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South Kensington Zero Emission Neighbourhood Heat Network

Baseline Report

Imperial College London

LEA Project. Reference: GLA 81635 Local Energy Framework

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Contents

1. Introduction

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Project background

Arup was appointed by Imperial College London ('Imperial') to conduct a feasibility study on decarbonising the heat network by finding heat recovery options within the South Kensington Area as part of a holistic decarbonisation plan for the area.

The area was served by an original heat network which was installed in the late 1950s and originated in the Natural History Museum ('NHM') Energy Centre. This heat network supplied four institutions: Natural History Museum, Imperial College London, Science Museum ('ScM') and the Victoria & Albert Museum ('V&A').

Imperial and the ScM disconnected from the original heat network between 1999 and 2006. The V&A space heating is still provided by the NHM heat network.

There are two electrical supply points within the four institutions: one at Imperial, which feeds only Imperial, and one feeding all three of the Museums, located at the NHM.

Arup was appointed to investigate the technical possibilities to reconnect Imperial, ScM, NHM and V&A to the heat network, and to consider decarbonised heat sources to supply the heat network. Solutions such as waste heat recovery from underground stations, sewers and chillers will be considered.

A map of the wider South Kensington site comprising NHM, Imperial, ScM and V&A is shown in Figure 1.

This project is split into two main work packages, the first one being 'WP-I: Baseline review'. WP-I aims to investigate the current energy infrastructure within the four institutions, the existing connections to the heat network and to produce a baseline energy model of the demands.

The second Work Package 'WP-II: Feasibility Study' is dedicated to investigating opportunities to decarbonise the heat network and develop an energy model of the potential carbon and energy savings. Each scenario will be assessed against the following criteria:

- Energy performance
- Capital and operational costs
- Difficulty of implementation
- Whole life carbon emissions
- Available grid electrical capacity.

1. Introduction

Site overview

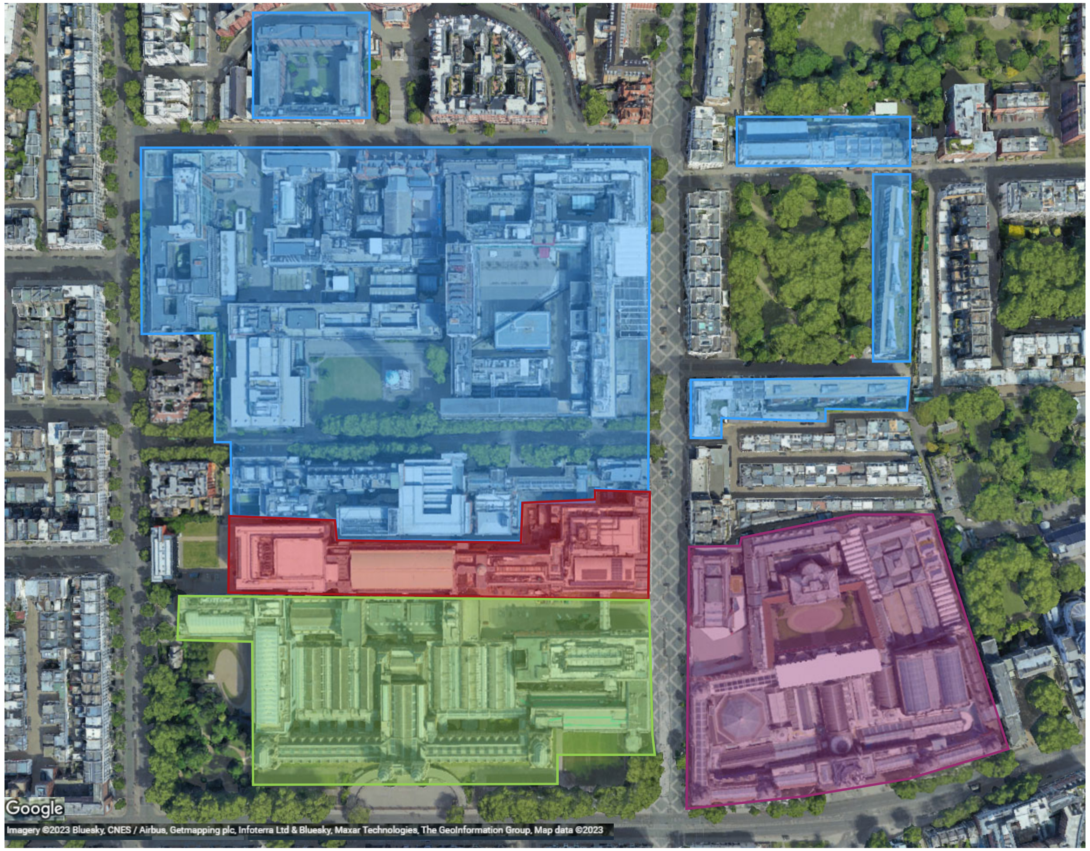

Figure 1. South Kensington site map showing the relevant institutions

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2. Review of the existing information

Review of the previous works

Arup have undertaken a number of projects for Imperial regarding their energy strategy and heat network since 2013, and are currently assisting with their current energy infrastructure project, which is removing the centrally-provided steam system and removing steam from their buildings.

Arup have assisted the NHM since 2019 in a similar capacity. The team that have undertaken the majority of this work are also assisting on this project, to maximise the outputs over the short project duration.

In addition to supplying any relevant Arup reports to the team undertaking this work, the following reports were also provided and have been reviewed:

- "Carbon Reduction Masterplan for the 1851 Estate", Cynergin, 2011
- "Science Museum Heat Decarbonisation Plan", Buro Happold, 2022 (Revision P01 draft)
- Sustainability strategies for each institution from their respective websites (as available in April 2023).

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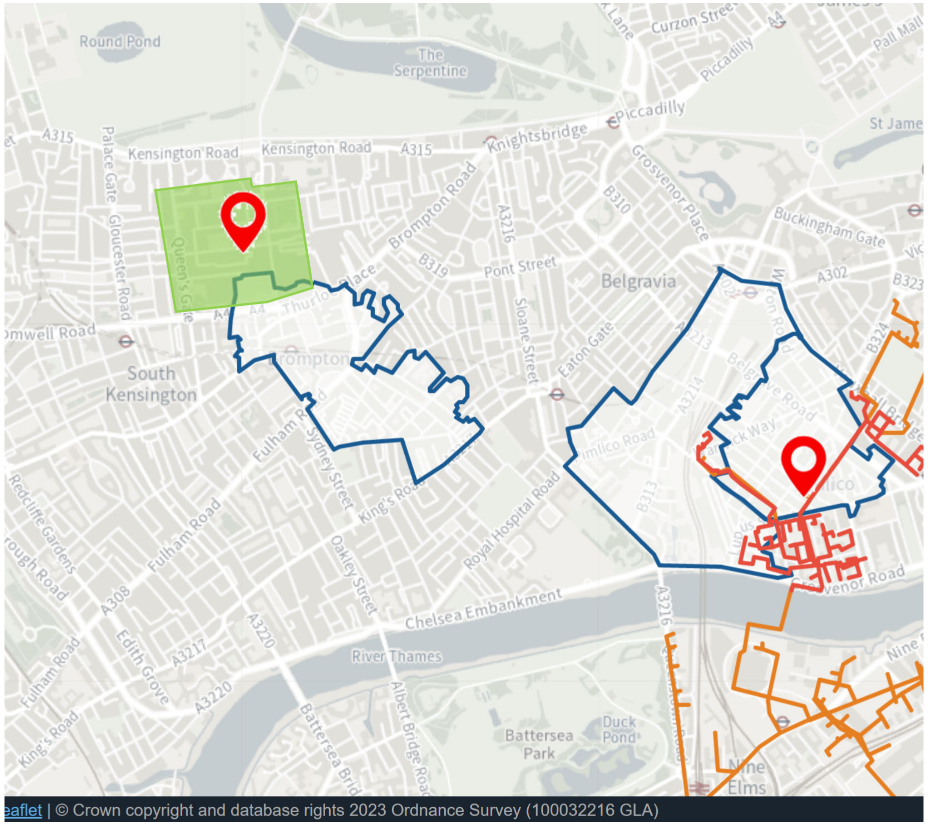
2. Review of the existing information

London Heat map

The London heat map was investigated to determine the presence of any existing heat networks in the area with a potential to connect into. As can be seen in Figure 2, the nearest heat network is in Pimlico, approximately 2.1km away. This concludes that there are no feasible nearby heat network connections for the site.

The heat map also indicates Transport for London (TfL) Potential Waste Heat Supply Sites, which can be seen intersecting with the SK ZEN site. This promising opportunity is further explored in the stakeholder engagement section under the ‘Interface with external partners’ section (on page 27). Arup have discussed this matter with TfL.



Proposed Heat Networks
Existing Heat Networks
South Kensington site
TfL Potential Waste Heat Supply Sites

Figure 2. London heat map (https://maps.london.gov.uk/heatmap/)

3. Current energy infrastructure

Site investigations

Arup has undertaken several site visits as part of these works. These visits have enabled us to have a comprehensive understanding of the current energy infrastructure in the overall South Kensington site, as well as the existing connections to the heat network. By conducting these initial visits, potential solutions were identified that will be further explored in the subsequent phase of the project.

At the initial site visit to the V&A, ScM, and NHM, the focus was on examining the existing energy facilities. Each visit involved identifying the installed chillers and exploring the potential for recovering waste heat from the condenser side.

At the V&A, the location of the heat network connections to the NHM and the two LTHW plate heat exchangers in the basement were identified with the help of the V&A team. These are presented as #1 and #2 respectively in Figure 3.

The site visit to the ScM further clarified the installed capacities and historic connection with the help of the ScM team. The boiler house which is #3 in Figure 3 was inspected. Furthermore, the connection leading to the NHM boiler house is also identified.

The NHM visit enabled us to understand the Energy Centre and its historical connection to other institutions. There is a tunnel which is accessible from the NHM boiler house to the ScM and potentially to Imperial. This tunnel includes several hot water pipes and some other services. A photo taken from the entrance of the tunnel is presented in #4 of Figure 3. This connection was further investigated and it was found as a route to reconnect the network to all institutions.

