is proposed to include a buffer vessel to protect the ASHP.

Whilst not currently allowed for, a separate thermal store may allow them to operate effectively when building heat demand is close to their capacity, thus any excess heat energy created by the ASHP will be stored, and then used after the ASHP has stopped running. So when the ASHP stops running, the thermal store becomes the building energy source, and when the thermal store is exhausted the ASHP is called back into action. This maximises the use of the ASHP, and of course minimises the use of the gas boilers.

The gas boilers will therefore only be used when ASHP and thermal store capacity is exceeded – when it is very cold outside, when the building is heating up from cold, or when ASHP's are unavailable due to equipment failure or planned maintenance.

The thermal store impact should be assessed in the next stage of design.

This solution will reduce the use of direct fossil fuel energy sources by the Building Services heating installation, and thus reduce the carbon emissions of the building. Electrical loads will be increased, but the expected decarbonisation of the National Grid means that the building energy use is decarbonised overall.

Note that costs for this option include for 3 new 630kW gas boilers. This is intended to account for replacement of the existing (fairly new) boilers when they reach the end of their useful life.

4.1.1.2 PSDS Funding

As previously noted in the Milestone 1 report, PSDS rules explicitly excludes the funding of replacement of fossil fuel equipment. In AECOMs experience, bivalent/hybrid systems[4] retaining aged gas fired boilers have been

[4] https://www.salixfinance.co.uk/sites/default/files/2023-09/FAQs%20on%20bivalent%20and%20resilience%20systems%20PSDS%20scheme%20requirement_1.pdf

refused funding. AECOM is currently engaging with Salix to identify the formal position of the fund for round 4 and future rounds.

AECOM is continuing to pursue a formal clarification on this matter.

Currently, it is not expected that this type of system would attract PSDS funding due to the retention of gas fired boilers.

4.1.2 Mechanical Engineering Services

The following scope includes for a better than usual level of redundancy (dual risers, dual thermal stores) to allow for plant or pipework failures, but given the probable permanence of the building's function, this is also intended to allow continued running, albeit at some reduction of capacity, when replacement of parts of the installation is required at end of life.

4.1.2.1 Scope of Works

Installation of 445kW ASHP – this will be provided as a number of ASHP units, ideally 2no at 50%, to provide some redundancy for maintenance or equipment failure, to suit the plant spaces identified and the commercially available sizes, and provide a level of redundancy for maintenance activities or ASHP failure. These need to be installed in open air, and the ideal location is at roof level, minimising loss of useful space and reducing planning risk. The weights of the units will need to suit any structural limitations of the roof structure.

Installation of a 2 x 5m^3 buffer vessel at basement level. There is adequate space for these in the basement plantrooms. The purpose of the buffer vessel is for compressor protection and is not sized for plant optimisation or peak lopping. Additional performance may be delivered via a thermal store but this should be considered in the next stage of design.

Installation of run and standby pumps at basement level to serve the ASHP circuit. There is adequate space for this in the basement plantrooms.

Installation of dual plate heat exchangers to sit between the existing heating and the ASHP circuit.

Installation of new electrical services to ASHP's, new circulation pumps, and new controls.

Building management System (BMS) modifications to control the ASHP system, and to prioritise ASHP over the gas boilers on heating demand. A new MCC will be provided to serve the ASHP equipment.

Pipework risers between basement and designated ASHP locations at roof level – dual risers proposed to allow for riser replacement when required in the future.

Electrical risers between basement and designated ASHP location at roof level.

Pipework modifications in the basement to connect the ASHP circuit into the secondary heating circuits, including all controls necessary to achieve the prioritisation of the ASHP as the preferred heat source.

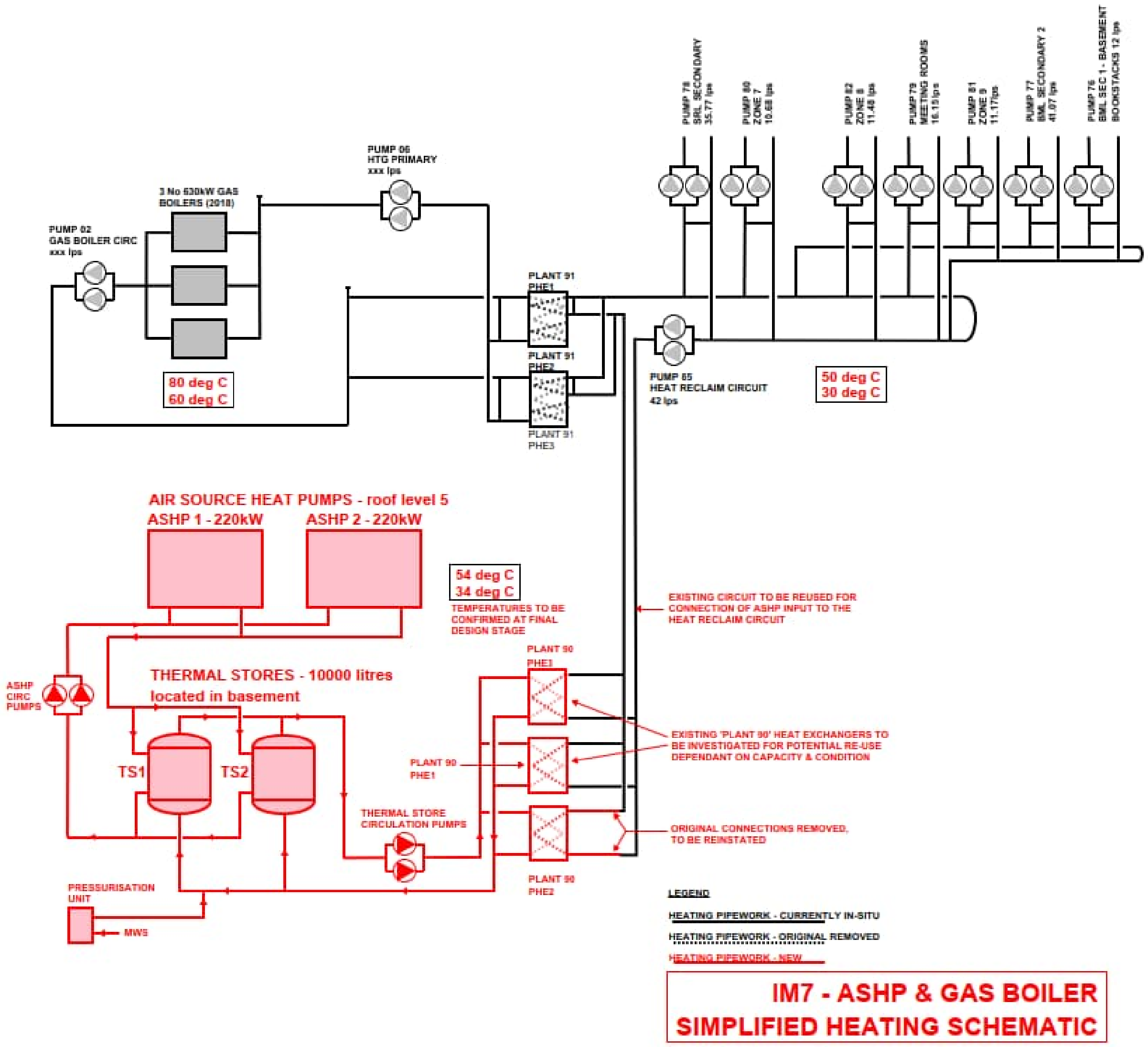
All required valves and ancillaries including isolating valves, commissioning valves, control valves, strainers, air vents, drain points, anti-vibration connections etc

Insulation and identification of all pipework

New pressurisation plant to serve the ASHP system.

4.1.2.2 Outline Heating Plant Schematic

Refer to Appendix A for the existing outline heating schematic for information



4.1.2.3 Plant & Equipment

The following are preliminary selections to be finalised at a later design stage.

Air Source Heat Pumps

- 2 no @ 220 kW
- Location – level 5 roof
- Controls – the ASHP system shall include a manufacturer's dedicated controls system to provide duty share, auto-changeover, and to collate fault signals – the system will be capable of full communication with the Building BMS.

ASHP circulation pumps

- 2No inverter driven pumps
- Duty – 5.5 lps @ 250 kPa
- Location - basement

Buffer Vessel circulation pumps

- 2No inverter driven pumps

- Duty – 5.5 lps @ 250 kPa
- Location - basement

Buffer Vessel

- Capacity – 2 no at 5,000 litres
- Location - basement

4.1.2.4 Controls Changes

The Building Management System (BMS) will have new controls functions installed to achieve the following:

- Provide a demand signal to the ASHP control system
- Communicate with the ASHP control system
- Control pump set for enable, duty change, auto-changeover, pump failure
- Metering of heat output energy flow and electrical consumption for each WWHP.

4.1.2.5 Strip Out of Existing Services

No significant sections of the existing are to be stripped out.

4.1.3 Electrical Engineering Services

4.1.3.1 LV Distribution

The power supplies for the Roof top mounted Air Source Heat Pumps (ASHP) and circulation pumps will be derived from new Motor Control Centres (MCC's). It is intended the MCC's associated with the ASHP's will be located at the appropriate roof levels. The supplies for the additional circulation pumps will be supplied for the existing MCC's where practicable. The number and final location of the MCC's will be determined as part of the detailed design stage.

4.1.3.2 General Power and Lighting

The small power requirements in the vicinity of the roof top and basement plants will be reviewed to ensure sufficient outlets are provided to undertake maintenance tasks.

The general and emergency lighting within the vicinity of the roof top and basement plant room will be reviewed to ensure adequate lighting in the vicinity of the control panels and maintenance points.

The extent of these works shall be determined as part of the detailed design stage.

4.1.4 Fire Detection and Alarm

The existing fire detection, interface and shut off systems will be reviewed and modified to suit the new installation and code compliance. Any redundant equipment shall be removed.

The extent of these works shall be determined as part of the detailed design stage.

4.1.5 Public Health Engineering Services

No significant works.

