NHS
Kingston Hospital
NHS Foundation Trust

KINGSTON HOSPITAL – HEAT DECARBONISATION PLAN

Report presented to Kingston Hospital NHS Foundation Trust

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1. Executive Summary

1.1 Purpose

Reaching our country's ambitions under the Paris Climate Change Agreement could see over 5,700 lives saved every year from improved air quality. Parliament announced a climate change emergency in 2019 and with the NHS representing more than 5% of the UK's total carbon footprint, NHS England have recently released a report setting out the ambitious targets of net zero for its NHS Carbon Footprint and its NHS Carbon Footprint Plus by 2040 and 2045 respectively.

Kingston Hospital NHS Foundation Trust is continuously evaluating the ideal solution to decarbonise its activities. The Trust has gained full visibility of the impact of its activities following the completion of the Heat Options Appraisal. The key step to achieve NHS England's ambitious carbon targets involves decarbonising electrical and heat generation at building, as the majority of the Trust's electricity and heat is generated using carbon intensive technologies. With the recent public government announcement that the electricity grid will decarbonise by 2035, the Trust must utilise available renewable sources to generate heat.

Due to 3rd party control of the hospital's energy generation, the Trust is looking to capitalise on the upcoming contract expiry in 2024 by initiating low carbon solutions implementation. Decarbonisation of the Trust's heat will lead to a 41% reduction of the Trust's NHS Carbon Footprint. Combined with the natural decarbonisation of the electricity grid, the Trust can decarbonise 90% of its NHS Carbon Footprint by focusing on heat decarbonisation alone.

The Trust is currently positioned worse than the upper quartile of all Trusts with regard to carbon emissions associated with heat generation normalised against floorspace. This is predominantly due to the age of the Trust's buildings and its reliance on natural gas. Combined with the ageing infrastructure currently in place, the Trust is in a unique position to showcase best practice to achieve full decarbonisation of heat, as we currently utilise a wide range of assets. Combined with the natural decarbonisation of the electricity grid, the Trust can decarbonise 90% of its NHS Carbon Footprint by focusing on heat decarbonisation alone.

By reducing our impact on the environment, we can expect to see significant improvements in our healthcare services as well as the health of the population. The NHS has an effect on every individual in this country, and its impact on the environment cannot be ignored. As the country collectively pushes towards a carbon neutral economy, further steps would be required to achieve net-zero due to activities that fall outside the scope of this Heat Decarbonisation Plan, however, the Trust has prioritised this document and the actions within it as it enables this organisation and the wider NHS England to make a big step towards its target.

1.2 Net Zero Governance at KHT

The Trust's Board Level Net Zero Carbon lead is Yarlini Roberts; Chief Financial Officer. The Board recently approved the Trust's Green Plan which includes a commitment to 'produce a heat decarbonisation plan to transform the way buildings are heated.' The implementation of this plan will be led by Philip Griffiths; Director of Estates & Facilities.

1.3 Summary

There are three main components in any organisation's decarbonisation journey: energy efficiency, low carbon technology installation and carbon offsets. This document outlines the method by which the Trust will implement the first two steps, the cost of each opportunity and the impact each opportunity will have on operational cost and carbon emissions.

Following a detailed audit of each site, various optimisation opportunities were evaluated that would minimise electricity and heat consumption. The primary aim of these opportunities is to a) drive down operational costs b) minimise the size of the low carbon technologies which will drive down total cost of the projects c) minimise the cost of enabling works required to implement each solution.

This document ties in findings from XXXXX. RE: FIT project, district heat network study from XX XXX and heat options appraisal by XXXXXX.

The current electricity and heat infrastructure at Kingston NHS FT are unsuitable for the immediate transition to a low carbon technology. Enabling works are required to ensure that the Trust optimises operation of all assets as well as deliver the facility required to operate any new assets. These enabling works can swing the total cost of each project significantly, therefore controlling the parameters that can minimise the amount of required enabling works streamlines the decarbonisation journey and reduces the risk of each project.

The overall solution for the Trust is clear up to 2032, to decarbonise the Trusts NHS carbon footprint by 80% in line with guidance set out by NHS England. A summary of works required at the Kingston site:

- Improve building fabrics to minimise heat consumption in each building. This primarily involves wall insulation and double-glazing improvements. *(£700K, -310 tCO_2e/year, ROI 20+ years)*
- Improve energy efficiency of building to minimise electricity consumption. This includes LED and AHU upgrades *(£85k, -234 tCO_2e/year, ROI 6 years)*
- Improve site metering and verification, BMS and analytics leading to better control, fault find and efficient use of resources*. (£100k, ROI 8 years)*
- Install solar PV to maximise carbon savings from low carbon energy. *(£700k, -181 tCO_2e/year)*

  (Carbon emissions reduced to 8723 tCO_2e/year as a result of optimisation works and grid decarbonisation)

- Disconnect the CHP in 2024 to minimise use of carbon intensive gas for electricity and heat generation and switch to grid consumption and proposed district heat network. *(£2mill, -3,825 tCO_2e/year)*
- De-steam the site and expand existing LTHW network *(£1.7mill, 74 tCO_2e/year)*
- Convert heat emitters and pipework within most buildings to operate the heating infrastructure at lower temperatures. This is a key step to ensure efficient operation of the heat pumps and District Heat Network. *(£2mill for DHN)*
- Install decentralised heat pumps for outbuildings to deliver heat via the electricity grid as this provides the most economical solution to decarbonise heat. *(£1mill)*
  (-3155 tCO_2e/year from DHN and Heat pumps)
- Re-visit low carbon technology in 2032 to completely remove the site's reliance on natural gas.

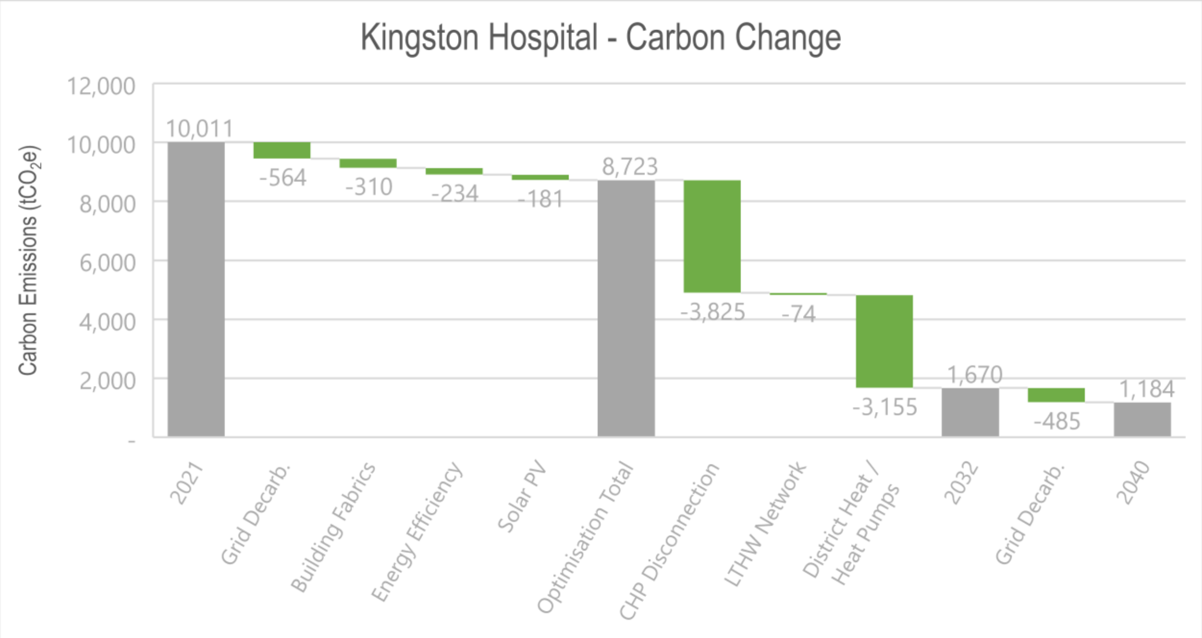

Figure 1: Kingston Hospital decarbonisation waterfall

Estimated 1,670 tCO_2e/year from heat and electricity remains in 2032 after heat decarbonisation efforts to meet the intermediate 80% carbon reduction target.

Disconnecting the CHP when the contract expires in 2024 and connecting to the proposed local DHN will significantly reduce the sites reliance on natural gas. This will in effect de-steam the site and thus a new LTHW network is required to heat the main site. The DHN will be designed to cover 80% of the main sites peak heat demand with the remaining load being met by natural gas fired LTHW boilers. Appendix I illustrates the proposed LTHW network and proposed location of the new energy centre. The outbuildings, excluded from the LTHW network, will be heated with decentralised heat pumps. The Trust will conduct geological surveys to explore if a larger ground source heat pump is suitable for the site.

In terms of electrical infrastructure for the heat pumps, this would be dependent on the capacity of the heat pump and available network capacity. Due to the heat pumps requiring large supplies, the common practice is to install a new substation directly off the HV main, to a stepdown transformer and new switchboard. This limits the risk of available board capacity on existing and ensures a purpose-designed switchboard and supply is installed for the units.

By 2032 the site's reliance on gas will be significantly reduced, although not completely, 20% of the main buildings peak heat demand is will still be reliant on LTHW gas boilers. The Trust will re-visit low carbon technologies in 2032 and opt for the most economically feasible solution to move the site away from its reliance on natural gas. This will allow low carbon technologies such as hydrogen, battery energy storage and carbon capture that to develop further.

1.4 Recommendations

The Trust plans to implement the above solutions in a phased approach, in line with Salix funding announcements and NHS England's carbon targets. Additionally, depending on the Trusts decision on where the boundary of responsibility is for the new DHN energy centre, there is an alternative funding route, if it is decided that this shall be owned and operated by a 3rd party then, a proportion of the CAPEX is covered by the 3rd party but comes does with higher standing and variable charges.

Recommendations for the Trust are summarised below:

1) Progress optimisation opportunities such as LED lighting, double glazing installations as highlighted in the RE: FIT project.
2) Investigate PPA agreement for solar panels and battery energy storage (BESS) supplier agreement
3) Engage Local Authority to indicate interest in collaborating for a District Heat Network (DHN) connection (consider coming to Heads of Terms for a future relationship)
4) Improve cost certainty for Trust CAPEX requirements for DHN scenario through budget quotations
5) Create detailed submeter plan to obtain maximum visibility of consumption across Kingston Hospital. Connect existing and new meters to a M&T software to collect granular half hourly data for future analysis.
6) Conduct enabling activities that could be investigated whilst the Trust awaits funding announcements:
    a. Ground surveys for ground source heat pumps
    b. Assess feasibility of improving wall insulation, particularly buildings with cavity walls
7) Where the Trust receives funding, complete all recommended insulation works across all sites.

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2 Introduction

2.1 Context

Our planet is facing a climate emergency which is predominantly being driven by our reliance on fossil fuels for heat, power and transport. In response, the UK has set a legally binding target under the Climate Change Act 2008 to reduce its emissions to Net Zero by 2050. The heating of buildings represents a significant proportion of current emissions, 2% of which can be attributed to the public sector. It is therefore clear that the public sector has a significant part to play in the drive towards Net Zero and should demonstrate leadership through early action on the decarbonisation of heat.

Last year, the NHS published its "Delivering Net-Zero" report which sets out its commitment for the NHS to achieve Net-Zero direct carbon emissions by 2040. In late 2020 the department of Business Energy & Industrial Strategy (BEIS) announced a £1bn fund to support decarbonisation schemes for public sector bodies (PSBs) which included the Low Carbon Skills Fund (LCSF), a grant scheme which enabled PSBs to access expert consultancy support. The LCSF was administered by Salix Finance on behalf of BEIS. Salix Finance have now announced a second phase to the LCSF which makes £11.5m available for PSBs (including NHS Trusts) to apply for additional consultancy support to develop Heat Decarbonisation Plans.

2.2 What is a Heat Decarbonisation Plan?

The purpose of this Heat Decarbonisation Plan, HDP, is to describe how the organisation intends to replace fossil fuel reliant systems with low carbon alternatives to meet the challenge of net zero and decarbonise its buildings. This HDP describes the current state of Kingston Hospital NHS Foundation Trust's energy use, provides an overview of understanding within the organisation, and its plans for reducing and/or decarbonising its energy use. The plan outlines what the Trust has already done, what it is currently doing and describes our plans for the future. The plan explains what actions are going to be taken, over what timescales, and the intended outcomes.

2.3 Background of Trust & Estate

Kingston hospital NHS FT are a district general hospital supporting around 350,000 people in Kingston, Richmond, Elmbridge (Surrey), Merton, Wandsworth and Sutton. We provide a full range of diagnostic and treatment services and have a national reputation for innovative developments in healthcare, particularly in 'patient-focused' care across our services including emergency, day surgery and maternity services. Staff are committed to providing quality healthcare, working hard to ensure that we build up a wide range of clinical services.

This HDP study will focus on our main Kingston site, it is located in Galsworthy Rd, Kingston upon Thames KT2 7QB. This site comprises a wide range of buildings from admin offices, to emergency care and walk-in day clinics.

The surveyed buildings at Kingston hospital are the following:

1. Davies Wood House - offices
2. Mortuary & Patient Affairs
3. Staff Day Nursery
4. Vera Brown House - offices
5. Wolverton Centre - Clinic
6. Accident Emergency Department (ED)
7. Kingston Surgical Centre (KSC)
8. Main Outpatients
9. Princess Alexandra Dental Wing
10. Esher Wing – Wards and clinical
11. Bernard Meade Wing - wards and clinical
12. Maternity & Day Surgery Unit
13. Estates & facilities

14. Sir William Rous unit – wards and clinical
15. Rowan Bentall Wing - clinical

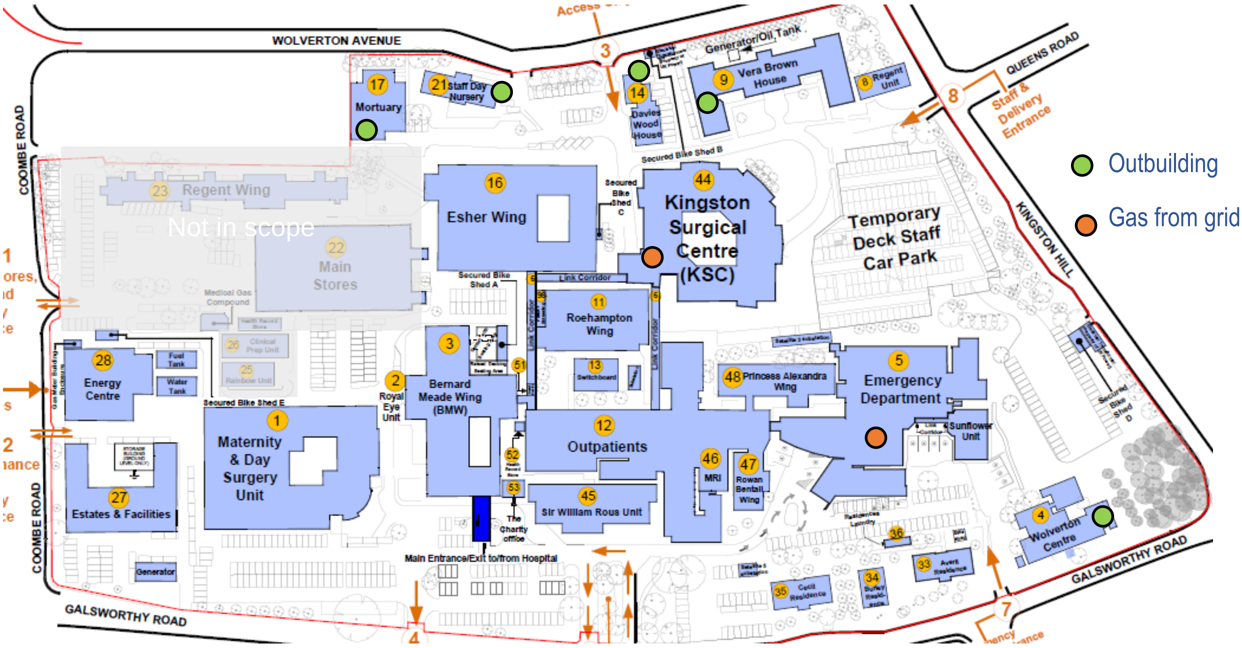


Figure 2 Kingston Hospital site plan

2.4 Trust Carbon Emissions

The first stage on the road to reducing carbon emissions is understanding the Trust's GHG emissions, to calculate a benchmark which ultimately provides a way to measure progress over time. Figure 3 outlines the scope of carbon emissions within the NHS, which includes two broad categories of emission; the NHS Carbon Footprint, which represents emission sources over which the Trust has direct control, and NHS Carbon Footprint Plus, which represents indirect emissions outside of the organisation's control but which the Trust is able to influence.

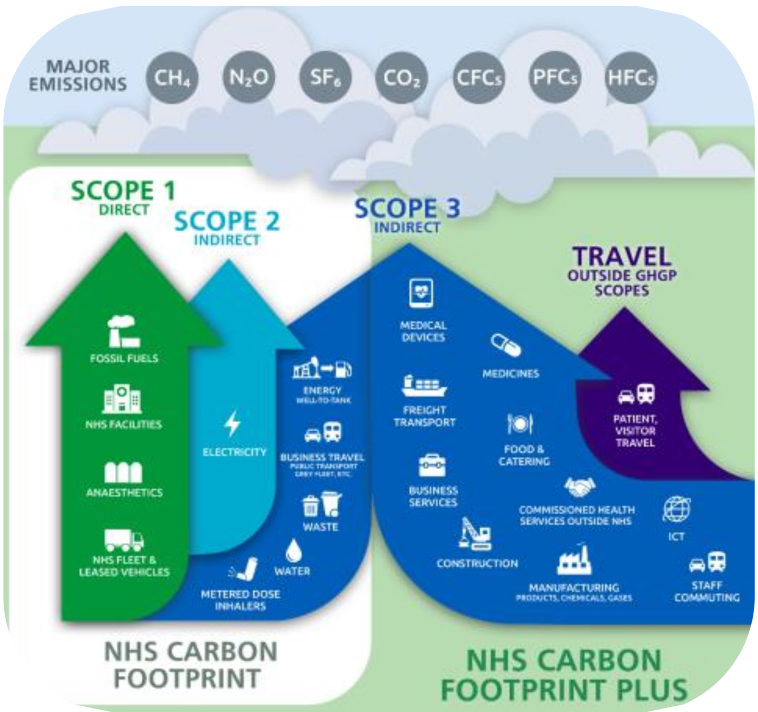


Figure 3 Carbon emissions in the context of the NHS [2]

Utilising the categories outlined within Figure 3, the NHS *Delivering a 'Net Zero' National Health Service report* [2] evaluated the breakdown of carbon emissions associated with each category. This NHS wide average is outlined in Figure 4.

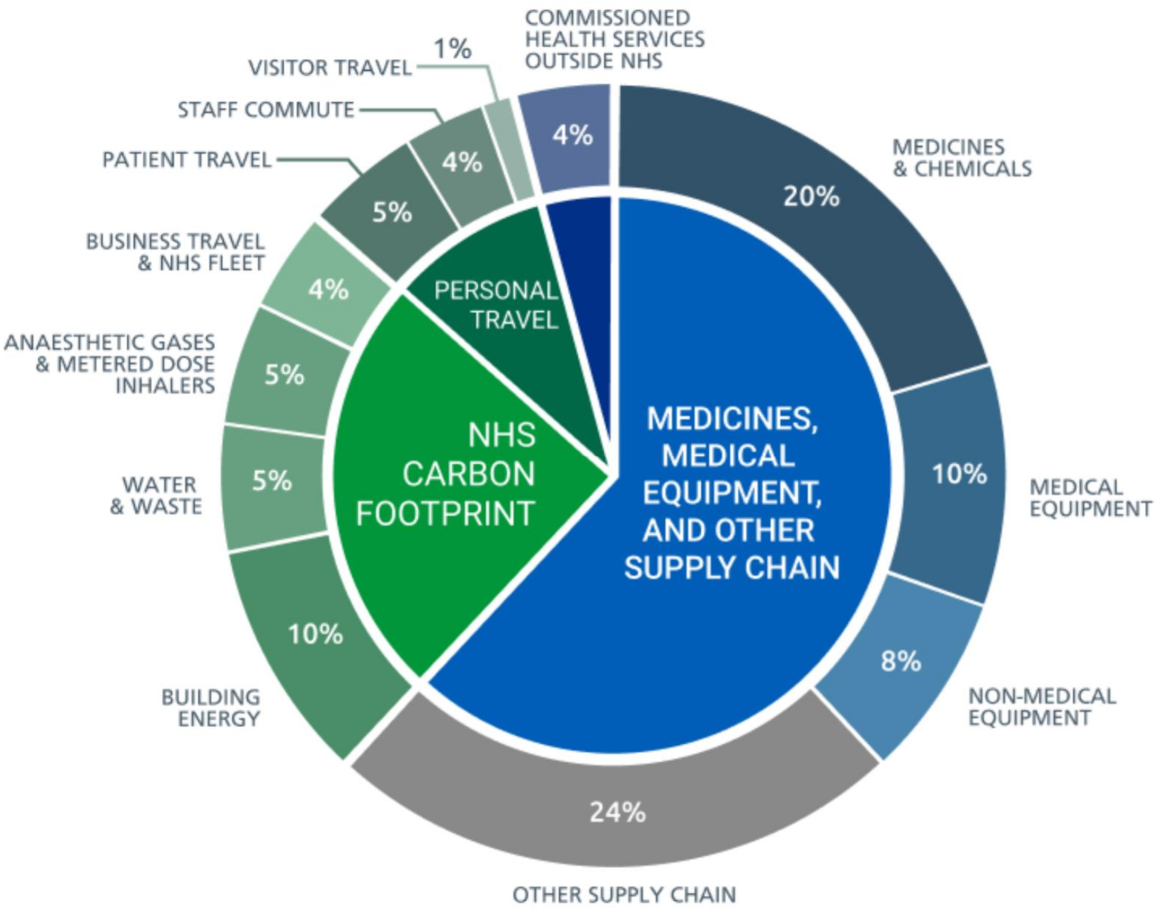


Figure 4: Breakdown of NHS Carbon Footprint Plus across the whole NHS

Whilst it is important to note that the proportion of emissions linked to the NHS Footprint Plus is larger than those associated with the NHS Footprint, the purpose of this HDP is to create a plan targeting which specifically addressed the short-term challenge of reducing the NHS Carbon Footprint by 2040.

With the aim of the HDP to target emissions resulting from building energy use, a breakdown of the Trust's carbon emissions is shown in Figure 5. The Trust's Energy demand is 46.3 GWh which equates to a carbon impact of 9,724 tCO_2e (including scope 3 FERA emissions). The graphs include activities that fall outside the scope of this report, however, the pie chart, *2020 Carbon Split by End-Use*, indicates that the Trust is capable of targeting approximately 41% of its carbon via the Heat Decarbonisation Plan. Equally the majority of the Trust consumption by the resource is gas, so the Trust will need to transition away from its reliance on CHP as a core energy strategy.

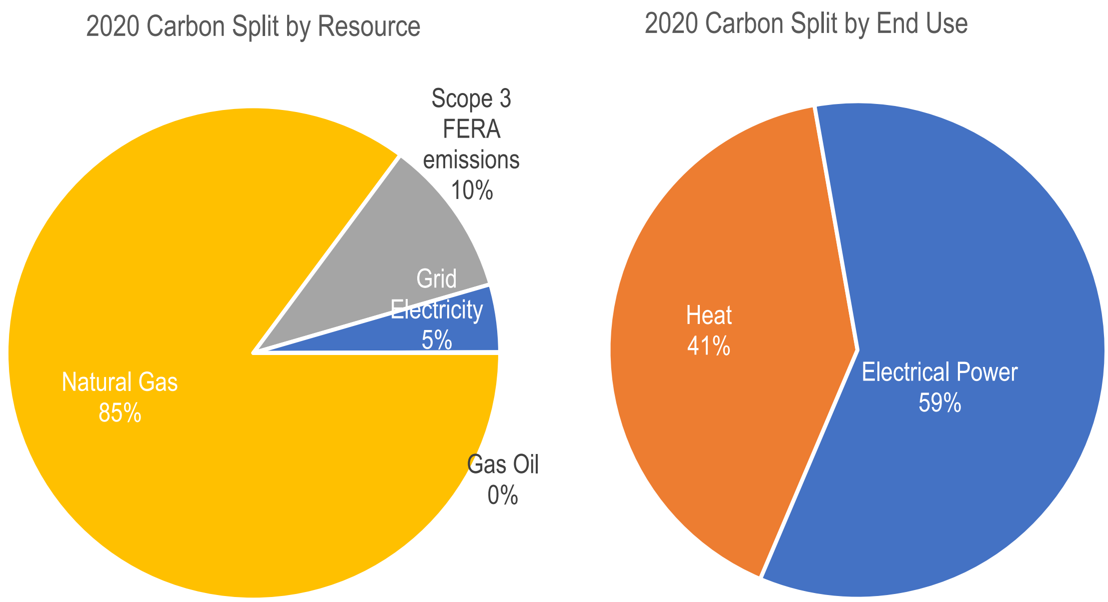


Figure 5 Carbon breakdown by resource and end use (source: Kingston FT NHS Heat Options Appraisal)

Figure 4 shows that the biggest opportunity for the Trust to reduce its direct carbon emissions is by targeting the energy consumption within its buildings. Currently, the majority of the site is heated and powered by the energy centre. Outbuildings, such as Vera Brown house have their own supply of electricity and gas from the grid. In addition, ED and KSC have their own gas supply to the building.

The Combined Heat & Power (CHP) system located within the energy centre is set to be decommissioned in 2024. Using gas as the fuel, it generates electrical and thermal energy. Approximately 50% of the engine's thermal power is used to generate steam and the remaining waste heat produces Low Temperature Hot Water (LTHW). The site's steam network, fed by the CHP and additional boilers can provide heat to around 56% of the hospital's occupied area. The LTHW heat network can currently only supply around 25% of the site and therefore a significant proportion of this energy is wasted each year owing to a lack of demand. In summer months, excess CHP heat can be supplied to an absorption chiller to provide cooling. Appendix I outlines the steam and LTHW networks.

The electricity generated from the CHP feeds into the site's HV ring which is also supplied with electricity from the grid via two main incomers, Appendix II.

The "outbuildings" are not connected to the main HV ring, steam and LTHW networks. Instead, they are heated with gas and take electricity from a substation outside of the Trust's control.

Table 1 provides an overview of key information relating to the surveyed buildings at Kingston hospital.

Building Name	Use	Weekday Hours	Weekend Hours	Age	UPRN	Postcode	GIA (m2)	MPAN	MPRN	DEC Rating	Additional Information
Davies Wood House	Office	12	0	1897	128047046	KT2 7QB	449	1900070268910	72519600	N/A	Admin
Mortuary & Patient Affairs	Hospital	24	24	1986	128047047	KT2 7QB	529	1900070699844 / 1900070699853	72519510	G	Mortuary
Staff Day Nursery	Pre-school Facility	12	0	1920	128007434	KT2 7QB	527	1900028023652	72530902	G	Nursery
Vera Brown House	Office	12	0	1928	128007438	KT2 7QB	3432	1900091189539	9340187701	A	Admin
Wolverton Centre	Health Centres & Clinics	12	0	1962	100023059235	KT2 7QB	801	1900045021008	72519207	E	Clinic
ED	Hospital	24	24	2001	128047035	KT2 7QB	3924	1900070699844 / 1900070699853	9153683810	E	ED
KSC	Hospital	24	24	2007	128047043	KT2 7QB	9324	1900070699844 / 1900070699853	82023700	F	PFI operated
Main Outpatients	Hospital	24	24	1962	128047038	KT2 7QB	6065	1900070699844 / 1900070699853	82023700	F	Clinical
Princess Alexandra Dental Wing	Hospital	24	24	1975	128047037	KT2 7QB	967	1900070699844 / 1900070699853	82023700	D	Admin
Esher Wing	Hospital	24	24	1975	128047044	KT2 7QB	19399	1900070699844 / 1900070699853	82023700	F	Wards & theatres
Bernard Meade Wing	Hospital	24	24	1991	128047029	KT2 7QB	5415	1900070699844 / 1900070699853	82023700	F	Wards & theatres
Maternity & Day Surgery Unit	Hospital	24	24	1995	128041430	KT2 7QB	7483	1900070699844 / 1900070699853	82023700	F	Maternity
Estates	Office	24	24	1963	128047049	KT2 7QB	694	1900070699844 / 1900070699853	82023700	G	Admin
Sir William Rous unit	Hospital	24	24	2008	128047032	KT2 7QB	1751	1900070699844 / 1900070699853	82023700	F	Clinical
Rowan Bentall Wing	Hospital	24	24	1994	128047034	KT2 7QB	360	1900070699844 / 1900070699853	82023700	F	Clinical

Table 1 Summary of Kingston hospital buildings

2.5 Previous Works

To date, the Trust has replaced a significant amount lighting with low-energy LED lighting. A lighting survey conducted in 2019 identified the remaining fittings to be replaced, giving the Trust a clear idea of where works need to be completed.