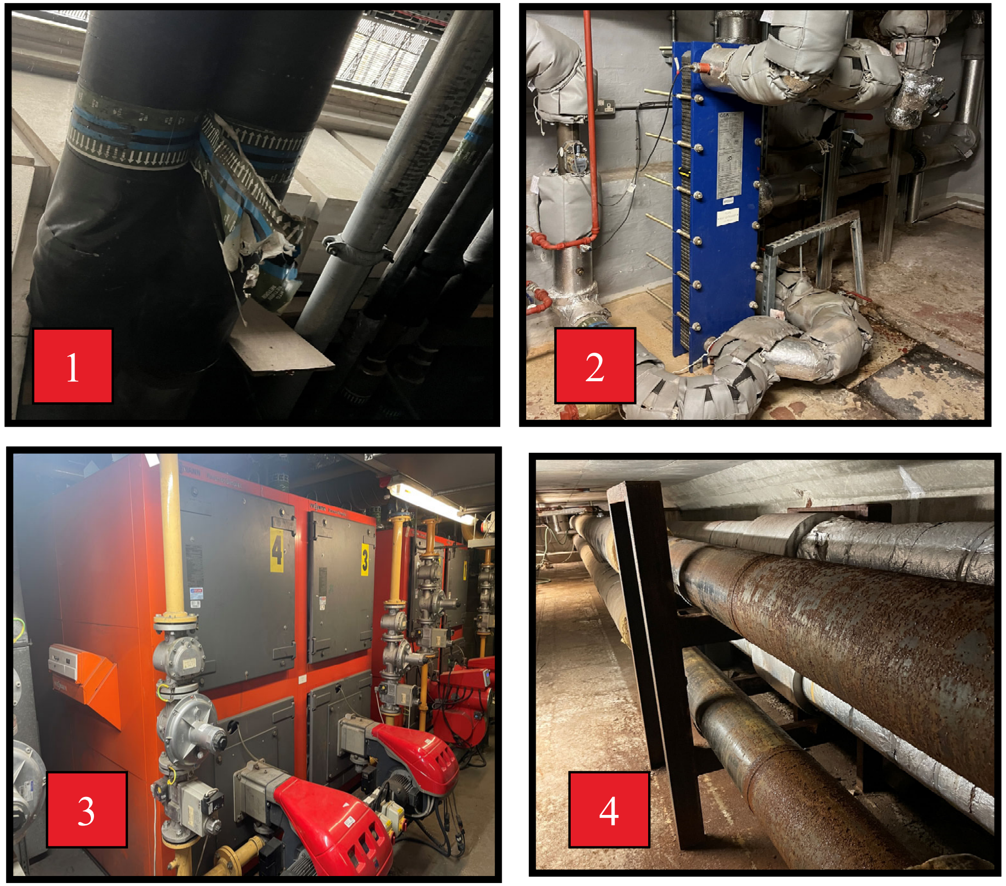


Figure 3. Key findings of the site visits

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3. Current energy infrastructure

Existing Energy Services Agreements (ESA)

A review of the current contracts that Imperial and NHM have with their Energy Services Companies (ESCos) has been undertaken to understand the opportunities and constraints for any future decarbonisation initiatives for each of the sites. They are referred to as Energy Services Agreements (ESA).

At both Imperial and NHM, the ESCo that runs each of their CHP plant facilities and heating infrastructure is Vital Energi.

Common features of both ESAs

Both ESAs have the following things in common:

- They cover the operation and maintenance of the Energy Centre energy plant and the associated heating networks. (In the case of the NHM, the heat network operation and replacement guarantee items only covers the NHM's heating system, not the V&A's.)

- Should any of the covered plant need replacement during the duration of the contract, this is covered by a replacement guarantee service.

- Performance Guarantees are in place such that Vital Energi are incentivised to ensure that the plant operates efficiently and achieves high availability. There is also the provision that the CHP plant should only be run when financially viable (e.g. when it saves them cost compared to turning it off and using boilers and imported electricity instead).

- Both contracts allow for voluntary termination by the client (Imperial or NHM as appropriate), however this is not at no cost, indeed the costs could be considerable, depending on several contractual variables.

Imperial ESA

The Imperial ESA started in August 2015, and terminates in June 2028. As a result of the current heat network and plant modifications being undertaken on the campus, it is currently being updated in line with the works.

The ESA does not specifically allow for low carbon technologies to be included within it. Indeed, the performance indicators are based around running the CHP plant for as long as possible whilst financially viable. However, the contract does allow for Imperial to request that the CHP plant is not run, as long as they pay the costs for the maintenance contract on it (sub-contracted to Clarke Energy).

As such, if any other heat provision was provided via new low carbon solutions, they would reduce the amount of heat provided by the CHP plant, and hence affect the financial impact of this ESA. In order to obtain best value, this ESA may need to be renegotiated, or if near to the termination date, tendered.

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3. Current energy infrastructure

Existing Energy Services Agreements (ESA)

NHM ESA

Vital Energi are currently replacing the CHP plant at NHM, and providing another energy plant as part of a refreshing of the Energy Centre plant. An air source heat pump (ASHP) is being provided with water source heat pumps (WSHP), to boost the temperature of the ASHP and CHP plant low grade heat circuits to provide heat to the heat network.

As the works are currently still being undertaken, the full agreement is yet to start. The expiry date of the contract is 15 years after the commencement of the full services, so it would be 2038 if commencement happens this year.

The performance guarantees within the ESA also incentivise the use of the CHP plant, but it allows for the heat pumps to be used instead. Both the CHP plant and the heat pumps have guaranteed efficiencies.

The NHM ESA was produced with decarbonisation in mind, the NHM having a target to be net zero carbon by 2035. An external source of low carbon heat was not necessarily considered though, so the options for this remain the same as for Imperial (if near to the termination date, retender, if not, renegotiate the ESA to reduce the CHP plant running hours and costs).

Summary of contract review

Both ESAs allow for the heat required from the Energy Centres to reduce as the site heat demands reduce. If the annual heat demands reduce below the outputs of the CHP plant output guaranteed, and this is because the site heat demand is being met by an offsite low-carbon source (or, for that matter, from the NHM or Imperial Energy Centres where the heat network between them is restored) it is likely that Vital Energi would request to vary the contract.

In any case, should the heat networks be reconnected, a more in-depth review of the ESAs should be undertaken.

3. Current energy infrastructure

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Current energy infrastructure

Table 1 provides a summary of the existing heating systems with their capacities. It also addresses the condition of these plants and any planned future upgrade. The expected lifecycle for this equipment is added based on CIBSE Guide M. For some of the items, further information is included.
There are various chillers on site of varying age and size, and we have surveyed some of them. When replacing the chillers that are approaching their end life, it would be advantageous for them to be replaced with a 4-pipe solution, to allow the recovery of the heat rejected into the LTHW heat network. It is recommended that this option is evaluated on a case-by-case basis for each chiller at the time of replacement.

Table 1. Main energy centres; asset details, expected lifecycles for replacement, and planned future changes

Energy Centre	Plant item	Current Capacity	Date installed	Expected lifecycle (per CIBSE Guide M)	Survey/ Condition	Planned Future Changes
Imperial	2 no. gas fired CHP engines	2 × JMS624 4.5 MW electrical output	2015	15 years	No problem identified. Maintenance strategy must be aligned with CIBSE Guide M.	Currently under consideration.
Imperial	3 no. gas fired steam boilers	3 × 12 MW steam boilers	1999	20 years	Currently being replaced – to be complete by end of 2023.	Replacement of steam boilers to LTHW boilers: 2 × combination boilers rated at 10MW (gas fired) + 2MW (heat recovery). 1 × 10MW gas fired only boiler.
ScM	5 no. gas fired boilers	5 × 0.895 MW	1998	20 years	No problem identified. Maintenance strategy must be alligned with CIBSE Guide M.	Currently under consideration.
NHM	1 no. gas fired CHP engine	1 × JMS612 1.8 MW electrical output (not yet operational nor commissioned)	2023	20 years	Currently being installed - not yet commissioned.	N/A
NHM	2 no. gas fired boilers	2 × 10.5 MW	1982	20 years (but under a 15 year warranty)	No problem identified. Maintenance strategy must be aligned with CIBSE Guide M.	Not planned within the next 15 years.
NHM	1 no. ASHP with associated WSHP temperature boost	1 × ASHP 456 kW and corresponding WSHP capacities (not yet operational or commissioned)	2023 (not yet commissioned)	15 years	Currently being provided – not yet commissioned.	N/A

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3. Current energy infrastructure

Current energy projects

Natural History Museum
The NHM is undertaking several energy-saving projects as part of their refurbishment of the Energy Centre, including the replacement of fans in their Air Handling Units. These measures also include replacing the existing CHP plant, installing photovoltaic panels and air-source and water-source heat pumps. The CHP plant will continue to operate in conjunction with the existing gas boilers. The project is expected to be completed during the summer of 2023.

Imperial College London
Imperial is in the process of extensive works under the Public Sector Decarbonisation scheme, which includes the removal of centrally-provided steam on site. The carbon savings will result from the new higher efficiency low temperature hot water boilers, a reduction in losses from the LTHW network due to network upgrades and the removal of significant losses associated with steam networks. The project is expected to be completed by the end of 2023.

3. Current energy infrastructure

Feasibility of re-installing historical network connections

Visual evidence in the NHM energy centre, displayed on wall drawings (Figure 5), confirms that the four institutions were formerly interconnected to the heat network, receiving their heat supply from the NHM.

The connection tunnels were also observed during the site visit, which confirmed this situation. There is some evidence that steps have been undertaken by people unknown to prove that the network still works (this is evidenced by the removal of the Imperial and ScM connection from the NHM main header and installation of a pump). A photograph of the installation is shown in Figure 4.

Arup have also seen the 1961 heat supply contract between Imperial and the NHM.

There are two road access plates that need to be removed to visually inspect the network, and arrangements need to be made to finalise it. It is hoped this will be done by the time of the final report.

Connecting the institutions is considered feasible, but the following issues need to be considered:

- Imperial typically operate their heat network at 90°C flow, but have the ability to raise it to, nominally, 105°C in stress events (it should be noted that this was not required during the ‘Beast from the East’ cold weather event in March 2018).
- NHM’s heat network operates at a flow temperature of between 85°C and 95°C, so is compatible with Imperial’s.
- Imperial is increasing the capacity of their heat network, as they are moving the steam network loads to the LTHW network (and removing the steam network), so the pipes from the NHM to Imperial are likely to be undersized for the peak flow conditions if the Imperial Energy Centre were decommissioned. Indeed, it may be easier to supply the load the other way around (from the Imperial energy centre to the NHM).

Figure 4. Historical connection between NHM and ScM

3. Current energy infrastructure

Historical Pipe Route Diagram

The historic pipe route diagram is shown in Figure 5 opposite. It was drawn by Heating Ventilating Design Service (HVDS) and is dated October 1991. It is understood that the networks could be restored to a similar configuration, though geographically slightly different as some new buildings have been built over the top of some of the tunnels (for example the Sir Alexander Flemming Building in 1998). This is shown on the next page.