4.2 IM9 Partial Air Source Heat Pumps with Electric Boilers

4.2.1 Introduction

i. Intended Effects

The proposal is to provide the majority of the building heating needs from Air Source Heat Pumps (ASHP) which are electrically driven, to provide two carbon emissions improvements:

- to use the ASHP refrigeration cycle to produce approximately 2.7kW of heating for each 1kW of electricity used at design conditions – the ratio of input to output is known as the 'Coefficient of Performance' (CoP) and varies between makes and models of ASHP, and also varies dependent on external temperatures and required output temperatures, with ESEER (European Seasonal Energy Efficiency Ratio - effectively an 'annual' CoP) used to allow for external temperature variations. Deciding system water temperatures and equipment selection will be key to optimising energy savings.

- To transfer the majority of the heating energy source to electrical power in place of the existing gas energy source, taking advantage of the ongoing decarbonisation of the National Grid electricity supply.

The 445kW capacity of the ASHP installation may appear very low in comparison to the existing 1890kW gas boiler installation – this is for two main reasons:

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- Installation of ASHP's matching the boiler capacity would involve excessive cost and excessive use of the available roof areas (with associated planning and structural risk)

An assessment has been carried out at the previous stage to determine the most effective ASHP capacity, determined as 445kW, and this is calculated to satisfy 90% of the annual building heating energy demand.

The ASHP's need, like most major plant, to run for a reasonable period of time to achieve their peak efficiency and reliability – rapid stops and starts cause unnecessary wear and tear. Therefore, to minimise ware it is proposed to include a buffer vessel to protect the ASHP.

Whilst not currently allowed for, a separate thermal store may allow them to operate effectively when building heat demand is close to their capacity, thus any excess heat energy created by the ASHP will be stored, and then used after the ASHP has stopped running. So when the ASHP stops running, the thermal store becomes the building energy source, and when the thermal store is exhausted the ASHP is called back into action. This maximises the use of the ASHP, and of course minimises the use of the gas boilers.

The gas boilers will therefore only be used when ASHP and thermal store capacity is exceeded – when it is very cold outside, when the building is heating up from cold, or when ASHP's are unavailable due to equipment failure or planned maintenance.

The thermal store impact should be assessed in the next stage of design.

The new electric boilers will be sized to include for the domestic hot water load – hot water is pre-heated by the solar water system, but requires top-up to achieve the required temperatures, currently achieved by a gas-fired water heater (if required to achieve acceptable PSDS submission – see section 4.2.1.2).

This solution will remove all direct fossil fuel energy sources from the Building Services heating installation, and thus reduce the carbon emissions of the building. Electrical loads will be increased compared to existing, but the expected decarbonisation of the National Grid means that the building energy use is decarbonised overall.

4.2.1.2 PSDS Funding

Whilst this solution results in the LTHW associated gas combustion reducing to zero, the steam raising gas and catering gas remain. AECOM are engaging with Salix to identify whether the fund would consider the separate application for each of the gas systems, or whether the fund would consider them together.

If Salix would consider the gas streams separately, then this IM would denote compliance with the current understanding of the rules.

If Salix pursue a site based gas approach, this IM would need to be presented in coordination with;

- The removal of the gas-fired steam generators as detailed in section 4.5 (IM27) will also need to be undertaken.
- The removal of the gas catering systems (unlikely as this is process-based gas usage and not linked to the building's performance)

AECOM is currently engaging with PSDS to establish whether this project may be presented as a single energy stream and funded independently of the humidification gas use and catering gas use. We are aware that this approach has been applied under other applications and is considered that this should be achievable.

PSDS funding would need to be applied for by October 2024 and have all funds expended by March 2027. 12% match funding would need to be shown by October 2024. This will be considered in Milestone 3 reporting.

4.2.2 Mechanical Engineering Services

4.2.2.1 Scope of Works

Installation of 445kW ASHP – this will be provided as a number of ASHP units, ideally 2 at 50%, to provide some redundancy for maintenance or equipment failure, to suit the plant spaces identified and the commercially available sizes, and provide a level of redundancy for maintenance activities or ASHP failure. These need to be installed in open air, and the ideal location is at roof level, minimising loss of useful space and reducing planning risk. The weights of the units will need to suit any structural limitations of the roof structure.

Installation of a 2 x 5m^3 buffer vessels at basement level. There is adequate space for these in the basement plantrooms. The purpose of the buffer vessels is for compressor protection and is not sized for plant optimisation or peak lopping

Installation of run and standby pumps at basement level to serve the ASHP circuit. There is adequate space for this in the basement plantrooms.

Installation of dual plate heat exchangers to sit between the existing heating and the ASHP circuit.

Installation of 3 no 630kW electric boilers, replacing the existing gas boilers.

Installation of replacement domestic hot water vessel with Heating Primary off electric boiler 80/60 deg C service top-up/back-up (in place of existing gas-fired Hot Water Vessel)

Installation of new electrical services to ASHP's, new electric boilers, new pumps, replacement hot water generator, and new controls.

Building management System (BMS) modifications to control the ASHP system, and to prioritise ASHP over the electric boilers on heating demand.

Pipework risers between basement and designated ASHP locations at roof level – dual risers proposed to allow for riser replacement when required in the future.

Electrical risers between basement and designated ASHP location at roof level.

Pipework modifications in the basement to connect the ASHP circuit into the secondary heating circuits, including all controls necessary to achieve the prioritisation of the ASHP as the preferred heat source.

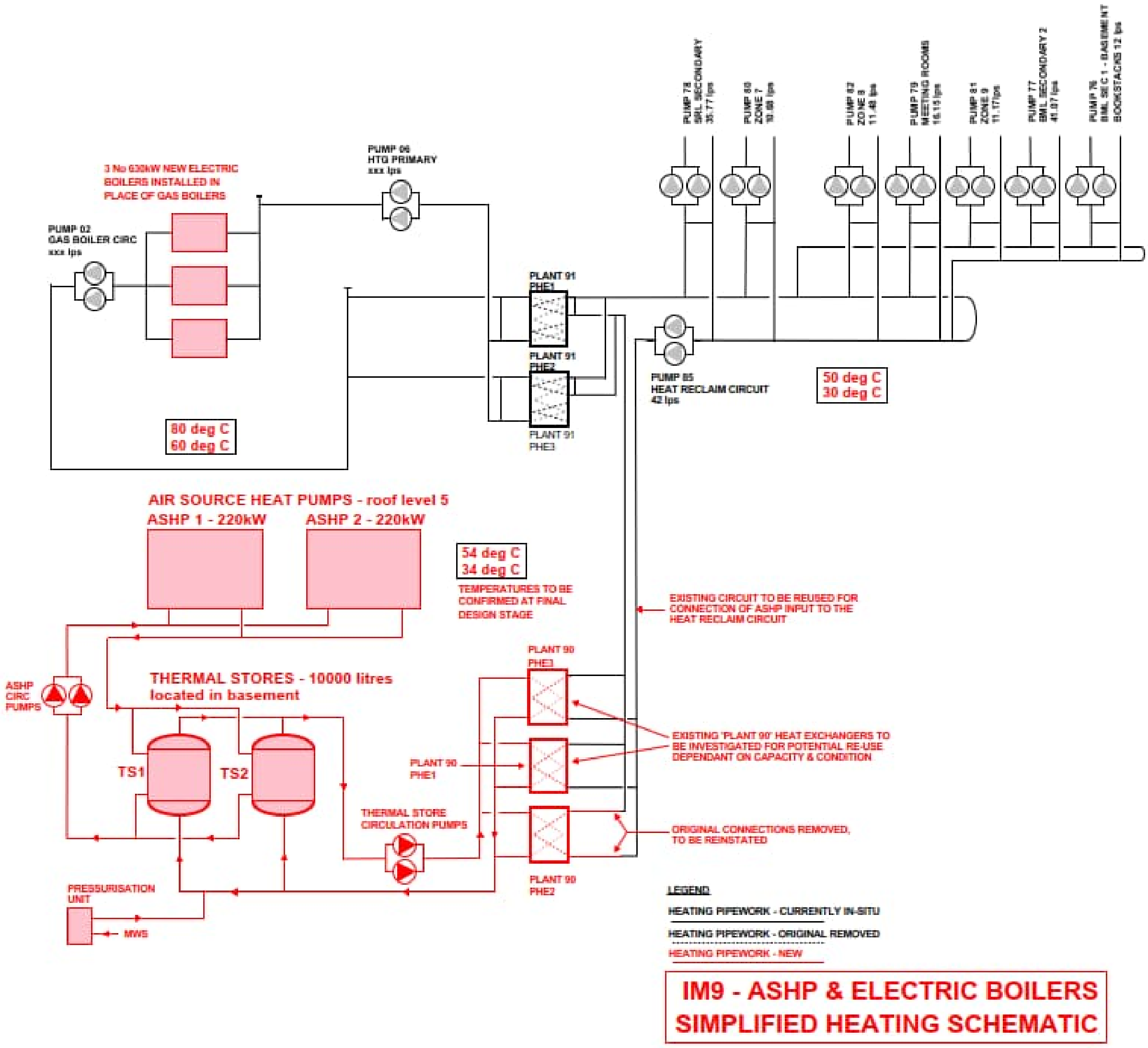
All required valves and ancillaries including isolating valves, commissioning valves, control valves, strainers, air vents, drain points, anti-vibration connections etc

Insulation and identification of all pipework

New pressurisation plant to serve the ASHP system.

4.2.2.2 Outline Heating Plant Schematic

Refer to Appendix A for the existing outline heating schematic for information



4.2.2.3 Plant & Equipment

The following are preliminary selections to be finalised at a later design stage

Air Source Heat Pumps

- 2 no @ 220 kW
- Location – level 5 roof
- Refrigerant – zero or very low GWP, zero ODP
- Controls – the ASHP system shall include a manufacturer's dedicated controls system to provide duty share, auto-changeover, and to collate fault signals – the system will be capable of full communication with the Building BMS.

ASHP circulation pumps

- 2No inverter driven pumps
- Duty – 5.5 lps @ 250 kPa
- Location - basement

Buffer Vessel circulation pumps

- 2No inverter driven pumps
- Duty – 5.5 lps @ 250 kPa
- Location - basement

Buffer Vessel

- Capacity – 2 no at 5,000 litres
- Location - basement

Electrode Boilers

- 3 no @ 630 kW
- Location - basement

4.2.2.4 Controls Changes

The Building Management System (BMS) will have new controls functions installed to achieve the following:

- Provide a demand signal to the ASHP control system
- Communication with the ASHP control system
- Modify boiler control to suit electrode boilers controls & fault reporting
- Control pump set for enable, duty change, auto-changeover, pump failure
- Metering of energy flows and consumption.