To improve the energy efficiency of our buildings, in particular, reducing energy required to heat our buildings, Davies Wood House has had its windows upgraded to double glazing, replaced an old boiler and replaced old radiator pipework.

There is a small extension in Esher Wing Level 2, approximately 140m² that is yet to complete.

2.6 Planned Works

As part of Kingston NHS FT's commitment to sustainability, to reach net-zero by 2040 and 80% reduction in *NHS carbon footprint* by 2032, the Trust completed a number of surveys and studies to understand where we are now, the energy efficiency projects to undertake, and viable low carbon technologies.

A RE: FIT project conducted in 2021 surveyed six carbon reduction initiatives - LED Lighting, BMS Optimisation, AHU fans, and Steam Trap Improvement. This report identified key optimisation opportunities that the Trust can focus on in order to reduce the Trust carbon emissions and energy demand.

However, in order to understand the pathway to net-zero a *Heat Options Appraisal* report was developed in late 2021. This began the Trusts evaluation of future plans to reach net-zero taking into account the energy reduction opportunities highlighted in the RE: FIT survey. This report incorporated actual consumption data to determine the Trust's carbon baseline for energy consumption. The report also forecasted the site's consumption to 2050, taking into account future carbon intensity of resources. Then it evaluated different pathways based on cost, carbon, complexity and credibility for a number of scenarios:

- Business as usual (BAU)
- Optimise only
- Steam Boilers Only
- Hydrogen Boilers
- District heat networks (DHN) & LTHW Boilers
- DHN & Ground source heat pumps (GSHP)

Reaching net-zero by 2040 is an ambitious target, so BAU, optimise only and steam boilers only options alone are not enough. Hydrogen boilers are not expected to be widely available until at least 2030, and even then, the majority will likely be directed to the industrial and commercial sectors as opposed to building heat. The report concluded that DHN & GSHP as the most viable options for achieving the targets set out by NHS England.

Previous studies conducted by the Trust led to the natural progression of developing this HDP. Although the Trust has made progress in its sustainability journey through the completion of energy efficiency projects and studies, these were evaluated separately from integrating low carbon technologies. The Trust looks to cement a clear plan to decarbonise its major source of emissions.

The Trust's ongoing plans to reduce emissions involve continued conversion to low-energy LED lighting, improve metering and verification for all buildings. By doing so, the Trust will have a significantly lower electricity demand, better management of large buildings during working hours and significantly reduce emissions.

In terms of decarbonising heat, how the Trust will be heated in the future is still under consideration, however moving away from CHP as a source of heat and in effect de-steaming the site is certain. Opting for heat pump will mean the Trust will need to move towards LTHW and thus will need to modify and expand the current LTHW network, Appendix I.

As part of this decision, the Trust also needs to decide how the Trust looks to decarbonise electricity, either opt for a new smaller CHP or remove it entirely when the existing CHP reaches end of life in 2024.

There are also preliminary plans to move the energy centre to maximise the efficiency of the site.

For further information on previous studies please revert to the appendix of this report.

2.7 Methodology

The findings from these works have been integrated in the Heat Decarbonisation Plan. Further findings will be added to the document after its completion as the Trust will continue developing the HDP following its submission to Salix on the 31st March 2022.

Pre-survey data analysis involved evaluating the buildings within each site to assess their size and type as well as the quality of the billing and meters on site. Furthermore, the opportunity of district heat networks in the area surrounding each site was investigated along with a desktop evaluation of the building's electrical capacities. Finally, a baseline was defined by assessing previous energy efficiency and carbon reduction projects and by mapping both the current resource use between now and 2040 and the forecasted changes in carbon intensity and utility prices based on BEIS forecasts.

Next, site surveys were undertaken to review existing heat systems on site. This involved identifying and assessing the assets and fuel types in each building and the distribution infrastructure used, i.e., radiators, radiant panels, AHUs, FCUs, and underfloor heating. Once a picture was developed by collecting this information, a technical solution was developed to consider low carbon alternatives and to estimate the project costs using benchmark pricing.

Finally, the findings of the surveys were summarised and used to evaluate operating cost implications of the proposed projects. With these proposed projects, delivery plans were then developed, and key challenges were identified. This was then summarised in a draft HDP report for the Trust Board to review and provide feedback before issuing the final report.

3. Energy Consumption and Carbon Emissions

3.1 Carbon baseline

Having defined the hospital's carbon baseline, (section 2.4), it is important to consider how the site's impact can be expected to change in a 'business as usual' context within the timescale of the targets set out by *For A Greener NHS*. Within the NHS "Delivering a 'Net Zero' National Health Service" [1] document, the following targets are outlined;

- For emissions that can be controlled, the NHS Carbon Footprint, Trusts must reach Net Zero by 2040, with an ambition to reach an 80% reduction by 2028 to 2032;
- For emissions that can be influenced, the NHS Carbon Footprint Plus, Trusts must reach Net Zero by 2045, with an ambition to reach an 80% reduction by 2036 to 2039.

For this reason, forecasts of the carbon intensity of energy resources provided by the Dept. of Business, Energy & Industrial Strategy (BEIS) have been utilised to project emissions towards the 2040 net zero target date for the NHS Carbon Footprint. Figure 6 shows that, with no action, no change in energy demand and a continued reliance on CHP, the effects of the UK's electricity grid decarbonising will reduce the Trust's carbon emissions by a negligible 5%. Taking utility costs also forecasted by BEIS, operating costs are expected to increase by 19%. It should be noted that these utility costs do not reflect the significant price fluctuations being experienced within the energy sector at the time of writing.

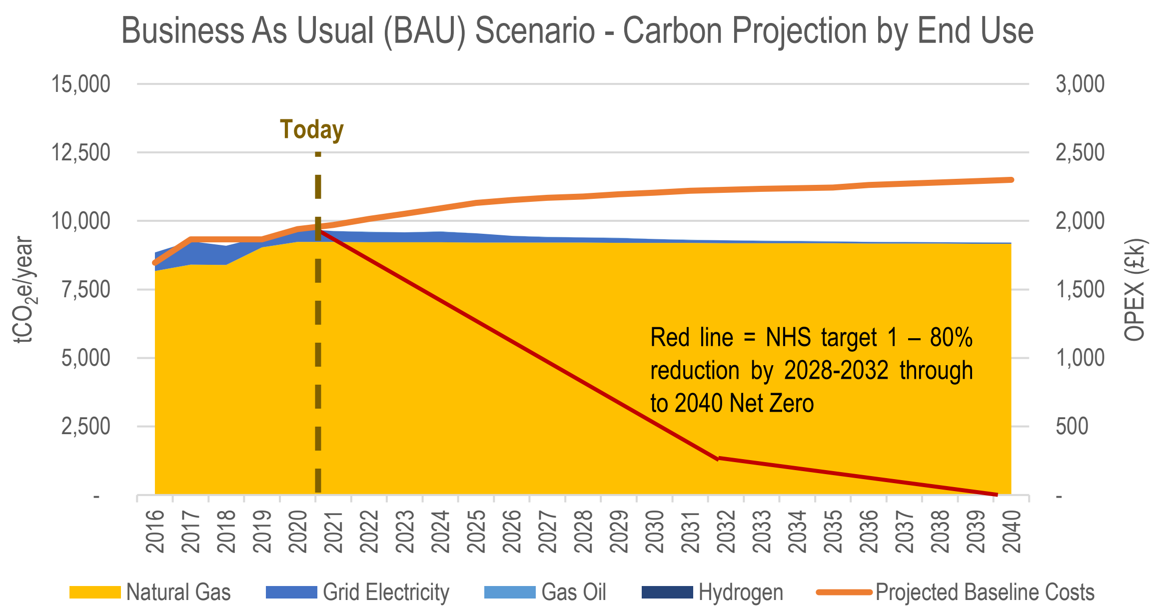


Figure 6 Trust emissions and OPEX projected to 2040 (Kingston Hospital NHS FT NZC Roadmap)

As outlined by BEIS in October 2021, the UK has committed to decarbonise the electricity grid by 2035. however, these effects have a limited impact on the Trust's overall carbon emissions due to the current high reliance on gas. Figure 7 shows the Trust positioned above the upper quartile of all NHS hospitals in the UK with regard to heat demand normalised against floorspace. This demonstrates that the Trust is well-positioned to make significant in-roads to decarbonising energy use in short timescales.

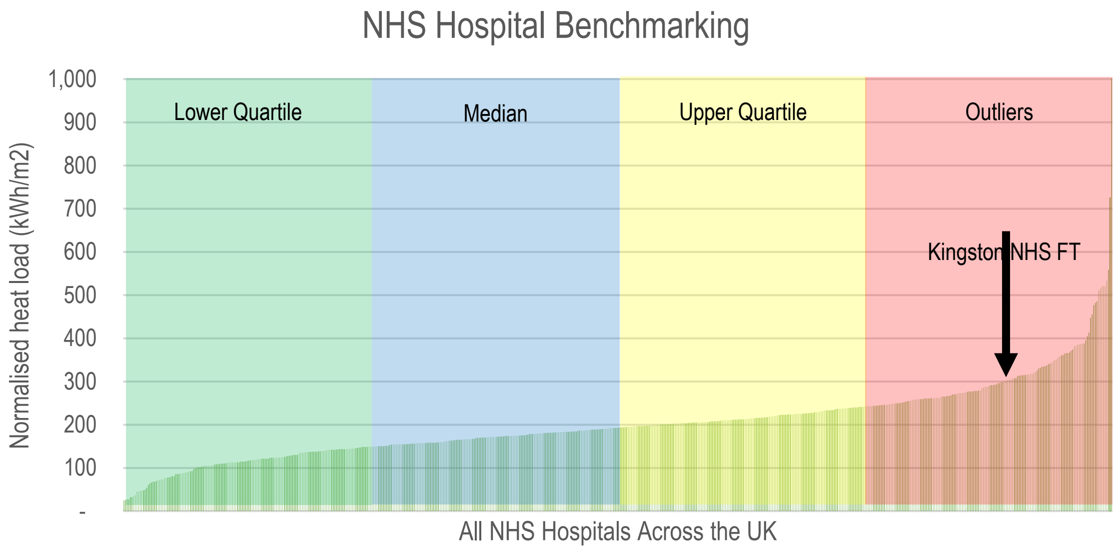


Figure 7 Normalised heat loads for all NHS hospitals in quartiles.

Taking into account the Trust carbon emissions and projected BAU case (red line in Figure 6), the Trust has to take action in order to reach Net Zero by 2040 and 80% reduction in NHS Carbon footprint by 2032. Decarbonising heat by moving away from gas to electricity as its source will bring the Trust closer to its ultimate ambition.

3.2 Energy Data Analysis

Half-hourly data was obtained for each site and analysed to identify patterns and profile usage. Profiles of average half-hourly electrical power were produced as well as the maximum electrical power demand.

Half-hourly gas data was analysed to create a comparison of monthly gas usage and heating degree days to identify the site's heating baseload and peaks through regression. Heat demand for buildings is impacted by local climatic conditions – outside air temperature (OAT), in the main. The lower the OAT, the greater the building's heat demand is likely to be. That is why the use of degree days is common in accounting for the weather when analysing building energy consumption. Heating degree days (HDD) are a measure of how much (in degrees C), and for how long (in days) the outside temperature was below a certain temperature (base temperature). In this report, we use degree days to analyse monthly consumption patterns of gas as well as determine the estimated baseload.

Not all buildings within Kingston hospital consume gas directly, but instead use steam or LTHW generated within the energy centre. Half-hourly steam and LTHW data have also been analysed to create a comparison of monthly gas usage to identify the site's heating baseload and peaks through regression (steam only). In this report, energy analysis for buildings on steam and LTHW will be covered in sections 3.3 and 3.4.

Peak heat demand was calculated by evaluating the heat loss from the building based on the existing building fabric using Salix's approved building heat loss calculator. The output from both methodologies was compared and the most appropriate peak heat loss was selected for future calculations.

Table 2 summarises the annual and peak electricity and heat loads for each building versus their benchmarks and calculation methodology. For Steam and LTHW these were calculated based on the building's percentage gross internal area, thus affected buildings will have the same heat and electrical demand per m^2. The addition of submeters or fiscal meters for those buildings will allow for better analysis in the future. Buildings with individual fiscal or sub-meters have a good degree of certainty and is covered in sections 4 to 4.7.

Table 2 Annual Heat and Elec demand versus benchmarks

	HEAT				ELECTRICITY			
Building	Annual Demand (kWh/m^2)	Peak Demand (W/m^2)	Method of Determination	Benchmark Annual Demand (kWh/m^2)	Annual Demand (kWh/m^2)	Peak Demand (W/m^2)	Method of Determination	Benchmark Annual Demand (kWh/m^2)
Davies Wood House	181	156	Fiscal meter	80-200	81	46	Fiscal meter	30-230
Mortuary & Patient Affairs	339	151	Submeter	300-500	222	44	Calculated	50-120
Staff Day Nursery	256	85	Calculated	100-200	222	44	Calculated	20-40
Vera Brown House	83	82	Fiscal meter	80-200	108	25	Fiscal meter	30-230
Wolverton Centre	133	37	Fiscal meter	80-200	88	34	Fiscal meter	30-230
ED	152	51	Submeter	300-500	222	44	Calculated	50-120
KSC	306	75	Submeter	300-500	222	44	Calculated	50-120
Main Outpatients	396	81	Calculated	300-500	222	44	Calculated	50-120
Princess Alexandra Dental Wing	310	71	Calculated	300-500	222	44	Calculated	50-120
Esher Wing	310	71	Calculated	300-500	222	44	Calculated	50-120
Bernard Meade Wing	396	81	Calculated	300-500	222	44	Calculated	50-120
Maternity & Day Surgery Unit	396	81	Calculated	300-500	222	44	Calculated	50-120
Estates	310	71	Calculated	80-200	222	44	Calculated	30-230
Sir William Rous unit	310	71	Calculated	300-500	222	35	Calculated	50-120
Rowan Bentall Wing – Hospital	310	71	Calculated	300-500	222	44	Calculated	50-120

3.3 Energy Centre Electrical Half-Hourly Data Analysis

Excluding - Davies Wood House, Mortuary & Patient Affairs, Staff Day Nursery, Vera Brown House and Wolverton centre the remainder of the site relies on electricity generated by the CHP and electricity from the two main incomers. The CHP is located at the energy centre and the other two main incomers are connected to the site HV ring where various buildings draw electricity from various Ring Main Unit (RMU) located across the site.

To identify the baseload a standard method is used to analyse average electrical consumption during the weekend and weekdays. Figure 8 represents the sites average electrical consumption. As this data contains a number of buildings, weekend and weekdays activity will be a mixture of low and high activity across the site and does not truly represent a building that does not operate during the weekends. In reality, each building will have a lower baseload compared to buildings that operate 24 /7. Nonetheless, Figure 8 shows an estimated baseload of 1200 kW.

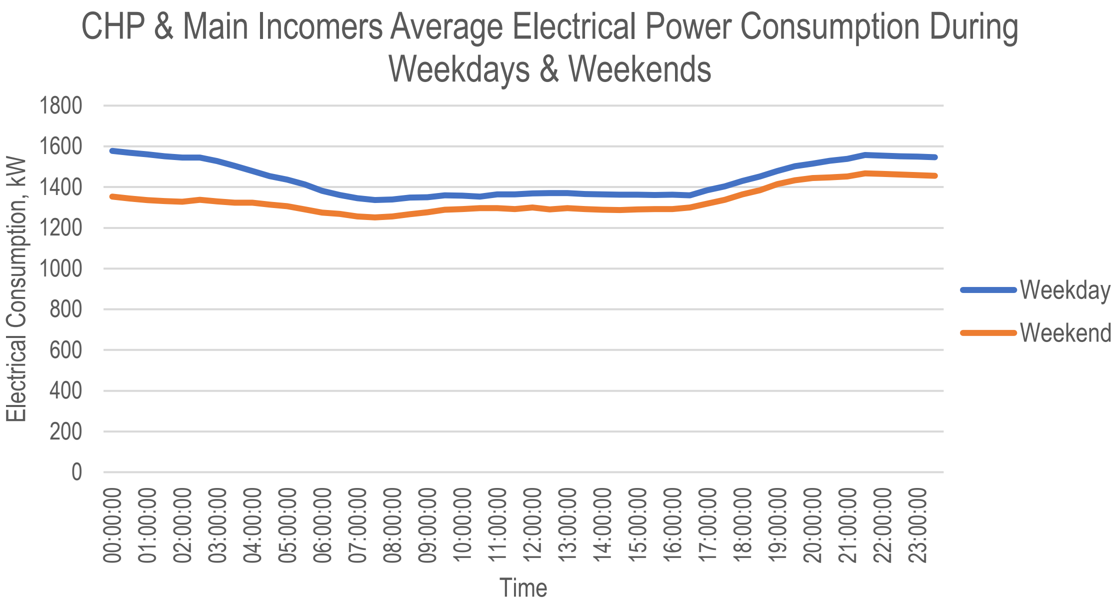


Figure 8 CHP and Main Incomer Weekend and Weekday electric profile

While Figure 8 provides an estimated baseload, analysing how this differs each month can help the Trust identify areas of inefficiencies. Figure 9 takes the average consumption for a given day each month. It is normally expected for months (Nov, Dec, Jan) when days are shorter, the electricity consumption to be relatively higher as lights are on for longer. Figure 9 does not show this trend, November and December appear to have significantly lower consumptions. Additionally, consumption was higher during the evening than during the day.

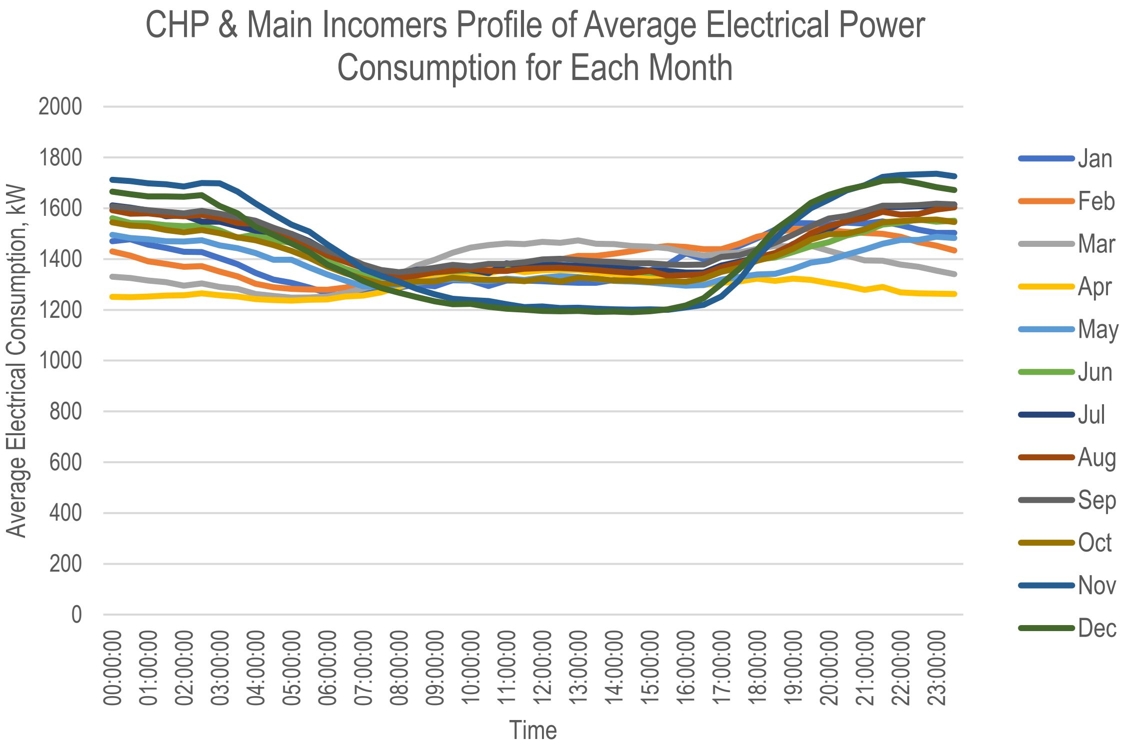


Figure 9 CHP generated and Main incomer electric average power consumption by month

Upon further investigation by year, Figure 10, shows 2021 electrical consumption decreased in the evening and increased during the day.

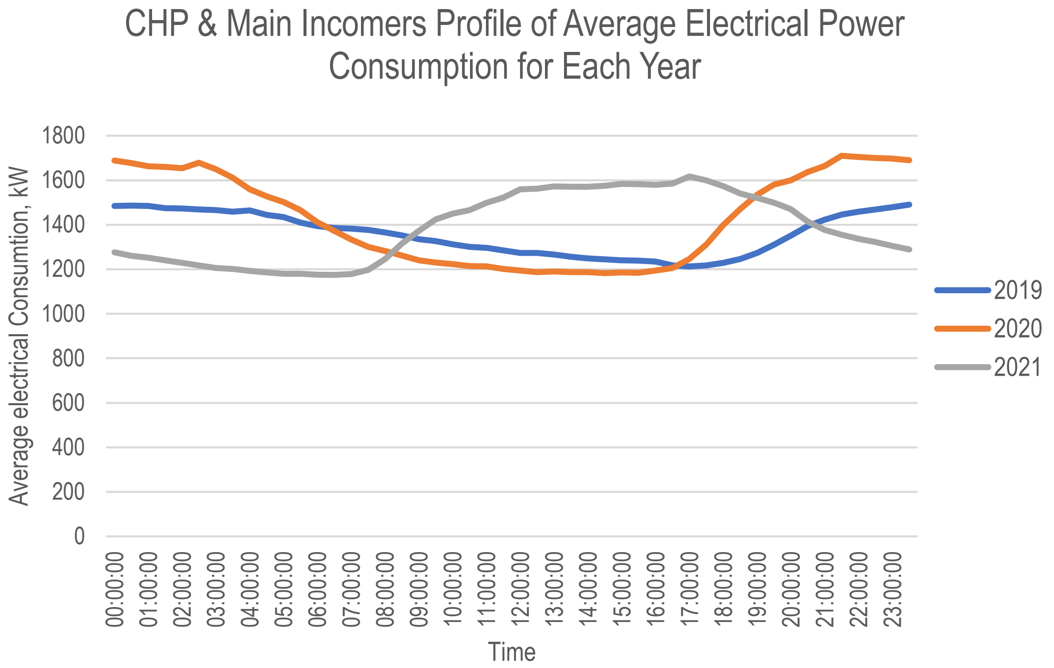


Figure 10 CHP generated and main incomer electric average power consumption by year

Re-evaluating Figure 9 but for 2021 only, the abnormally high consumption during the evening is no longer seen on the graph. Taking this graph as the basis of for our understanding, through the year, the site's average consumption during the day ranges from 1600 kW to 1800 kW. The variation seen in 2019 and 2020 could be a result of the change in normal operation, or it could be due to a meter error or another factor affecting electricity consumption.

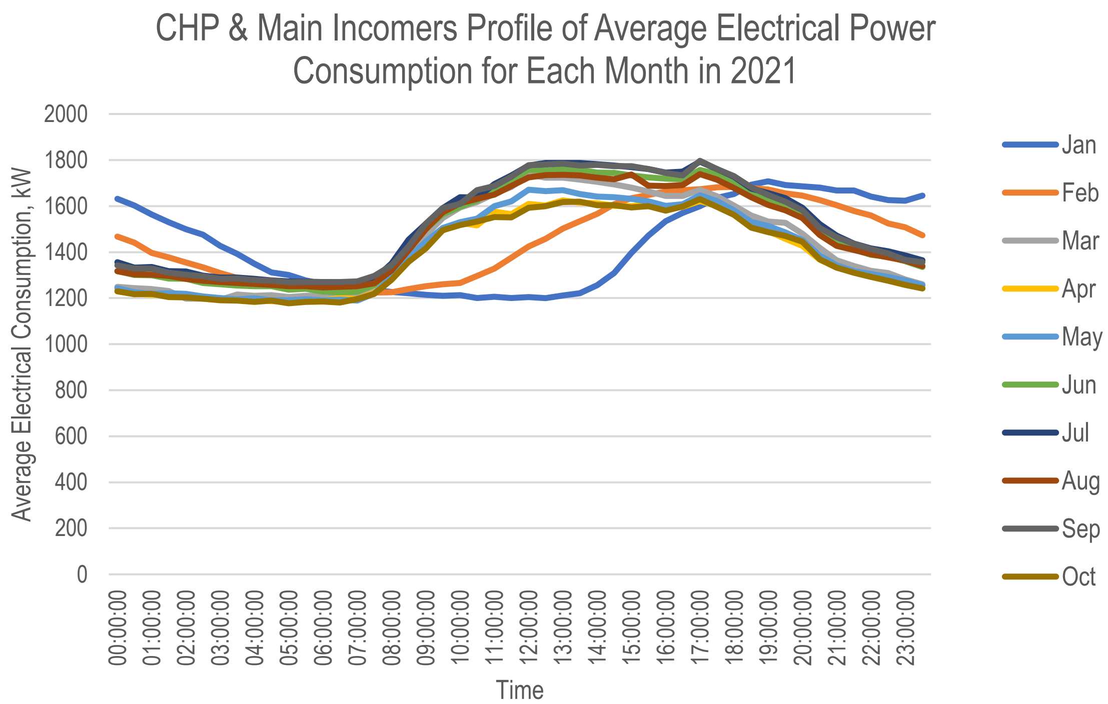


Figure 11 CHP generated and Main incomer electric average power consumption by month for 2021

Continuing to use 2021 as a basis, Figure 12 plots the maximum consumption for the time of day during 2021. Therefore, the peak consumption is determined to be around 2500 kW, 3000 kW peak is seen as an anomaly.

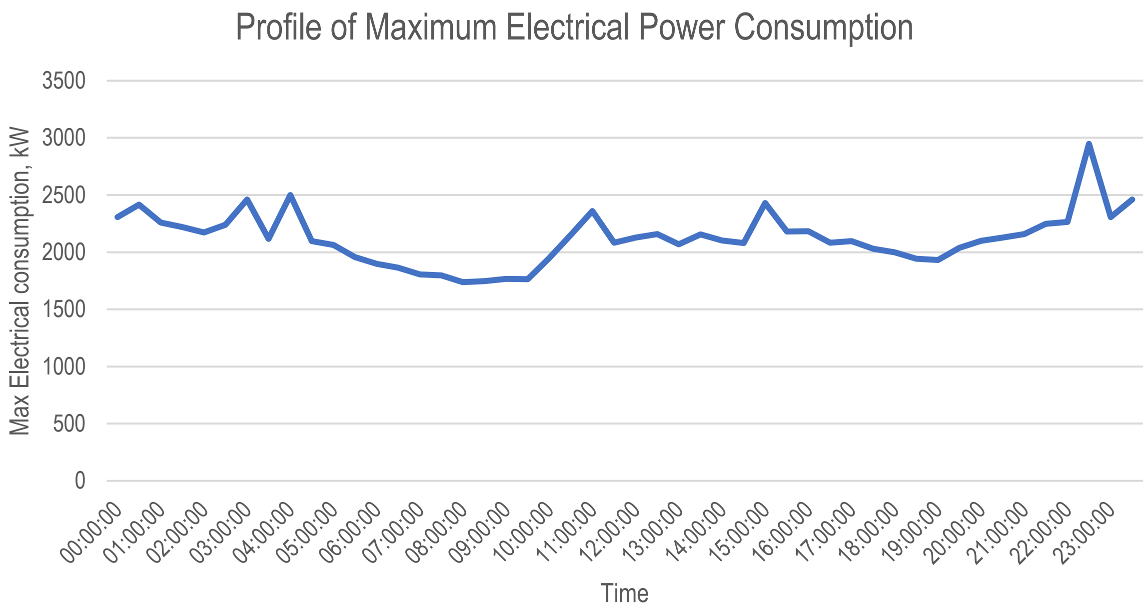


Figure 12 maximum electrical power consumption from main incomers and CHP generated electricity

3.4 Steam and LTHW Gas Half-Hourly Data Analysis

Table 3 outlines the buildings that use steam and LTHW to heat buildings. It should be noted that in addition to providing heating during the winter months, LTHW from the CHP can also be delivered to an absorption chiller to provide cooling during the summer months. The following sections will evaluate Steam and LTHW separately.

Table 3 Heating medium for each building

Site Name - Building	Heating Medium One	Heating Medium Two, if applicable
Davies Wood House	Gas	
Mortuary & Patient Affairs	Gas	
Staff Day Nursery	Gas	
Vera Brown House	Gas	
Wolverton Centre	Gas	
ED	Gas	
KSC	Gas	
Main Outpatients	Steam	LTHW
Princess Alexandra Dental Wing	Steam	
Esher Wing	Steam	
Bernard Meade Wing	Steam	LTHW
Maternity & Day Surgery Unit	Steam	LTHW
Estates	Steam	
Sir William Rous unit	Steam	
Rowan Bentall Wing	Steam	

3.4.1 Steam

Taking 18.5ºC as the base temperature below which healthcare buildings demand heat, Figure 13 compares the sites steam consumption per month to the corresponding HDD. In general, steam consumption levels are in line with the changes in outdoor temperatures.