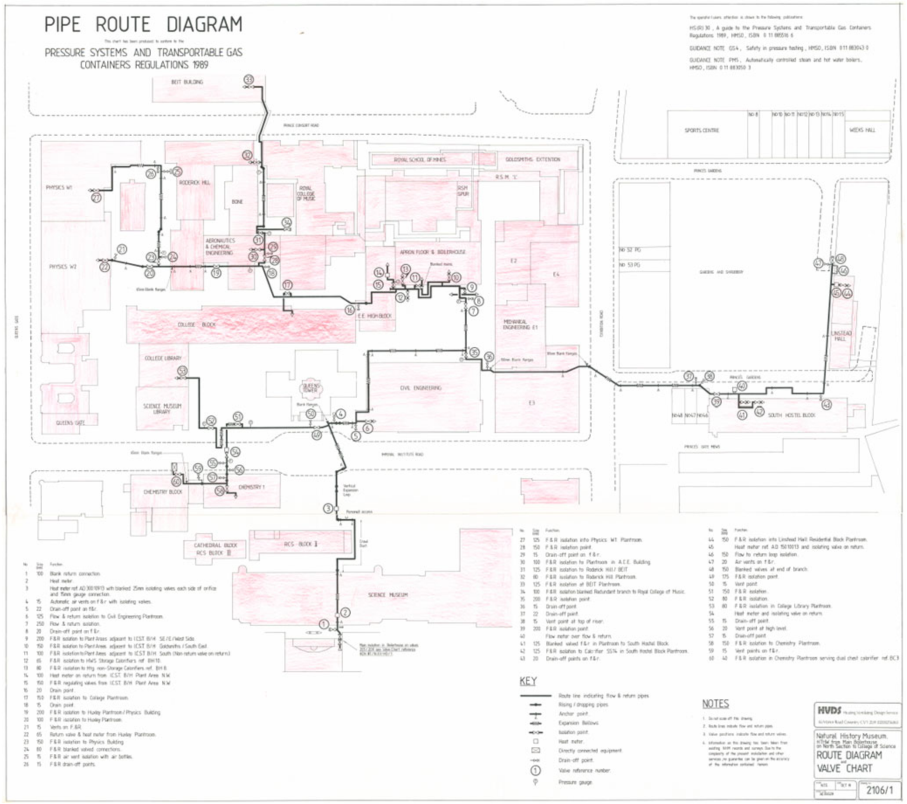

Figure 5. SK ZEN Historical connections between NHM – ScM – V&A (NHM wall drawing)

3. Current energy infrastructure

Current energy infrastructure diagram

After reviewing the existing documentation, record drawings and site visits; it can be seen how the four institutions were once connected.

Figure 6 presents the current connections in detail.

The connection between NHM, ScM and Imperial was investigated on-site and the existing sections of the previous connection between the ScM and NHM were identified, as can be seen in Figure 7.

Current LTHW works in progress

Existing LTHW heat network (verified on-site)

Existing LTHW Heat network (from record information)

NHM: VI 21 NHM LAY 001 - LTHW & Chilled Water Delivery & Termination Points
V&A: CHP-SCM-2 - High Temp Water Schematic
ICL: 50408-VEN-SW-XX-FA-M-5617- Steam &LTHW Site Distribution Layout

Historic LTHW heat network (verified on-site)

Figure 6. SK ZEN Heat Network – Existing Connections – All institutions

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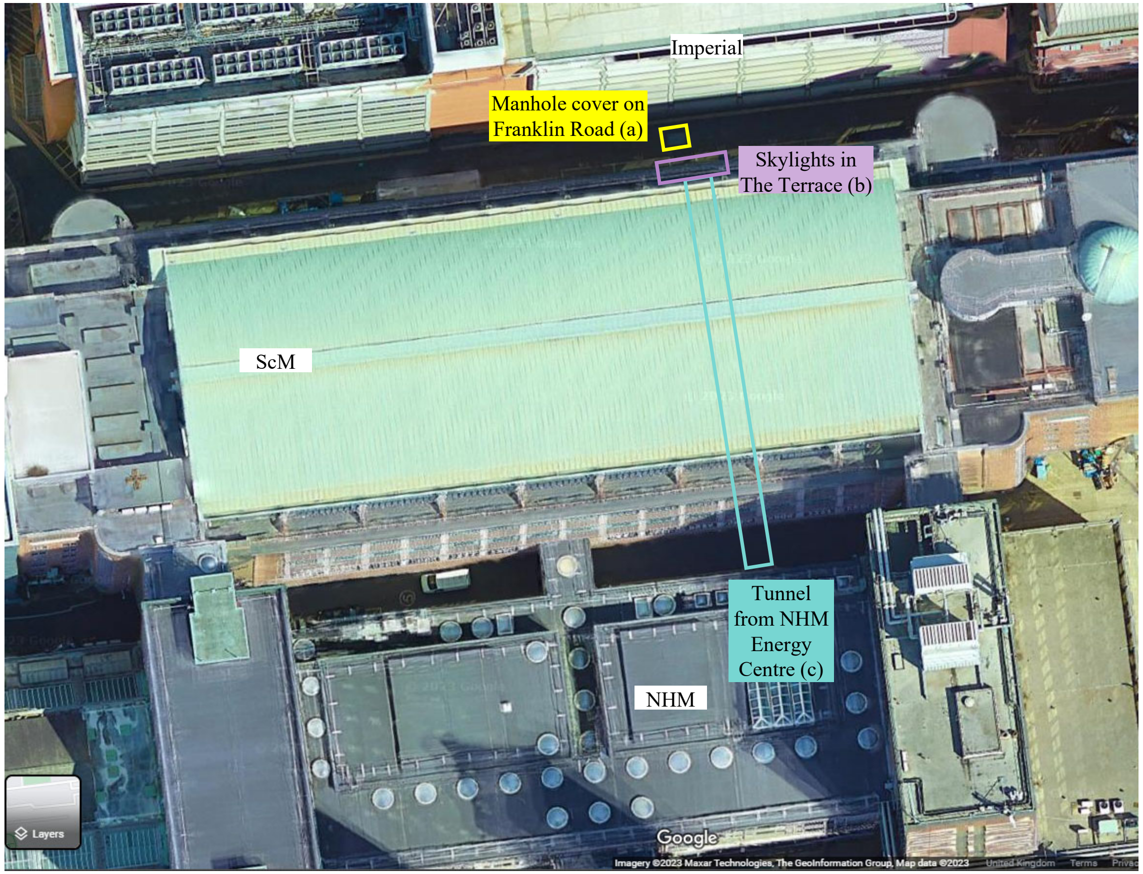
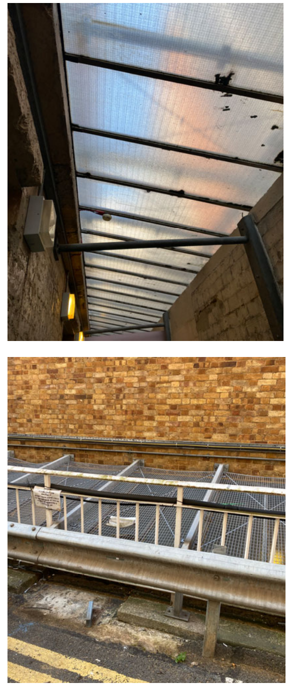
3. Current energy infrastructure

Re-establishing the network

Manhole cover on Franklin Road (a)

Tunnel (c)





Skylights in The Terrace (b)

Figure 7. Historic connection between NHM, ScM and Imperial

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3. Current energy infrastructure

Re-establishing the network

In order to reconnect the institutions, two connections are required:

1. Extending the current capped connection in the NHM Energy Centre to connect into the existing flow header.
2. Extending the pipework from the ScM "The Terrace" underneath Franklin Road into the existing SAF (Sir Alexander Fleming building) tunnel network connection.

Considerations:

1. The connection into the SAF tunnel is limited to a DN250 connection due to the existing Imperial network sizes. These sizes could be used to circumvent network upgrades from Franklin Road back to the Imperial Energy Centre underneath Electrical Engineering. However, careful control and hydraulic studies are required to balance the network connection.
2. A cost estimate of re-establishing this connection was done based on a DN250 pipe and found to be £250,000. This assumes that the existing pipework can be retained. This excludes penetrations into the SAF tunnel.
3. Road closures, traffic redirections and general disruptions were not included in this estimate.

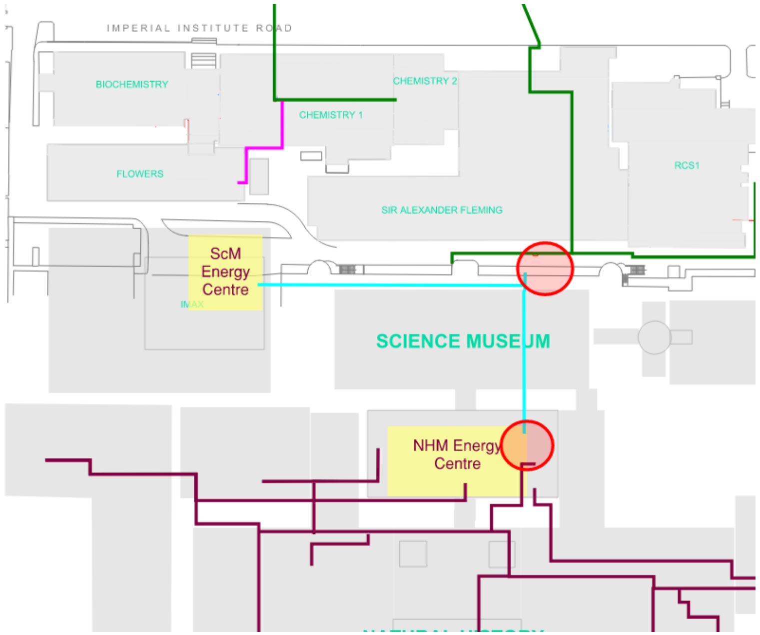

Figure 8. Heat network extensions to the existing infrastructure required

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4. Energy modelling

a. Methodology

To size plant at the next project stage, a heat load duration curve is required for each of the four connected institutions and a total one. As information was not available on an hourly basis for the institutions, it was needed to calculate a synthetic heating profile.

The modelling approach involved developing an energy model using a spreadsheet (MS Excel) to perform a comprehensive technical and financial evaluation of various decarbonization possibilities. The objective is to identify appropriately sized solutions for this project.

The first step of the energy modelling exercise was to assess data received from the institutions, including heating and electricity demands. For the museums, only monthly heat and gas consumption data was available.

Excel-based modelling is by nature a high-level modelling approach. To ensure maximum accuracy, it is essential to employ modelling based on hourly data. Converting monthly energy data into hourly data can be achieved through various methods. In this case, a regression analysis was conducted, specifically correlating heat consumption with heating degree days. Please refer to Figure 9 for a visual representation of this approach.

Detailed Imperial hourly data was available. The baseline period was fixed between August 2017 to July 2018.

To calculate the heating degree days (HDD), it was assumed that the base temperature at which the institutions turn heating on was 15.5 ºC. This is a typical assumption for museums and offices to reach an internal temperature between 17-19ºC. The outside dry bulb temperature for the period from August 2017 to July 2018 was provided by the Imperial weather station. Seasonal/local heating strategies adopted by the institutions were also taken into account to calculate the HDD. The assumptions used are summarized in Appendix B.