4.2.2.5 Strip Out of Existing Services

The following significant sections of the existing are to be stripped out.

- Gas boilers
- Gas fired HWS vessel (if required to achieve acceptable PSDS submission – see section 4.2.1.2)
- Flues
- Gas service (including HWS vessel supply if required to achieve acceptable PSDS submission – see section 4.2.1.2)
- Associated electrical services

4.2.3 Electrical Engineering Services

4.2.3.1 LV Distribution

The power supplies for the Roof top mounted Air Source Heat Pumps (ASHP), electric boilers and associated circulation pumps will be derived from new Motor Control Centres (MCC). It is intended the MCC's associated with the ASHP's will be located at the appropriate roof level. The supplies for the electric boilers and additional circulation pumps will be supplied from new MCC's located within the basement plant room. The number and final location of the MCC's will be determined as part of the detailed design stage.

4.2.3.2 General Power and Lighting

The small power requirements in the vicinity of the roof top and basement plants will be reviewed to ensure sufficient outlets are provided to undertake maintenance tasks.

The general and emergency lighting within the vicinity of the roof top and basement plant room will be reviewed to ensure adequate lighting in the vicinity of the control panels and maintenance points.

The extent of these works shall be determined as part of the detailed design.

4.2.4 Fire Detection and Alarm

The existing fire detection, interface and shut off systems will be reviewed and modified to suit the new installation and code compliance. Any redundant equipment shall be removed.

The extent of these works shall be determined as part of the detailed design.

4.2.5 Public Health Engineering Services

Installation of replacement domestic hot water vessel with Heating Primary off the electric boiler 80/60 deg C service to provide top-up/back-up to the solar hot water system (in place of existing gas-fired Hot Water Vessel)

4.3 IM11 Waste Heat Recovery

4.3.1 Introduction

4.3.1.1 Intended Effects

The proposal is to provide a proportion of the building heating needs from Water to Water Heat Pumps (WWHP) reclaiming heat from the chiller condenser water circuit. The WWHP's are electrically driven, to provide two carbon emissions improvements:

- to use the WWHP refrigeration cycle to produce approximately 6.5kW of heating for each 1kW of electricity used at design conditions – the ratio of input to output is known as the 'Coefficient of Performance' (CoP) and varies between makes and models of WWHP, and also varies dependent on input temperatures and required output temperatures, with ESEER (European Seasonal Energy Efficiency Ratio - effectively an 'annual' CoP) used to allow for external temperature variations. Deciding system water temperatures and equipment selection will be key to optimising energy savings.
- To transfer the majority of the heating energy source to electrical power in place of the existing gas energy source, taking advantage of the ongoing decarbonisation of the National Grid electricity supply.

The 420kW capacity of the WWHP installation may appear very low in comparison to the existing 1890kW gas boiler installation – this is for two main reasons:

- The actual heating demand of the building varies continuously, principally in response to external temperature, and rarely approaches the installed boiler capacity, and for the majority of the time is less than the output of a single gas boiler.
- Installation of WWHP's matching the boiler capacity would involve excessive cost and possibly exceed the heat reclaim available off the chiller condenser water circuits

An assessment has been carried out at the previous stage to determine the most effective WWHP capacity, determined as 420kW plant capacity, and this is calculated to satisfy circa 23% of the annual building LTHW associated heating energy demand. This IM will not impact the current gas usage for the humidification or catering applications.

The WWHP's need, like most major plant, to run for a reasonable period of time to achieve their peak efficiency and reliability – rapid stops and starts cause unnecessary wear and tear. Therefore, to allow them to operate effectively when building heat demand is close to their capacity it is intended to include a thermal store, thus any excess heat energy created by the WWHP will be stored, and then used after the WWHP has stopped running. So when the WWHP stops running, the thermal store becomes the building energy source, and when the thermal store is exhausted the WWHP is called back into action. This maximises the use of the WWHP, and of course minimises the use of the gas boilers.

In addition the chiller condenser water circuit will not be running at full capacity much of the time when heating is required, so the thermal store for this solution is significantly larger than for the buffer vessel ASHP solutions proposed under IM7 and IM9, to allow the thermal store to retain reclaimed energy at high cooling demand, for later use at high heating demand.

The gas boilers will therefore only be used when WWHP capacity and thermal store capacity is exceeded – when it is very cold outside, when the building is heating up from cold, or when WWHP's are unavailable due to equipment failure or planned maintenance.

Note that costs for this option exclude the 3 new boilers. The costs for new boilers are accounted for in IM7 and IM9, depending on approach taken.

4.3.1.2 PSDS Funding

Under the previous PSDS scheme this IM would not attract PSDS funding because it does not eliminate gas sourced heating entirely. The rules of the next PSDS funding stream are not yet known, but it is unlikely that it will change in this regard. IM11 would need to be implemented alongside other gas reducing/eliminating IMs.

AECOM is currently engaging with Salix to identify the formal position of the fund for round 4 and future rounds. AECOM is continuing to pursue a formal clarification on this matter.

Currently, it is not expected that this type of system would attract PSDS funding due to the retention of gas fired boilers.

4.3.2 Mechanical Engineering Services

4.3.2.1 Scope of Works

Installation of 420kW WWHP – this will be provided as a number of WWHP units, 2 at 50%, selected to suit the plant spaces available and the commercially available sizes, and provide a level of redundancy for maintenance activities or WWHP failure. These can be installed in the basement plantroom.

Installation of 30 m^3 of thermal storage at basement level.

Installation of pumps at basement level to boost each condenser water circuit through plate heat exchangers.

Installation of plate heat exchangers at basement level (condenser water circuit to WWHP input circuit)

Installation of run and standby pumps at basement level to serve the WWHP input circuit.

Installation of pressurisation plant to serve WWHP input circuit.

Installation of new electrical services to WWHP's, new circulation pumps, and new controls.

Building Management System (BMS) modifications to control the condenser water diversion from cooling tower to WWHP input, the WWHP system, and to prioritise WWHP over the gas boilers on heating demand.

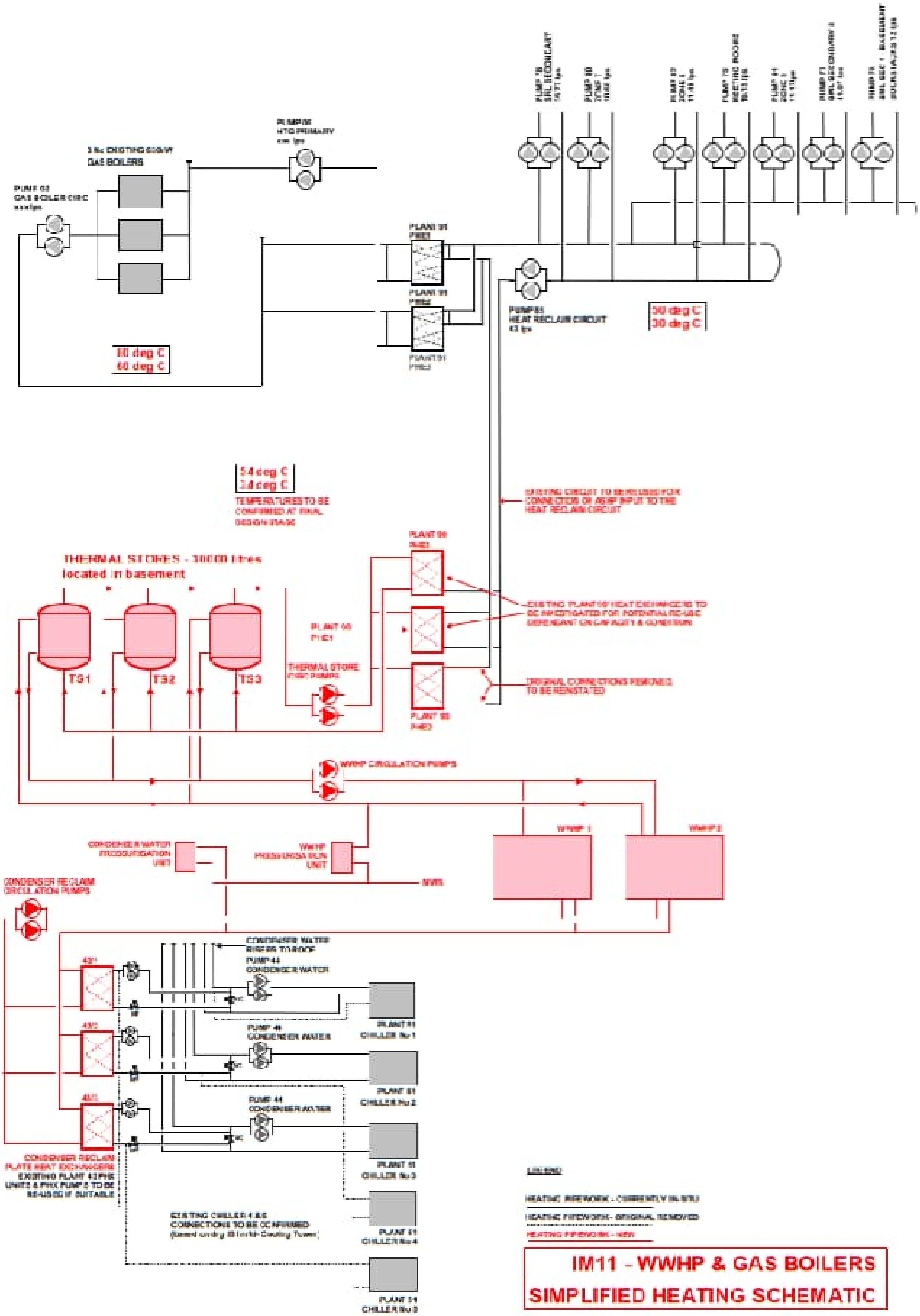
Pipework modifications in the basement to connect the condenser water to the WWHP input via plate heat exchangers, the WWHP circuit into the secondary heating circuits, including all controls necessary to achieve the prioritisation of the WWHP as the preferred heat source.

All required valves and ancillaries including isolating valves, commissioning valves, control valves, strainers, air vents, drain points, anti-vibration connections etc

Insulation and identification of all pipework

4.3.2.2 Outline Heating Plant Schematic

Refer to Appendix A for the existing outline heating schematic for information



4.3.2.3 Plant & Equipment

The following are preliminary selections to be finalised at a later design stage.