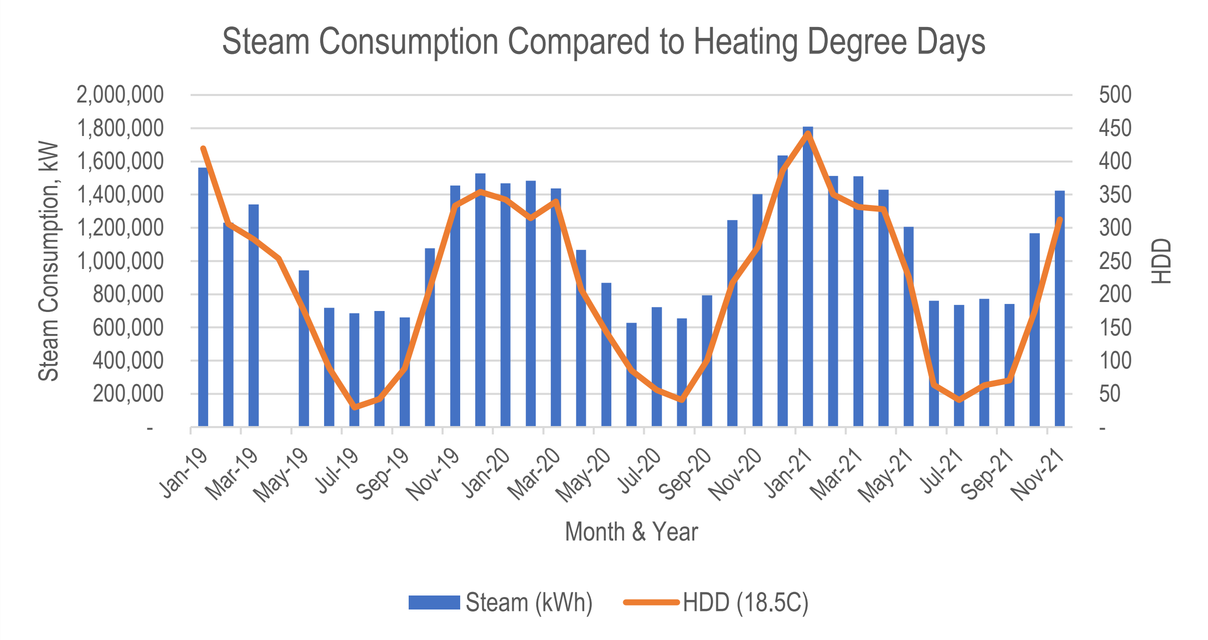


Figure 13 Steam monthly consumption compared to heating degree days (April-19 removed due to error in readings)

Using the assumed 18.5ºC base temperature, a regression analysis, shown in Figure 14, confirms the relationship between steam demand and OAT. The analysis reveals that the baseload on the site steam system is

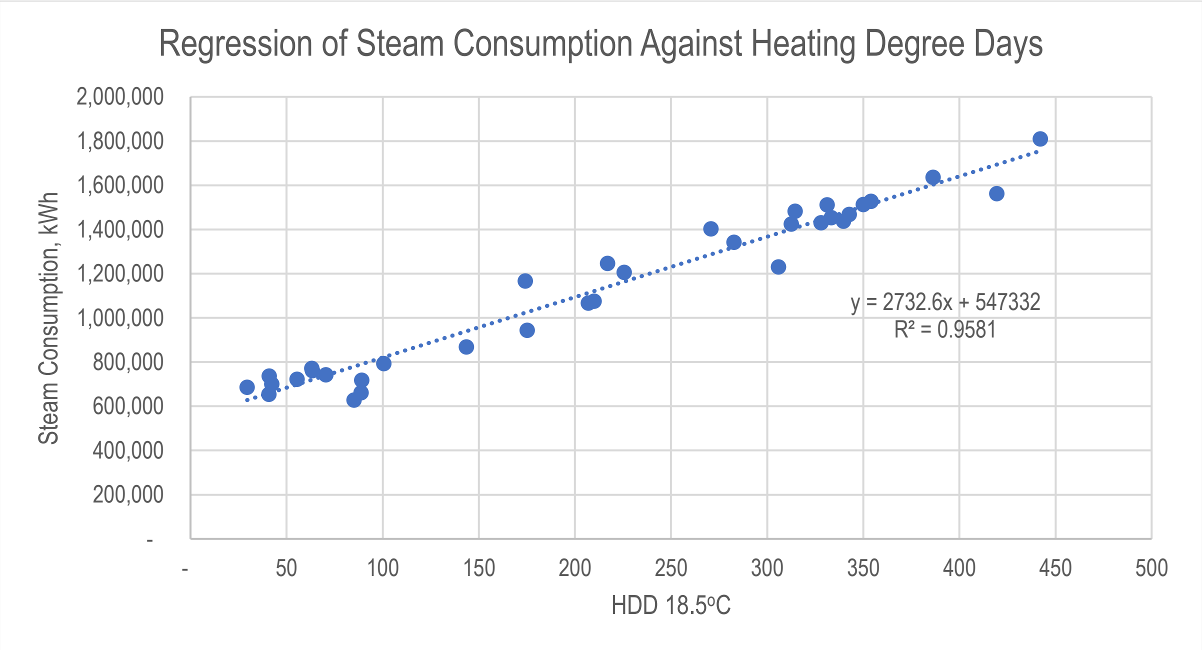


Figure 14 regression of steam usage against heating degree days

Table 4 displays key figures determined from the regression analysis of the site steam system.

Table 4 Steam Baseload and Heating Loads

Steam Baseload	547,332	kWh/month
Baseload	748	kW
Average Heat Load	1,492	kW_{th}
Average Space Heating Load	744	kW_{th}
Max heat load	3000	kW_{th}
Max space heating load	2,252	kW_{th}
Baseload %	50%	

3.4.2 LTHW

LTHW raised from the CHP engine is used to heat a number of site buildings directly and, during the summer months, can supplement cooling demand through the absorption chiller.

In order to evaluate the current heating of Trust buildings, LTHW delivered to the absorption chiller must be accounted for. In conjunction with running hours data for the absorption chillers, Table 5 assumed performance values were used:

Table 5 Absorption chiller estimated performance

COP, %	69%	
Absorption Chiller Efficiency, %	55%	
kW rating	340	kW

Due to the use of estimated values, it is difficult to determine exactly how much LTHW was used for heating. However, the calculation can give an indication of the split between heating and cooling throughout the year, Figure 15. During the warmer months it can be seen that the majority of LTHW heat is used to cool buildings.

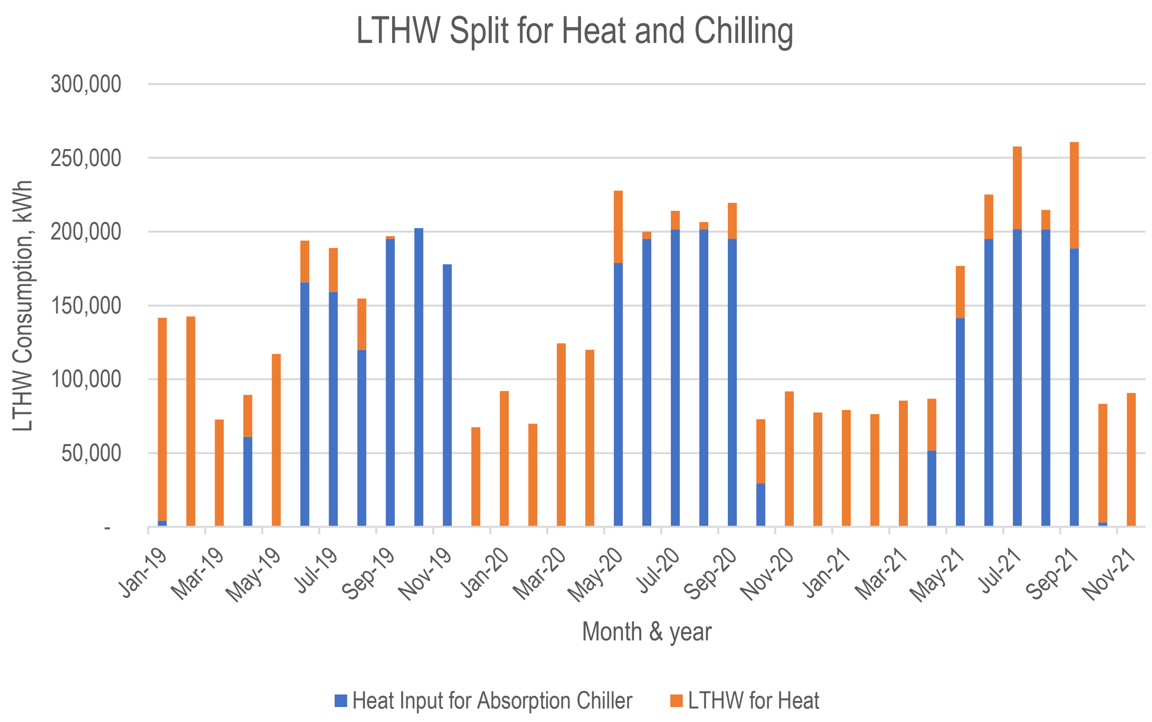


Figure 15 LTHW Consumption split by heating and cooling load

Site heating demand met by LTHW from the CHP has been determined by deducting the estimated heat consumed by the absorption chiller, thus Table 6 shows calculated heat and baseloads.

Table 6 LTHW Baseload and Heating Loads

LTHW Baseload	1899	kWh/month
Baseload	3	kW
Average Heat Load	186	kW_{th}
Average Space Heating Load	184	kW_{th}
Max heat load	195	kW_{th}
Max space heating load	192	kW_{th}
Baseload %	1%	

4. Buildings

Within the Kingston site, there are 15 buildings. A basic introduction to each building is listed here as well as analysis of the electrical and gas consumption where fiscal and submeters are available.

4.1 Davies Wood House

4.1.1 Built Environment

Davies Wood House is a two-storey, solid brick wall, slate pitched roof with recently renovated double glazed windows throughout the building. It spans approximately 449m². Built-in 1897, it accommodates the Trust headquarters with a reception, various offices, a kitchen for staff. It operates 12hrs a day during the week and is closed during the weekend. Figure 2 shows Davis wood house located in the northwest of the site, building number 14.

Table 7 Davies Wood House Summary

Building Name	Use	Weekday Hours	Weekend Hours	Age	UPRN
Davies Wood House	Office	12	0	1897	128047046
Postcode	**GIA (m²)**	**MPAN**	**MPRN**	**DEC Rating**	**Additional Information**
KT2 7QB	449	1900070268910	72519600	N/A	Admin

Table 8 Davies Wood House building fabrics

Building Name	Roof		Wall		Floor		Windows		Doors
	Type	Insulation	Type	Thickness (cm)	Type	Area (m2)	Glazing Type	Material	
Davies Wood House	Pitched	Rafters	Solid	33	Suspended	435	Double	PVC	Single glazed wood frame

4.1.2 Electrical infrastructure

Buildin g	Electrical Supply / Infrastructure	Meter Type	Electrical Supply Point (If Sub-Meter)	Capacity to Building (kVA - Bill)	Capacity of LV Supply to Building (A)	Capacity of Infrastructure Within Building (A)
Davies Wood House	Three Phase (400/415 V)	Fiscal	-	-	200A	-

4.1.3 Electrical Half-Hourly Data Analysis

Figure 16 shows the average profile between 2019-2021 for Davies Wood House. The building is closed during the weekends and operates 12 hours a day during the week. Therefore, the power consumption remains constant at around 2 kW at weekends, the electrical baseload for this building. In contrast, during the weekdays the consumption increases to 9 kW.

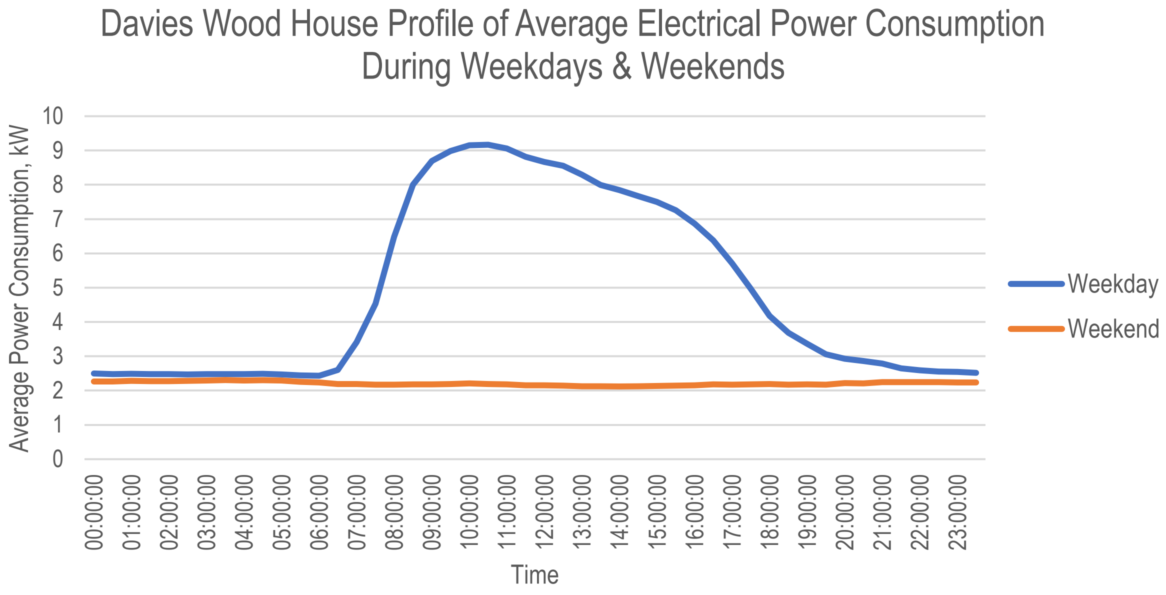


Figure 16 Davies Wood House weekend and weekday electric profile

While the average electrical consumption during weekend and weekdays can identify the baseload of the building it does not show how this ranges throughout the year. Figure 17 shows the building's average electrical consumption in months. When days are shorter (November, December, January), there is a higher demand, up to 11kW. This is likely because of lights being on for longer hours compared to the summer where it peaks at 4kW.

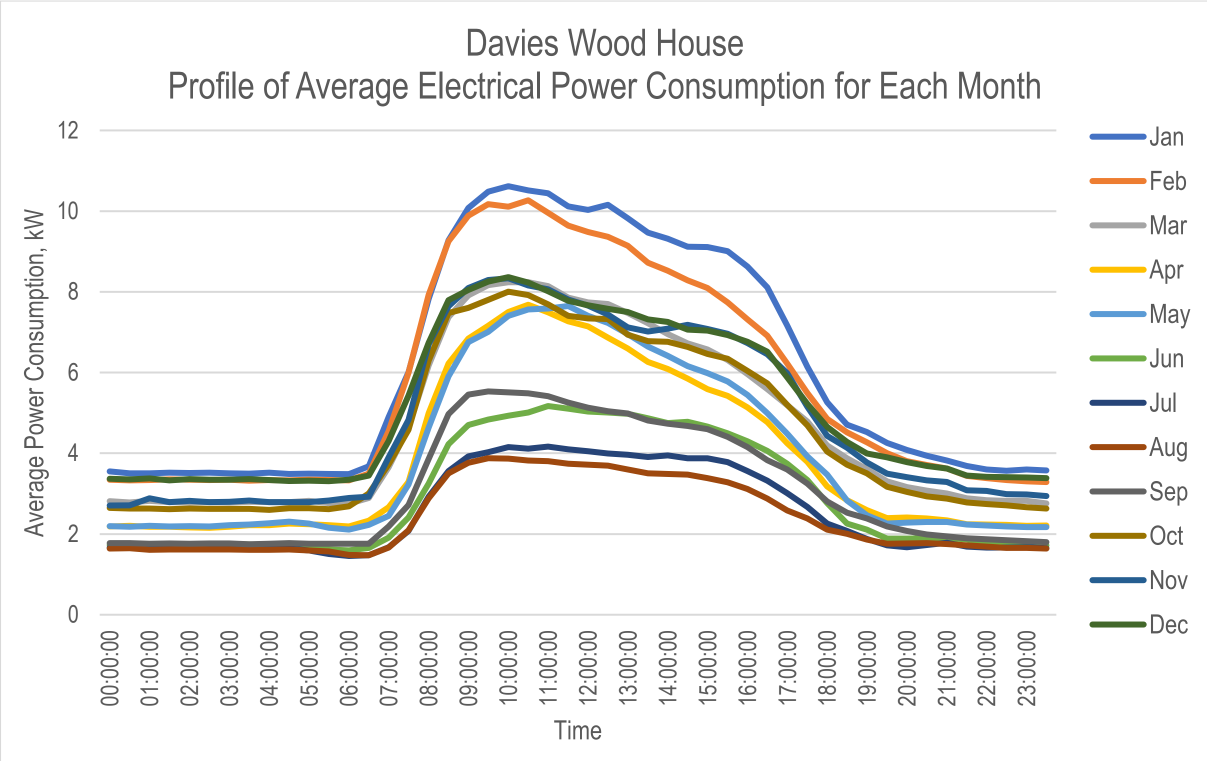


Figure 17 Davies Wood House average power consumption by month

Figure 16 and Figure 17 show the average profile of the electrical power consumption for Davies Wood House, thus providing a good understanding of the building's baseload. On the other hand, Figure

18,Figure 18 shows Davies Wood House maximum power consumption throughout the day between Jan 2019- Oct 2021, here the building's peak load can be identified at 20-27 kW.

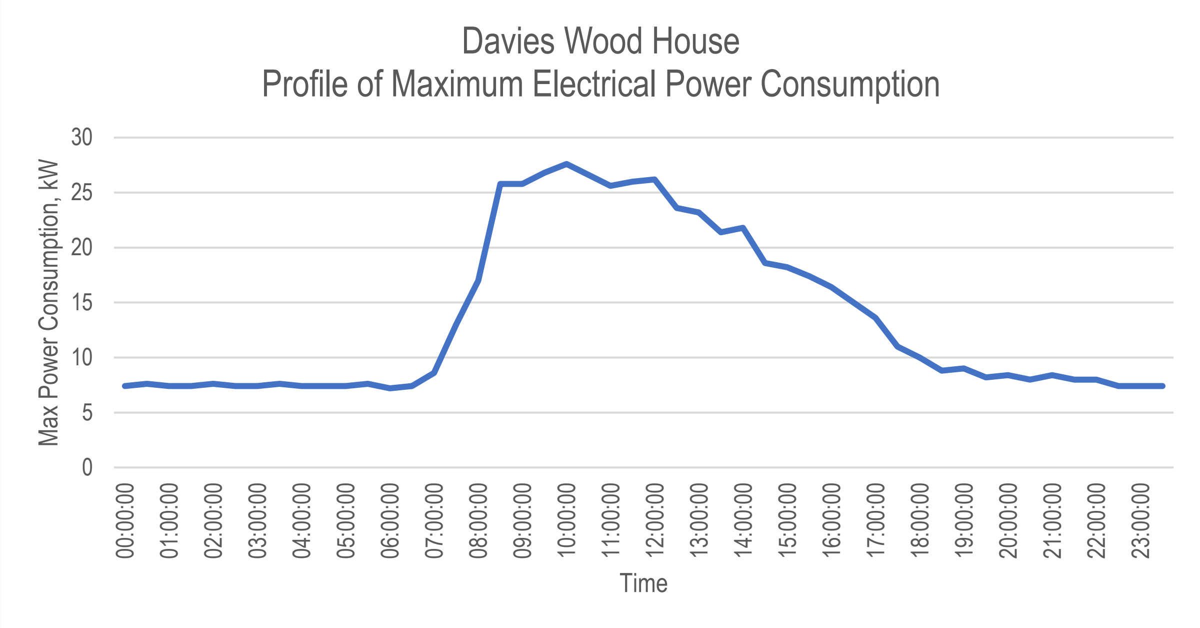


Figure 18 Davies Wood House Profile of Maximum Electrical Power Consumption

4.1.4 Heating System

The fuel used to supply heat to Davies Wood House is natural gas. The new boiler is located external to the building and heats the building through new copper pipes to old and new radiators with thermostatic radiator valve (TRV) control. The new boiler combined with new double-glazed windows will reduce the input peak in the future. In the past, most staff had their own small electric heater, which means electrical consumption is also expected to have reduced.

Table 9 List of Heating Assets for Davies Wood House

Asset Type	Existing heating medium	Type	Number of Assets	Make & Model Number	Input rating kW	Year of Manufacture	Gross eff (%)
1	Gas	Boiler	1	Remeha Quinta Ace 115	104	2021	88%

4.1.5 Gas Regression Analysis on Monthly Data

Figure 19 plots the gas usage each month and the corresponding heating degree day (HDD) of that month. As a public institution, the accepted base temperature of buildings is typically 18.5°C, however, for Davies Wood House, a regression analysis revealed that this was closer to 19.5ºC. In Figure 19, the gas usage follows a similar path to the HDD.

There is also a noticeable reduction in gas consumption in late 2020 to 2021, this is likely a result of the Covid-19 pandemic where the majority of staff would have worked from home. Additionally, there looks to be an element of manual control, gas usage is zero during the summer months. Whilst this graph does not show this, recent upgrades to the building insulation in 2021 will show a reduction gas usage.

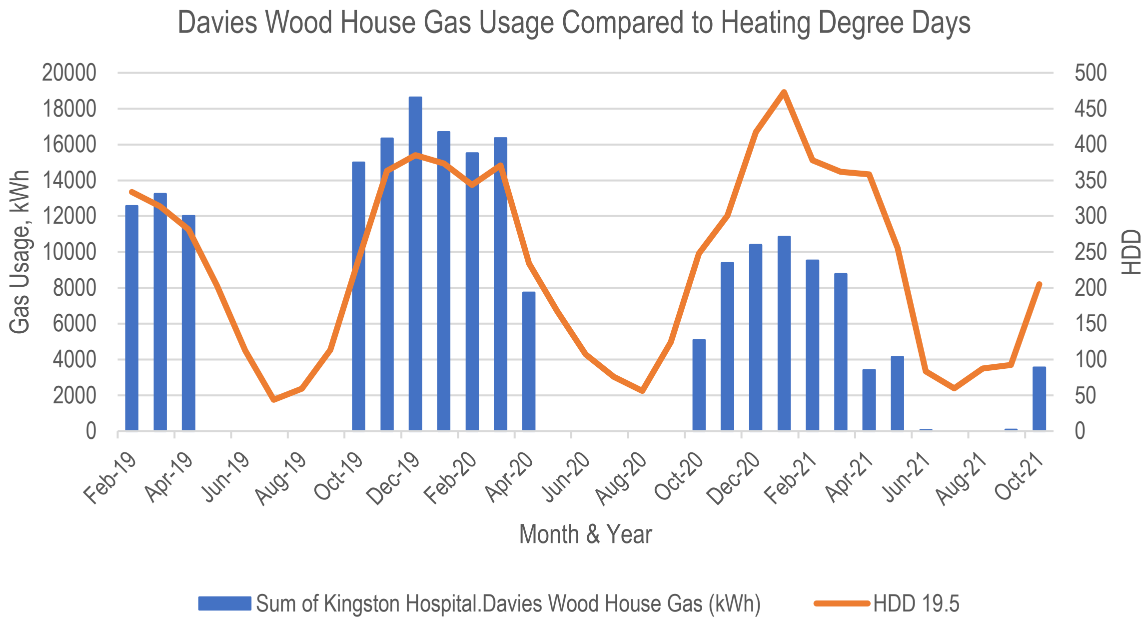


Figure 19 Davies Wood House monthly gas usage compared to heating degree days

Figure 20 shows that there is a positive correlation between gas usage and heating degree days. Therefore, a regression was carried out to not only prove the correlation further but to also identify the site's baseload. A good correlation typically has an R-value of 0.9 or greater. After analysing varying HDD temperatures, 19.5ºC albeit weak provided the best correlation of 0.7032. There can be a number of reasons why this correlation is weak, it could be due to additional forms of heating in the building such as electric heaters, poor control of heat systems, and events such as Covid-19 that affect staff numbers in the office. In addition, Figure 19 shows 0 kWh consumption during the warmer months, suggesting that heating is completely turned off and DHWS is provided by direct electric means during this time.

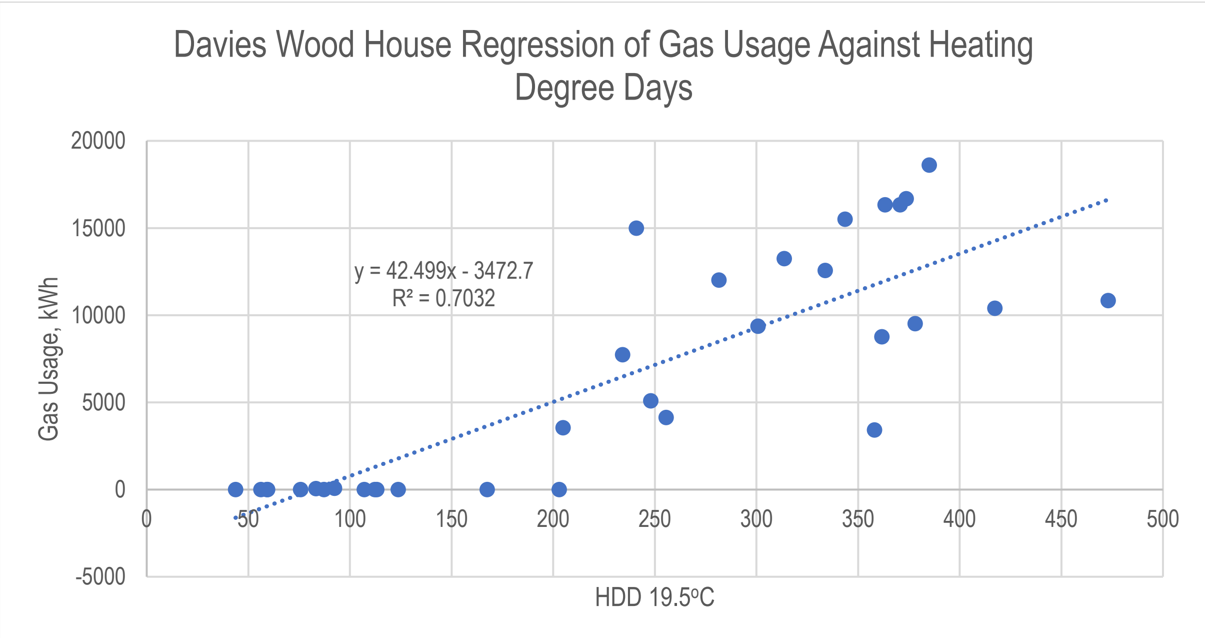


Figure 20 Davies Wood House regression of gas usage against heating degree days

The equation of the trendline was used, the intercept is the baseload, 3,473 kWh per month. There is a high degree of error in this model as the R-value is less than 0.9. Figure 19, shows that the baseload is 0.

Table 10 shows how baseload was used to determine heat baseload, the average heat and space heating load, and the maximum heat and the space heating load. The average boiler efficiency is based on the heating assets within the building.

Table 10 Gas Baseload and Heating Loads of Davies Wood House

Baseload	0.0	kWh/month
Baseload Heat	0.0	kW
Average Boiler Efficiency	88%	
Heat Baseload	0.0	kW_{th}
Average Heat Load	9	kW_{th}
Average Space Heating	9	kW_{th}
Input Peak	70	kW
Max Heating Load	61.6	kW_{th}
Max Space Heating Load	61.6	kW_{th}
Baseload %	0%	

4.2 Mortuary and Patient Affairs

4.2.1 Built environment

The Mortuary & Patient Affairs building is a single-story, brick cavity wall with a pitched roof and double-glazed windows throughout building from 1986. It spans approximately 529m². The building typically operates from 08:00 to 16:00 Monday to Friday, although autopsy sessions are often held outside of these core hours. Figure 2 shows Mortuary & Patient Affairs located in the west side of the site, building number 17.

Table 11 Mortuary & Patient Affairs Summary

Building Name	Use	Weekday Hours	Weekend Hours	Age	UPRN
Mortuary & Patient Affairs	Hospital	24	24	1986	128047047
Postcode	**GIA (m2)**	**MPAN**	**MPRN**	**DEC Rating**	**Additional Information**
KT2 7QB	529	1900070699844 / 1900070699853	72519510	G	Mortuary

Table 12 Mortuary and patient affairs building fabrics

Building Name	Roof		Wall		Floor		Windows		Doors
	Type	Insulation	Type	Thickness (cm)	Type	Area (m2)	Glazing Type	Material	
Mortuary & patient affairs	Pitched	Rafters – 50 mm	Cavity partial fill	30	Solid	529	Double	Metal	Single glazed wood frame

4.2.2 Electrical infrastructure

Electricity is supplied from the site's HV ring where its electricity is supplied from the grid and the energy centre. Mortuary and Patient Affairs supply comes from substation D located at Esher Wing rated at 1250A. See Appendix I for information relating to site electrical infrastructure.