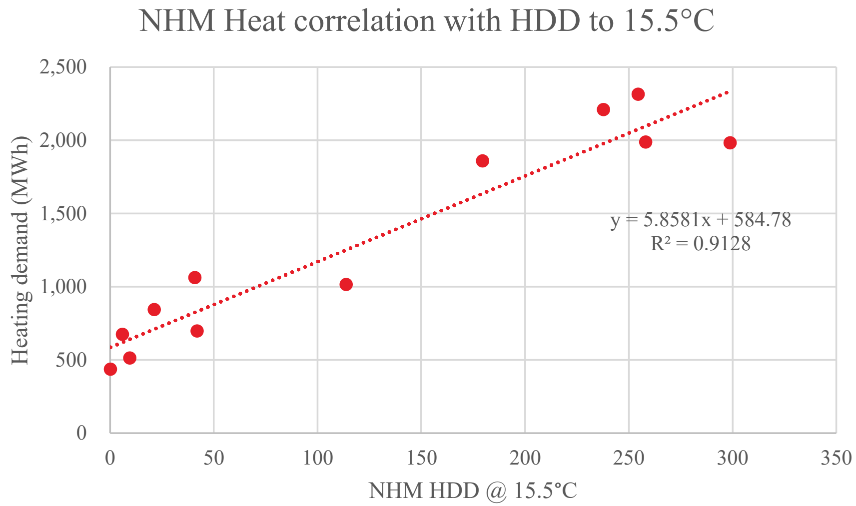

Figure 9. NHM regression analysis of heat consumption and HDD

Example outputs from the regression analysis include:

- $R^2 > 0.85$, which shows that there is a strong correlation between the heating degree days and the NHM's monthly heating data.

- The monthly Domestic Hot Water (DHW) load equals 585 MWh (the x-axis intercept).

4. Energy modelling

a. Methodology

The regression formula presented in the previous slide was used for the heat demand correction as shown below.

After calculating the Heating Degree Days (HDD) as shown in Figure 10, the hourly profile was then applied to the monthly corrected space heating data to produce an hourly profile resolution of the space heating data as well, Figure 11.

The corresponding figures for the V&A and the ScM are presented in Appendix C.

Table 2. NHM monthly heating data (original and corrected)

Timestamp	NHM Heat, MWh	NHM heat demand correction, MWh	NHM space heating, MWh	NHM DHW, MWh
Aug-17	674	620	35	585
Sep-17	843	710	125	585
Oct-17	1,062	825	240	585
Nov-17	1,858	1,637	1,052	585
Dec-17	2,314	2,076	1,491	585
Jan-18	2,209	1,978	1,394	585
Feb-18	1,982	2,336	1,751	585
Mar-18	1,987	2,097	1,512	585
Apr-18	1,015	1,252	667	585
May-18	697	831	246	585
Jun-18	512	641	56	585
Jul-18	436	586	1	585

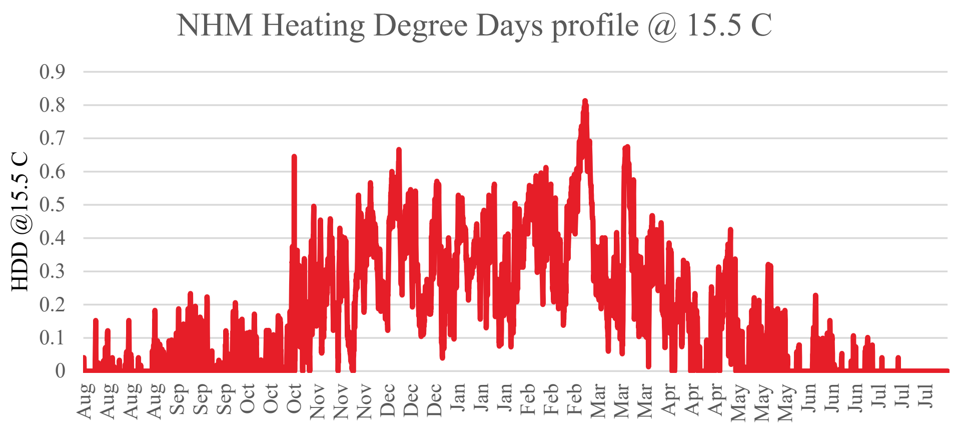

Figure 10. NHM HDD profile

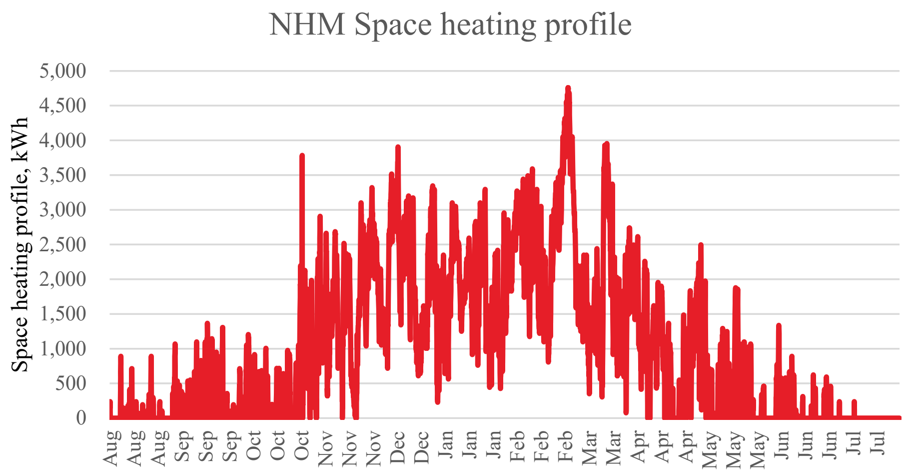

Figure 11. NHM space heating profile

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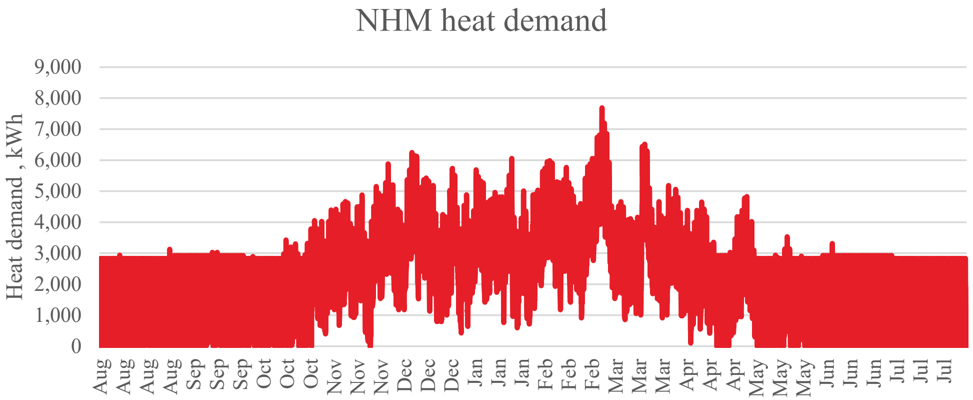
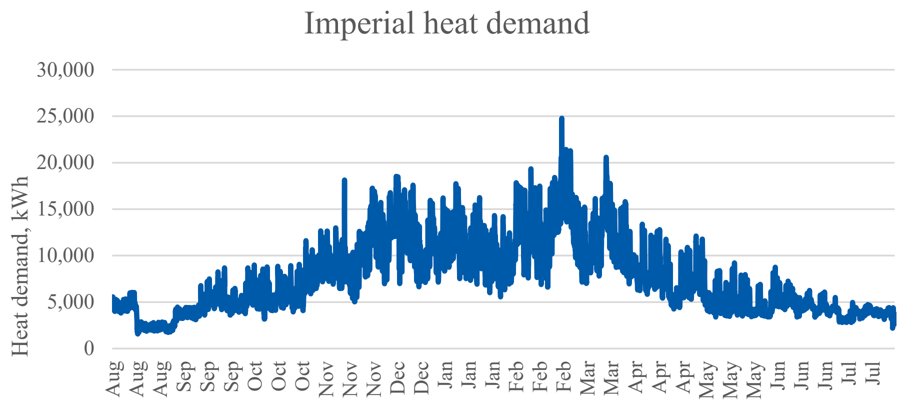
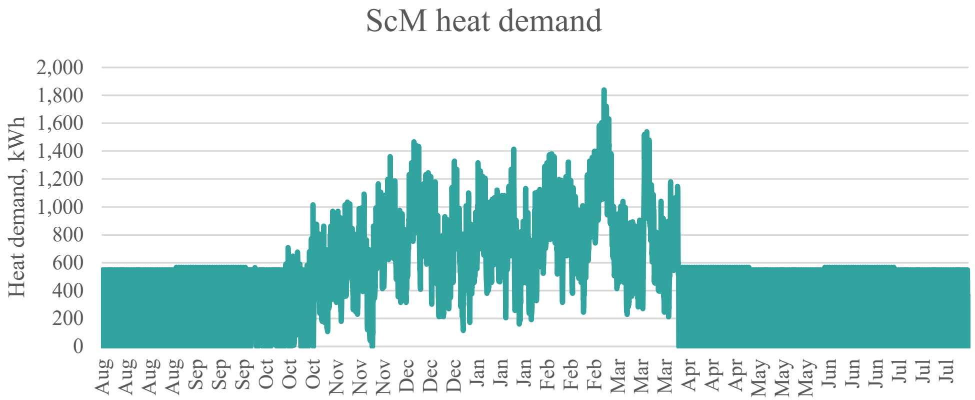
4. Energy modelling

b. Baseline annual heat consumption

Figure 12 presents the total heat demand for all institutions from August 2017 – July 2018. The figures were calculated based on the provided data.







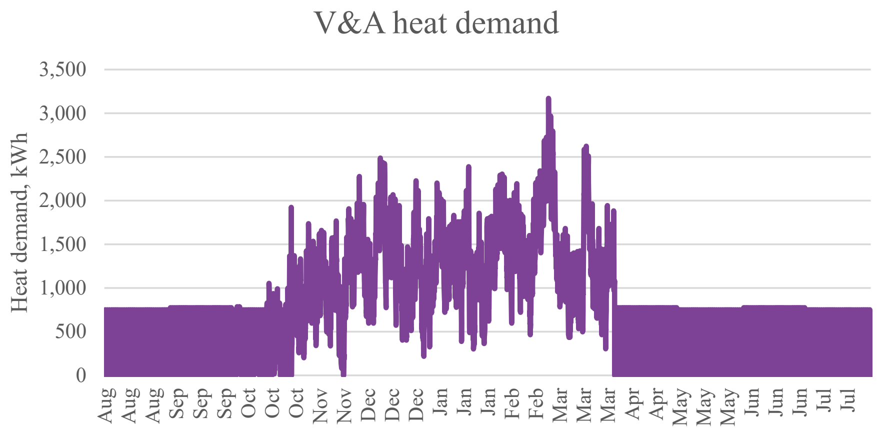


Figure 12. Calculated total heat demand

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4. Energy modelling

c. Heat load duration curve

The duration of the heat loads for each institution is shown in Figure 13. The heat load duration curves will be critical at sizing low carbon heating systems such as heat pumps or electrical boilers. The heat load duration curve also indicates the time for which a load occurs, preventing oversizing of equipment.