Water to Water Heat Pumps (WWHP)

- 2 no @ 210 kW
- Location – basement
- Refrigerant – zero or very low GWP, zero ODP
- Controls – the WWHP system will include a manufacturer's dedicated controls system to provide duty share, auto-changeover, and to collate fault signals – the system will be capable of full communication with the Building BMS.

Condenser Reclaim circulation pumps

- 2 No inverter driven pumps
- Duty - 2 lps @ 150 kPa

WWHP circulation pumps

- 2 No inverter driven pumps
- Duty - 5 lps @ 200 kPa

Thermal Store circulation pumps

- 2No inverter driven pumps
- Duty - 5 lps @ 150 kPa

Thermal Stores

- Capacity – 3 No @ 10000 litres - 30,000 litres total
- Location - basement

4.3.2.4 Controls Changes

The Building Management System (BMS) will have new controls functions installed to achieve the following:

- Provide a demand signal to the WSHP unit control system
- Communicate with the WSHP unit control system
- Control of WWHP Input Circuit Pump Set for enable, duty change, auto-changeover, pump failure
- Control of Condenser Water Boost pumps
- Enable and fault reporting for pressurisation unit
- Metering of energy flows

4.3.2.5 Strip Out of Existing Services

No significant sections of the existing are to be stripped out.

4.3.3 Electrical Engineering Services

4.3.3.1 LV Distribution

The power supplies for the Water to Water Heat Pumps (WWHP) and pumps, pressurisation unit etc located within the basement plant spaces will be derived from new Motor Control Centres (MCC). It is intended the MCC's associated with the WWHP's will be located at basement. The supplies for the additional pumps may be supplied from the existing MCC's if practicable. The number and final location of the MCC's will be determined as part of the detailed design stage.

4.3.3.2 General Power and Lighting

The small power requirements in the vicinity of the new basement plant will be reviewed to ensure sufficient outlets are provided to undertake maintenance tasks.

The general and emergency lighting within the vicinity of the new basement plant will be reviewed to ensure adequate lighting in the vicinity of the control panels and maintenance points.

The extent of these works shall be determined as part of the detailed design.

4.3.4 Fire Detection and Alarm

The existing fire detection, interface and shut off systems will be reviewed and modified to suit the new installation and code compliance. Any redundant equipment shall be removed.

The extent of these works shall be determined as part of the detailed design.

4.3.5 Public Health Engineering Services

No significant works.

4.4 IM16 Temperature Reduction

4.4.1 Introduction

4.4.1.1 Intended Effects

The intention was to change the BMS set points on the AHU heating circuits to control to 60ºC, for a number of reasons:

- The lower temperature allows optimum operation of either Air Source Heat Pumps or Water Source Heat pumps, and thus assists with the energy reduction gains of IM7, IM9 or IM 11.
- It allows the potential for connection to a future District Heating Scheme
- To reduce heat losses from pipework.

This was believed to require replacement of a number of heat emitters, and a change of existing AHU coils (or addition of duct mounted coils) to enhance output to suit the lower heating water temperatures.

On further investigation it is apparent that the secondary circuits serving AHU's and other emitters already run at lower temperatures and no modifications are required to the AHU's or other emitters.

4.4.1.2 PSDS Funding

PSDS funding is no longer required of this Intervention Measure as the capital value is now £0.

4.4.2 Mechanical Engineering Services

No works required.

4.4.3 Electrical Engineering Services

No works required.

4.4.4 Fire Detection and Alarm

No works required.

4.4.5 Public Health Engineering Services

No works required.

4.5 IM27 Ultrasonic Humidification

4.5.1 Introduction

4.5.1.1 Intended Effects

The installation of ultrasonic humidification to each of the AHU's that serve areas requiring humidity control is intended to contribute to the decarbonisation of the St Pancras site in two ways:

- Ultrasonic humidification uses significantly less energy than remotely or locally generated steam humidification. The energy used to produce the required humification effect by ultra-sonic means is significantly lower than that needed for the steam system. In addition the ultrasonic has no standing losses from hot steam generators and pipework.
- To transfer the steam generation energy source to electrical power in place of the existing gas energy source, taking advantage of the ongoing decarbonisation of the National Grid electricity supply

4.5.1.2 PSDS Funding

AECOM is currently engaging with PSDS to establish whether this project may be presented as a single energy stream and funded independently of the humidification gas use and catering gas use. We are aware that this approach has been applied under other applications and is considered that this should be achievable.

PSDS funding would need to be applied for by October 2024 and have all funds expended by March 2027. 12% match funding would need to be shown by October 2024.

4.5.2 Mechanical Engineering Services

It should be noted that steam humidification adds heat to the supply air, whereas ultrasonic humidification cools the air slightly – this has implications on the energy used, with some additional heating required in the AHU when the areas served need heating, but less cooling required in the AHU when the areas served need cooling. At the next design stage the detailed humidification loads and effects on the heating capacity of the AHU will be assessed, adjustments to heating capacity identified, and solutions sought for any shortfall of heating that is identified.

In addition, while ultrasonic humidification uses significantly less water, it has to use the correct water quality to prevent excessive maintenance and avoid any potential health hazard (as does steam generation, but it is a different water quality). De-ionised water needs to be used and it is proposed that this is produced in local areas to serve a number of AHU's in the vicinity. Boosted water services will be taken to each deionisation unit.

4.5.2.1 Scope of Works

The works required to achieve ultrasonic humidification are as follows:

Installation of dehumidifiers in each AHU or supply duct which currently has steam humidification - approximately 19 no off central steam system, approximately 5 no local steam generators (TBC).

Each humidifier to include integral control of supply air condition.

Allowance for modification of ductwork in some cases where no existing suitable installation location is available.

Recommissioning of heating valves to offset ultrasonic cooling effect

Recommissioning of pumped circuits to adjust heating flows if necessary

Installation of de-ionised water generators and pipework distribution to humidifiers

Installation of mains or boosted water supplies to de-ioniser plant

Installation of electrical supplies from local distribution boards to humidifiers and de-ionisers

Modifications to BMS to modify the existing enable signals to humidifiers to suit the ultrasonic controls (in place of the existing steam controls)

BMS wiring from local outstations to new humidifiers (assumed that new cables will be required)

BMS wiring from local MCC's to deionisation equipment

4.5.2.3 Plant & Equipment

Humidifiers

- 24 no @ varying outputs to match existing steam generated capacity
- Location – at supply air duct from AHU
- Controller – integral control of supply air condition, with BMS input of required supply condition.

Deionisers

- 5 no anticipated
- Locations – in plant room area near AHU's served

4.5.2.4 Controls Changes

Modifications to BMS to modify the existing enable signals to humidifiers to suit the ultrasonic controls (in place of the existing steam controls)

BMS wiring from local outstations to new humidifiers

BMS wiring from local MCC's to deionisation equipment

4.5.2.5 Strip Out of Existing Services

The decommissioning and removal of the existing steam generation plant and associated pipework, electrical supplies, controls and ancillaries. This will include the following for humidifiers fed from the steam generators located in the basement plantroom:

  - Steam Humidifiers in 19 No AHU's, including making good of AHU compartment
  - Steam Generators
  - Condense Pumps
  - Ancillaries – water supply tank, water treatment equipment
  - Steam pipework and insulation
  - Condense pipework and insulation
  - Associated electrical supplies
- Include also strip-out of local electric humidifiers in remote plantrooms:
  - Steam Humidifiers in 5 No AHU's (TBC), including making good of AHU compartment
  - Electrical supplies to electric humidifiers

4.5.3 Electrical Engineering Services

4.5.3.1 LV Distribution

The power supplies for the ultrasonic humidification units associated with the Air Handling Units (AHU's) shall be derived from new Motor Control Centres (MCC's) which will be fed from the existing electrical switch panels.

4.5.3.2 General Power and Lighting

General power and lighting supplies shall be reviewed with regard to current code compliance.

New power supplies, isolators and associated interface units shall be provided for the new ultrasonic humidification equipment and De-ionised water equipment. The final number, rating and locations shall be further developed during the detailed design phase.

4.5.4 Fire Detection and Alarm

Fire alarm interfaces shall be installed to ensure current code compliance. The final number and locations shall be further developed during the detailed design phase.

4.5.5 Public Health Engineering Services

The following works are required to the public health services:

Installation of boosted water distribution from existing water service to deionisation equipment, with all valves, drain points, and ancillaries as necessary.

Pipework to be soldered copper, fully insulated and identified

Drains from new humidifier locations to connect to existing steam humidifier drains

4.6 IM28 BMS Upgrades

4.6.1 Introduction

4.6.1.1 Intended Effects

There are two existing issues identified with the operation of the current BMS.

- The current BMS set points do not align with the measurements taken by the conservation team.
- The current BMS is rigid in its approach to set points whereas the conservation team would allow variation in set point whilst retaining deadband control

These items have complex implications on system operation, making it impossible to accurately identify associated energy impact, but are fundamental to providing improved operational control at the site.

4.6.1.2 PSDS Funding

It has not been possible to identify the associated energy savings with this Intervention Measure. The Milestone 1 report identified means of quantifying the scale of energy savings available. As no savings are currently identified, it would only attract PSDS funding if the application had excess carbon saving beyond £325/tn of CO_2 saved.

Availability of PSDS funding capacity will be assessed as part of Milestone 3 works.

4.6.2 Mechanical Engineering Services

4.6.2.1 Scope of Works

BMS changes only

4.6.2.2 Plant & Equipment

No works required.

4.6.2.3 Controls Changes

The works required fall into two categories:

- Investigation into the disparities between BMS readings and local readings to identify recalibration required or new sensors that may be required, or to identify & record offsets between BMS and local readings where these are situational (e.g. related to the different locations where these are measured),
- Discussion with Curation team to identify where temperatures may be allowed to vary more than currently permitted by BMS deadbands, and subsequent modifications to BMS control deadbands.

4.6.3 Strip Out of Existing Services

No works required.

4.6.4 Electrical Engineering Services

No works required.

4.6.5 Fire Detection and Alarm

No works required.

4.6.6 Public Health Engineering Services

No works required.