Table 13 Electrical infrastructure for Mortuary and Patient Affairs

Building	Electrical Supply / Infrastructure	Meter Type	Electrical Supply Point (If Sub-Meter)	Capacity to Building (kVA - Bill)	Capacity of LV Supply to Building (A)	Capacity of Infrastructure Within Building (A)
Mortuary and Patient Affairs	Three Phases (11kV on site substation)	Sub Meter	Esher Wing	RMU D - 1250A	-	250A

4.2.3 Electrical Half-Hourly Data Analysis

As Mortuary and patient affairs electricity is supplied from via the site's HV network, HH analysis is covered in section 3.3

4.2.4 Heating System

Heating in Mortuary and Patient Affairs is provided via local natural gas-fired boilers. The building has no real control despite being connected to the BMS system, thus having an impact on comfort levels. LTHW supplies to both radiators and AHU.

Table 14 List of Heating Assets for Mortuary and Patient Affairs

Asset Type	Existing heating medium	Type	Number of Assets	Make & Model Number	Input rating kW	Year of Manufacture	Gross eff (%)
1	Gas	Boiler	2	Hamworthy UR 300	88.8	1994	77%
2	Gas	DHW storage heater	2	Andrews 65/173PP	50	2008	79%

4.2.5 Gas Regression Analysis on Monthly Data

Heating degree days (HDD) analysis was used to determine how the building responds to outdoor temperatures and assist in identifying the base heat load. Figure 21 shows Mortuary and patients affairs monthly gas usage and the corresponding HDD for that month, taking the base temperature of 18.5°C. The graphs below show a good fit between HDD and the building's gas usage during the colder months, but remains high during the summer months.

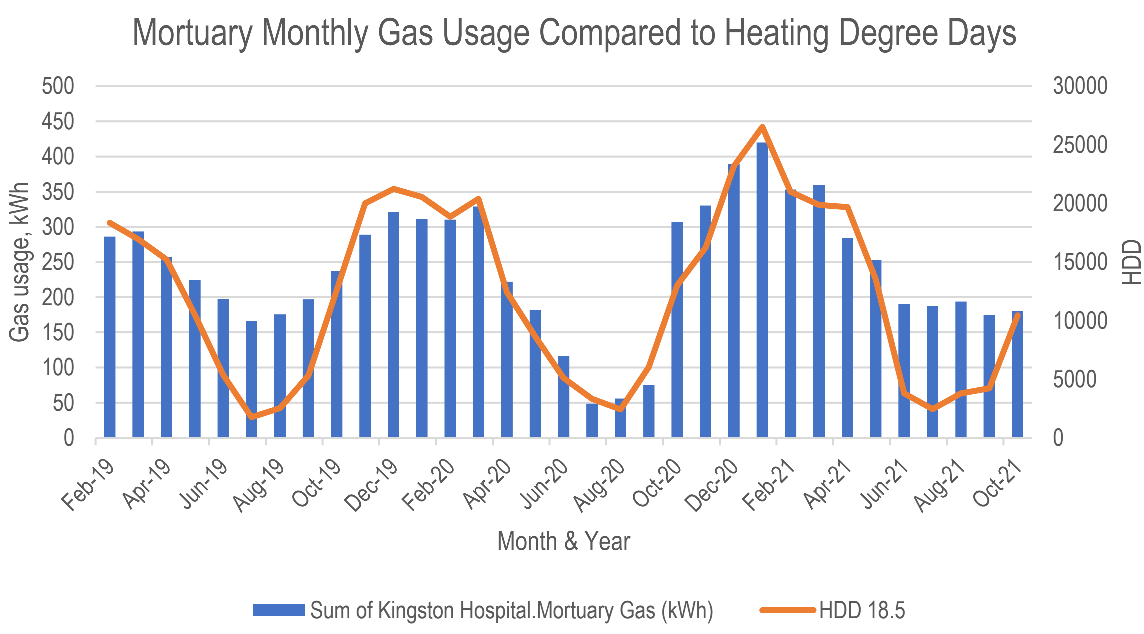


Figure 21 Mortuary and Patient affairs monthly gas usage compared to heating degree days

To confirm the relationship and baseload a regression analysis was completed for the HDD and gas usage. Not apparent in Figure 21 but clear in Figure 22, the R-value is less than 0.9, which does not suggest a good model to predict the buildings baseload. This does suggest other factors affecting usage, such as poor control as observed during the survey.

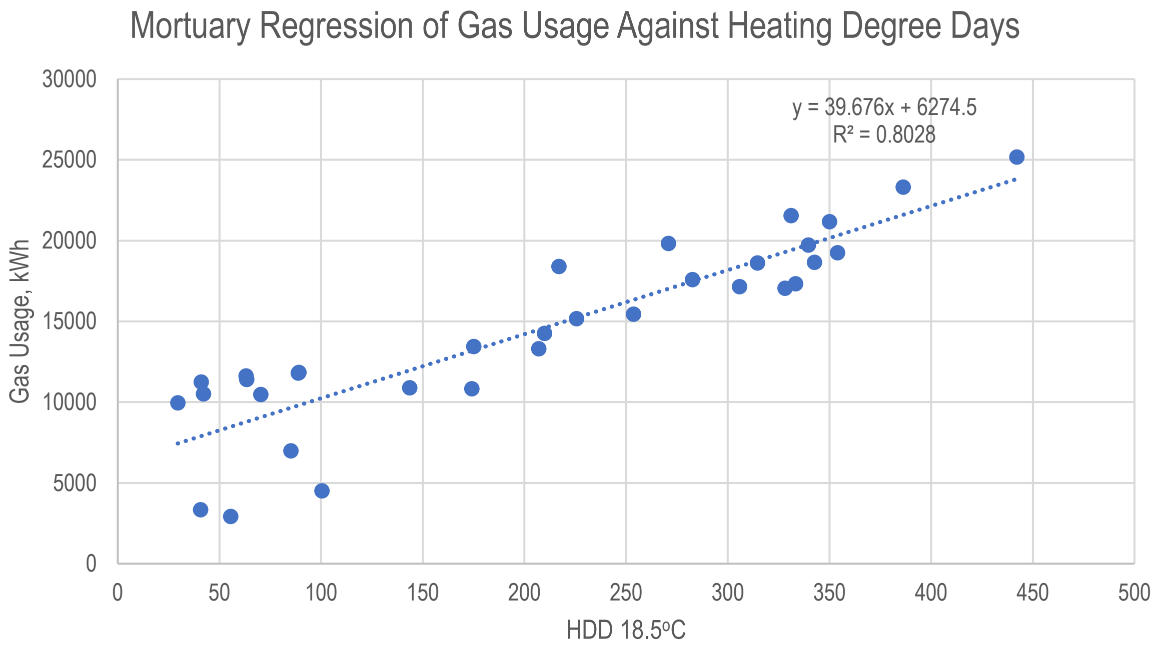


Figure 22 Mortuary and Patient affairs regression of gas usage against heating degree days

The trendline of Figure 22 provides allows an estimated gas baseload to be determined. Some degree of error is expected in the calculated values as the R-value is less than 0.9. Table 15 takes this into consideration when calculating heat loads of the building.

Table 15 Gas Baseload and Heating Loads of Mortuary and Patient affairs

Baseload	6274.5	kWh/month
Baseload Heat	7	kW
Average Boiler Efficiency	78%	
Heat Baseload	5	kW_{th}
Average Heat Load	29	kW_{th}
Average Space Heating	24	kW_{th}
Input Peak	62	kW
Max Heating Load	57	kW_{th}
Max Space Heating Load	5	kW_{th}
Baseload %	19%	

4.3 Staff Day Nursery

4.3.1 Built environment

The Staff Day Nursery (SDN) building is a two-storey solid brick wall with a pitched tile roof building that spans approximately 529m^2. Built-in 1920, the building accommodates the nursery for the hospital employees' kids. Figure 2 shows SDN located in the west side of the site, building number 21.

Table 16 Staff Day Nursery summary

Building Name	Use	Weekday Hours	Weekend Hours	Age	UPRN
Staff Day Nursery	Pre-school Facility	12	0	1920	128007434
Postcode	**GIA (m²)**	**MPAN**	**MPRN**	**DEC Rating**	**Additional Information**
KT2 7QB	527	1900028023652	72530902	G	Nursery

Table 17 Staff Day Nursery building fabrics

Building Name	Roof		Wall		Floor		Windows		Doors
	Type	Insulation	Type	Thickness (cm)	Type	Area (m2)	Glazing Type	Material	
SDN	Pitched	Rafters – 50 mm	Solid	30	Solid	300	Single	hardwood	Wooden

4.3.2 Electrical infrastructure

Staff day nursery is not connected to the site HV ring and takes electricity from the grid.

Table 18 Electrical infrastructure for Staff Day Nursery

Building	Electrical Supply / Infrastructure	Meter Type	Electrical Supply Point (If Sub-Meter)	Capacity to Building (kVA - Bill)	Capacity of LV Supply to Building (A)	Capacity of Infrastructure Within Building (A)
Staff Day Nursery	Three Phase (400/415 V)	Fiscal	-	-	200A	63A

4.3.3 Electrical Half-Hourly Data Analysis

No electrical consumption data was available for analysis.

4.3.4 Heating System

Natural gas is combusted in local boilers to supply heat to Staff Day Nursery. During the survey, it was noted that despite the new installation, there are heating flow issues causing uneven distribution of heat. Hot water also does not flow to some rooms.

Table 19 List of heating assets for Staff Day Nursery

Asset Type	Existing heating medium	Type	Number of Assets	Make & Model Number	Input rating kW	Year of Manufacture	Gross eff (%)
1	Gas	Boiler	2	Green Star FS 42 CDI	42	2019	89%
2	Gas	DHW storage heater	2	AO Smith EQH 200 G	18.3	2018	83%

4.3.5 Gas Regression Analysis on Monthly Data

Figure 23 shows SDN's gas usage and the corresponding heating degree day (HDD) of that month. The relationship of gas usage appears to align with the HDD. After the boiler upgrade in 2021, the corresponding gas usage does drop below the HDD trend which is different to previous years, it could reflect the issue with comfort levels as identified during the survey.

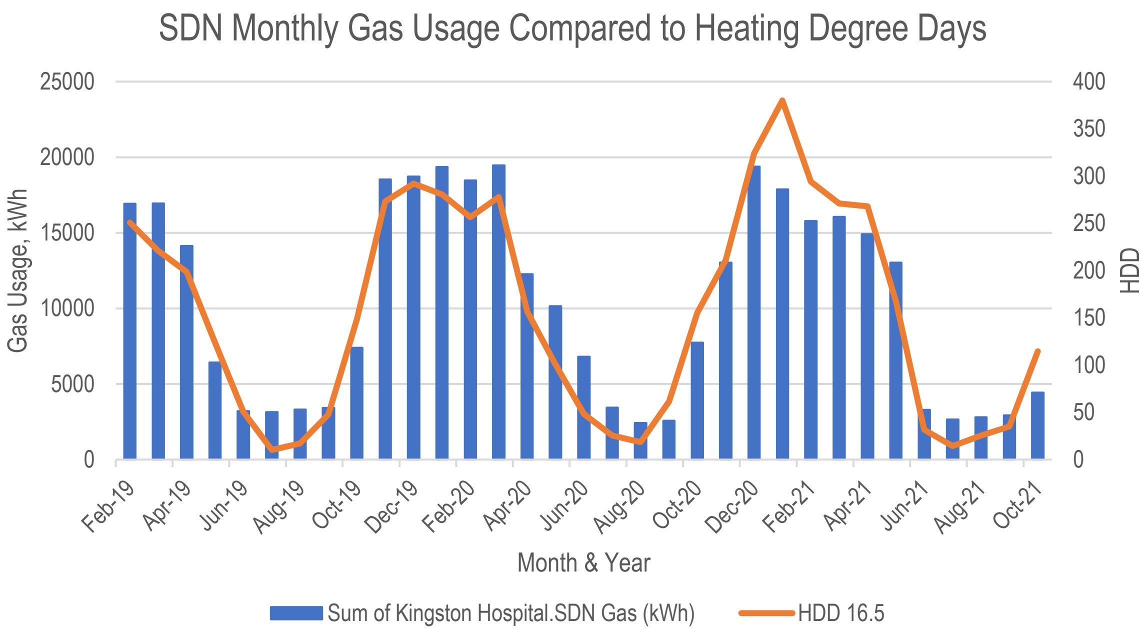


Figure 23 SDN monthly gas usage compared to heating degree days

16.5ºC was found to provide the best fitting model for the staff day nursery building. The correlation is strong at 0.9, and therefore the baseload is estimated to be 1,683 kWh.

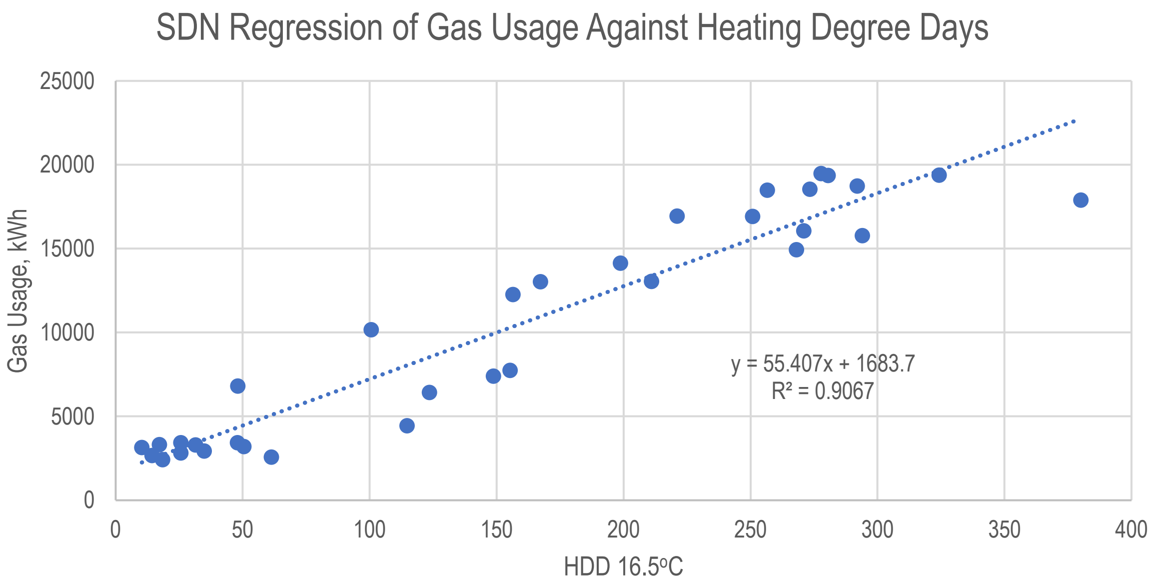


Figure 24 SDN regression of gas usage against heating degree days

Using the estimated baseload provided by the regression analysis, the below heat loads are calculated.

Table 20 Gas baseload and heating loads of SDN

Baseload	1683.7	kWh/month
Baseload Heat	2 to 5	kW

Average Boiler Efficiency	87%	
Heat Baseload	2	kW_{th}
Average Heat Load	17	kW_{th}
Average Space Heating	15	kW_{th}
Input Peak	45	kW
Max Heating Load	39	kW_{th}
Max Space Heating Load	37	kW_{th}
Baseload %	11%	

4.4 Vera Brown House

4.4.1 Built environment

Vera Brown House is a four-storey solid brick wall, flat roof, double glazed throughout building built-in 1928 which spans approximately 3,432m². It predominantly accommodates the Hospital staff and is not opened to the public. Main activities are administrative: IT, Finance and H&R department. Figure 2 shows Vera brown house located in the northwest side of the site, building number 9.

Table 21 Vera Brown House Summary

Building Name	Use	Weekday Hours	Weekend Hours	Age	UPRN
Vera Brown House	Office	12	0	1928	128007438
Postcode	**GIA (m²)**	**MPAN**	**MPRN**	**DEC Rating**	**Additional Information**
KT2 7QB	3,432	1900091189539	9340187701	A	Admin

Table 22 Vera Brown House Building Fabric

Building Name	Roof		Wall		Floor		Windows		Doors
	Type	Insulation	Type	Thickness (cm)	Type	Area (m2)	Glazing Type	Material	
Vera Brown House	Flat roof	-	Solid	48	Solid	1074	Double	PVC	Wooden

4.4.2 Electrical infrastructure

Vera Brown house is not connected to HV ring and takes electricity from a separate substation. There is also a separate generator not listed here that supplies for essential supplies within this building.

Table 23 Electrical infrastructure for Vera Brown House

Building	Electrical Supply / Infrastructure	Meter Type	Electrical Supply Point (If Sub-Meter)	Capacity to Building (kVA - Bill)	Capacity of LV Supply to Building (A)	Capacity of Infrastructure Within Building (A)
Vera Brown House	Three Phase (400/415 V)	Fiscal	-	-	800A	400A

4.4.3 Electrical Half-Hourly Data Analysis

Figure 25 shows a similar profile to Davies Wood House but as it is a larger building it has a higher electrical demand. The power consumption remains constant at around 32 kW during the weekends when the building is closed, this is estimated to be the electrical baseload. During the weekdays when this building is occupied it reaches 61 kW at the start of the workday and stays at this power until it drops off at the end of the workday.

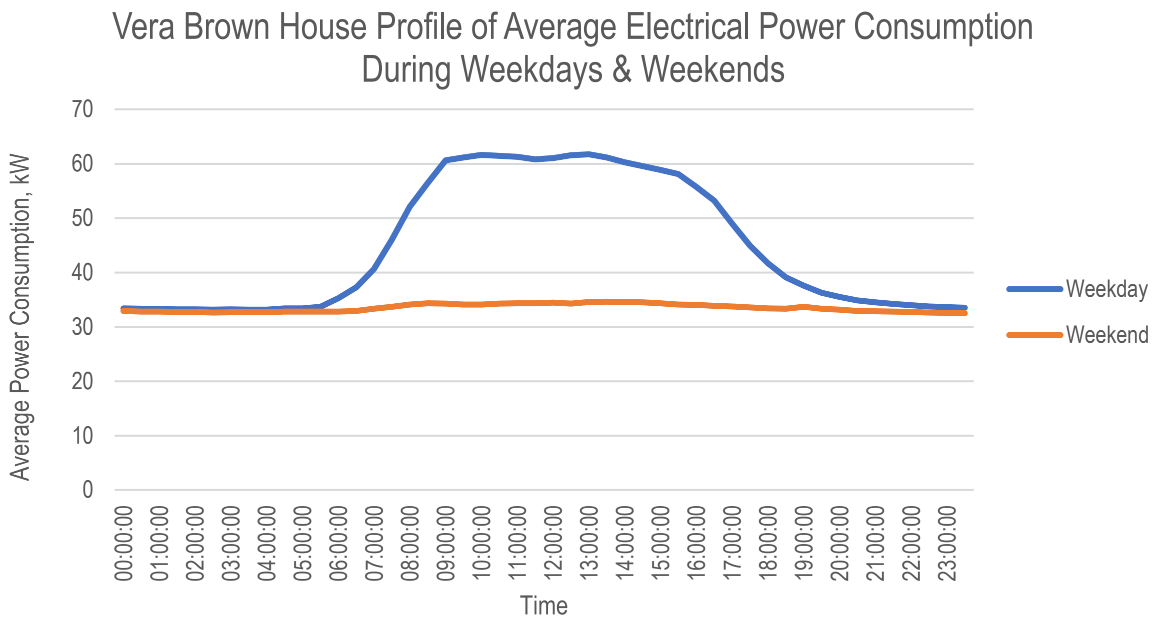


Figure 25 Vera Brown House Weekday and Weekend Electric profile

Figure 26 Shows Vera Brown's house power consumption by month, here we can identify changes between different times of the year. As expected during longer days the maximum power consumption is 50 kW, whereas during shorter days this is higher with an average peak of 60 kW. The higher consumption is likely due to light being on for longer hours in the day.

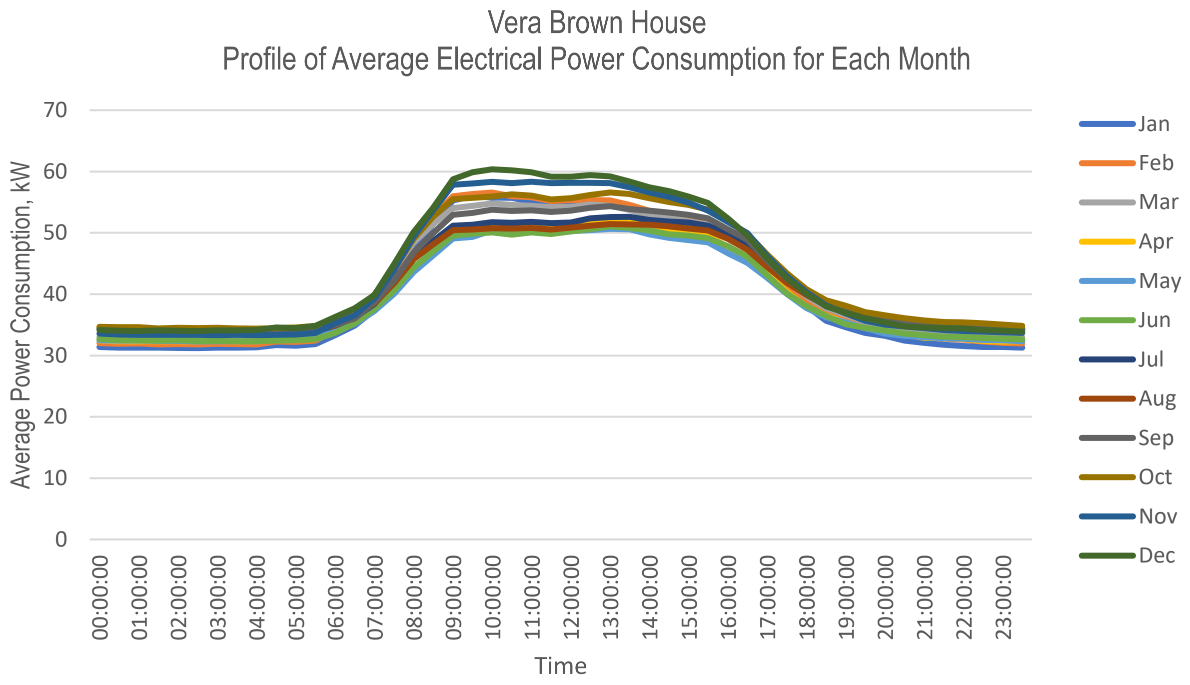


Figure 26 Vera Brown House average power consumption by month

Figure 27 shows the maximum power consumption for Vera Brown House throughout the day. The maximum power consumption occurs just after 9 am when most staff would have arrived to start the workday where 111 kW is the peak load of this building.

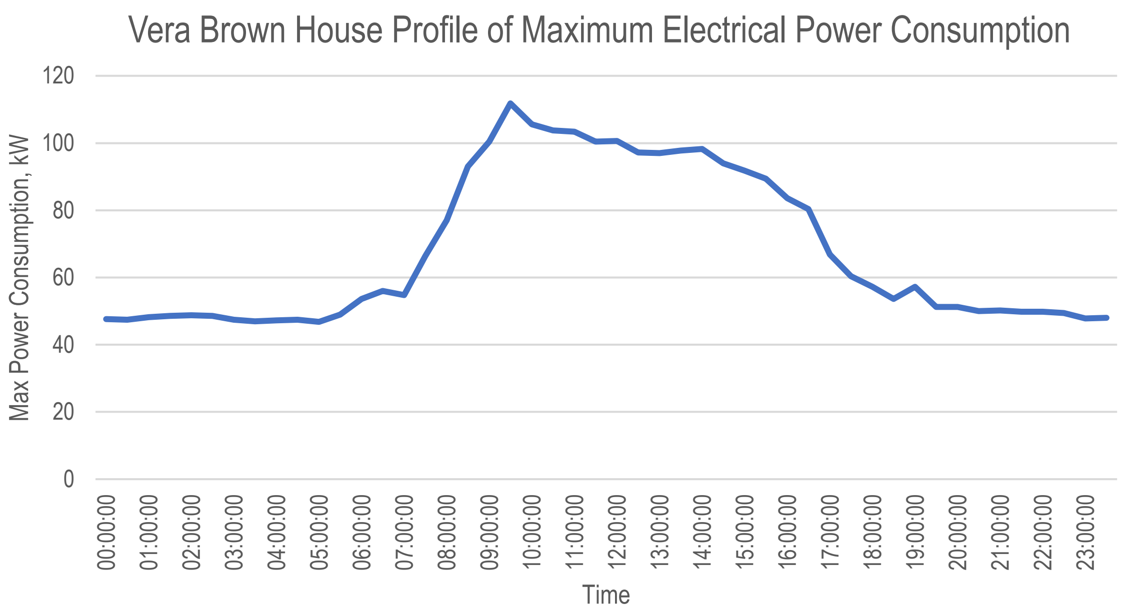


Figure 27 Vera Brown House Profile of Maximum Electrical Power Consumption

4.4.4 Heating System

The fuel used to supply heat to Vera Brown is natural gas. Although the heating system is connected to the site BMS, heating is controlled locally. Upgraded in 2020, the 3 boilers supply heat to two secondary circuits. The first circuit is the legacy circuit that feeds 1st and 2nd floor radiators. The other, part of the latest upgrades, feeds the 2nd & 3rd floor radiant panels.

Table 24 List of Heating Assets for Vera Brown House

Asset Type	Existing heating medium	Type	Number of Assets	Make & Model Number	Input rating kW	Year of Manufacture	Gross eff (%)
1	Gas	Boiler	3	Hamworthy MK2 S2-100	100	2019	89%

4.4.5 Gas Regression Analysis on Monthly Data

Figure 28 shows gas usage and the corresponding HDD for Vera Brown house, at first glance it shows a similar pattern each summer where heating is turned off each summer before it is turned on again in October. In summer 2021, an increase occupation is reflected in the gas usage.

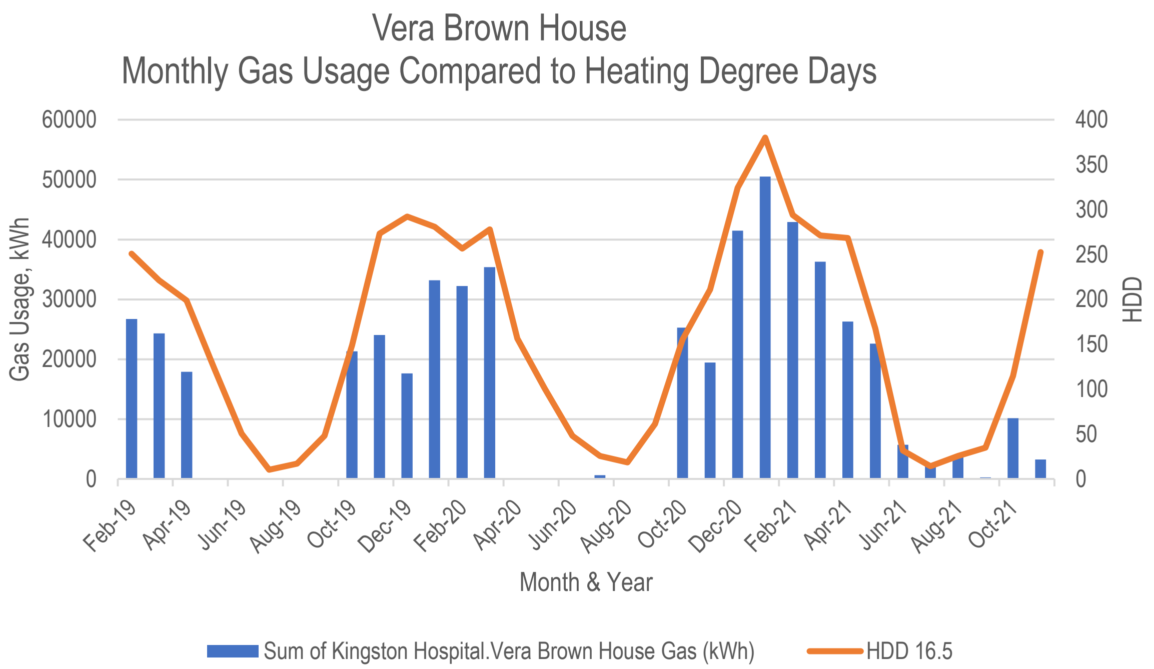


Figure 28 Vera Brown House monthly gas usage compared to heating degree days

Regression analysis revealed a HDD base temperature of 16.5ºC. The R-value less than 0.9, so a guidance baseload of 4,047 kWh is taken into consideration.