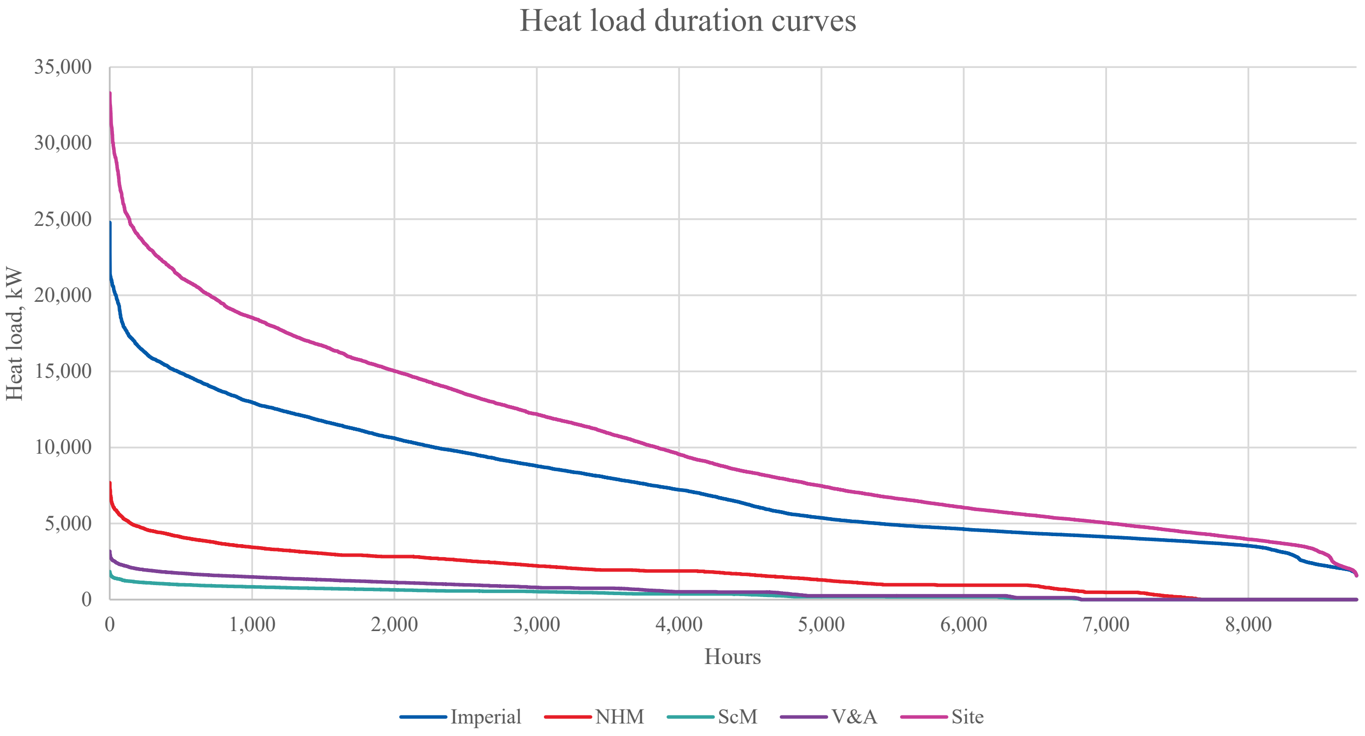

Figure 13. Heat load duration curves

4. Energy modelling

d. Baseline scenario – summary 2018

The table below summarizes the heat data for the baseline scenario. A breakdown of heat consumption of each institution is also provided. As shown in the Table 3, the total site heat consumption of the site is approximately 87 GWh. The graphs in Figure 14 illustrate the amount of heat provided by boilers and/or CHP to each institution.

All the NHM (including V&A) data presented in the table below is for the period January 2018 – December 2018.
All Imperial data presented in the table below is from the Vital Energi end of year 2018 operational report.

Table 3. Baseline heat summary

Baseline Heat Data	Annual heating, kWh	Heating, kWh/m²
Total heat provided from gas boiler plant	32,548,609	170
• Imperial heat provided by gas boilers	24,183,134	72
• ScM heat provided by gas boilers	3,268,435	52
• NHM heat provided by gas boilers	5,097,040	46
Total heat provided from CHP plant	54,524,395	266
• Imperial heat provided by CHP plant	40,883,435	122
• ScM heat provided by CHP plant	N/A	N/A
• NHM heat provided by CHP plant	13,640,960	122
NHM absorption chiller heat consumption	2,345,400	21
Total site heat consumption	87,073,004	368
• Imperial site-wide heat consumption	65,066,569	195
• ScM site-wide heat consumption	3,268,435	52
• NHM site-wide heat consumption	13,571,000	122
• V&A site-wide heat consumption	5,167,000	N/A

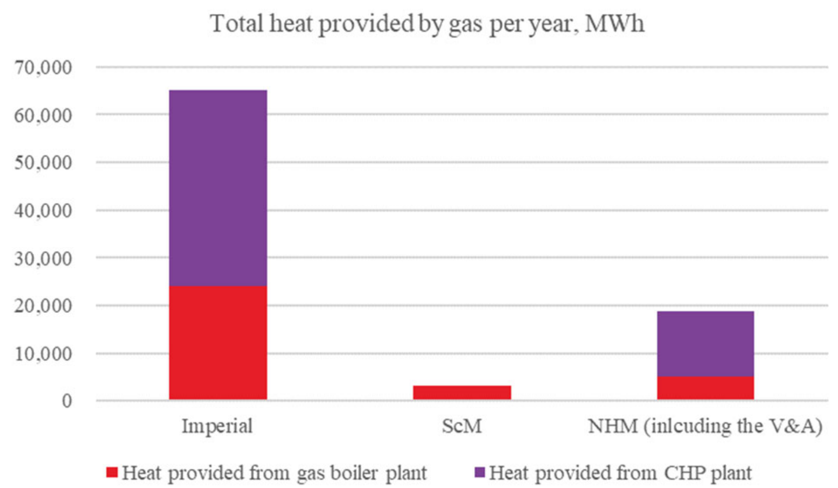

Figure 14. Total heat provided (MWh)

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4. Energy modelling

d. Baseline scenario – summary 2018

The table below summarizes the gas data for the baseline scenario. A breakdown of gas consumption for each institution is also provided. As shown in the Table 4, the total site gas consumption of the site is approximately 244 GWh.

All the NHM (including V&A) data presented in the table below is for the period January 2018 – December 2018.
All Imperial data presented in the table below is from the Vital Energi end of year 2018 operational report.

Table 4. Baseline gas summary

Baseline Gas data	Gas usage, kWh	Gas usage, kWh/m²
Total site gas boiler gas consumption	**43,624,533**	**258**
• Imperial consumption	26,690,339	80
• ScM consumption	3,845,218	61
• NHM consumption	13,088,976	117
Total site CHP gas consumption	**200,104,833**	**825**
• Imperial consumption	162,195,943	485
• ScM consumption	N/A	N/A
• NHM consumption	37,908,890	340
Total site boiler and CHP plant gas	**243,729,366**	**1,083**
• Imperial consumption	188,886,282	565
• ScM consumption	3,845,218	61
• NHM consumption	50,997,866	458

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4. Energy modelling

d. Baseline scenario – summary 2018

The table below summarizes the electricity data for the baseline scenario. A breakdown of electricity consumption for each institution is also provided. As shown in the Table 5, the total site electricity consumption is approximately 111 GWh.

All the NHM (including V&A) data presented in the table below is for the period January 2018 – December 2018.
All Imperial data presented in the table below is from the Vital Energi end of year 2018 operational report.

Table 5. Baseline electricity summary

Baseline electricity data	Electricity usage, kWh	Electricity usage, kWh/m²
Total imported electricity	**32,605,216**	**179**
• NHM imported electricity	13,678,216	123
• Imperial imported electricity	18,927,000	57
Total exported electricity	**405,000**	**1**
• NHM exported electricity	0	0
• Imperial exported electricity	405,000	1
Total CHP generated electricity	**78,159,985**	**322**
• NHM CHP generated electricity	14,683,500	132
• Imperial CHP generated electricity	63,476,485	190
Total site electricity consumption	**111,012,188**	**472**
• Imperial electricity consumption	82,403,485	246
• NHM electricity consumption	14,171,015	127
• Export electricity to ScM	6,204,926	98
• Export electricity to V&A	8,232,762	N/A

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4. Energy modelling

d. Baseline scenario – summary 2018

Table 6 summarizes the total carbon emissions of the site for the period January 2018 – December 2018, detailing emissions from gas and electricity. These results are also shown in Figure 15. Their corresponding greenhouse gas conversion factors are outlined in Table 7.

Table 6. Baseline scenario summary

Baseline carbon dioxide emissions	Units	Values
Total emissions	tCO_2e	67,968
Emissions from gas	tCO_2e	44,490
Emissions from electricity	tCO_2e	23,478

Table 7. Greenhouse gas conversion actors (BEIS)

Greenhouse gas conversion factor, 2022	Units	Values
UK electricity (including transmission and distribution)	$kgCO_2e\ kWh^{-1}$	0.21107
Natural Gas (Based on Gross Calorific Value)	$kgCO_2e\ kWh^{-1}$	0.18

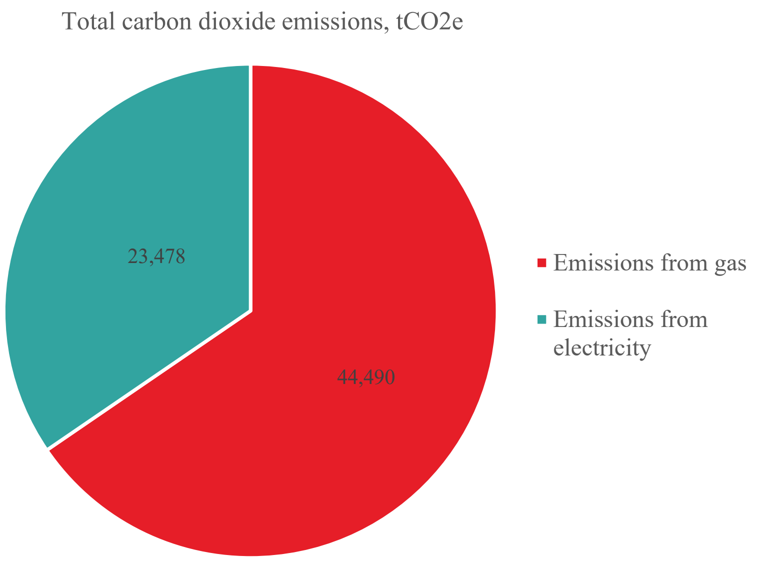


Figure 15. Baseline CO_2 emissions

4. Energy modelling

e. Results of the energy modelling (load benchmarking)

After receiving electricity and heat data from the institutions, the data was assessed, and a baseline energy model was produced to allow the benchmarking of the existing energy load at each of the four institutions and at the site level. The key outputs from this baseline energy modelling are:

- Total heat demand of the site
- Total electricity demand of the site
- Total gas consumption of the site
- Total carbon emissions.