4.7 IM30 Photovoltaics

4.7.1 Introduction

4.7.1.1 Intended Effects

To utilise the available exposed roof areas which have significant sunlight through the day to produce electricity for use on the site, or for export if electricity production exceeds site use. If export is not permitted by the District Network Operator (DNO) or it is felt that excess energy can be better utilised within the building a Battery Energy Storage System (BESS), optimised for the anticipated PV output / building use profile, will be considered to maximise the benefit of the PV output.

The installation aims to reduce Network Electricity use, to reduce building operating costs and reduce carbon emissions.

4.7.1.2 PSDS Funding

Photo Voltaics are eligible for PSDS funding. The Round 3c rules will be used to assess funding potential under Milestone 3 works if this Intervention Measure is taken into consideration.

4.7.2 Mechanical Engineering Services

4.7.2.1 Scope of Works

There are no mechanical works associated with the Photovoltaic Installation.

4.7.3 Electrical Engineering Services

4.7.3.1 Photovoltaic Installation

Preliminary consideration of the available roof areas, roof orientation and shading suggest that 6 No. photo-voltaic arrays can be usefully installed on the existing roofs, orientated to maximise the full potential of the available space. Care will also be taken to ensure adequate access is provided to ensure all maintenance tasks can be undertaken in a safe manor.

The confirmation of the number of installations along with the number of PV panels shall be further developed in the detailed design phase. The extent of the installation will be dependent on orientation and shading of the available roof areas, and detailed modelling shall be undertaken at the next design stage to optimise the installation.

The modelled solution will need to be submitted for consideration by the planning authorities.

4.7.3.2 Battery Energy Storage System (BESS)

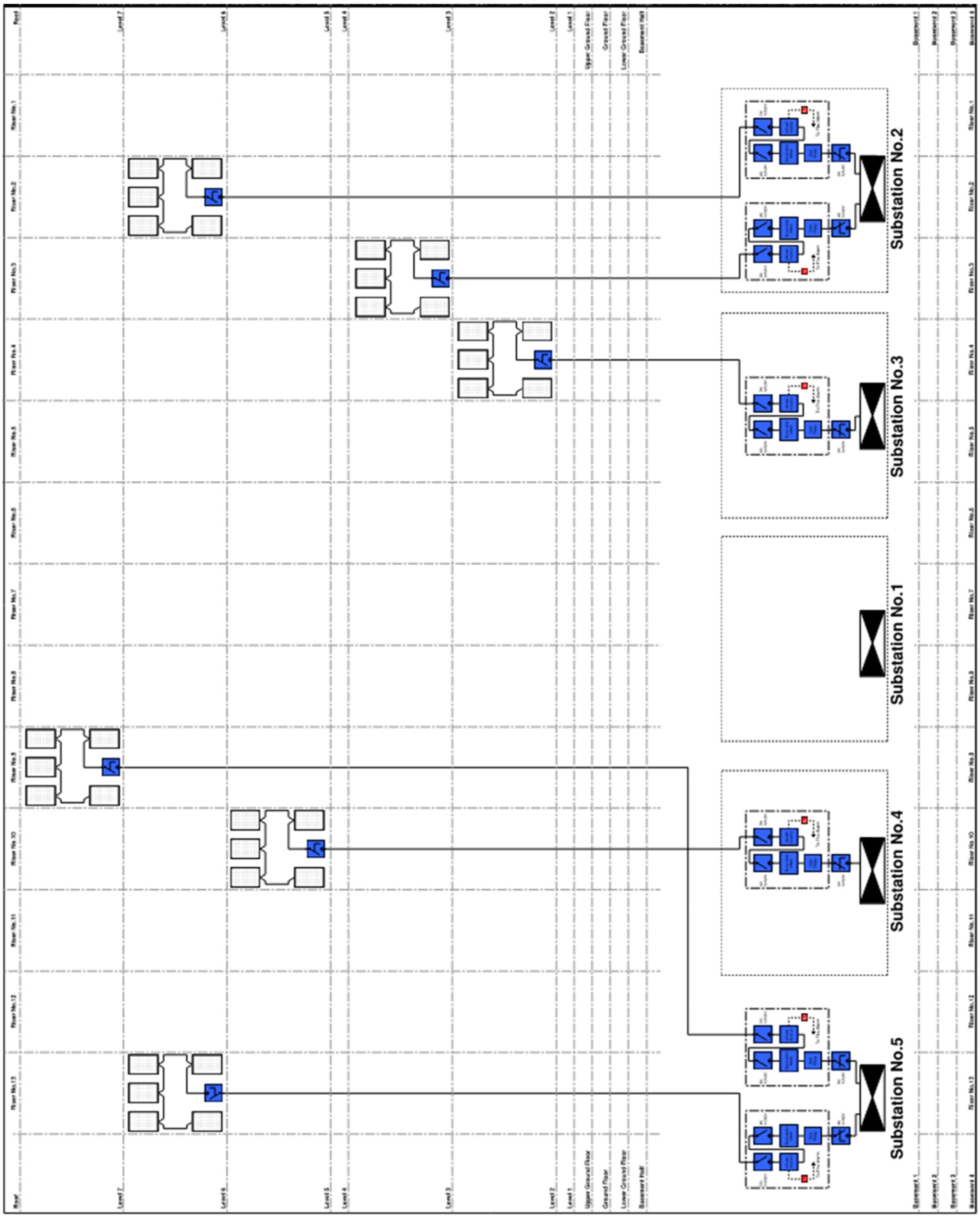
The installation of a BESS will need to be further investigated during the detailed design stage once a detailed understanding of the building's operation load profile and the potential output from the PV's is fully understood. It will also consider the safe operation requirements of locating a BESS within the basement area.

4.7.3.3 LV Distribution

Each of the 6 No. roof top mounted photo-voltaic arrays shall be treated as a stand-alone system. Each system shall comprise points of isolation, Export metering, G99 protection relays, power inverters and fire alarm interface units. A District Network Operator (DNO) application will be made to allow export of excess electricity produced.

The roof top arrays shall have a local dc isolator with cables routed via the associated electrical riser to the Basement level 1. The Inverter, Metering and Protection relays shall be located within the switch room.

The final configuration of the LV installation will be further developed during the detailed design phase in response to the final PV solution based on the modelling results and relevant planning permission.



4.7.3.4 General Power and Lighting

General power and lighting supplies shall be provided to ensure maintenance tasks can be undertaken.

4.7.4 Fire Detection and Alarm

The existing fire detection and alarm system shall be extended to incorporate the necessary interface units to ensure the PV system is isolated under fire situations.

The Fire alarm interface will need to be further developed during the detailed design phase to ensure compliance with the current regulations.

4.7.5 Public Health Engineering Services

A suitable water connection shall be provided adjacent to each roof top mount PV array. The supply shall be from the building boosted water services, via a category 5 system (with air gaps, break tank and booster pump) in accordance with the Water Bylaws, to prevent contamination of the building water supply, and adequately sized to support any required cleaning or general maintenance tasks that are required to ensure optimal operation of the PV array.

The number and size of each supply will need to be further developed during the detailed design phase.

4.7.6 Fire Suppression

The existing fire suppression systems will be reviewed and enhanced where required to support the installation of a BESS.

This review will be further developed during the detailed design phase.

4.8 IM38 Electrified Catering

4.8.1 Introduction

4.8.1.1 Intended Effects

The removal of all gas fired equipment in the existing catering facilities, and replacement with electrically powered equipment, to take advantage of the ongoing decarbonisation of the National Grid electricity supply.

4.8.1.2 PSDS Funding

The Intervention Measure is not considered to be eligible for PSDS funding as the asset is linked to "unregulated"[5] energy and not "regulated"[6] energy.

4.8.2 Mechanical Engineering Services

4.8.2.1 Scope of Works

Minor modifications of existing ventilation services may be required to adapt existing services to new equipment requirements. Provided that the new equipment is 'like for like' apart from the energy source, changes are expected to be minor.

The design will require the development of schedules of replacement equipment to identify any modified ventilation requirements and to ensure that it can be supported by the existing infrastructure. The existing infrastructure will be reviewed to ensure compliance with current regulations and codes.

4.8.2.2 Strip Out of Existing Services

The existing Gas Services to the catering equipment shall be stripped out. Where access restrictions or disruption of other services are likely, for instance in risers, gas pipework may be left in place after purging, capping off and clear identification as redundant.

4.8.3 Electrical Engineering Services

4.8.3.1 LV Distribution

The catering facilities on the Ground floor, Upper Ground floor and levels 2, 3 and 4 are not envisioned to have extensive works as these facilities are either Café's or re-heat/finishing kitchens. The kitchen located on Level 1 appears to be the main catering facility and will benefit from the installation of electric appliances in lieu of the existing gas appliances. The existing electrical supplies will require reconfiguration to accept the addition load and comply with current regulations.

The final extent of the installation will be further developed during the detailed design phase in conjunction with the catering equipment supplier.

4.8.3.2 General Power and Lighting

General power and lighting supplies shall be reviewed with regard to current code compliance.

New power supplies and suitably located isolators shall be provided for the new electrical equipment.

4.8.4 Fire Detection and Alarm

The existing fire detection sensors shall be reviewed to ensure current code compliance and any redundant equipment be removed.

The Fire alarm interface shall be further developed during the detailed design phase to ensure compliance with the current regulations.

[5] Unregulated energy is building energy consumption resulting from a system or process that is not 'controlled', ie energy consumption from systems in the building on which the Building Regulations do not impose a requirement. For example, this may include energy consumption from systems integral to the building and its operation, e.g. IT equipment, lifts, escalators, refrigeration systems, external lighting, ducted-fume cupboards, servers, printers, photocopiers, laptops, cooking, audio-visual equipment and other appliances.

[6] Regulated energy is building energy consumption resulting from the specification of controlled, fixed building services and fittings, including space heating and cooling, hot water, ventilation, fans, pumps and lighting. Such energy uses are inherent in the design of a building.'

4.8.5 Public Health Engineering Services

Minor modifications of existing water services and drainage services from equipment will be required to adapt existing services to new equipment connection points. Provided that the new equipment is 'like for like' apart from the energy source, changes are expected to be minor.

4.9 Energy Management Systems

If the British Library do pursue grant funding, it will be mandated to include specific energy monitoring to demonstrate the performance of the funded intervention.

AECOM recommend the development of Energy Management System (EMS) functionality on all projects. Whilst an EMS will not deliver any direct energy or carbon reductions , they are critical in providing data to an Energy Manager and can provide evidence to support investment decisions, alter operational approaches or identify plant failure.