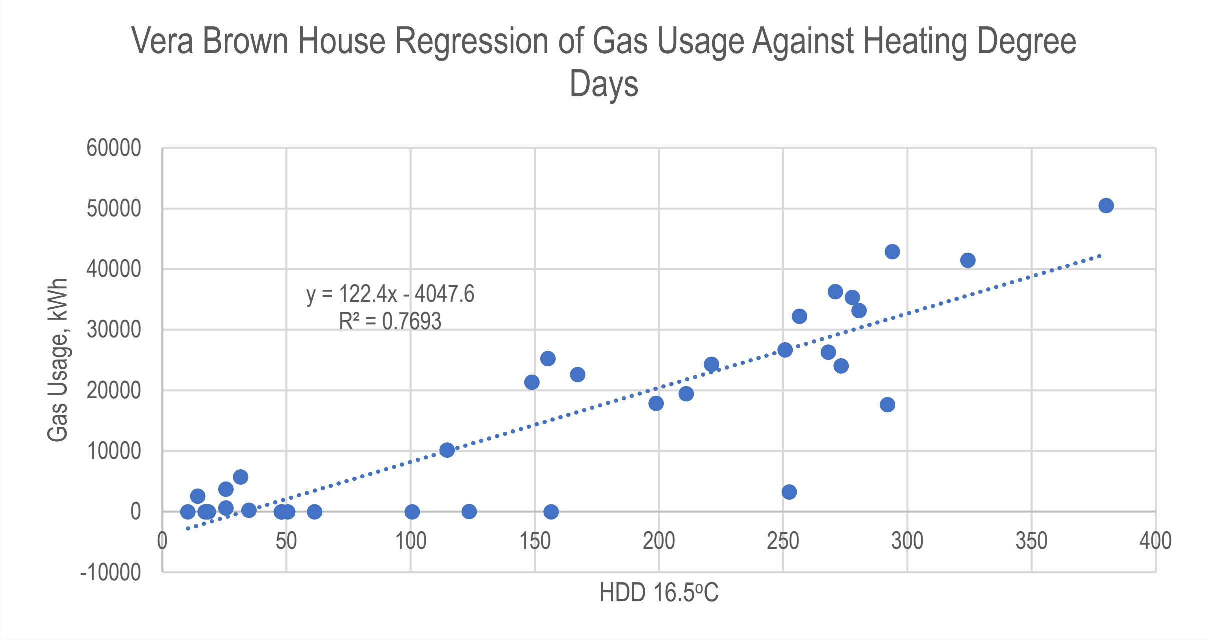


Figure 29 Vera Brown House regression of gas usage against heating degree days

Table 25 uses the baseload calculated from the intercept of Figure 32.

Table 25 Gas Baseload and Heating Loads of Vera Brown House

Baseload	4047.6	kWh/month
Baseload Heat	8	kW
Average Boiler Efficiency	89%	
Heat Baseload	7	kW_{th}
Average Heat Load	35	kW_{th}
Average Space Heating	28	kW_{th}
Input Peak	280	kW
Max Heating Load	249	kW_{th}
Max Space Heating Load	242	kW_{th}
Baseload %	20%	

4.5 Wolverton Centre

4.5.1 Built Environment

The Wolverton Centre is a two-storey brick cavity wall building with a pitched roof and double-glazed windows throughout. Built-in 1962, the building was refurbished around 2010, it spans approximately 801m². The Wolverton Centre accommodates the Sexual Health Clinic with offices, waiting rooms, a staff kitchen, several consultation rooms and an IT room.

The Centre typically operates from 08:00 to 20:00 Monday to Friday. The centre is closed on weekends and bank holidays. Public opening hours for walk-in are 08:00-11:00 Monday to Friday. Appointments can be taken from 12:50-19:20 Monday to Friday.

Figure 2 shows Wolverton located in the northeast side of the site, building number 4.

Table 26 Wolverton Centre summary

Building Name	Use	Weekday Hours	Weekend Hours	Age	UPRN
Wolverton Centre	Health Centres & Clinics	12	0	1962	100023059235
Postcode	**GIA (m^2)**	**MPAN**	**MPRN**	**DEC Rating**	**Additional Information**
KT2 7QB	801	1900045021008	72519207	E	Clinic

Table 27 Wolverton Centre House building fabrics

Building Name	Roof		Wall		Floor		Windows		Doors
	Type	Insulation	Type	Thickness (cm)	Type	Area (m2)	Glazing Type	Material	
Wolverton Centre	Pitched roof	Rafters	Cavity clear	30	Solid	595	Double	PVC	Single/double glazed wood/metal frames

4.5.2 Electrical infrastructure

Wolverton Centre not connected to the HV ring and therefore does not consume electricity from the energy centre. Electricity is supplied from a separate substation managed by EDF/UKPN. The building has a supply capacity of 400A.

Table 28 Electrical infrastructure for Wolverton Centre

Building	Electrical Supply / Infrastructure	Meter Type	Electrical Supply Point (If Sub-Meter)	Capacity to Building (kVA - Bill)	Capacity of LV Supply to Building (A)	Capacity of Infrastructure Within Building (A)
Wolverton Centre	Three Phase (400/415 V)	Fiscal	-	-	400A	400A

4.5.3 Electrical Half-Hourly Data Analysis

Wolverton is open to both staff and patients, the average power consumption for weekday and weekends reflect a different pattern to Vera Brown house and Davies Wood house which is not open to patients and visitors. During the weekday there is an increase in power consumption around 8 PM before dropping again before the next working day. Wolverton Centre is closed on the weekends and this is reflected in Figure 30, the baseload is therefore estimated to be 2.5 kW.

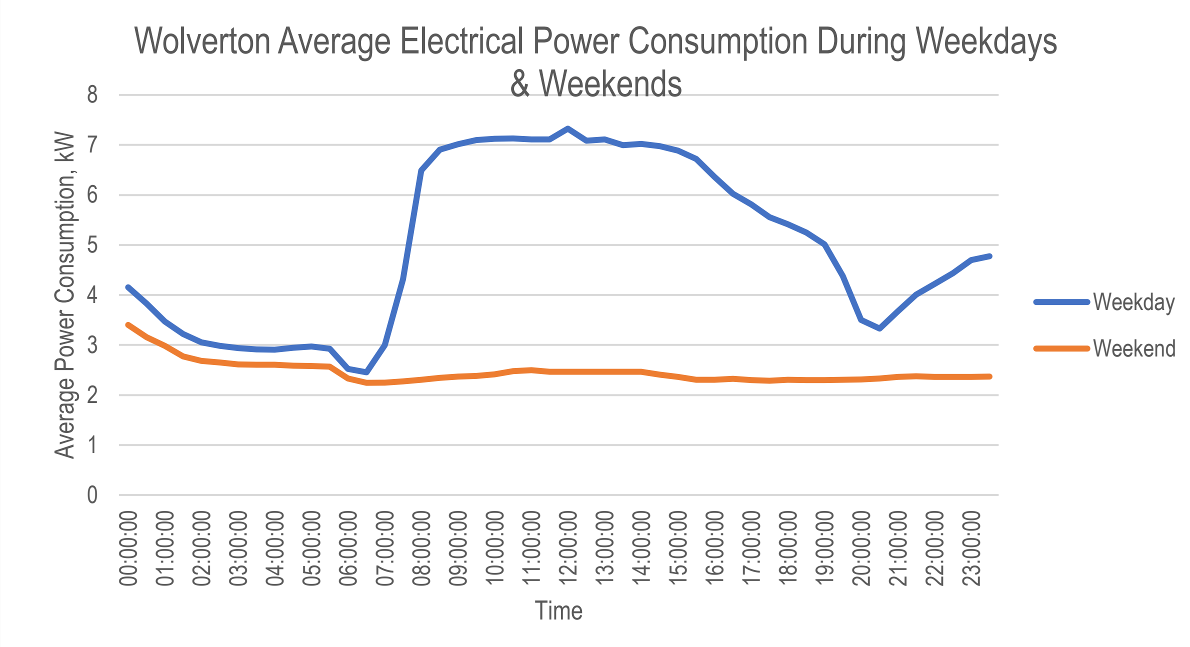


Figure 30 Wolverton House Weekday and Weekend Electric profile

Figure 31 shows Wolverton's monthly power consumption, similar to Figure 30 there is a slight rise in consumption from 8 pm. Whilst this graph shows a typical trend of higher consumption, 7 kW, during shorter days where lights are on for longer hours. April and May, when days are longer, show a significantly lower power consumption compared to other months and when the longest day in the year is in June.

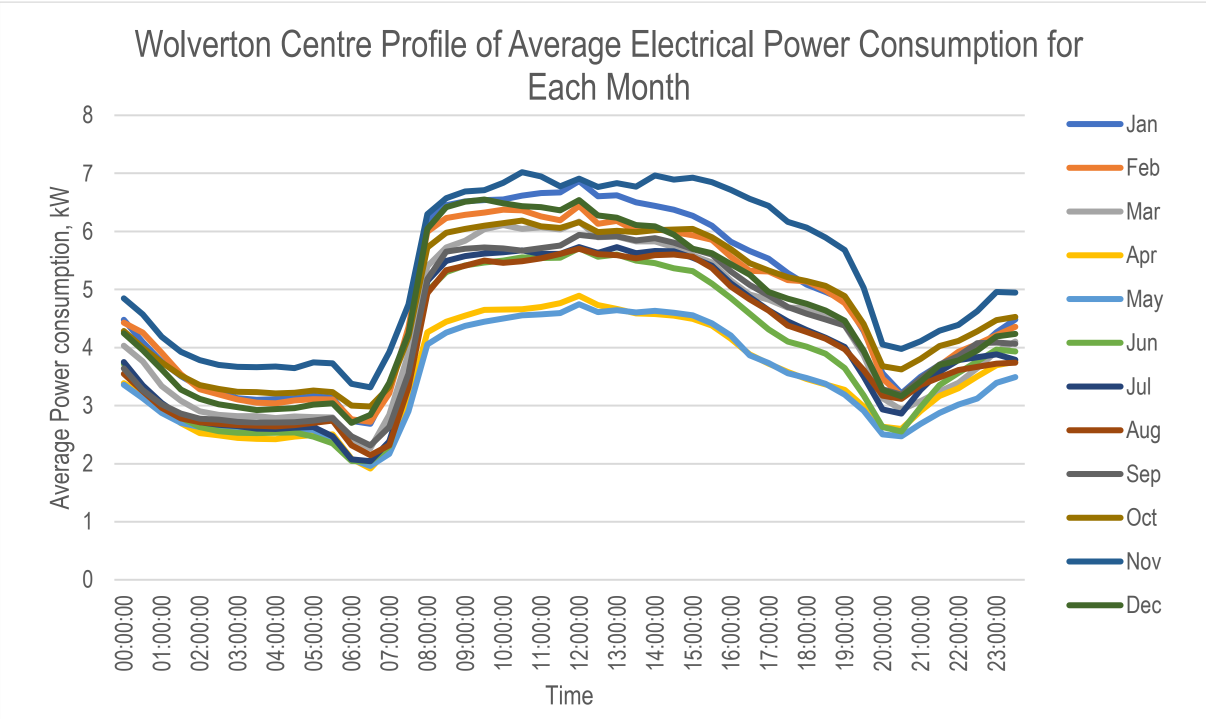


Figure 31 Wolverton House average power consumption by month

Whilst the previous graphs give a good insight of Wolverton electrical consumption throughout the day it does not show what the sites peak load is. Figure 31 shows Wolverton's maximum consumption during the day between Jan 2019 to Oct 2021. Although not as apparent compared to other buildings, Wolverton's peak load is 16.7 kW.

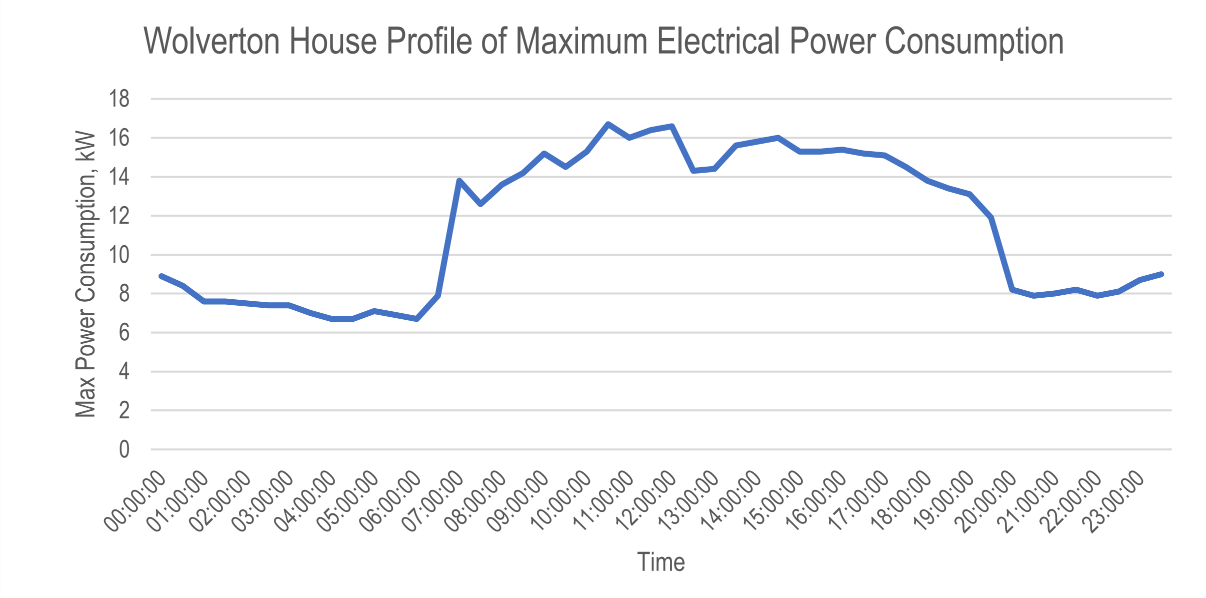


Figure 32 Wolverton House profile of maximum electrical power consumption

4.5.4 Heating System

Gas is used to supply heat to Wolverton Centre. The boilers in Wolverton centre supplies heating to radiators and DHW for the whole building. Approximately 75% of radiators have TRV control.

Table 29 List of Heating Assets for Wolverton Centre

Asset Type	Existing heating medium	Type	Number of Assets	Make & Model Number	Input rating kW	Year of Manufacture	Gross eff (%)
1	Gas	Boiler	1	Remeha Gas 210 Eco Pro 160	166	2007	88%

4.5.5 Gas Regression Analysis on Monthly Data

Figure 33 shows Wolverton Centre average monthly gas consumption with the corresponding monthly heating degree day of 16.5°C. There is a noticeable reduction in consumption early in 2021, which is likely due to Covid-19. During the warmer months, gas consumption is also slightly higher than the HDD trend.

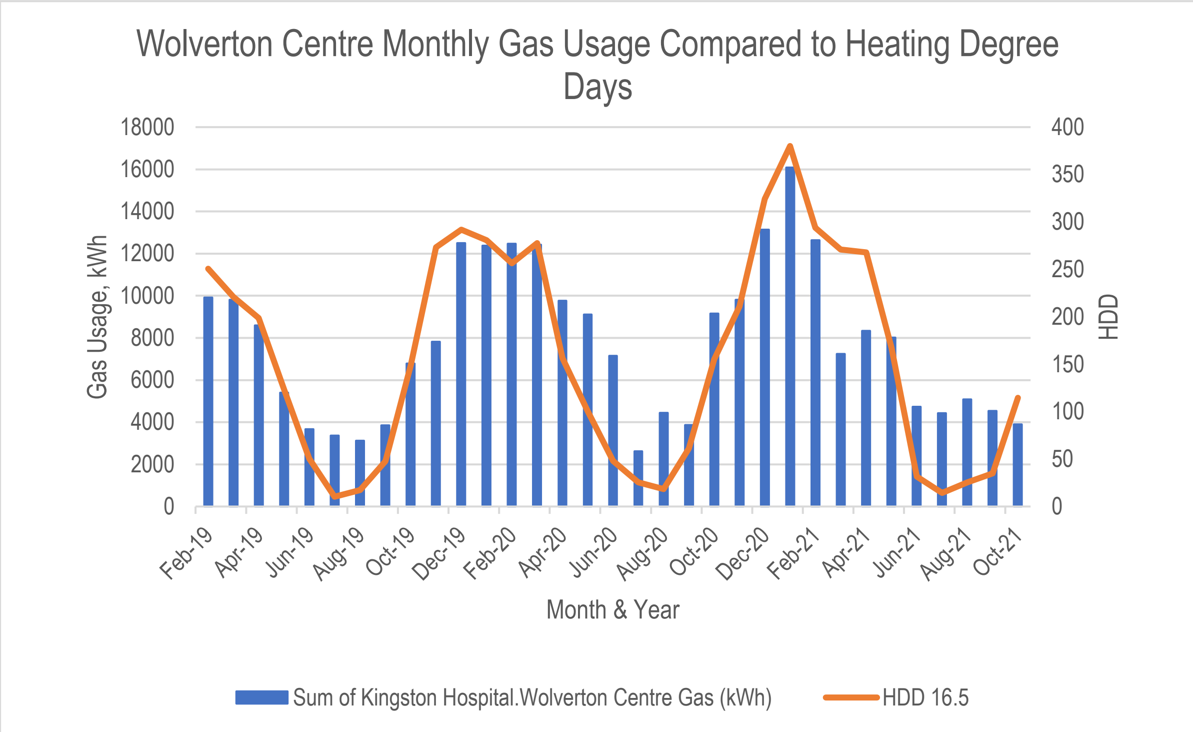


Figure 33 Wolverton Centre monthly gas usage compared to heating degree days

Using the same method as other buildings HDD regression analysis was used to estimate the baseload. Figure 34 shows Wolverton's gas consumption verses a 16.5ºC HDD base temperature. The intercept and therefore the estimated baseline is 3,293 kWh. Again, the low R-value suggests there is another factor influencing in the building heat.

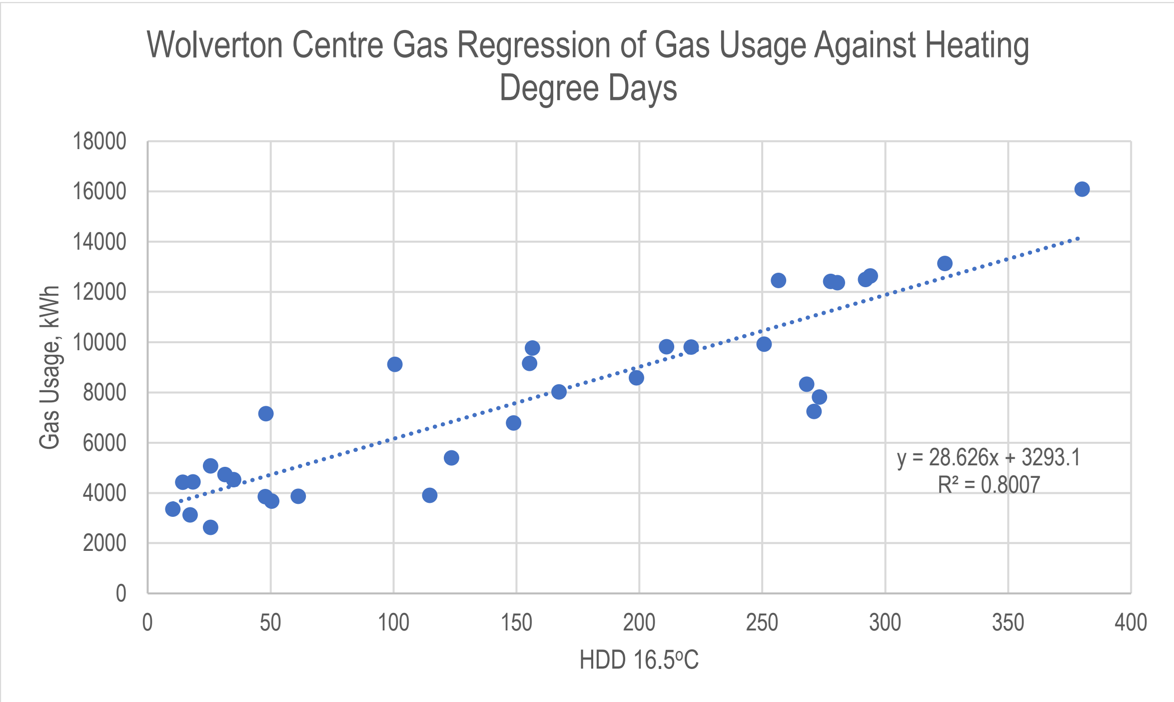


Figure 34 Wolverton Centre Gas Regression of Gas Usage Against Heating Degree Days

Finally, the baseload is used to calculate heat loads in Table 30.

Table 30 Gas Baseload and Heating Loads of Wolverton Centre

Baseload	3293.1	kWh/month
Baseload Heat	4 to 5	kW
Average Boiler Efficiency	88%	
Heat Baseload	4	kW_{th}
Average Heat Load	13	kW_{th}
Average Space Heating	10	kW_{th}
Input Peak	30	kW
Max Heating Load	26	kW_{th}
Max Space Heating Load	23	kW_{th}
Baseload %	26%	

4.6 Accident & Emergency Department (ED)

4.6.1 Built Environment

The Accident & Emergency Department (A&E) building is located next to Rowan Bentall wing. The department resides within a three-storey cavity brick wall with double glazed windows which spans approximately 3,924m². The building is made up of the main 'old' ED department and extensions in three parts built in 2001 and 2018, these are the sunflower unit, majors & resuscitation and urgent treatment centre (UTC). To fulfil its activities the site possesses various offices, cubicles for consultations, triage rooms, waiting rooms, examination rooms, observation rooms, resuscitation rooms, toilets, showers and a reception. Due to the nature of the work carried out by the department the building operates 24/7 all year long.

Figure 2 shows ED located in the northeast side of the site, building number 5.

Table 31 ED summary

Building Name	Use	Weekday Hours	Weekend Hours	Age	UPRN
ED	Hospital	24	24	2001	128047035
Postcode	**GIA (m²)**	**MPAN**	**MPRN**	**DEC Rating**	**Additional Information**
KT2 7QB	3924	1900070699844 / 1900070699853	9153683810	E	ED

Table 32 ED building fabric

Building Name	Roof		Wall		Floor		Windows		Doors
	Type	Insulation	Type	Thickness (cm)	Type	Area (m2)	Glazing Type	Material	
ED	Metal clad roof	-	Cavity full fill	30	Solid	2940	Double	metal	Double glazed metal frames

4.6.2 Electrical infrastructure

Electricity is supplied from the site's HV ring where its electricity is supplied from the grid and the energy centre. ED then takes this supply from substation E located near Princess Alexander Wing rated at 2000A. See Appendix I for information relating to the onsite HV ring.

Table 33 Electrical infrastructure for ED

Building	Electrical Supply / Infrastructure	Meter Type	Electrical Supply Point (If Sub-Meter)	Capacity to Building (kVA - Bill)	Capacity of LV Supply to Building (A)	Capacity of Infrastructure Within Building (A)
ED	Three Phases (11kV on site substation)	-	-	RMU E (2000A)	-	-

4.6.3 Electrical Half-Hourly Data Analysis

As Emergency Department electricity is supplied from the HV ring its analysis is covered in section 3.3

4.6.4 Heating System

The fuel used to supply heat to ED is Gas in the old ED plantroom and electricity in the Urgent Treatment Centre (UTC) plantroom.

The old plantroom has recently had legacy boilers replaced. It supplies heating for AHU, batteries, air curtains and radiant panels via the CT circuit to the ED building. The VT circuit supplies heating for radiators in the ground and lower ground floors. The Lochinvar calorifiers supplies DHW for the building as well as to the humidifiers.

The UTC plantroom supplies heat for heater batteries in major and resuscitation departments as well as heating and DHW for the UCC department.

Table 34 List of heating assets for ED

Asset Type	Existing heating medium	Type	Number of Assets	Make & Model Number	Input rating kW	Year of Manufacture	Gross eff (%)
1	Gas	Boiler	4	Purewell Variheat MK2	60	2017 estimated	96%
2	Gas	DHW storage heater	2	Lochinvar CHA 200g CE	86.5	2001	86%
3	Elec	DHW Calorifier	1	Climaclyss	Unknown	2017	99%
4	Elec	Heat Pump	2	Mitsubishi - PWFY - P100 VM - E - VU <G>	12.5	2016	-

4.6.5 Gas Regression Analysis on Monthly Data

Figure 35 compares ED's gas consumption against a 17.5 heating degree day. In general, the consumption follows the trend of outdoor temperature.

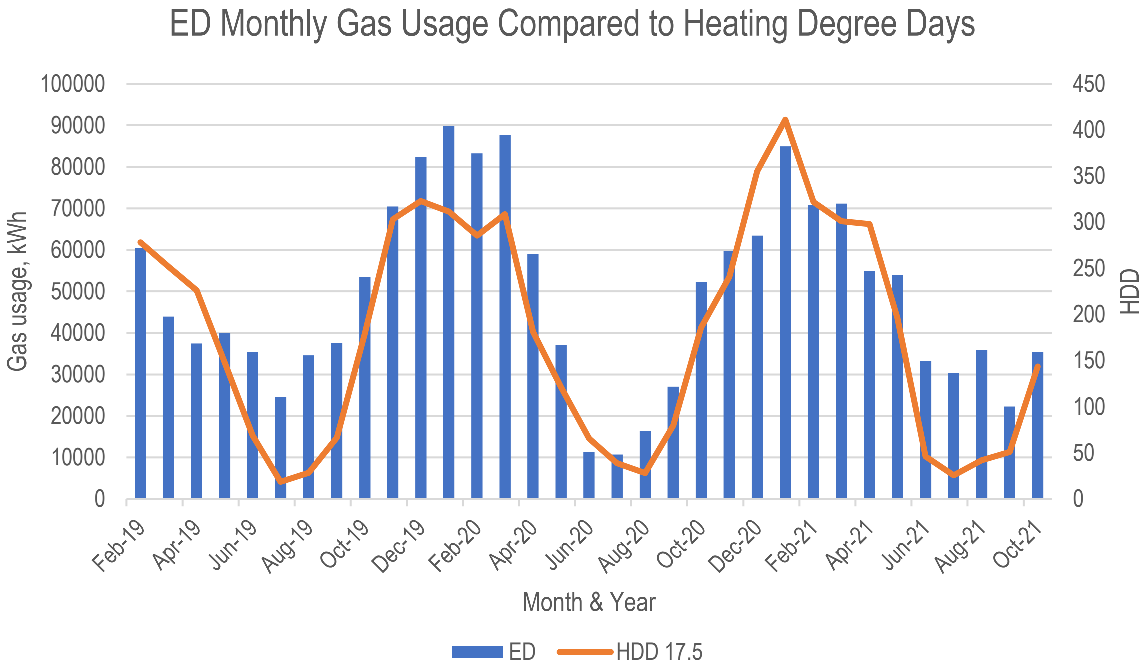


Figure 35 ED monthly gas usage compared to heating degree days

Figure 35 is regression analysis for gas usage and HDD. The base temperature of 17.5ºC gave the higher R-value. Thus, an estimated baseload of 18,517 kWh. The low R- Value suggests that there are other factors affecting gas usage, including the fact that the ED building is made up newer and older builds and parts of the building is heated with heat pumps.

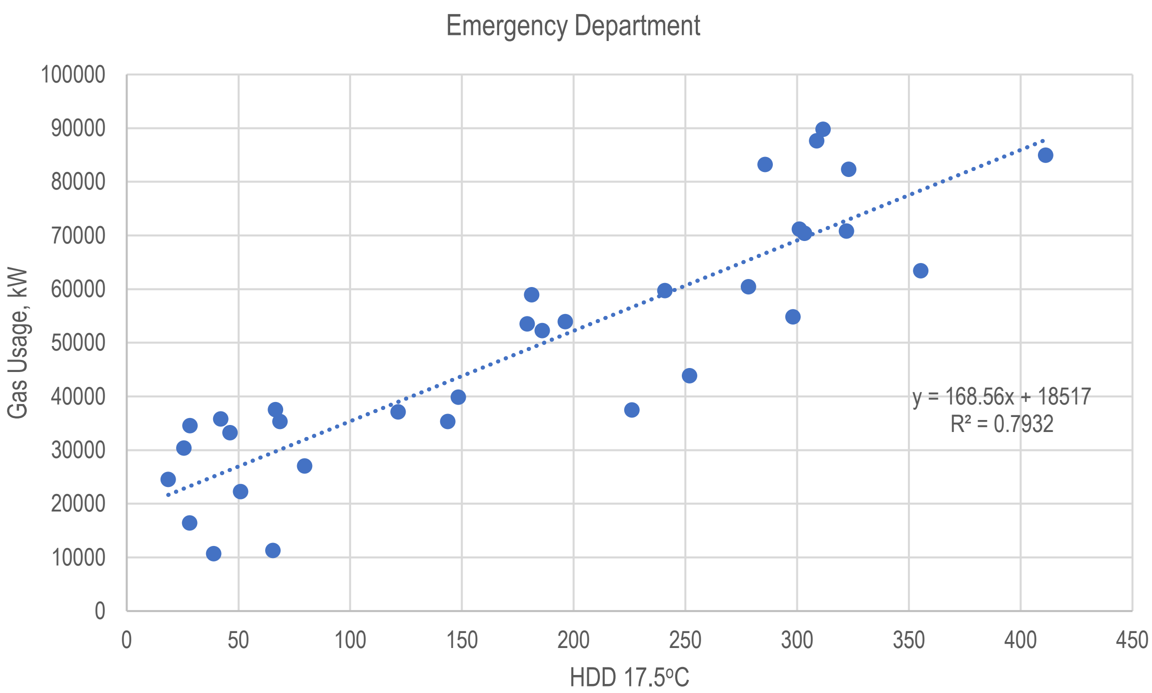


Figure 36 ED Gas Regression of Gas Usage Against Heating Degree Days

Using the estimated Baseload, the following heating loads are calculated.