A consolidated energy infrastructure record plan was also produced; please refer to Appendix A. The ongoing and planned possible retrofit changes to the site have also been considered in the preparation of this baseline energy infrastructure record plan. From this baseline, a full carbon trajectory can be created when considering the interventions in the next phase where the decarbonisation measures will be compared to the baseline figures summarized in Tables 3, 4, 5 and 6.

5. Interfaces with external partners

Stakeholder Engagement

Within the scope of this feasibility study on heat network decarbonisation, there are opportunities to investigate the potential for heat recovery from various sources, including the region's sewers, adjacent underground systems, and buildings in close proximity. Arup have also engaged with the potential stakeholders at this stage of the project.

Thames Water
An initial meeting with Thames Water was held on the 18 April 2023, where Arup provided background on this project to the Thames Water team. Thames Water seemed eager to help with providing the data needed for the waste heat recovery modelling upon receipt of an NDA, which Arup has since submitted.
Key conclusions from the Arup/Thames Water meeting:

- Thames Water are developing a pricing mechanism for selling heat recovered from the sewers.
- Thames Water can provide a sewer map for the South Kensington area, however this is a lengthy process.
- Sewer water temperature is typically between 15 – 25ºC.

Transport for London (TfL)
Arup had a meeting with Transport for London on the 9 May 2023 to discuss the SK ZEN project and potential heat recovery from nearby underground stations, particularly the South Kensington (SK) Station. TfL are keen to support and they mentioned the availability of a constant underground pumped water source in the station. They also explained that the station ventilation fans are not operational all the time, therefore the warm air in the tube is not useful as a potential reliable heat source. TfL provided their pumped water source report, as it was written by Arup, which is used as a basis for the feasibility study, but which cannot be shared as it was supplied on a confidential basis.

Westminster City Council (WC)
Arup met with Westminster City Council Energy Team on 19 April 2023. The goal was to identify any nearby heat networks, heating and cooling sources. Buro Happold are developing heat maps for the area, which are going to be shared with Arup within the framework of this project.

Royal Borough of Kensington and Chelsea (RBKC)
Arup met with the Royal Borough of Kensington and Chelsea on the 4 May 2023 for the same reasons as for Westminster City Council. We are also exploring the potential to benefit from the existing or future heat networks developed within these boroughs. There will be a follow up meeting at the end of the May 2023 to learn further about the recent developments.

5. Interfaces with external partners

Stakeholder Engagement

UKPN

- The UKPN supply locations were identified.
- These were discussed with the UKPN representative and confirmation was received of these locations.

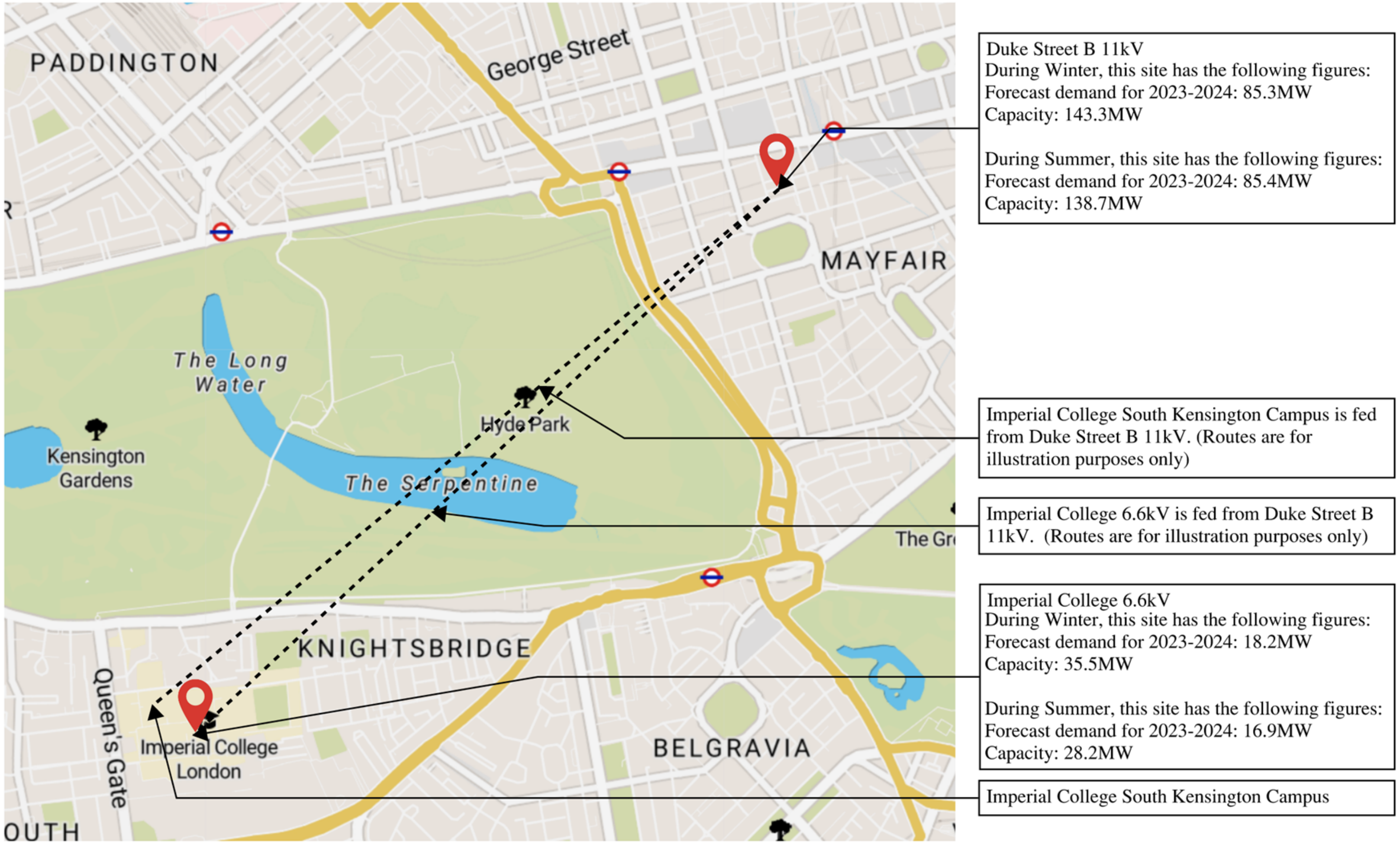


Figure 16. Electrical supply connection from Duke Street to Imperial College

5. Interfaces with external partners

Stakeholder Engagement

UKPN

- Imperial College South Kensington Campus is supplied from the Duke Street 11kV Site.
- Imperial 6kV Site then supplies to the NHM.
- The NHM Site then distributes to the SCM and the V&A.
- The electrical supply diagrams are provided in Appendix D.