Will may developed in the future, dependant on the British Library's decision on scope and intent of the EMS will be. AECOM would recommend the following functionality;

- Primary Fuel
  - Metering of all incoming primary fuel (gas and electricity) including mains potable water
  - Additional primary fuel metering on all major plant i.e. boilers, air handling units and chillers
- Renewables
  - Link in existing meters to proposed EMS
- Heat
  - Metering on all main plant outputs either on individual plant or groups
  - Metering on all heating and domestic hot water circuits
- Coolth –
  - Metering on all main plant outputs either on individual plant or groups
  - Metering on all coolth circuits
- Electricity
  - Metering on individual boards
  - Metering to move towards end use rather than building geography i.e. lighting

– All data should be captured, communicated and stored in a secure manner that would enable the Energy Manager to access and analyse data at a frequency no less than 30 minutes. Data should be stored to enable long term trend analysis.

– It is proposed that the British Library considers the development of an expandable platform that can accommodate the inclusion of additional meters as time progresses. Communication can be a combination of wired and wireless solutions.

– The solution may be integrated into the Building Management System or as a stand alone item but the two should have a level of communication as plant operation can benefit from the data sets. Additionally, the EMS may also require additional data such as temperatures to enable complete analysis of performance.

– A new BMS could be specified to have expandable EMS functionality. Data availability from the existing meters would need to be obtained but costs have been allowed to add additional British Library meters to guarantee ownership of the meter and data. This additional meter, and data, may be used to verify billing information.

– This approach would also support a future Digital Twin environment.

5. Cost Planning

Costs have been developed from Milestone 1. AECOMs Cost Consultants have completed their assessment and all costs are in the costing process.

Intervention Measure	Capital Budget (ex VAT)
IM7 – Partial Air Source Heat Pump with Gas Boilers	£2,182,315
IM9 – Partial Air Source Heat Pump with Electric Boilers	+£1,820,907[7]
IM11 – Waste Heat Recovery	£992,261
IM16 – LTHW Temperature Reduction	£0
IM27 – Ultrasonic Humidification	£780,419
IM28 – New BMS	£432,900
IM30 – Photo Voltaics	£606,216
IM38 – Electrified Catering	+£167,700[8]
Energy Management System	£296,365

All costs include for materials, labour in addition to on-costs such as Contractor's Preliminary Costs, Contractor Overheads and Profit, Design Costs and generally 20% Risk.

Inflation, tax and cost of capital has not be accounted for.

A more detailed breakdown of the individual IM costs are available in Appendix B.

[7] Please note stated value demonstrates the additional cost to IM7 due to the electric boilers and need for diesel generator resilience
[8] Additional cost over installing a gas based catering refit

6. Carbon Performance

Following completion of the Milestone 2 work, section 3 of the Milestone 1 is being updated to the figures shown below.

Each option has been assessed for 25yr capital, operational and replacement cost performance measured against the current operational system. In addition, each Intervention Measure has had its carbon emission saving calculated against the current system. This information has been used to developed a Marginal Abatement Cost Curve (MACC) shown in Figure 1.

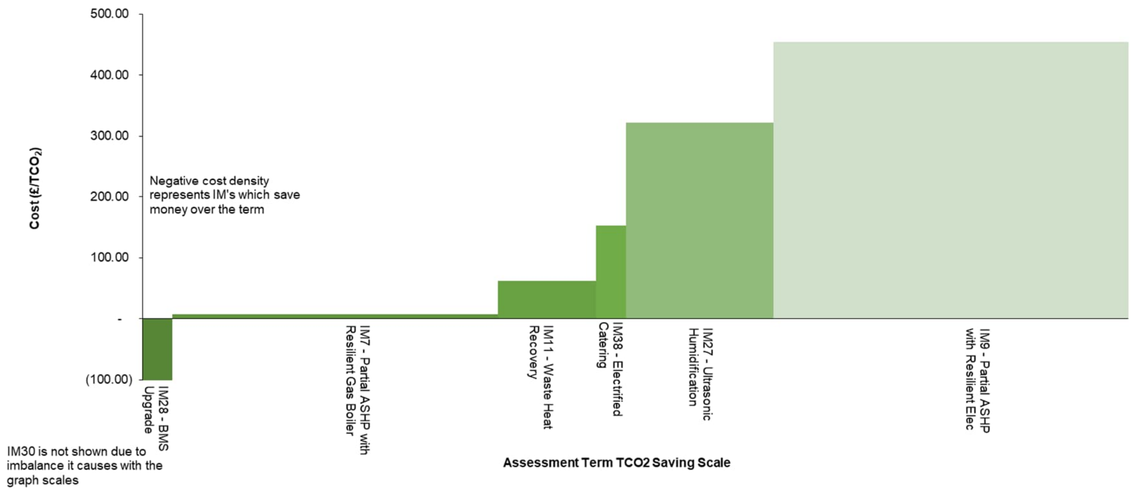


Figure 1 – 25yr Marginal Abatement Cost Curve (MACC) from TEM Workbook

Table 1 – Numerical Values Associated with Individual Intervention Measures and MACC

Intervention Measure	25yr Cost Difference	Emissions Reduction (TCO_2)	Cost Density (£/TCO2)
IM30 - Photo Voltaics	-£340,556	87	-3,908.04
IM28 - BMS Upgrade	-£3,702,200	1,232	-3,005.77
IM11 - Waste Heat Recovery	£231,111	3,694	62.56
IM7 - Partial ASHP with Resilient Gas Boiler	£932,991	13,034	71.58
IM27 - Ultrasonic Humidification	£781,180	5,800	134.68
IM38 - Electrified Catering	£167,700	1,096	153.03
IM9 - Partial ASHP with Resilient Elec Boiler	£6,343,997	13,976	453.93

M2 MACC Notes

- Generally, the higher value Cost Density metric, the “worse” the overall sustainable performance of the IM is

- Unlike the Milestone 1 assessment, the IMs have been linked together when assessing the decarbonisation of the LTHW system. IM11 has been applied first and then IM07 or IM09 show subsequent impact. This results in the impact of IM7/9 being lower than presented in Milestone 1, as IM11 has already offset a portion of the thermal energy prior to IM7 or 9 being applied.
- Costs have been updated to accommodate a more conservative approach to procurement route and scales of award. This has seen Prelims and Profit allocation increase
- Additional costs added for acoustic protection and fabric impact linked to the building status.
- Risk allocation remains at 20% of gross material value. A formal assessment should reduce this as the design develops.
- IMs with negative Cost Difference denote a cost saving to the site. IM30 is the only intervention providing cost reductions. All other IMs will lead to a cost increase due to planned operation and maintenance cost as well as factoring the capital costs.
- All carbon savings are based on the electrical grid decarbonising. Grid factors are based of Green Book data dated November 2023 and assume grid average central.
- IM30 has very small carbon saving associated due to the impact of grid decarbonisation
- IM28 was set up to be cost neutral on predicated saving for M1. Based on the revised costa approach this has now been set up for a 5% gas saving and 2.5% electrical saving.
- IM11 has good performance as it reclaims waste heat but still requires electrical energy and maintenance of additional assets, which offsets the financial performance. Should the electrical grid tariff be decoupled from gas, this IM performance would improve.
- IM7 is a common approach to decarbonisation of heat but with an SCoP 2.7 and an electrical tariff of ~4.0 greater than gas, this is a more expensive approach and results in additional maintenance costs due to the additional plant.
- IM27 offers good decarbonisation but due to the aforementioned electrical tariff being @4 time greater than gas, this IM cannot compete directly. Account has been made of the improved efficiency over the gas system but it does not offset the gas tariff difference.
- IM38 provides limited carbon performance due to the small volume of gas it displaces. Additional the capital and operational costs are higher. It remains recommended but has no direct financial value.
- IM9 is not currently recommended but is shown for comparison

A lot of the comparative performance is financial performance is reduced as electricity prices remain significantly higher than gas prices and there are no direct financial mechanisms to offset this difference. There is continued discussion about decoupling UK electricity prices from gas but there are no policies in place at time of writing.

All IMs provide significant carbon savings and identify a route to full degasification of the site, subject to the projected UK electrical grid decarbonising in line with current UK international commitments.

Alternative fuel impact and offsetting have not been taken into account in this assessment but remains an option.

7. Conclusions and Next Steps

Apart from IM16 all IMs remain viable to be taken forward in some context. IM16 is not proposed to be taken forward as it was established the works have already been completed and the LTHW heating systems are already operating at <60ºC flow temperature.