Table 35 Gas Baseload and Heating Loads of ED

Baseload	18,517	kWh/month
Baseload Heat	25.3 to 30	kW
Average Boiler Efficiency	88%	
Heat Baseload	26	kW_{th}
Average Heat Load	82	kW_{th}
Average Space Heating	55	kW_{th}
Input Peak	200	kW
Max Heating Load	176	kW_{th}
Max Space Heating Load	150	kW_{th}
Baseload %	32%	

4.7 Kingston Surgical Centre (KSC)

4.7.1 Built environment

KSC is a PFI operated and owned building consisting of six floors brick cavity wall, flat roof, double glazed throughout building built-in 2007 which spans approximately 9,324m^2. The building accommodates of a canteen, treatment rooms and wards and teaching facilities including a lecture theatre.

Figure 2 shows KSC located in the centre northwest of the site, building number 44.

Table 36 KSC summary

Building Name	Use	Weekday Hours	Weekend Hours	Age	UPRN
KSC	Hospital	24	24	2007	128047043
Postcode	**GIA (m^2)**	**MPAN**	**MPRN**	**DEC Rating**	**Additional Information**
KT2 7QB	9324	1900070699844 / 1900070699853	82023700	F	PFI

Table 37 KSC building fabrics

Building Name	Roof		Wall		Floor		Windows		Doors
	Type	Insulation	Type	Thickness (cm)	Type	Area (m2)	Glazing Type	Material	
KSC	Pitched	At rafters	Cavity clear	40	Solid	2133	Double/ Triple	Metal	Single/Double Glazed Metal Frame

4.7.2 Electrical infrastructure

Electricity is supplied from the site's HV ring where its electricity is supplied from the grid and the energy centre. KSC then takes this supply from substation E located near Princess Alexander Wing rated at 2000A. See Appendix I for information relating to the onsite HV ring.

Table 38 Electrical infrastructure for KSC

Building	Electrical Supply / Infrastructure	Meter Type	Electrical Supply Point (If Sub-Meter)	Capacity to Building (kVA - Bill)	Capacity of LV Supply to Building (A)	Capacity of Infrastructure Within Building (A)
KSC	Three Phases (11kV on site substation)	Sub Meter	RMU E (2000A)	RMU E (2000A)	-	160A

4.7.3 Electrical Half-Hourly Data Analysis

As KSC's electricity is supplied from HV ring its analysis is covered in section 3.3.

4.7.4 Heating System

The fuel used to supply heat to KSC is Gas. Similar to other outbuildings, KSC is heated independently despite being one of the larger buildings on site. Boilers supply heating for Fan Coil Units (FCU), AHU and DHW.

Table 39 List of Heating Assets for KSC

Asset Type	Existing heating medium	Type	Number of Assets	Make & Model Number	Input rating kW	Year of Manufacture	Gross eff (%)
1	Gas	Boiler	8	Wessex ModuMAX 220 high efficiency	262	2007	87%

4.7.5 Gas Regression Analysis on Monthly Data

Figure 37 shows KSC's gas consumption by month in relation monthly heating degree days of 19.5ºC. There is a noticeable increase in consumption in 2021.

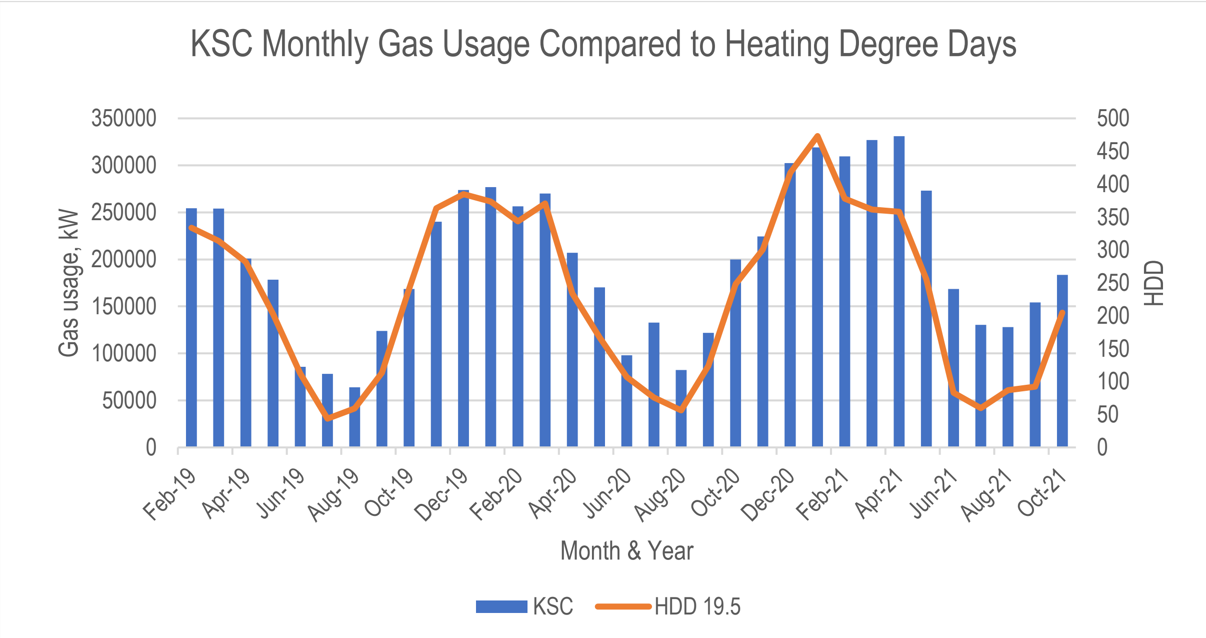


Figure 37 KSC monthly gas usage compared to heating degree days

The increase in gas consumption during 2021 has led to a lower R-value in Figure 38, however, when the data is analysed separately, 2021 and 2019 to 2020 the R valve is above 0.9 showing a good fit with 19.5ºC. Selecting a temperature that closely reflects the buildings response to changing outdoor temperatures helps better the buildings baseload.

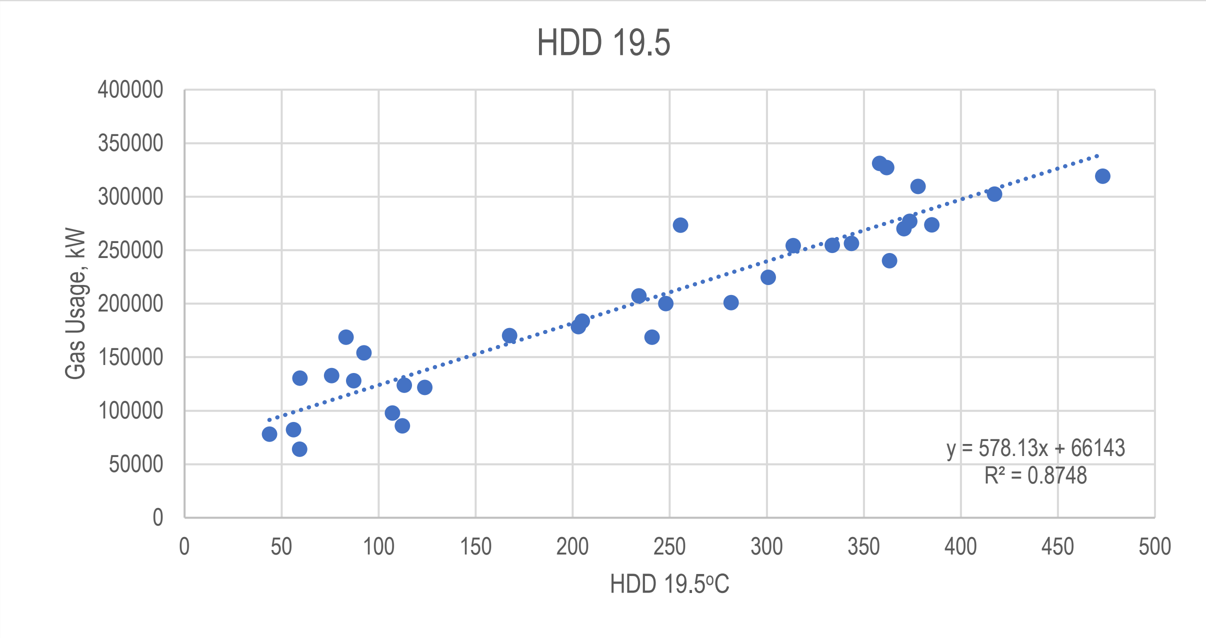


Figure 38 KSC Gas Regression of Gas Usage Against Heating Degree Days

Table 40 shows the outcome after determining the baseload.

Table 40 Gas baseload and heating loads of KSC

Baseload	66143	kWh/month
Baseload Heat	90 to 115	kW
Average Boiler Efficiency	88%	
Heat Baseload	79	kW_{th}
Average Heat Load	371	kW_{th}
Average Space Heating	292	kW_{th}
Input Peak	700	kW
Max Heating Load	616	kW_{th}
Max Space Heating Load	537	kW_{th}
Baseload %	21%	

4.8 Main Outpatients

4.8.1 Built Environment

The Outpatients department resides in a four-storey, brick cavity wall with a pitched roof and double-glazed windows throughout the building, built in 1962, which spans approximately 6,065m². It operates blood tests, Kingston-on-call, Outpatients Reception, Pharmacy, Radiology and X-ray on level 3 as well as the RVS Tea Shop on level 4.

Figure 2 shows outpatients located in the centre west of the site, building number 12.

Table 41 Main Outpatients summary

Building Name	Use	Weekday Hours	Weekend Hours	Age	UPRN
Main Outpatients	Hospital	24	24	1962	128047038
Postcode	**GIA (m²)**	**MPAN**	**MPRN**	**DEC Rating**	**Additional Information**
KT2 7QB	6065	1900070699844 / 1900070699853	82023700	F	Clinical

Table 42 Main Outpatients Building Fabric

Building Name	Roof		Wall		Floor		Windows		Doors
	Type	Insulation	Type	Thickness (cm)	Type	Area (m2)	Glazing Type	Material	
Main Outpatients	Flat roof	At rafters	Cavity clear	35	Solid	3099	Single/ Double	Metal / softwood	Single glazed metal and wooden framed

4.8.2 Electrical infrastructure

Electricity is supplied from the site's HV ring where its electricity is supplied from the grid and the energy centre. This building then takes this supply from substation B rated at 2000A. See Appendix I for information relating to onsite HV ring.

Table 43 Electrical infrastructure for Main Outpatients

Building	Electrical Supply / Infrastructure	Meter Type	Electrical Supply Point (If Sub-Meter)	Capacity to Building (kVA - Bill)	Capacity of LV Supply to Building (A)	Capacity of Infrastructure Within Building (A)
Main Outpatients	Three Phases (11kV on site substation)	Sub Meter	RMU E (2000A)	RMU E (2000A)	-	160A

4.8.3 Electrical Half-Hourly Data Analysis

As Outpatients electricity is supplied from the HV ring, its analysis is covered in section 3.3.

4.8.4 Heating System

Steam and LTHW from the energy centre supply heat to Main Outpatients.

The Outpatients plantroom supplies heating for Main outpatients, MRI, Rowan Bentall, and Princess Alexander Dental Wing. Asset 1 supplies for heating for radiators and AHU's. Asset supplies for DHW. Asset 3 supplies for outpatients 2 to 4ʳᵈ floor AHU's and Radiators as well as Rowan Bentall wing and the MRI department and Princess Alexander Wing.

Table 44 List of Heating Assets for Main Outpatients

Asset Type	Existing heating medium	Type	Number of Assets	Make & Model Number	Input rating kW	Year of Manufacture	Gross eff (%)
1	LTHW	Plate Heat Exchanger	1	LTHW - Alfa Laval	150	2007 estimated	-
2	Steam	DHW Plate Heat Exchanger	2	Alfa Laval/ ts6mfg	150	2018	-
3	Steam	Plate Heat Exchanger	2	Spirax	1300	2018	-

4.9 Princess Alexandra Dental Wing

4.9.1 Built Environment

The Princess Alexandra Dental Wing is a 2 storey, brick cavity wall, pitched slated roof, and double-glazed building built in 1975. The site spans approximately 967m². It accommodates the dental related cares of the hospital with numerous equipped consultations room, offices, reception, waiting rooms, toilets and staff rooms.

Figure 2 shows Princess Alexander Wing located adjacent to ED, building number 48

Table 45 Princess Alexandra Dental Wing summary

Building Name	Use	Weekday Hours	Weekend Hours	Age	UPRN
Princess Alexandra Dental Wing	Hospital	24	24	1975	128047037
Postcode	**GIA (m²)**	**MPAN**	**MPRN**	**DEC Rating**	**Additional Information**
KT2 7QB	967	1900070699844 / 1900070699853	82023700	D	Admin

Table 46 Princess Alexandra Dental Wing Building Fabric

Building Name	Roof		Wall		Floor		Windows		Doors
	Type	Insulation	Type	Thickness (cm)	Type	Area (m2)	Glazing Type	Material	
Princess Alexandra Dental Wing	pitched	At rafters	Cavity clear	35	Suspended	628	Double	Metal/ softwood	Double glazed metal and wooden

4.9.2 Electrical infrastructure

Electricity is supplied from the site's HV ring where its electricity is supplied from the grid and the energy centre. This building then takes this supply from substation E rated at 2000A. See Appendix I for information relating to the onsite HV ring.

Table 47 Electrical infrastructure for Princess Alexander Wing

Building	Electrical Supply / Infrastructure	Meter Type	Electrical Supply Point (If Sub-Meter)	Capacity to Building (kVA - Bill)	Capacity of LV Supply to Building (A)	Capacity of Infrastructure Within Building (A)
Princess Alexander Wing	Three Phases (11kV on site substation)			RMU E (2000A)	-	-

4.9.3 Electrical Half-Hourly Data Analysis

As Princess Alexander Dental Centre is supplied from the HV ring its analysis is covered in section 3.3.

4.9.4 Heating System

Princess Alexander Dental Centre is heated from the outpatient's plantroom.

Table 48 List of Heating Assets in Outpatients plantroom for Princess Alexander Dental Centre

Asset Type	Existing heating medium	Type	Number of Assets	Make & Model Number	Input rating kW	Year of Manufacture	Gross eff (%)
1	Steam	DHW Plate Heat Exchanger	2	Alfa Laval/ ts6mfg	150	2018	-
2	Steam	Plate Heat Exchanger	2	Spirax	1300	2018	-

4.10 Esher Wing

4.10.1 Built Environment

The Esher Wing building is an eight-storey building made of a steel frame, double glazing and flat roof. Brise solar was installed recently to decrease solar gain throughout the year and enable naturally cooler room temperatures. The site spans approximately 19,399m^2. The Esher Wing hosts 14 out of the 18 Wards of Kingston Hospital.

Figure 2 shows Esher Wing located in the centre west of the site, building number 16.

Table 49 Esher Wing Summary

Building Name	Use	Weekday Hours	Weekend Hours	Age	UPRN
Esher Wing	Hospital	24	24	1975	128047044
Postcode	**GIA (m^2)**	**MPAN**	**MPRN**	**DEC Rating**	**Additional Information**
KT2 7QB	19399	1900070699844 / 1900070699853	82023700	F	Wards & theatres

Table 50 Esher Wing Building Fabric

	Roof	Wall	Floor	Windows	Doors

Building Name	Type	Insulation	Type	Thickness (cm)	Type	Area (m2)	Glazing Type	Material	
Esher Wing	Flat roof	-	Solid	22	Solid	3840	Double	Metal	Double glazed metal frame

4.10.2 Electrical infrastructure

Electricity is supplied from the site's HV ring where its electricity is supplied from the grid and the energy centre. This building then draws this supply from substation D rated at 1250A. See Appendix I for information relating to the onsite HV ring.

Table 51 Electrical infrastructure for Esher Wing

Building	Electrical Supply / Infrastructure	Meter Type	Electrical Supply Point (If Sub-Meter)	Capacity to Building (kVA - Bill)	Capacity of LV Supply to Building (A)	Capacity of Infrastructure Within Building (A)
Esher Wing	Three Phases (11kV on site substation)			RMU D (1250A)	-	160A

4.10.3 Electrical Half-Hourly Data Analysis

As Esher Wing is supplied from the HV ring its analysis is covered in section 3.3.

4.10.4 Heating System

Steam from the energy centre is used to supply heat to Esher Wing. During the survey poor insulation of pipework was noted. Additionally, 2 no. calorifiers required maintenance.

The Esher Wing plant room supplied heating for radiators, DHW, and AHU

Table 52 List of Heating Assets for Esher Wing

Asset Type	Existing heating medium	Type	Number of Assets	Make & Model Number	Input rating kW	Year of Manufacture	Gross eff (%)
1	Steam	DHW Plate Heat Exchanger	3	Spirax Sarco Easiheat EH-5W-ST-DHW-EL-PL-P	855 estimated	2013	-
2	Steam	Calorifier	4	Cotswold 555 X	200	1972	-

4.11 Bernard Meade Wing (BMW)

4.11.1 Built environment

The Bernard Meade Wing including the Royal Eye Unit is a five-storey brick cavity wall building with a pitched slate roof built in 1991. The building spans approximately 5,415m^2. The Bernard Meade Wing building possesses the main entrance/reception of the Hospital and is linked to other wings/buildings by a link corridor/bridge. Its primary activities are Outpatient services including pathology. The wing operates the Royal Eye Unit, 2 Wards (Dolphin & Sunshine), Children's Outpatient, Coffee Shop open to the public, the Patient Advise and Liaison Services (PALS) and the Pathology department.

Figure 2 shows BMW located in the centre of the site, building number 3.

Table 53 Bernard Meade Wing summary

Building Name	Use	Weekday Hours	Weekend Hours	Age	UPRN
Bernard Meade Wing	Hospital	24	24	1991	128047029
Postcode	**GIA (m²)**	**MPAN**	**MPRN**	**DEC Rating**	**Additional Information**
KT2 7QB	5415	1900070699844 / 1900070699853	82023700	F	Wards & theatres

Table 54 Bernard Meade Wing Building Fabric

Building Name	Roof		Wall		Floor		Windows		Doors
	Type	Insulation	Type	Thickness (cm)	Type	Area (m2)	Glazing Type	Material	
BMW	pitched	At rafters	Cavity clear	30	Solid	1824	Double	PVC	Double glazed, Metal frame

4.11.2 Electrical infrastructure

Electricity is supplied from the site's HV ring where its electricity is supplied from the grid and the energy centre. This building then takes this supply from substation C rated at 1250A. See Appendix I for information relating to onsite HV ring.

Table 55 Electrical infrastructure for BMW

Building	Electrical Supply / Infrastructure	Meter Type	Electrical Supply Point (If Sub-Meter)	Capacity to Building (kVA - Bill)	Capacity of LV Supply to Building (A)	Capacity of Infrastructure Within Building (A)
BMW	Three Phases (11kV on site substation)			RMU C (1250A)	-	-

4.11.3 Heating System

Steam and LTHW is used to supply heat to BMW. This plantroom raises heat for AHU, radiators and DHW.

Table 56 List of Heating Assets for BMW

Asset Type	Existing heating medium	Type	Number of Assets	Make & Model Number	Input rating kW	Year of Manufacture	Gross eff (%)
1	LTHW	Plate Heat Exchanger	1	LTHW - Alfa Laval	150	2007	-
2	Steam	Calorifier	2	-	-	1991	-

3	Steam	DHW Calorifier	2	-	-	1991	-

4.12 Maternity & Day Surgery Unit (DSU)

4.12.1 Built Environment

The Maternity & DSU is a three-storey building with a steel frame, brick cladding, slate pitch roof and double glazed throughout, built in 1995. It spans approximately 7,483m^2.

The department has a Day Assessment Unit and a Day Surgery Unit on the ground floor open from 07:00-19:00hrs all week. Level 2 has the Delivery Suite and Antenatal clinic. The Malden Suite, Neonatal Ward and Thameside Suite are located at level 3 and hosts women who gave birth and their new-borns. The upper floors operate 24/7 due to the nature of the activities carried out.

Figure 2 shows maternity and DSU located in the south of the site, building number 1.

Table 57 Maternity & DSU summary

Building Name	Use	Weekday Hours	Weekend Hours	Age	UPRN
Maternity & DSU	Hospital	24	24	1995	128041430
Postcode	**GIA (m²)**	**MPAN**	**MPRN**	**DEC Rating**	**Additional Information**
KT2 7QB	7483	1900070699844 / 1900070699853	82023700	F	Maternity

Table 58 Maternity & DSU Building Fabric

Building Name	Roof		Wall		Floor		Windows		Doors
	Type	Insulation	Type	Thickness (cm)	Type	Area (m2)	Glazing Type	Material	
Maternity & DSU	pitched	At rafters	Cavity clear	44	Solid	3344	Double/ Single	Metal	Single glazed metal frame. Wooden and metal

4.12.2 Electrical infrastructure

Electricity is supplied from the site's HV ring where its electricity is supplied from the grid and the energy centre. This building then takes this supply from substation C rated at 1250A. See Appendix I for information relating to onsite HV ring.

Table 59 Electrical infrastructure for Maternity and DSU

Building	Electrical Supply / Infrastructure	Meter Type	Electrical Supply Point (If Sub-Meter)	Capacity to Building (kVA - Bill)	Capacity of LV Supply to Building (A)	Capacity of Infrastructure Within Building (A)
Maternity and DSU	Three Phases (11kV on			RMU C (1250A)	-	-

	site substation)						

4.12.3 Electrical Half-Hourly Data Analysis

As Maternity and DSU is supplied from the HV ring, its analysis is covered in section 3.3.

4.12.4 Heating System

Steam and LTHW from the energy centre are used to supply heat to Maternity and DSU. The Maternity plantroom is located in the ground floor workshop plantroom.

LTHW supplies heating to the buildings frost and heating coils of the AHU as well as HWS for the calorifiers (asset 3). Steam heat exchangers (asset 2) supplies radiator heating via a VT circuit to 5 zones, AHUs via CT circuit, and a separate VT circuit for workshop heating as well as a HWS supply to the DHW calorifier (asset 3).

Table 60 List of Heating Assets for Maternity and DSU

Asset Type	Existing heating medium	Type	Number of Assets	Make & Model Number	Input rating kW	Year of Manufacture	Gross eff (%)
1	LTHW	Plate Heat Exchanger	1	LTHW - Alfa Laval	220	2007	-
2	Steam	Calorifier	2	IMI Rycroft Ltd, NSZF 3818s	100	1994	-
3	Steam	DHW Calorifier	2	IMI Rycroft Ltd, MXHC	-	1994	-

4.13 Estates & facilities

4.13.1 Built Environment

The maintenance and estates department resides within a single storey brick cavity wall with a flat roof and double glazed throughout building. The building was built in 1963 and spans approximately 694m^2.

Figure 2 shows Estates & facilities located in the south of the site, building number 27.

Table 61 Estates & facilities summary

Building Name	Use	Weekday Hours	Weekend Hours	Age	UPRN
Estates & facilities	Hospital	24	24	1963	128047049
Postcode	**GIA (m^2)**	**MPAN**	**MPRN**	**DEC Rating**	**Additional Information**
KT2 7QB	694	1900070699844 / 1900070699853	82023700	G	Admin

Table 62 Estates & facilities Building Fabric

	Roof	Wall	Floor	Windows	Doors

Building Name	Type	Insulation	Type	Thickness (cm)	Type	Area (m^2)	Glazing Type	Material	
Estates & facilities	Flat roof	-	Cavity clear	32	Solid	1040	Double/ single	PVC/ softwood/ metal	Double glazed Metal/PVC frame, wooden and metal

4.13.2 Electrical infrastructure

Electricity is supplied from the site's HV ring where its electricity is supplied from the grid and the energy centre. This building then takes this supply from substation A rated at 1600A. See Appendix I for information relating to onsite HV ring.

Table 63 Electrical infrastructure for Estates & Facilities

Building	Electrical Supply / Infrastructure	Meter Type	Electrical Supply Point (If Sub-Meter)	Capacity to Building (kVA - Bill)	Capacity of LV Supply to Building (A)	Capacity of Infrastructure Within Building (A)
Estates & Facilities	Three Phases (11kV on site substation)			RMU A (1600A)	-	-

4.13.3 Electrical Half-Hourly Data Analysis

As Estates & Facilities electricity is supplied from HV ring its analysis is covered in section 3.3.

4.13.4 Heating System

Steam from the energy centre is used to supply heat to Estates & Facilities.

Table 64 List of Heating Assets for Estates & Facilities

Asset Type	Existing heating medium	Type	Number of Assets	Make & Model Number	Input rating kW	Year of Manufacture	Gross eff (%)
1	Steam	Calorifier	2	-	-	-	-

4.14 Sir William Rous unit

4.14.1 Built environment

The Sir Williams Rous Unit is a two-storey brick cavity wall, flat roof, double glazed building. The site spans approximately 1751m². The building typically operates from 07:00-19:00hrs with one or two extra hour a day for cleaning.

Figure 2 shows Sir William Rous located in the east side of the site, building number 45.

Table 65 Sir William Rous unit summary

Building Name	Use	Weekday Hours	Weekend Hours	Age	UPRN
Sir William Rous unit	Hospital	24	24	2008	128047032

Postcode	GIA (m^2)	MPAN	MPRN	DEC Rating	Additional Information
KT2 7QB	1751	1900070699844 / 1900070699853	82023700	F	Clinical

Table 66 Sir William Rous unit Building Fabric

Building Name	Roof		Wall		Floor		Windows		Doors
	Type	Insulation	Type	Thickness (cm)	Type	Area (m^2)	Glazing Type	Material	
Sir William Rous unit	Flat roof	-	Cavity clear	42	Solid	799	Double	Metal	Double glazed Metal, metal

4.14.2 Electrical infrastructure

Electricity is supplied from the site's HV ring where its electricity is supplied from the grid and the energy centre. This building then takes this supply from substation B rated at 2000A. See Appendix I for information relating to the onsite HV ring.

Table 67 Electrical infrastructure for Sir William Rous Wing

Building	Electrical Supply / Infrastructure	Meter Type	Electrical Supply Point (If Sub-Meter)	Capacity to Building (kVA - Bill)	Capacity of LV Supply to Building (A)	Capacity of Infrastructure Within Building (A)
Sir William Rous Wing	Three Phases (11kV on site substation)	Sub Meter	-	RMU B (2000A)	400v	160A

4.14.3 Electrical Half-Hourly Data Analysis

As Sir William Rous Wing electricity is supplied from HV ring its analysis is covered in section 3.3.

4.14.4 Heating System

Steam is used to supply heat to Sir William Rous Wing from the energy centre. Heat raised in the plantroom supplies for DHW, radiant panels and AHU's

Table 68 List of Heating Assets for Sir William Rous Wing

Asset Type	Existing heating medium	Type	Number of Assets	Make & Model Number	Input rating kW	Year of Manufacture	Gross eff (%)
1	Steam	Plate Heat Exchanger	1	Spirax Sarco - PHS-1H-ST-HTG-EL3-HL-V	100	2008	-
2	Steam	DHW Plate Heat Exchanger	1	Spirax Sarco - PHS-2H-ST-DHW-EL3-HL-V	418	2008	-

4.15 Rowan Bentall Wing

4.15.1 Built Environment

Rowan Bentall Wing is a one storey extension built in 1964 which is situated between Accident and Emergency facilities and Main Outpatients. It resides within a single-storey building with double glazed windows. The building spans approximately 360m^2.

Figure 2 shows Rowan Bentall Wing located in the centre of the site, building number 3.

Table 69 Rowan Bentall Wing Summary

Building Name	Use	Weekday Hours	Weekend Hours	Age	UPRN
Rowan Bentall Wing	Hospital	24	24	1994	128047034
Postcode	**GIA (m^2)**	**MPAN**	**MPRN**	**DEC Rating**	**Additional Information**
KT2 7QB	360	1900070699844 / 1900070699853	82023700	F	clinical

Table 70 Rowan Bentall Wing Building Fabric

Building Name	Roof		Wall		Floor		Windows		Doors
	Type	Insulation	Type	Thickness (cm)	Type	Area (m^2)	Glazing Type	Material	
Rowan Bentall Wing	Pitched	At rafters	Cavity clear	22	Solid	412	Double	Metal	Double glazed Metal

4.15.2 Electrical infrastructure

Electricity is supplied from the site's HV ring where its electricity is supplied from the grid and the energy centre. This building then takes this supply from substation E rated at 2000A. See Appendix I for information relating to onsite HV ring.

Table 71 Electrical infrastructure for Rowan Bentall Wing

Building	Electrical Supply / Infrastructure	Meter Type	Electrical Supply Point (If Sub-Meter)	Capacity to Building (kVA - Bill)	Capacity of LV Supply to Building (A)	Capacity of Infrastructure Within Building (A)
Rowan Bentall Wing	Three Phases (11kV on site substation)	-	-	RMU E(2000A)	-	N/A

4.15.3 Electrical Half-Hourly Data Analysis

As Rowan Bentall wing's electricity is supplied from the HV ring its analysis is covered in section 3.3.

4.15.4 Heating System

Rowan Bentall wing is heated from the outpatient's CT circuit.