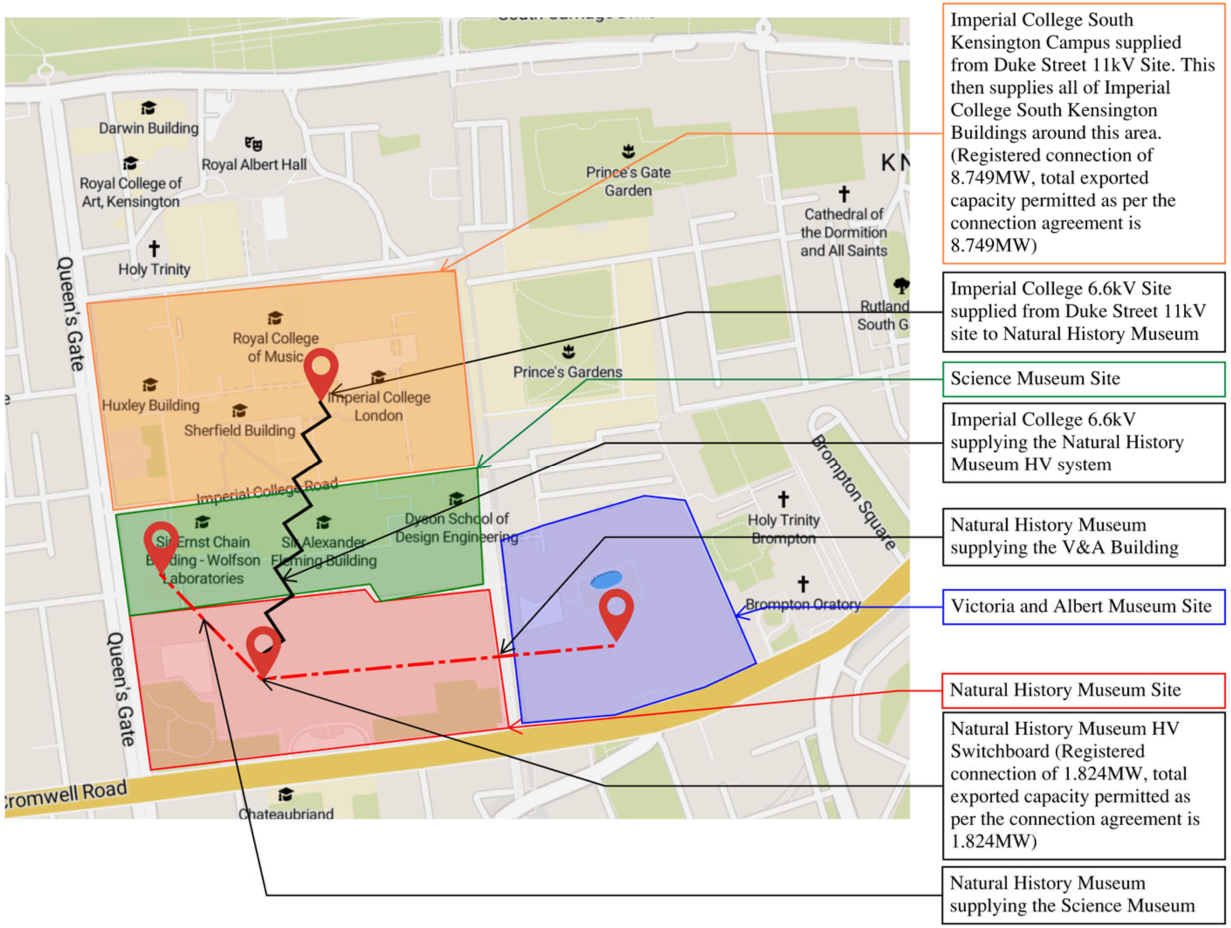


Figure 17. Electrical supply network between the institutions

Appendix A

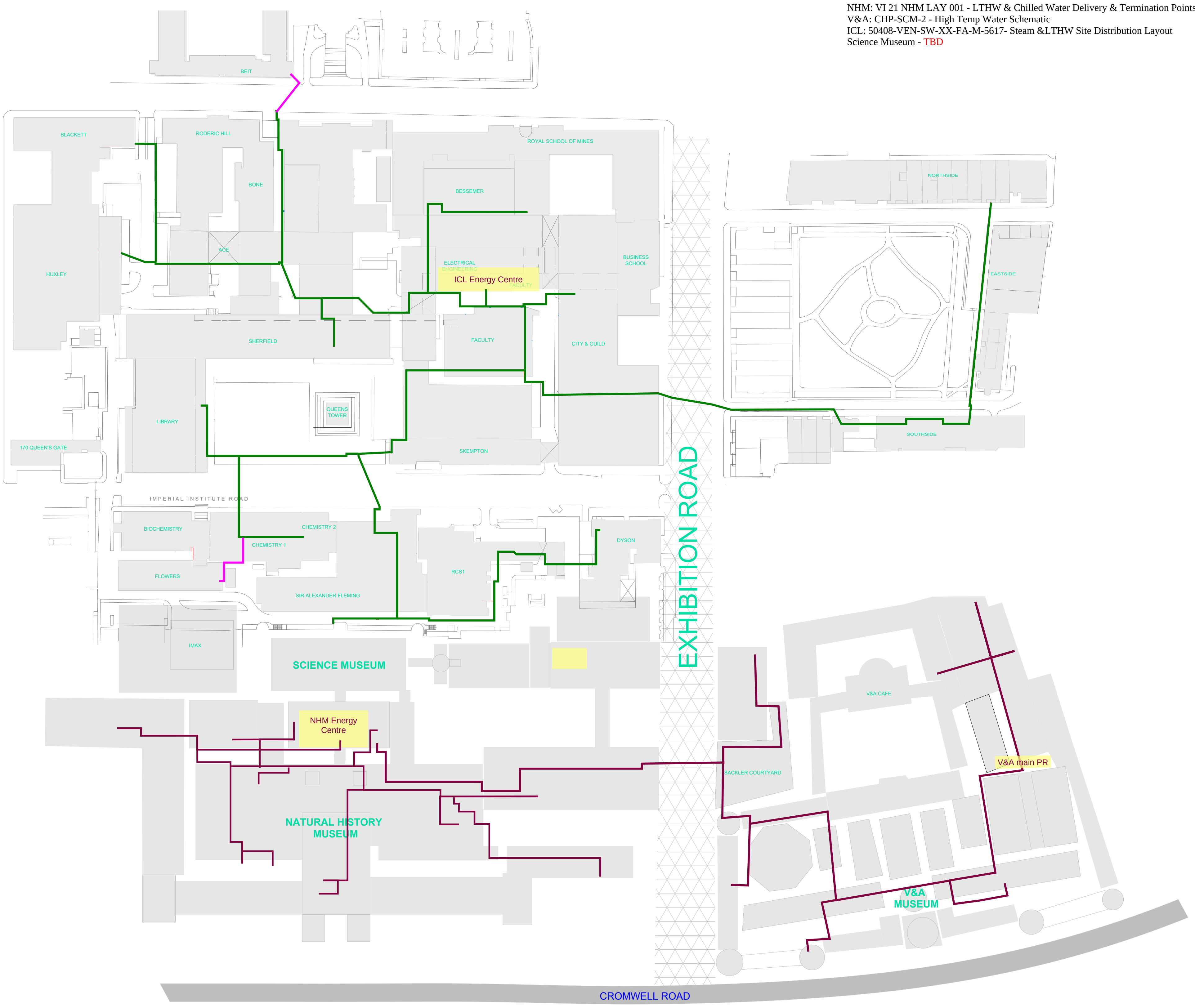
Current energy infrastructure diagram

Current LTHW works in progress

Existing LTHW heat network (verified on-site)

Existing LTHW Heat network (from record information)

NHM: VI 21 NHM LAY 001 - LTHW & Chilled Water Delivery & Termination Points
V&A: CHP-SCM-2 - High Temp Water Schematic
ICL: 50408-VEN-SW-XX-FA-M-5617- Steam &LTHW Site Distribution Layout
Science Museum - TBD



ARUP

Job Title			Job No.
SK ZEN			294740-00
Sketch Title			Sketch No.
Simplified existing LTHW heat network			SK-00-0001
Purpose of Issue			Scale
For Information			NTS
By	Checked	Revision	Date
AdT	DW	01	18/05/23

ARUP

Appendix B

Modelling assumptions

Number	Assumption	Reference
1.	Imperial heat data – baseline period from August 2017 to July 2018.	Arup previous project
2.	Imperial electricity hourly data.	Arup previous project
3.	ScM - Monthly heating data for August 2017 to July 2018.	ScM
4.	HDD baseline temperature assumed to be 15.5C to achieve a temperature inside the Museums and offices between 17 – 19C	
5.	NHM monthly heat data for August 2017 – July 2018.	NHM
6.	NHM half hourly electrical data	NHM
7.	V&A heat data missing for couple months between August 2017 – July 2018. Average values have been calculated from the received data.	V&A
8.	Outdoor dry bulb temperature	Imperial weather station
9.	Imperial Heat network losses 11%	DECC
10.	Gas and electricity carbon factors: - Electricity kgCO2/kWh 0.21149 - Gas kgCO2/kWh 0.18254	BEIS Carbon factors 2022

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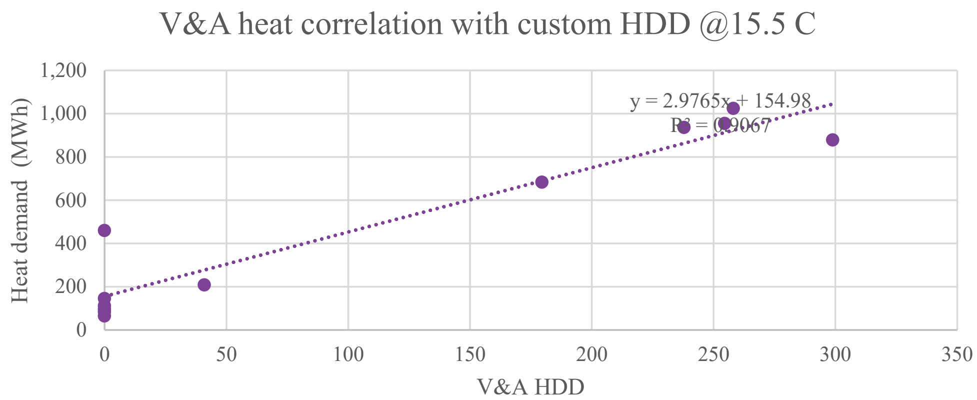
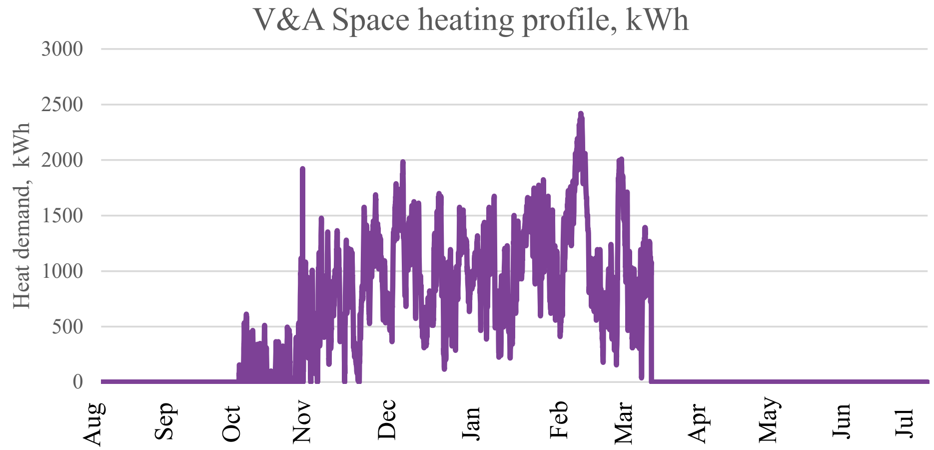
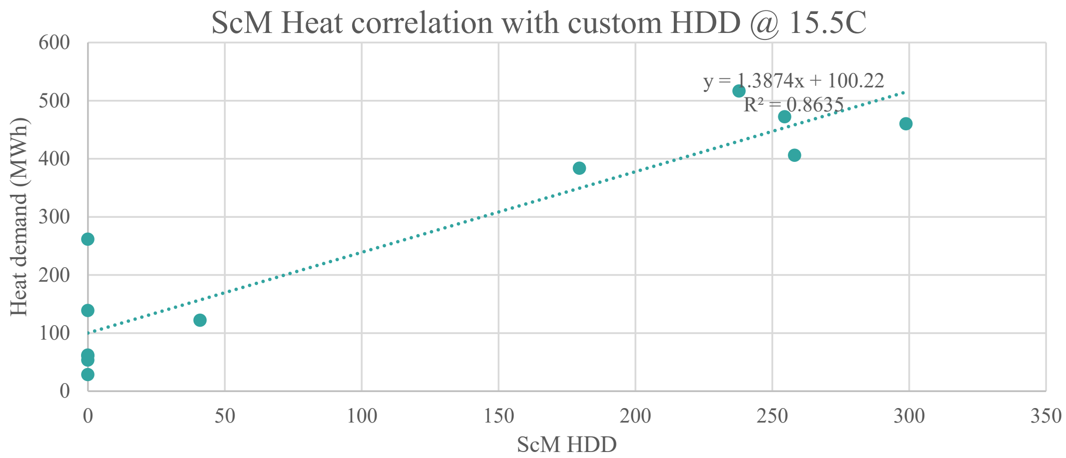
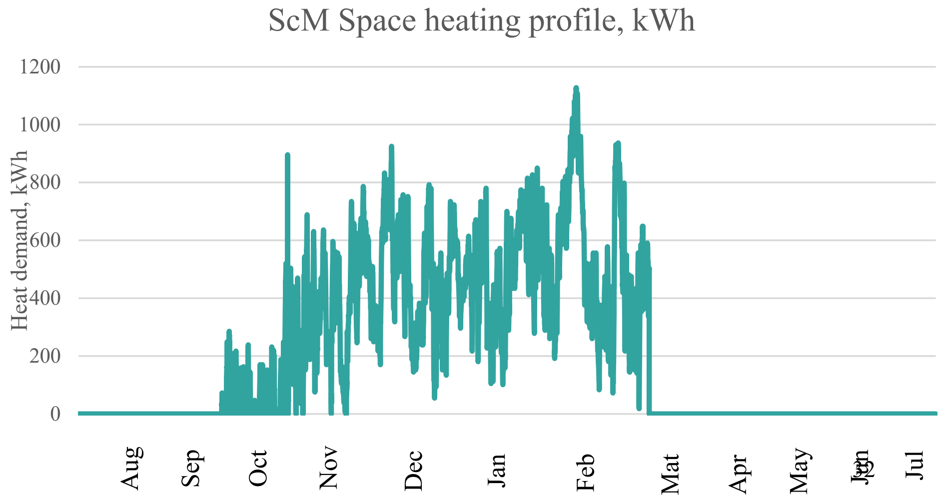
Appendix C