Following the conclusion of this report, the next steps have been identified

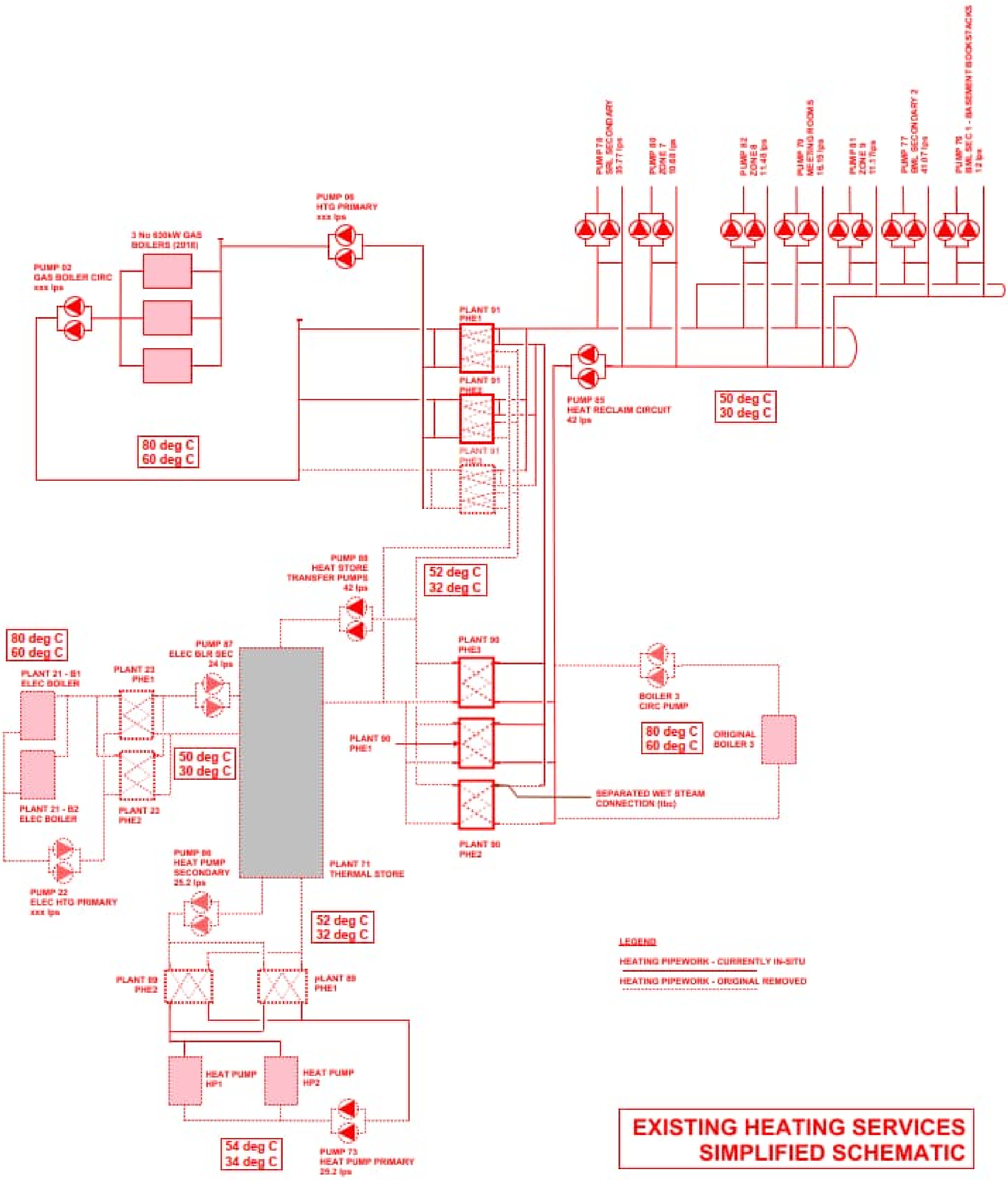
- Review and agree which options are to be taken forward into Milestone 3 and for PSDS funding
  - Level of match funding available to be identified
  - Utilise PSDS Round 3c application sheet (in lieu of availability of Round 4 being available) and identify potential grant funding levels (maximum 88% subject to £325/TCO_2 limitation)
  - Pursue Salix to discuss applicability of proposed solutions
- Develop long term capital funding plan (beyond PSDS Round 4) for works not taken forward for an immediate PSDS application
- Potential to engage with Somers Town Heat Network and allow them access to BL land for the installation of a larger scale ASHP solution which would serve BL and form a decarbonisation solution for the Somers Town Heat Network. This approach has the potential to remove the capital burden to BL whilst enabling significant heat decarbonisation via a service arrangement. AECOM has offered to facilitate a meeting between Somers Town and the British Library to explore this option in greater detail.
- Decide on how to progress with IM7 or 9. A valid decision can be to split the IM into the hybrid air source component and defer the boiler replacement decision until the existing asset is at end of life. When the existing LTHW gas boilers reach end of life, they may be replaced with another gas boilers, electric boilers, additional ASHP capacity or possibly an external heat source (decarbonised Somers Town supply). The decision factors on this separate "resilient" heat source should be based on prevailing sustainability

Milestone 2 has taken forward the risks identified in the Milestone 1 report and derisked reflective of the level of design undertaken. This is shown in Appendix C. AECOM actions are substantially derisked, based on current mitigation. There remain a number of risks that are considered normal at this stage of design and would need to be considered should BL take IMs forward into construction. Planning remains a significant barrier to both IM7/9 and 30.

Costs have been revised and presented within the report. The Techno Economic Model is being updated to reflect the updated information and shall be issued as part of the AECOM works.

Appendix A – Heating Plant Schematic

EXISTING MAIN PLANT HEATING SERVICES - SIMPLIFIED SCHEMATIC



Appendix B – Intervention Measure Capital Budgets

IM07 – Hybrid ASHP with Gas Boilers

Direct Cost Item	Quantity	Unit	Rate	Total	Comment
External hard standing and screening for ASHP	64	m²	£2,000	£128,000	
New ASHP	450	kW	£750	£337,500	
Connect new ASHP to existing services	200	m	£1,400	£280,000	
Pipework ancillaries	1	no.	£75,000	£75,000	Includes associated plant etc
Filling and flushing	1	no.	£5,000	£5,000	
Thermal store	20	m³	£1,800	£36,000	
Electrical works from sub to ASHP compound	450	kW	£100	£45,000	
Gas Boiler Installation	1,890	kW	£100	£189,000	Limited scope replacement - 2m connections
Removal of gas boilers	1,890	kW	£20	£37,800	limited scope removal; - unit and 2m local connections
Diesel Generators	0	kW	£600	£0	Not required
Cranage	2	no.	£10,000	£20,000	
Metering	2	no.	£4,000	£8,000	Electrical and heat metering
Commissioning	1,161,300	%	6%	£69,678	
Builders' Works	1,161,300	%	10%	£116,130	5% BWIC and 5% firestopping. Additional BWIC to be covered by risk if necessary
Direct Cost Sub-Total				£1347,108	

On-Cost Item	Quantity	Unit	Rate	Total	Comment
Capital Works Project - Contractor's Preliminaries	1,347,108	%	20%	£269,422	
Capital Works Project - Contractors OHP	1,347,108	%	12%	£161,653	
Location Costs	1,347,108	%	5%	£67,355	SPONs rate for Inner London
Professional Fees	1,347,108	%	5%	£67,355	
Project Costs	1,347,108	%	0%	£0	
Project Risk	1,347,108	%	20%	£269,422	
On-Cost Sub-Total				**£835,207**	

IM07 Total Cost = £2,182,315 ex VAT

IM09 – Hybrid ASHP with Elec Boilers

Direct Cost Item	Quantity	Unit	Rate	Total	Comment
External hard standing and screening for ASHP	64	m²	£2,000	£128,000	
New ASHP	445	kW	£750	£333,750	
Connect new ASHP to existing services	200	m	£1,400	£280,000	
Pipework ancillaries	1	no.	£75,000	£75,000	Includes associated plant etc
Filling and flushing	1	no.	£5,000	£5,000	
Thermal store	20	m³	£1,800	£36,000	
Electrical works from sub to ASHP compound and Boilers	2,335	kW	£100	£233,500	
Elec Boiler Installation	1,890	kW	£75	£141,750	Limited scope replacement - 2m connections.
Removal of gas boilers	1,890	kW	£20	£37,800	limited scope remove; - unit and 2m local connections. Gas and flue capped
Diesel Generator	1,512	kW	£600	£907,200	Required for electrical resilience
Metering	2	no.	£4,000	£8,000	Electrical and heat metering
Cranage	2	no.	£10,000	£20,000	Electrical and heat metering
Commissioning	2,178,000	%	6%	£130,680	
Builders' Works	2,178,000	%	10%	£217,800	5% BWIC and 5% firestopping. Additional BWIC to be covered by risk if necessary
Direct Cost Sub-Total				**£2,336,600**	

On-Cost Item	Quantity	Unit	Rate	Total	Comment
Capital Works Project - Contractor's Preliminaries	2,336,680	%	20%	£467,336	
Capital Works Project - Contractors OHP	2,336,680	%	12%	£280,402	
Location Costs	2,336,680	%	5%	£116,834	SPONs rate for Inner London
Professional Fees	2,336,680	%	5%	£116,834	
Project Costs	2,336,680	%	0%	£0	
Project Risk	2,336,680	%	20%	£467,336	
On-Cost Sub-Total				**£1,448,742**	

IM09 Total Cost = £4,003,222 ex VAT
(+£1,820,907 on IM7)

IM11 – Waste Heat Recovery

Direct Cost Item	Quantity	Unit	Rate	Total	Comment
External hard standing and screening for ASHP	0	m²	£2,000	£0	
WWHP	447	kW	£750	£335,445	
WWHP Pipework	50	m	£1,400	£70,000	
Pipework ancillaries	1	no.	£75,000	£75,000	
Filling and flushing	1	no.	£5,000	£5,000	
Thermal store	20	m³	£2,000	£40,000	
Electrical works from sub to WWHP	447	kW	£50	£22,363	
Electric Boiler Installation	0	kW	£75	£0	
Removal of gas boilers	0	kW	£20	£0	
Diesel Generators	0	kW	£600	£0	
Metering	2	no.	£2,000	£4,000	Electrical meter and heat meter
Commissioning	551,808	%	6%	£33,108	
Builders' Works	551,808	%	5%	£27,590	2.5% BWIC and 2.5% firestopping. Additional costs to be covered by risk if necessary
Direct Cost Sub-Total				**£612,507**	

On-Cost Item	Quantity	Unit	Rate	Total	Comment
Capital Works Project - Contractor's Preliminaries	612,507	%	20%	£122,501	
Capital Works Project - Contractors OHP	612,507	%	12%	£73,501	
Location Costs	612,507	%	5%	£30,625	SPONs rate for Inner London
Professional Fees	612,507	%	5%	£30,625	
Project Costs	612,507	%	0%	£0	
Project Risk	612,507	%	20%	£122,501	
On-Cost Sub-Total				**£379,754**	

IM11 Total Cost = £992,261 ex VAT

IM27 – Ultrasonic Humidification

Direct Cost Item	Quantity	Unit	Rate	Total	Comment
Ultrasonic Humidification System	5	no.	£56,000	£280,000	Local steam generators serving total 19 AHUs,. Cost includes local water treatment of raw water using existing steam water plant
Electrical and control cable Works	70	no.	£1,500	£105,000	
BMS works	70	no.	£200	£14,000	Additional control points
Electrical meters	70	no.	£500	£35,000	
Commissioning	434,000	%	6%	£26,040	
BWIC	434,000	%	5%	£21,700	2.5% BWIC and 2.5% firestopping. Additional costs to be covered by risk if necessary
Direct Cost Sub-Total				£481,740	

On-Cost Item	Quantity	Unit	Rate	Total	Comment
Capital Works Project - Contractor's Preliminaries	481,740	%	20%	£96,348	
Capital Works Project - Contractors OHP	481,740	%	12%	£57,809	
Location Costs	481,740	%	5%	£24,087	SPONs rate for Inner London
Professional Fees	481,740	%	5%	£24,087	
Project Costs	481,740	%	0%	£0	
Project Risk	481,740	%	20%	£96,348	
On-Cost Sub-Total				**£298,679**	