Table 72 List of heating assets in Main Outpatients plantroom to Rowan Bentall wing

Asset Type	Existing heating medium	Type	Number of Assets	Make & Model Number	Input rating kW	Year of Manufacture	Gross eff (%)
1	Steam	Plate Heat Exchanger	2	Spirax	1300	2018	-

5. Electrical Infrastructure Summary

Table 73 summarises the electrical infrastructure as discussed in Section 0

Table 73 Electrical Infrastructure Summary

Building	Electrical Supply / Infrastructure	Meter Type	Electrical Supply Point (If Sub-Meter)	Capacity to Building (kVA - Bill)	Capacity of LV Supply to Building (A)	Capacity of Infrastructure Within Building (A)
Davies Wood House	Three Phase (400/415 V)	Fiscal	N/A	N/A	200A	N/A
Mortuary and Patient Affairs	Three Phases (11kV on site substation)	Sub Meter	Esher Wing	RMU D - 1250A	-	250A
Staff Day Nursery	Three Phase (400/415 V)	Fiscal	-	-	200A	63A
Vera Brown House	Three Phase (400/415 V)	Fiscal	-	-	800A	400A
Wolverton Centre	Three Phase (400/415 V)	Fiscal	-	-	400A	400A
ED	Three Phases (11kV on site substation)	-	-	RMU E (2000A)	-	-
KSC	Three Phases (11kV on site substation)	Sub Meter	RMU E (2000A)	RMU E (2000A)	-	160A
Main Outpatients	Three Phases (11kV on site substation)	Sub Meter	RMU E (2000A)	RMU E (2000A)	-	160A
Princess Alexander Wing	Three Phases (11kV on site substation)			RMU E (2000A)	-	-
Esher Wing	Three Phases (11kV on site substation)			RMU D (1250A)	-	160A
BMW	Three Phases (11kV on site substation)			RMU C (1250A)	-	-
Maternity and DSU	Three Phases (11kV on site substation)			RMU C (1250A)	-	-

Estates & Facilities	Three Phases (11kV on site substation)			RMU A (1600A)	-	-
Sir William Rous Wing	Three Phases (11kV on site substation)	Sub Meter	-	RMU B (2000A)	400v	160A
Rowan Bentall Wing	Three Phases (11kV on site substation)	-	-	RMU E(2000A)	-	-

6. Heating Systems Summary

Table 75 summarises the heating systems infrastructure as discussed in Section 0

		Asset Type 1						Asset Type 2					
Building	**Existing heating medium**	Type	Number of Assets	Make & Model Number	Input rating kW	Year of Manufacture	Gross eff (%)	Type	Number of Assets	Make & Model Number	Input rating kW	Year of Manufacture	Gross eff (%)
Davies Wood House	Gas	Boiler	1	Remeha Quinta Ace 115	104	2021	88%	-	-	-	-	-	-
Mortuary & Patient Affairs	Gas	Boiler	2	Hamworthy UR 300	88.8	1994	77%	DHW storage heater	2	Andrews 65/173PP	50	2008	79%
Staff Day Nursery	Gas	Boiler	2	Green Star FS 42 CDI	42	2019	89%	DHW storage heater	2	AO Smith EQH 200 G	18.3	2018	83%
Vera Brown House	Gas	Boiler	2	Green Star FS 42 CDI	42	2019	89%	DHW storage heater	2	AO Smith EQH 200 G	18.3	2018	83%
Wolverton Centre	Gas	Boiler	1	Remeha Gas 210 Eco Pro 160	166	2007	88%	-	-	-	-	-	-
ED	Gas	Boiler	4	Purewell Variheat MK2	60	2017 estimated	96%	DHW storage heater	2	Lochinvar CHA 200g CE	86.5	2001	86%
ED	Elec	Heat Pump	2	Mitsubishi - PWFY - P100 VM - E - VU <G>	12.5	2016	-	DHW Calorifier	1	Climaclyss	3 (immersion)	2017	99%
KSC	Gas	Boiler	8	Wessex ModuMAX 220 high efficiency	262	2007	87%	-	-	-	-	-	-
Main Outpatients	LTHW	Plate Heat Exchanger	1	LTHW - Alfa Laval	150	2007 estimated	-	-	-	-	-	-	-

Main Outpatients/ Princess Alexander	Steam	DHW Plate Heat Exchanger	2	Alfa Laval/ ts6mfg	150	2018	-	-	-	-	-	-	-
Outpatients/ Princess Alexander/ Rowan Bentall	Steam	Plate Heat Exchanger	2	Spirax	1300	2018	-	-	-	-	-	-	-
Esher Wing	Steam	DHW Plate Heat Exchanger	3	Spirax Sarco Easiheat EH-5W-ST-DHW-EL-PL-P	855 estimate d	2013	-	Calorifier	4	Cotswold 555 X	200	1972	-
BMW	LTHW	Plate Heat Exchanger	1	LTHW - Alfa Laval	150	2007	-	-	-	-	-	-	-
BMW	Steam	Calorifier	2	-	-	1991	-	DHW Calorifier	2	-	-	1991	-
Maternity & DSU	LTHW	Plate Heat Exchanger	1	LTHW - Alfa Laval	220	2007	-	-	-	-	-	-	-
Maternity & DSU	Steam	Calorifier	2	IMI Rycroft Ltd, NSZF 3818s	100	1994	-	DHW Calorifier	2	IMI Rycroft Ltd, MXHC	-	1994	-
Estates & facilities	Steam	Calorifier	2	-	-	-	-	-	-	-	-	-	-
Sir William Rous unit	Steam	Plate Heat Exchanger	1	Spirax Sarco - PHS-1H-ST-HTG-EL3-HL-V	100	2008	-	DHW Plate Heat Exchanger	1	Spirax Sarco - PHS-2H-ST-DHW-EL3-HL-V	418	2008	-

7. Heat Networks and Opportunities on Site

It is estimated that by 2050, 70% of the world's population will be living in cities which means that cities will have to become increasingly efficient and self-sufficient in energy to not only meet demand but to improve air quality and reduce emissions. Heat networks connect multiple heat producers through pipework to recover waste heat arising as a by-product of industrial and commercial activities for building space heating and domestic hot water. The London Heat Map was created to spatially map the existing heat networks in each Borough of London, as well as proposed heating networks. A recent study commissioned by Kingston hospital in 2020 explored the potential of heat networks near the hospital, the proposal is seen in Figure 39 is available to view on the London Heat Map.

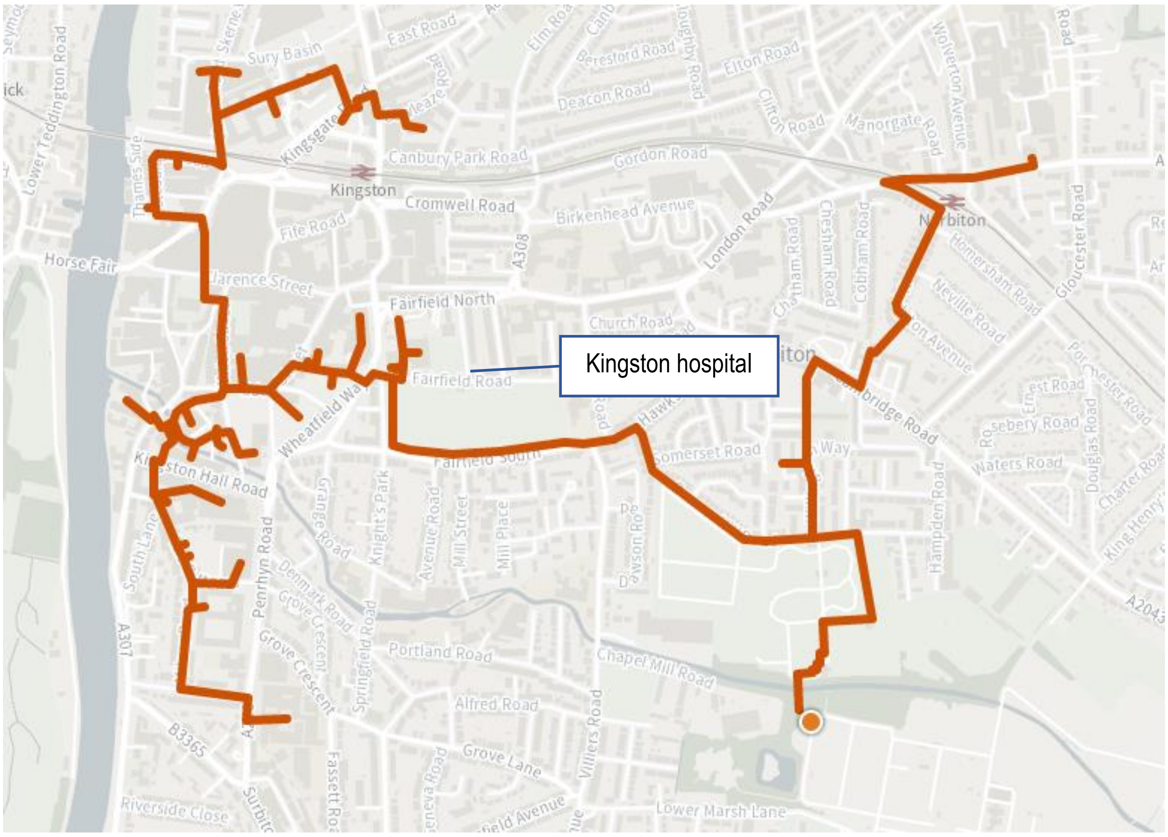


Figure 39 Planned Heat Networks Near Kingston Hospital

The proposed solution is to connect to the Hogsmill district heating network (DHN). In this network, waste heat is generated from treatment of sewage and waste heat from a crematorium.

The proposed DHN however, only provides enough for baseload heat. Figure 40 summarises various options that were studied to decarbonise heat at the Trust. To cover peak loads, the lowest carbon option is to use local LTHW boilers or heat pumps, identified in Figure 40. By opting for DHN connection and LTHW boilers or heat pumps the Trust will need to de-steam and convert the steam network to a wider LTHW network.

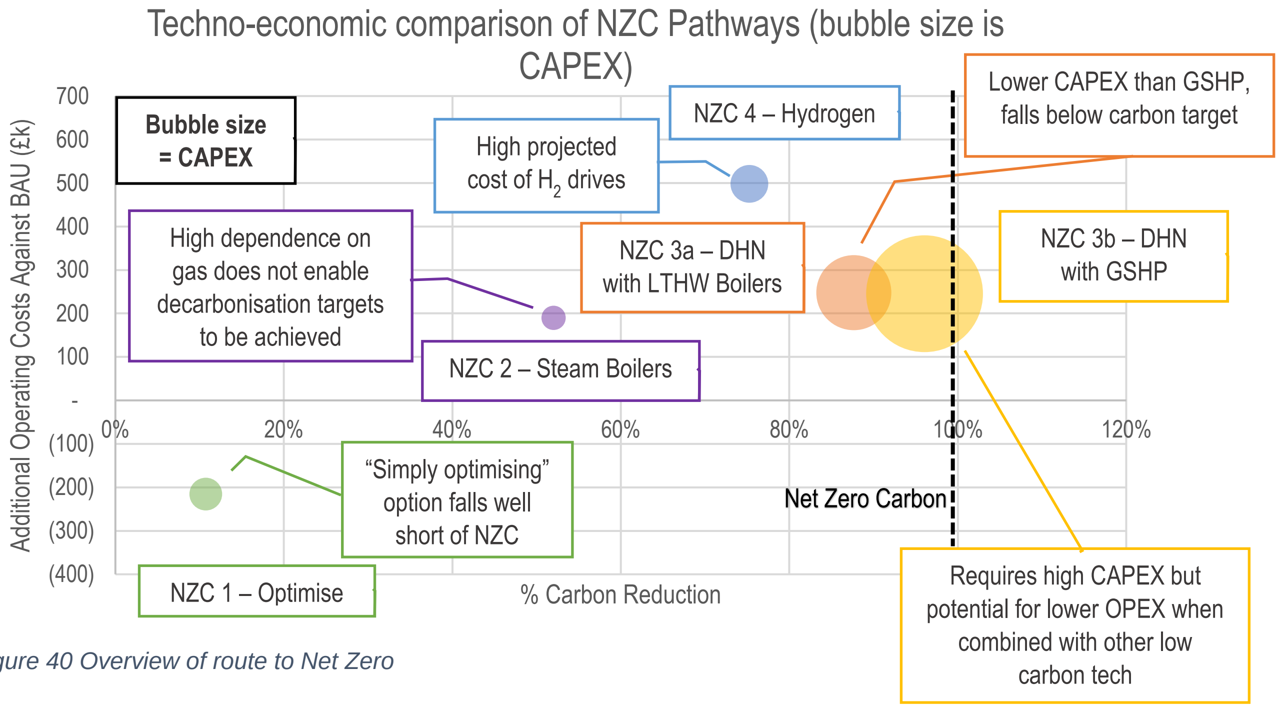


Figure 40 Overview of route to Net Zero

Due to complexity of the project, further detailed surveys are required to determine the feasibility, however the potential to access a local DHN will help significantly reduce the Trust carbon emissions, whilst potentially help fund the de-steaming of the site.

8. Determining the Whole Solution

8.1 Context & Methodology

Following the detailed analysis of energy consumption, creation of carbon emission baseline and projection of Trust emissions towards 2040, as well as detailed surveys of the outlined buildings with the Trust, the next phase of this HDP is a two-step process, which is outlined in Figure 41. Firstly, the Trust must optimise its energy consumption to minimise peak electrical and thermal energy demand. This has the following benefits;

- Operational cost savings through lower variable costs from energy bills
- Capital cost savings as the size of low carbon generation technology and associated infrastructure can be minimised

The second step is to identify the most feasible technology currently available to decarbonise heat. Although offsetting is likely to play an important part in the Trust's overall journey to net zero, it will not be discussed within this heat decarbonisation plan.

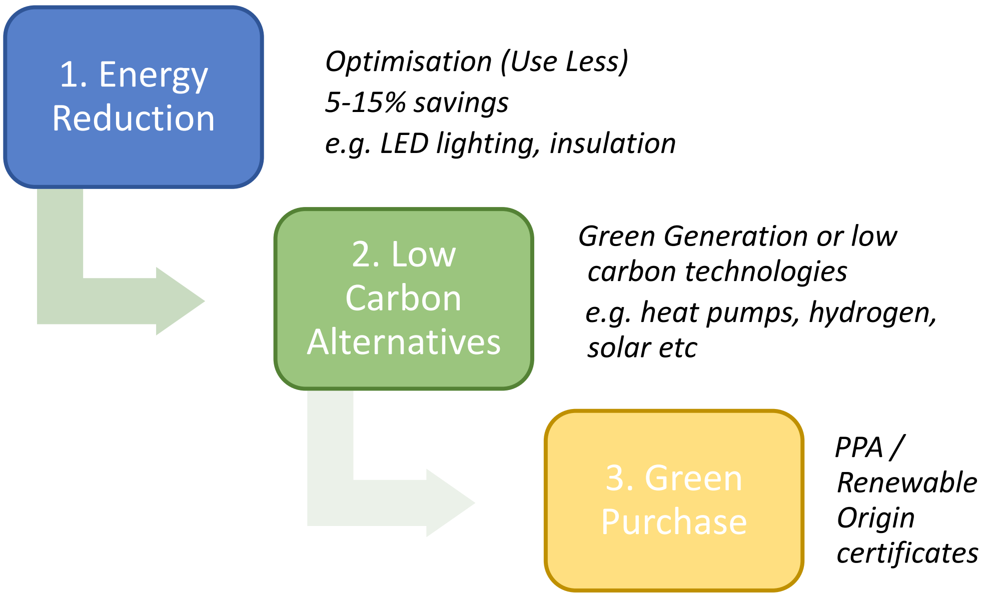


Figure 41 Stepped methodology to decarbonise heat

8.1.1 Whole Building Approach

As outlined within Figure 40 above, the first step in a HDP is to optimise electricity and heating fuel consumption, thus providing the best foundation for the installation of low carbon technology. While it is clear that aiming to decarbonise heat will lead to a focus on the various heat delivery systems within the Trust's building stock, there are other areas that also must be targeted by taking a whole building approach to optimisation including electricity loading and building fabric.

Taking a whole building approach will lead to a reduction in expenditure for the Trust in both operational costs as less electricity and natural gas is consumed, but will also lead to a reduction in capital expenditure as the reduction in heat and electricity peak demand will minimise the size of low carbon generation technology required, as well as any infrastructure upgrades resulting from the shift to low carbon technology.

8.1.2 Decarbonisation of Electricity

After optimisation the next challenge to be tackled is the decarbonisation of the 'fuel' providing heat within the Trust's building stock. Currently, this is provided by natural gas via boilers and CHPs. Figure

42 outlines the BEIS projected carbon intensities of the major utilities delivered via current grid infrastructures towards the NHS Footprint Plus net zero target year of 2040.

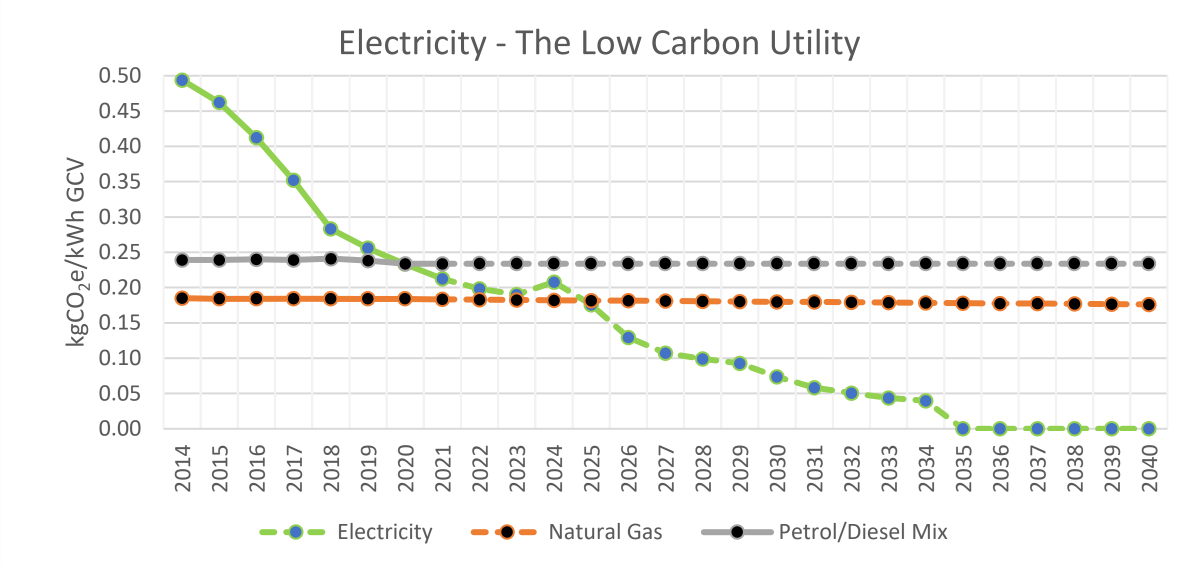


Figure 42: Carbon intensity forecasts for major utilities consumed by the Trust

This graph outlines that natural gas, as well as other fossil fuels, are not projected to decarbonise significantly. While there will be a small reduction in the decarbonisation of grid natural gas through grid injection of biomethane, the nature of fossil fuels means that they are not possible to decarbonise without technologies like carbon capture which are not currently commercially viable.

However, electricity delivered via current grid infrastructure is projected to decarbonise significantly through increased use of renewable or low carbon generation technologies such as wind, hydro, solar and nuclear. Furthermore, in October 2021 the UK Government announced a commitment to decarbonise the electricity grid by 2035, this makes electricity the current best available utility to decarbonise heat.

8.1.3 Heat Decarbonisation Technologies

Multiple technologies exist which could be theoretically be utilised to decarbonise the hospital's heat demand including currently-available technology such as biomass, hydrogen or direct electrical boilers. However, these have been discounted as viable options to decarbonise heat in this HDP on the reasons outlined within Table 74.

Table 74: Low carbon heat technologies considered unviable for Trust

Low Carbon Technology	Rationale for omission
Biomass	- High operating costs, - Resilience, space and safety challenges associated with delivery and storage of fuel - Ethical issues with use of land for biogenic fuel-source
Direct Electric	- Extremely high operating costs - Necessitates very large electrical infrastructure.
Solar Thermal	- High capital cost - Limited scope to deploy - Utilises space that could be used for solar PV systems
Hydrogen	- Projected high operating cost - Unlikely to be entirely zero carbon - Technology not expected to be available within initial 2030 decarbonisation timescale.

With the technologies outlined Table 74 deemed unsuitable, the core heating option that must be deployed to deliver the widescale heat decarbonisation will be heat pumps.

In basic terms, a heat pump works by extracting heat from a source, either air, water or the ground, upgrading this heat via a cycle of evaporation, compression, condensation and expansion of a refrigerant, and then transferring into a heating system. As the compressor and other pieces of equipment within a heat pump are electrically driven, heat pumps are able to take advantage of the decarbonising grid to provide a low carbon heat source.

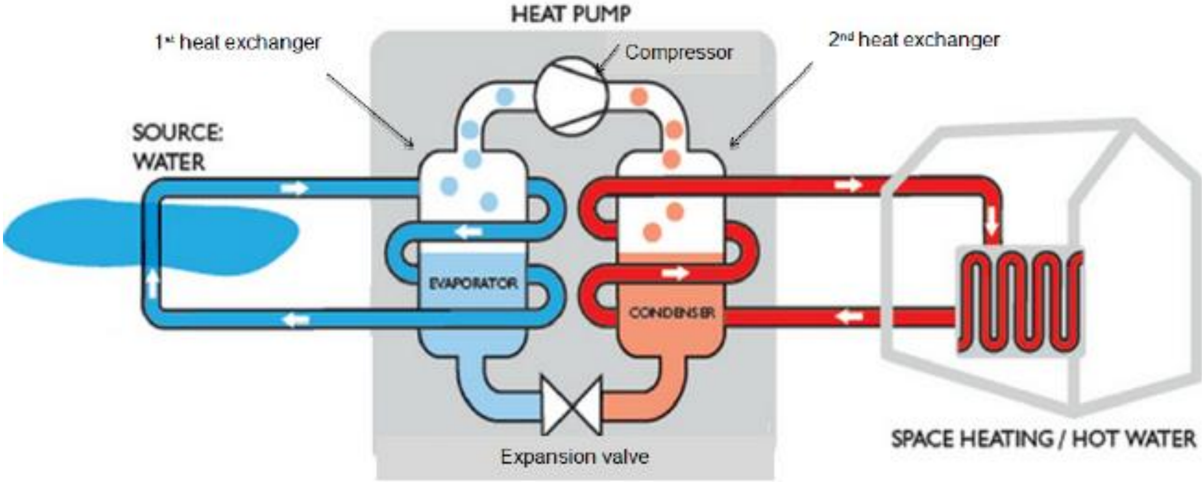


Figure 43: Diagram of a water-source heat pump (Ninikas et al., 2014)

The major advantage heat pumps have over direct electric heating system is efficiency. The efficiency of a heat pump is referred to as its coefficient of performance (COP) and a typical heating system yields a coefficient of performance for a heat pump system of around 2.5 - 4. Therefore, for every 1kW of electricity input, 3-4kW of heat output will be delivered. When compared to the efficiency of an electric boiler, with an efficiency equivalent to a COP of 1, the utilisation of a heat pump requires significantly less electricity which makes the technology much more affordable to operate and means the supporting electrical infrastructure need not be as highly rated.

The COP of a heat pump is dependent on the temperature difference between the heat source (e.g. air, ground, water) and the flow temperature of the heating system. The greater this difference, the lower the COP will fall and therefore more electricity will be needed to achieve the same level of heating thus increasing operational costs. For this reason, any heating systems being supplied with heat pumps should be operated at as low a temperature as possible.

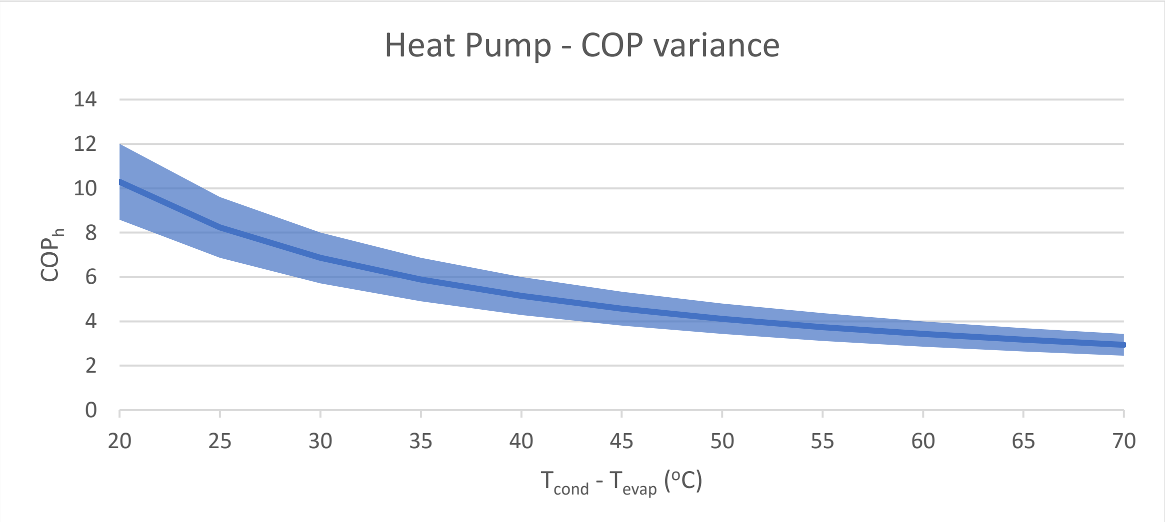


Figure 44: Impact of increasing temperature lift on typical heat pump coefficient of performance

8.1.4 Heat Pump Selection

The first challenge when selecting heat pumps is which type to select. They are broadly broken down into three types which relate to the source of heat utilised; air source (ASHP), ground source (GSHP) or water source (WSHP). Each of these types have positives and negatives associated with their choice, as well as limitations on their application.

Enabling Works for Heat Pumps

In the majority of instances where a heat pump is to be retrofit into a building which was previously supplied with heat from boilers, there are generally a range of enabling works which may be required. Firstly, due to the utilisation of electricity in heat pumps, the electrical infrastructure must be reviewed to confirm if the various stages of equipment have sufficient capacity, from the electricity grid to each point of use within buildings. Secondly, due to the desire for high efficiencies, the heating system used to heat buildings must be designed to be as low as possible. A typical gas boiler heating system can run at 70˚C+, whereas a heat pump heating system should be designed to run at closer to 50˚C to minimise electricity consumption. With this in mind, enabling works must be carried out to convert a heating system to operate at these lower temperatures, which includes conversion of secondary heating plant, replacement of heat emitters (e.g. radiators, radiant panels, heater battery & AHU coils) with larger-surface area equivalents which enable the same quantity of heat to be emitted at lower temperatures.

Air Source Heat Pump (ASHP)

An ASHP upgrades heat from the outside air to a heating system, which can be air-to-air, with heat supplied via a fan, or air-to-water, where the heat is transferred to a central heating system. The positives of ASHPs are that they typically require less capital expenditure than GSHPs/WSHPs and they are easier to install than a GSHP, however they typically have lower COPs and therefore are more expensive to operate. ASHPs also have a practical limit to the size of individual units which generally makes them unsuitable for large acute core buildings or centralised energy centres.

Ground Source Heat Pump (GSHP)

A GSHP upgrades heat from the ground to a heating system, which can be in the form of a horizontal or vertical open or closed loop GSHP. A horizontal array GSHP utilises coils of pipework buried 1-2m deep, whereas a vertical array utilises a borehole to access heat either via an open or closed loop system. An open loop system abstracts water from ground water (e.g. via an aquifer), then extracts the heat and returns the water via another borehole. A closed loop system consists of boreholes filled with a thermal liquid which takes heat out of the surrounding groundwater without physically abstracting water. The positives of GSHPs are that they are typically more efficient than ASHPs and therefore have lower running costs. Open-loop GSHPs are can be suitable for large thermal demands, as long as there is sufficient space and suitable ground conditions. The main drawbacks of GSHPs are that they require generally demand significantly more capital expenditure than ASHPs and their application can be limited due to lack of available space or unsuitable ground conditions.

Water Source Heat Pump (WSHP)

A WSHP can upgrade heat from a variety of sources including rivers or canals, sewers or from heat networks. While they are similar to GSHPs, the source of heat may require planning permission and specific project planning if trying to abstract heat from sewers or mine water, for example. However, generally WSHPs have similar or greater efficiencies to GSHPs due to the stable source temperature however can require significantly less capital and space requirements than GSHPs. WSHPs therefore typically offer the best option but the opportunities to deploy them are often very limited.

8.2 Optimisation Opportunities

Table 75 shows the optimisation opportunities at Kingston Hospital. It combines findings from the RE: FIT project as well as the site Energy appraisal project.

The RE: FIT project identified buildings with LED lighting, glazing, BMS, Solar and AHU opportunities and are included in the table below. LED lighting and double glazing continue to be upgraded as part of the RE: FIT Project.

The RE: FIT solar survey identified outpatients, ED, Esher wing and maternity buildings as viable options for Solar PV as they presented a shorter payback in years. To allow for a full analysis with low carbon options Table 75 includes buildings that also have a longer payback, such as Princess Alexander and Sir William Rous. There is potential for 500,00 kWh/year from solar PV.

Roof insulation for each building was evaluated during site surveys where an opportunity for improvement was identified has been included in Table 75.