Methodology continued – V&A and ScM energy breakdowns









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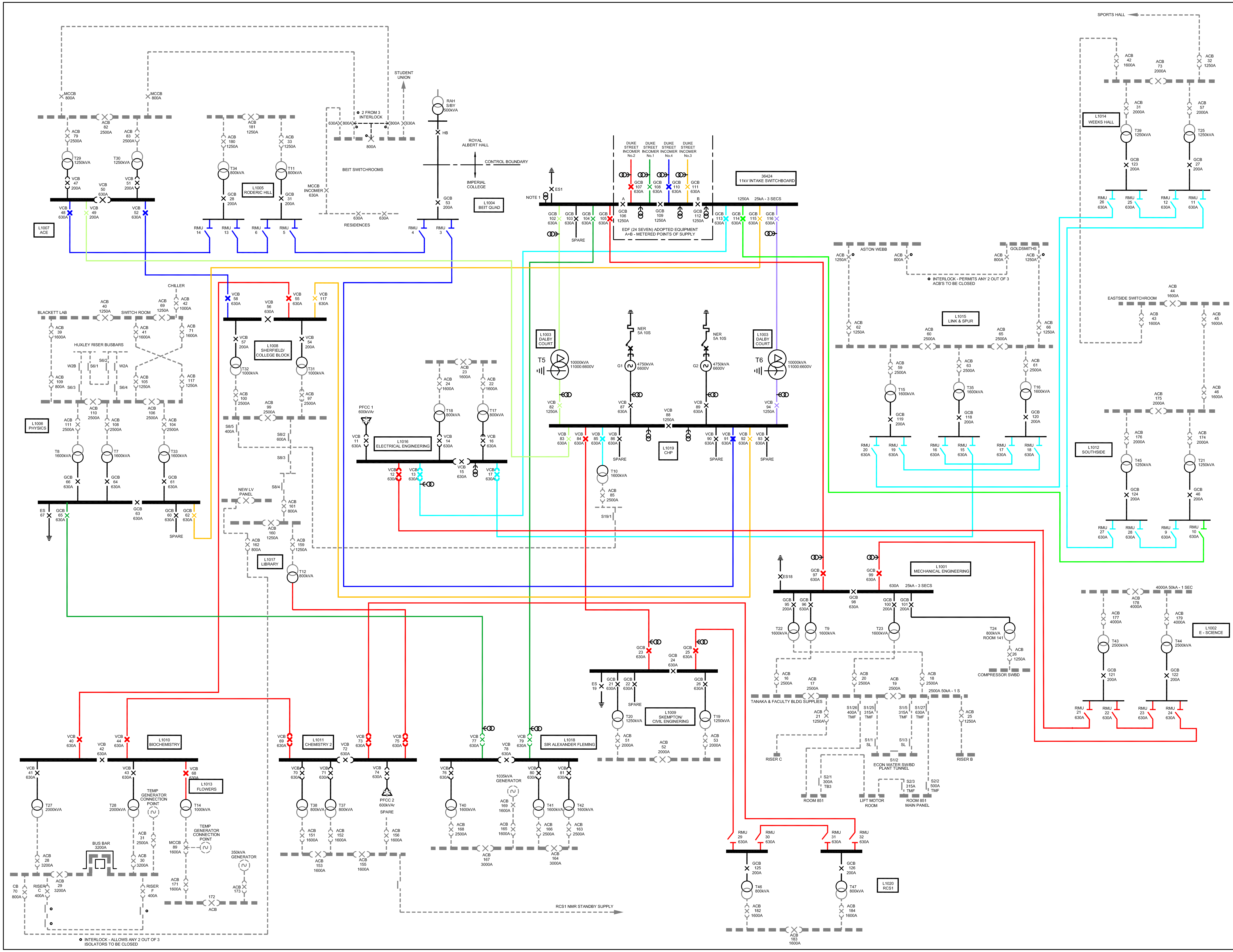
Appendix D

Electrical supply diagrams



LEGEND

- POWER TRANSFORMER
- DISTRIBUTION TRANSFORMER
- VOLTAGE TRANSFORMER
- ISOLATING CONTACTS (ACB)
- H.V CONTACTOR (NER)
- L.V DICONNECTOR/FUSE SWITCH – FUSE TYPE SHOWN FOR FUSE SWITCHES

ACB – AIR CIRCUIT BREAKER (LV)
OCB – OIL CIRCUIT BREAKER (HV)
VCB – VACUUM CIRCUIT BREAKER (HV)
GCB – GAS CIRCUIT BREAKER - SF6 (HV)
RMU – RING MAIN UNIT
NER – NEUTRAL EARTHING RESISTOR

- H.V DISTRIBUTION - 11kV
- H.V DISTRIBUTION - 6.6kV
- L.V DISTRIBUTION

NOTE

1. ISOLATION OF VT, LV ONLY

Revision	Description	Date
G	ACB31 & MCCB89 ADDED	16.07.13

Imperial College London

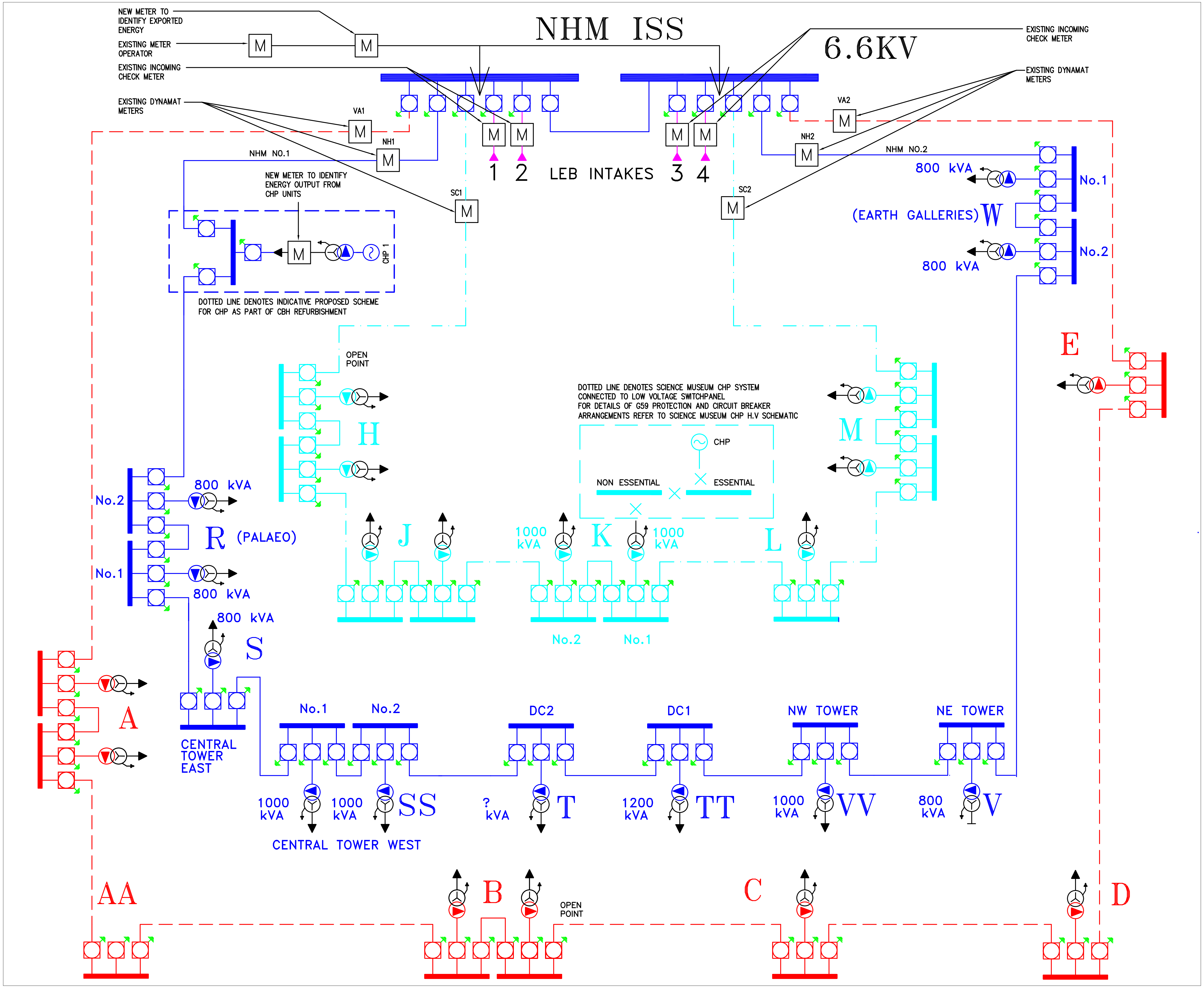
Estates
Project Office
South Kensington Campus London SW7 2AZ
Tel: 020 7594 8926 Fax: 020 7594 8925

Project: SOUTH KENSINGTON CAMPUS

Title: PRIMARY ELECTRICAL DISTRIBUTION SINGLE LINE DIAGRAM

Drawn by	Checked	File
FEP	LJ	SCHE0005G

Drawing Number	Revision	Scale	Date
CAMP/SCH/E/0005	H	N.T.S.	DEC 2015



NOTE

1.UNLESS OTHERWISE DENOTED ALL TRANSFORMERS ARE 800 kVA RATED

KEY

- NHM SYSTEM
- ScM SYSTEM
- V&A SYSTEM
- LEB SYSTEM

REV	DATE	MODIFICATION

ESTATE MANAGEMENT

NATURAL HISTORY MUSEUM

The Natural History Museum
Cromwell Road
London
SW7 5BD

PROJECT EXISTING H.V NETWORK

TITLE H.V SCHEMATIC SHOWING C.B.H PROPOSALS

DRAWN BY: GPB	SCALE: 1 : 100
DATE: Sept 2006	N.H.M. CHECKED BY
N.H.M. ESTATES AUTOCAD DRAWING REFERENCE NUMBER	
N.H.M. ESTATES DRAWING NUMBER: xx/xx/xxxxx	
REVISION	

ARUP