IM27 Total Cost = £780,419

IM28 – BMS Upgrade

Direct Cost Item	Quantity	Unit	Rate	Total	Comment
New Control System (BMS) and head end	1	no.	£100,000	£100,000	Assumed to be covered under catering contract
Additional wireless environmental sensors	100	no.	£250	£25,000	Initial allowance
Digital Twin Development	1	no.	£75,000	£75,000	Initial allowance for digital twin and modelling for algorithm creation
Site testing and on-going calibration/testing	1	no.	£50,000	£50,000	
Commissioning	250,000	%	6%	£15,000	
BWIC	250,000	%	5%	£12,500	2.5% BWIC and 2.5% firestopping. Additional costs to be covered by risk if necessary
Direct Cost Sub-Total				**£277,500**	

On-Cost Item	Quantity	Unit	Rate	Total	Comment
Capital Works Project - Contractor's Preliminaries	277,500	%	18%	£49,950	
Capital Works Project - Contractors OHP	277,500	%	8%	£22,200	
Location Costs	277,500	%	5%	£13,875	SPONs rate for Inner London
Professional Fees	277,500	%	5%	£13,875	
Project Costs	277,500	%	0%	£0	
Project Risk	277,500	%	20%	£55,500	
On-Cost Sub-Total				**£155,440**	

IM30 Total Cost = £432,900 ex VAT

IM30 – Photo Voltaics

Direct Cost Item	Quantity	Unit	Rate	Total	Comment
Install PV panels on roof inc mounting brackets and inverters	375	no.	£400	£150,000	
Integration of supply into HV switchgear, including metering and BMS interface	500	m	£250	£125,000	100m Allowance per roof area
Cranage	6	no.	£10,000	£60,000	Assumes one movement for each roof area
Commissioning	335,000	%	6%	£20,100	
BWIC	335,000	%	10%	£33,500	5% BWIC and 5% firestopping. Additional BWIC to be covered by risk if necessary
Direct Cost Sub-Total				**£388,600**	

On-Cost Item	Quantity	Unit	Rate	Total	Comment
Capital Works Project - Contractor's Preliminaries	388,600	%	18%	£69,948	
Capital Works Project - Contractors OHP	388,600	%	8%	£31,088	
Location Costs	388,600	%	5%	£19,430	SPONs rate for Inner London
Professional Fees	388,600	%	5%	£19,430	
Project Costs	388,600	%	0%	£0	
Project Risk	388,600	%	20%	£77,720	
On-Cost Sub-Total				**£217,616**	

IM30 Total Cost = £606,216 ex VAT

IM38 – Catering Electrification

Direct Cost Item	Quantity	Unit	Rate	Total	Comment
Replace Catering Equipment with new gas kitchen	0	no.	£250,000	£0	Provisional sum based on large commercial kitchens
Extra over cost to make kitchen electric over gas	20%	no.	£250,000	£50,000	Allowance of extra over cost
Internal electrical works to suit	200	kW	£250	£50,000	Allowance
Commissioning	100,000	%	3%	£2,500	Limited commissioning required
BWIC	100,000	%	5%	£5,000	2.5% BWIC and 2.5% firestopping. Additional costs to be covered by risk if necessary
Direct Cost Sub-Total				**£107,500**	

On-Cost Item	Quantity	Unit	Rate	Total	Comment
Capital Works Project - Contractor's Preliminaries	107,500	%	18%	£19,350	
Capital Works Project - Contractors OHP	107,500	%	8%	£8,600	
Location Costs	107,500	%	5%	£5,375	SPONs rate for Inner London
Professional Fees	107,500	%	5%	£5,375	
Project Costs	107,500	%	0%	£0	
Project Risk	107,500	%	20%	£21,500	
On-Cost Sub-Total				**£60,200**	

IM38 Total Cost = £167,700 ex VAT

Energy Management System

Direct Cost Item	Quantity	Unit	Rate	Total	Comment
EMS Head End	1	no.	£50,000	£50,000	
Incoming Gas Meters	3	no.	£2,500	£7,500	
Incoming Electricity Meters	14	no.	£2,000	£28,000	
Incoming Water Meters	2	no.	£2,000	£4,000	
LTHW circuit meters	5	no.	£1,000	£5,000	
CHW circuit meters	5	no.	£1,000	£5,000	
New plant metering	0	no.	£0	£0	Cost allowed for under individual IMs
Chillers	3	no.	£4,000	£12,000	Electrical and cooling measurement
AHUs	70	no.	£1,000	£70,000	Electrical metering
Basement plantroom general electrical metering	4	kW	£2,500	£10,000	
Commissioning	191,500	%	6%	£11,490	
BWIC	191,500	%	0%	£0	No associated BWIC
Direct Cost Sub-Total				**£202,990**	

On-Cost Item	Quantity	Unit	Rate	Total	Comment
Capital Works Project - Contractor's Preliminaries	202,990	%	18%	£36,538	
Capital Works Project - Contractors OHP	202,990	%	8%	£16,239	
Location Costs	202,990	%	5%	£10,150	SPONs rate for Inner London
Professional Fees	202,990	%	5%	£10,150	
Project Costs	202,990	%	0%	£0	
Project Risk	202,990	%	10%	£20,299	Reduced Risk Profile
On-Cost Sub-Total				**£93,375**	

EMS Total Cost = £296,365 ex VAT

Appendix C - Project Risk Register

Risk	Probability	Impact	Severity	Mitigation	Probability	Impact	Severity	Owner
Grid does not decarbonise	3	5	15	Carbon savings will not be realised impacting cost benefit analysis. Continue to monitor and update business as necessary. Make allowance to change approach should market conditions change.	3	3	9	British Library
Visual impact of new Air Source Heat Pumps on other buildings	3	4	20	Undertake initial Planning consultation to ascertain whether selected area minimises impact	2	4	8	British Library
Planning process and associated objections. Screening allowed for	3	4	20	Undertake initial Planning consultation to ascertain whether selected area minimises impact	2	4	8	British Library
Electrical capacity for Boilers	5	5	25	Verbal discussion held with BL site staff. Stated that sufficient capacity remains available for proposed electrical load increase. Undertake initial tests to ensure capacity available. If capacity not available apply for upgrade	2	4	8	British Library
Electrical capacity for ASHP	5	5	25	Verbal discussion held with BL site staff. Stated that sufficient capacity remains available for proposed electrical load increase. Undertake initial tests to ensure capacity available. If capacity not available apply for upgrade	2	4	8	British Library
Roof loadings for ASHP	4	3	12	If roof not suitable ground based solution will be required or placement on new portion of the building int the future	1	3	3	British Library
Route of electrics and pipework	4	4	16	M1 - Routes already present on-site. Milestone 2 to consider routes for further design development M2 – Routes identified	2	2	4	AECOM
Cold pluming impacting 10 storey extension building to north to be considered	3	5	15	Increasing concern during detailed design and Planning but often not an issue. Can be assessed and mitigated.	3	4	12	British Library
Detailed understanding of cooling and heating hourly loads	4	4	16	Loads need to be better understood. Recommend temporary metering or implementation of EMS. To be undertaken during detailed design	2	3	6	British Library
Electrical capacity for WWHP	5	5	25	Verbal discussion held with BL site staff. Stated that sufficient capacity remains available for proposed electrical load increase. Undertake initial tests to ensure capacity available. If capacity not available apply for upgrade	2	4	8	British Library

Risk	Probability	Impact	Severity	Mitigation	Probability	Impact	Severity	Owner
Additional AHU coil capacity not required, resulting in additional batteries not being required.	2	2	4	M1 - Should this occur, costs would reduce making the IM perform better. Temps to be verified in Milestone 2 work M2 – Temps confirmed and no additional coils required	1	1	1	AECOM
Unable to replace AHU heating coils in the ductwork due to spatial limitations	2	4	8	M1 - To be reviewed as part of Milestone 2 work M2 – Temps confirmed and no additional coils required	1	2	2	AECOM
Electrical capacity for humidification	5	5	25	Verbal discussion held with BL site staff. Stated that sufficient capacity remains available for proposed electrical load increase. Undertake initial tests to ensure capacity available. If capacity not available apply for upgrade	2	4	8	British Library
Unable to install humidification in the ductwork due to spatial limitations	2	4	8	M1 - To be reviewed as part of Milestone 2 work M2 – Design work undertaken and space verified	1	2	2	AECOM
Resilience requirements results in additional plant being installed.	3	2	6	M1 – Undertake discussion with BL site staff as part of Milestone 2 work. If existing plant kept for resilience, will have limited additional cost for maintenance. M2 – no single point of failure can be present. Unable to present a singular solution as it will depend on IMs taken forward by BL	1	2	2	AECOM
Control process changes lead to adverse conditions for the collection	5	5	25	Detailed proposal listed in technical discussion for IM. Risk to managed by considered and staged implementation. Cost allowed for undertake this process. Energy reduction targeted (~8%) is not considered within the TEM, only the CapEx limiting financial impact overall	2	5	10	British Library
MAJOR – Control process changes lead to adverse conditions for the building and/or building occupants	5	3	15	Detailed proposal listed in technical discussion for IM. Risk to managed by considered and staged implementation. Cost allowed for undertake this process. Energy reduction targeted (~8%) is not considered within the TEM, only the CapEx limiting financial impact overall	2	5	10	British Library
Planning objections to additional PV installation	3	4	20	Undertake initial Planning consultation to ascertain whether selected area minimises impact	2	4	8	British Library
Detailed assessment of PV output is required to be undertaken	3	3	9	M1 - Further analysis to be undertaken under Milestone 2 M2 – Concept design undertaken and data validated to current level	2	2	4	AECOM

Risk	Probability	Impact	Severity	Mitigation	Probability	Impact	Severity	Owner
Roof space availability for proposed PV installation	3	3	9	M1 Further analysis to be undertaken under Milestone 2 M2 – Concept design undertaken and data validated to current level	2	2	4	AECOM
Route of electrics and pipework	4	4	16	M1 - Routes already present on-site. Milestone 2 to consider routes for further design development M2 – Routes identified	2	4	8	AECOM

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