Table 75 Optimisation opportunities at Kingston Hospital

			Electricity		Heat	
Building	Opportunity	Description	Annual Reduction (kWh)	Peak Reduction (kW)	Annual Reduction (kWh)	Peak Reduction (kW)
Davies Wood House	Lighting	LED	4,939	2	-	-
	Glazing	Double	-	-	8,939	3
	Roof Insulation	High	-	-	7,099	10
Mortuary & Patient Affairs	Lighting	LED	5,819	1	-	-
	AHU Fan		12,045	1	-	-
	Roof Insulation	Low	-	-	3,759	7
	Controls	BMS & Analytics	2,349	0	3,587	0
Staff Day Nursery	Lighting	LED	5,797	2	-	-
	Glazing	Double	-	-	19,984	6
	Roof Insulation	High	-	-	7,920	4
Vera Brown House	Lighting	LED	18,018	6	-	-
	Controls	BMS & Analytics	7,429	2	5,668	2
Wolverton Centre	Lighting	LED	8,811	3	-	-
	Roof Insulation	High	-	-	5,491	24
ED	Lighting	LED	43,164	5	-	-
	Solar PV	-	58,820	7	-	-
	Controls	BMS & Analytics	17,421	2	11,955	1
KSC	AHU Fan					
	Roof Insulation	High	-	-	114,078	3
	Glazing	Double	-	-	90,861	26

Main Outpatients	Lighting	LED	66,715	8	-	-
	Solar PV	-	44640	5	-	-
	Wall Insulation	Internal	-	-	207,624	57
	Roof Insulation	High	-	-	86,651	161
	Controls	BMS & Analytics	26,926	3	48,060	5
Princess Alexandra Dental Wing	Solar PV	-	37,010	4	-	-
	Roof Insulation	High	-	-	11,382	21
Esher Wing	Solar PV	-	79,750	9	-	-
	Controls	BMS & Analytics	86,123	10	120,360	14
	Pipework	Insulation				
Bernard Meade Wing	Lighting	LED	59,565	7	-	-
	AHU	Run around coils				
	Wall Insulation	Internal	-	-	185,372	51
	Roof Insulation	High	-	-	77,364	52
	Controls	BMS & Analytics	24,040	3	42,909	5
	Pipework Insulation					
Maternity & Day Surgery Unit	Solar PV	-	227,700	26	-	-
	Roof Insulation	High	-	-	106,910	15
	Controls	BMS & Analytics	33,221	4	59,297	7
Estates	Controls	BMS & Analytics	9,998	3	9,998	3
Sir William Rous	Solar PV		20,290	2	-	-
	Roof Insulation	High	-	-	4,237	2

8.3 Low Carbon Technology Solution

A heat options appraisal study completed in associated with the compilation of this plan evaluated a number of low carbon generation and distribution technologies. Table 76 summarises the cost and carbon implications of this work.

Table 76 summary of low carbon technologies

Opportunity	2040 carbon saving (%)	2040 Cost saving (£/yr)	CAPEX (£)	Recommendations	Priority
Biofuel Generators	<1%	(£1.7k)	£0	Investigate possibility to use HVO in generator	Low
Solar PV	<1%	£31k	£0	Pursue possibility of installing solar PV through PPA agreement	Medium
Remove CHP	48%	(£332k)	£0	This is essential to widen scope for available low carbon technology implementation	Critical

LTHW Network	2%	£6k	£3.1m	Utilise available grants to minimise CAPEX impact of critical enabling project	Critical (for DHN)
District Heating Network	37%	(£63k)	£1.6m	Consider detailed survey to obtain accurate costs and explore funding options	High
GSHPs (with DHN)	9%	£2k	£7.9m	Consider survey to assess suitability of GSHPs	High
LTHW Boilers (with DHN)	0%	£0	£163k	Critical project for DHN connection if GSHP is not considered	High
Hydrogen boilers	25%	(£281k)	£810k	Keep abreast of policy developments which may improve H2 fuel economics	High

Based on the surveys conducted, the following low carbon solutions are proposed for each building. Subject to connection to the local district heat network (DHN), a new LTHW network is proposed. The proposed LTHW network will be heated by the DHN. Outbuildings will not be part of the LTHW network, LTHW will be raised with individual air source heat pumps (ASHP) instead. Moving the site away from steam will mean additional changes are required within the existing infrastructure, including pipeline upgrades, radiators, AHU and electrical capacity. The following solution also allows the site to move away from CHP as a main source of heat.

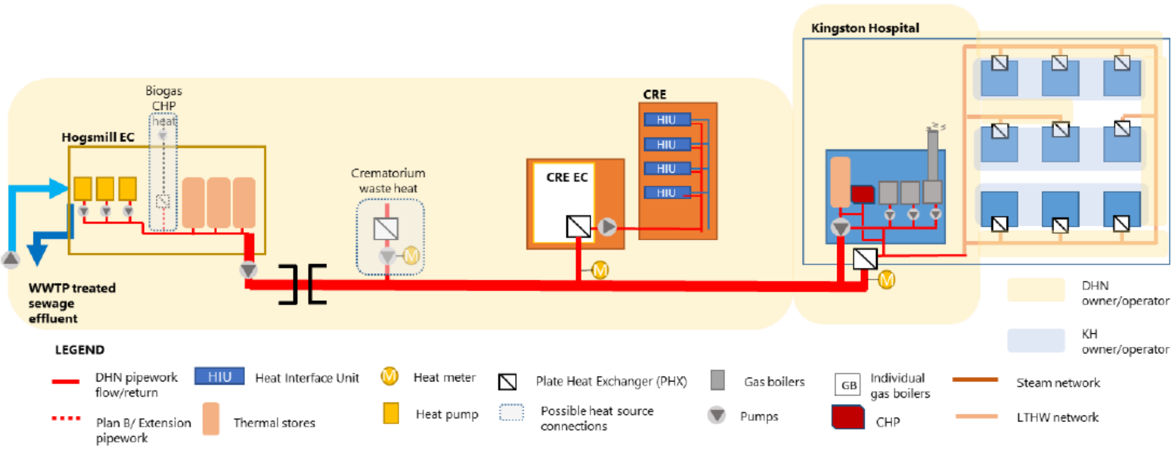


Figure 45

The proposed DHN studied by XX XXX. has been sized at 2 MW, approximately 80% of the proposed LTHW networks peak demand, a more detailed study is still required to ensure this is sufficient for the site and whilst still early in the project it may be possible for the DHN to scale up to supply 100% of the LTHW demand. The cost to connect to the DHN is estimated to be around £2million with flexible standing and variable rates. The boundary of operation is still under review with a strong preference to appoint a 3rd party to manage and operate at the new onsite DHN energy centre.

Table 77 Low carbon solutions for Kingston hospital

	Heat Pump						Heat Emitter Upgrade		
Building	Type	Rating (kW)	Location	Indoor Pipelines	Heat Meter	Impact on Capacity (kW)	Radiator	AHU	Additional Comments
Davies Wood House	ASHP	80	West side of building	Yes	1	18	Yes	-	
Mortuary & Patient Affairs	ASHP	140	North of building	Yes	1	32	Yes	1	
Staff Day Nursery	ASHP	150	Same as Mortuary	Yes	1	33	Yes	-	
Vera Brown House	ASHP	280	West side of building	Yes	1	63	Yes	-	
Wolverton Centre	ASHP	350	West side of building	Yes	1	79	Yes	-	Upgrade to electrical infrastructure required
ED	DHN			-	1		Yes	3	
KSC	DHN			Yes	1			5	Estimated no. of AHU
Main Outpatients	DHN			-	1		No	2	
Princess Alexandra Dental Wing	DHN			-	1		No	5	Estimated no. of AHU
Esher Wing	DHN			Yes	1		Yes	15	

Bernard Meade Wing	DHN	Yes	1	Yes	12	
Maternity & Day Surgery Unit	DHN	-	1	No	12	
Estates	DHN	-	1		-	
Sir William Rous	DHN	Yes	1	Yes	1	
Rowan Bentall Wing	DHN	-	1		1	

9. Energy & Carbon Impact

Figure 46 highlights the projected impact of the decarbonisation projects outlined in prior sections on the site's annual carbon emissions in 2040. The first bar represents the carbon emissions associated with energy use in 2021. Decarbonisation of the national electricity grid is forecast to reduce emissions by 6% with building fabric, energy efficiency and solar PV opportunities saving a further 7% resulting in annual emissions of 8723 tCO_2e following optimisation projects. By decommissioning the CHP on site, emissions will be further reduced by 44% as reliance on natural gas is reduced. The transition from boilers to district heating for base heat load supply and air source heat pumps for outbuildings will eliminate a further 31% of emissions to leave just 1,493 tCO2e in 2032 which meets the 80% carbon reduction target set by NHS England. The remaining carbon emissions can then be mitigated by transitioning away from the remaining gas and by procuring certified green electricity or through the use of GHG Removal certificates.

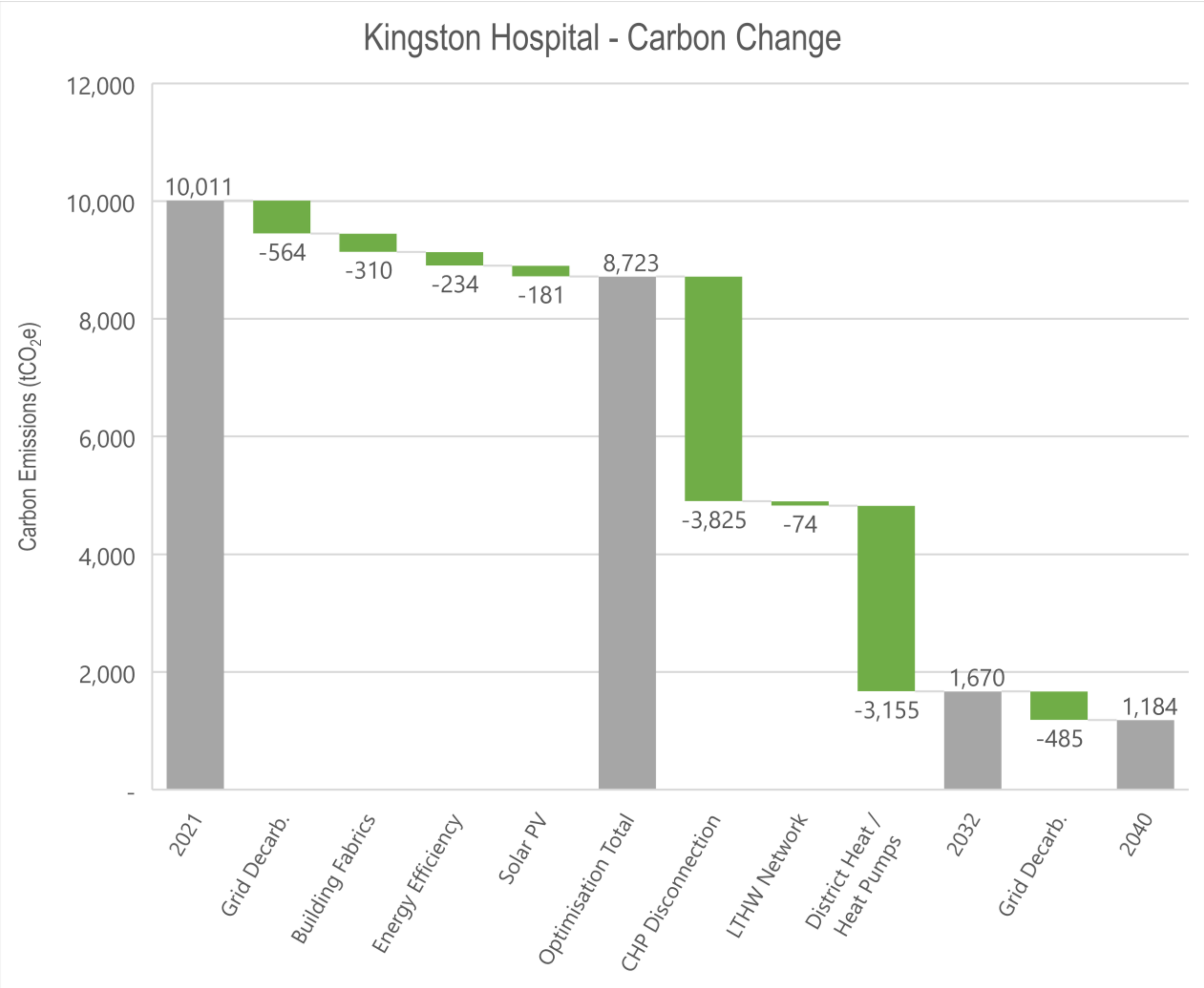


Figure 46. Waterfall chart of carbon change per opportunity

10. Estimating Cost

Table 78 summarises the types of opportunity that have been identified for each building across the acute campus. Budget costs were determined using a combination of supplier quotes following surveys, cost factors published in literature and experience of similar project delivery within other healthcare setttings.

Table 78. CAPEX for opportunities identified in each building at Kingston Hospital

Building	Item								
	LED	Solar	BMS & Analytics	Glazing	Wall Insulation	Roof insulation	CHP Removal	Plantroom & Heat Emitter Upgrades	Heat Pump
Davies Wood House	£1,976	-	-	£4,000	-	£19,400	-	£14,270	£82,800
Mortuary & Patient Affairs	£2,328	-	£1,212	-	-	£24,880	-	£22,201	£144,900
Staff Day Nursery	£2,319	-	-	£49,000	-	£10,000	-	£26,433	£155,250
Vera Brown House	£7,208	-	£3,346	-	-	-	-	£52,687	£289,800
Wolverton Centre	£3,525	-	-	-	-	£31,000	-	£44,306	£362,250
ED	£17,268	£86,248	£7,720	-	-	-	-	£29,315	-
KSC	-	-	-	-	-	£87,320	-	£253,039	-
Main Outpatients	£26,690	£60,365	£13,596	£102,000	£31,393	£20,800	-	£30,300	-
Princess Alexandra Dental Wing	-	£86,815	-	-	-	£27,120	-	£20,796	-
Esher Wing	-	£115,494	£41,528	-	-	-	-	£409,558	-
Bernard Meade Wing	£23,830	-	£12,139	-	£33,877	£74,960	-	£113,626	-
Maternity & Day Surgery Unit	-	£295,880	£16,775	£14,000	-	£135,760	-	£86,040	-
Estates	-			£22,500	-	-	-	£10,773	-
Sir William Rous	-	£52,220	£3,748	-	-	-	-	£43,451	-
Rowan Bentall Wing	-	-	-	-	-	£18,480	-	£9,141	-

Table 79 summarises the CAPEX costs of each opportunity whilst also including costs for the removal of the CHP, addition of a DHN and the overall costs of upgrading the LTHW network. The table also includes the impacts on utility cost for 2021 and 2040. The savings identified in this table combine both heat and electrical costs.

Table 79. CAPEX and OPEX impact for each opportunity at Kingston hospital

Building		Opportunity								
	LED	Solar	BMS & Analytics	Glazing	Wall Insulation	Roof insulation	LTHW Network inc. heat emitters and plantroom	CHP Removal	Heat Pump	DHN
CAPEX (£)	£85,000	£697,000	£100,000	£192,000	£65,000	£450,000	£1,700,000	-	£2,000,000	£1,035,000
Utility Cost Impact 2021 (£/year)	-£12,000	-£26,000	-£20,000	-£6,000	-£11,000	-£17,700	-£5,000	-	-	-
Utility Cost Impact 2032 – Post CHP Disconnection (£/year)	-£23,000	-£50,000	-£31,000	-£7,300	-£12,500	-£21,400	£3,000	-£134,000	<£1,000	£325,000

Figure 47 shows the cost change for each opportunity, including the impact of the change in the cost of grid utilities. The first bar represents the total costs associated with energy use in 2021. Due to the Trust's high dependence on gas, rising grid gas costs cause a 6.4% increase in utility costs despite decreasing grid electricity prices. The impact of rising gas prices will be avoided following CHP disconnection. Switching to district heat and air source heat pumps will have a negative impact on utility costs, causing a 16% increase in costs after all optimisation measures have been implemented. Decreasing grid electricity price will drive down total energy costs by 8% in 2040 from the projected 2032 costs.

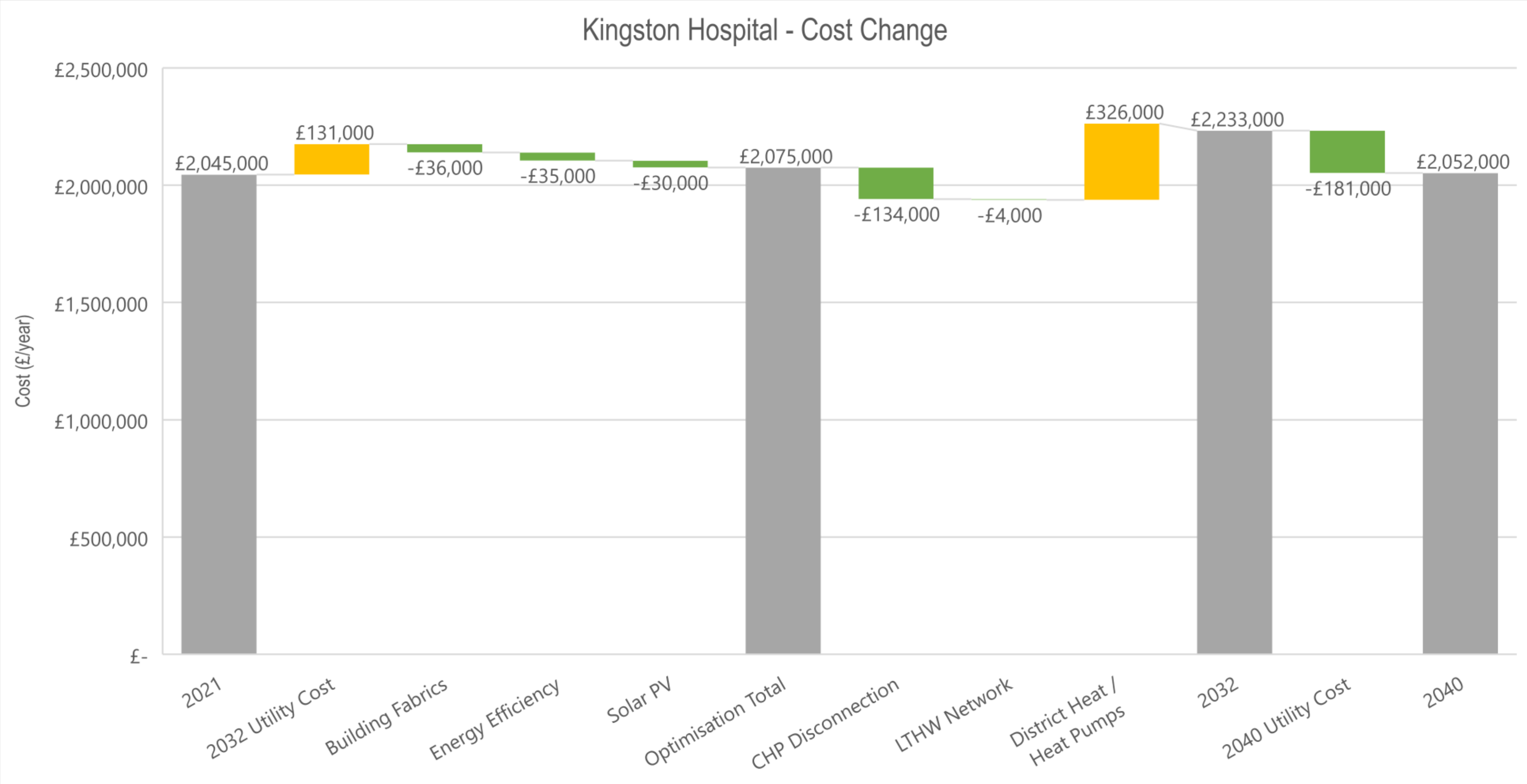


Figure 47 Projected change in OPEX at Kingston hospital, electrical power and heat only

11. Delivery & Resources

11.1 Governance

This plan will be presented to the senior management of the Trust and a summary will be presented to the Board. This will raise awareness of the transformations required to inform Trust operations that will last for the long term and deliver not only value for money but substantially diminish the negative externalities associated with carbon emissions.

The Trust intends to procure the design, building, operation and maintenance services to replace the existing Veolia service during the 2022-23 financial year. The solution will be delivered by August 2024 to coincide with the end of the current agreement. This Heat Decarbonisation Plan will form the foundation of the information provided to bidders.

The final delivered solution will be dependent on a number of factors including changes to the commercial and technical feasibility of technologies and the availability of capital or alternative funding solutions such as the Public Sector Decarbonisation Scheme and possibly third-party finance.

The delivery process will be tracked through the Trust's Estates Steering Group and annual Green Plan which is a board-level document.

Key performance indicators will include measures of carbon reduced as well as tracking the conservation measures needed to comply with the NHS's Net Zero trajectory.

11.2 Delivery & Monitoring Plan

While the majority of the preparatory work is planned to be carried out in 2022-24, the end result of this plan will take many years to complete. This document will act as a foundational document for all decision making around heating for at least the next 5 years.

Monitoring will be managed initially through the Energy Strategy Working Group which meets quarterly.

11.2.1 Project Phasing

Figure 48 outlines an indicative timeline for the implementation of the Trust's heat decarbonisation programme over the next 4 years. It should be noted that this is provisional and will be largely dependent on successfully securing suitable sources of funding (discussed in further detail in section 11.4.1). Figure 48 shows that the short-term priorities for the Trust will the progression of energy efficiency projects, a transition away from a CHP-led energy strategy and critically enabling works to transition to widescale deployment of low carbon heating systems.

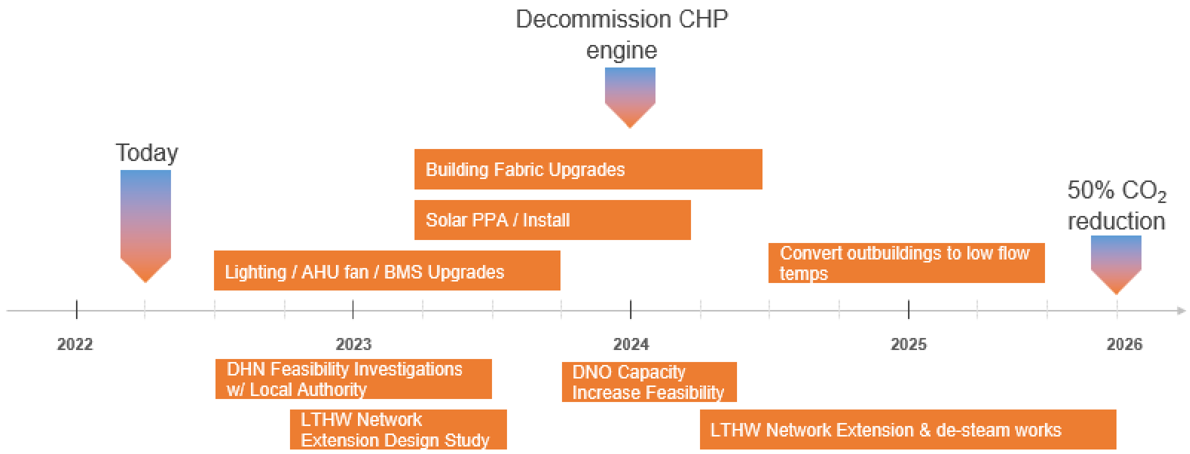


Figure 48: Indicative project phasing (short-term)

Figure 49 illustrates elements of the heat decarbonisation programme which will take place between 2026 – 2030. This primarily involves deploying heat pumps for buildings selected for decentralised solutions and connecting into the local District Heating Network. Further down the line, it will be important for the Trust to re-evaluate the low carbon heat technology landscape to consider whether the long-term strategy needs to flex to incorporate other options.

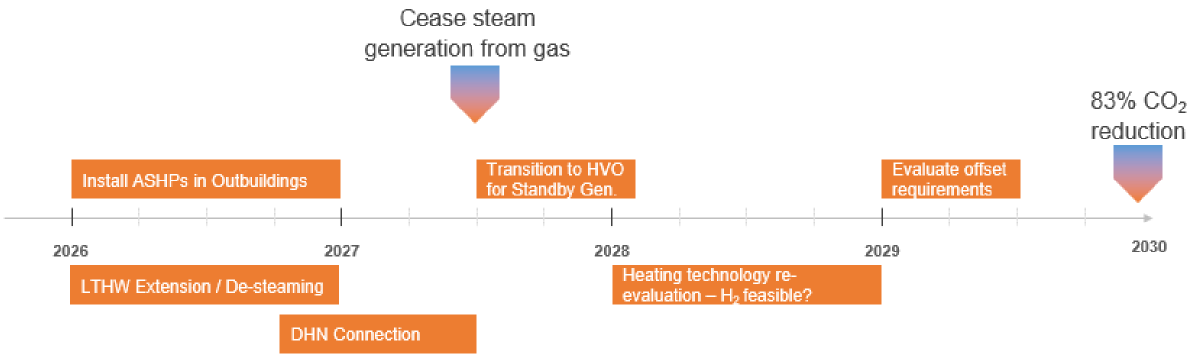


Figure 49: Indicative project phasing (long-term)

11.2.2 Measurement & Verification

Overview

The measurement and verification plan developed to monitor energy savings from the various projects outlined in previous sections of this report complies with the International Performance Measurement and Verification Protocol (IPMVP). As the energy savings cannot be directly measured in all cases, where direct measurement of savings can be metered, for example within the Solar PV project, savings will be determined by comparing measured normalised consumption before and after implementation of the project.

The standard approach we are proposing for measuring the savings is to use the avoided energy consumption approach. This means that we will create a mathematical regression model of the baseline period data. For the reporting period we will compare the output of the baseline model to the actual consumptions in the reporting period. The difference between the two will be the savings. The figure below is extracted from IPMVP and illustrates this principle.

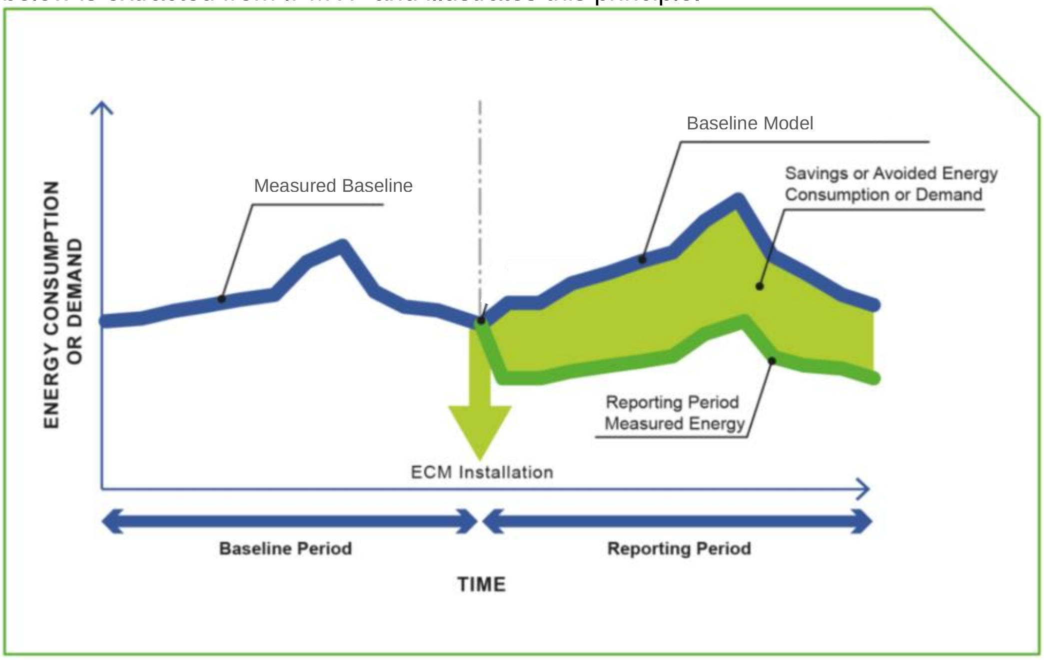


Figure 50 - Illustration from IPMVP

Metering Approach

To collect the necessary data for effective Measurement & Verification, M&V, the aim within each project where applicable is to include the installation of relevant types of meters to existing and new infrastructure. Direct Energy Measurement will be conducted, which will collect consumption data over an initial M&V period of 3 years and beyond. All data will be collated via the sites PLC or BMS and subsequently transferred to an existing automated Monitoring & Targeting software where currently available, or an applicable software solution will be sought out to enable easy access to the data.

Individual electrical and heat meters (sub meters) will be installed where relevant to measure the electricity and heat supplied. Additionally, by monitoring the gas consumption of the existing boilers using pre-existing submeters and by monitoring the electricity consumption to the newly installed equipment, we will clearly be able to verify the energy and carbon savings following installation of the new equipment.

Upon collection of this additional data, a baseline period will be selected to best determine the changes made by the various projects. This baseline will use actual data, not estimates, and aim to cover a period of 12 months before the effects of the COVID pandemic were felt on 'normal' operations. A normalisation factor will be utilised to allow for changes to energy consumption from factors such as weather and occupancy to be accounted for or eliminated, which is key to ensuring the true benefits of the projects are determined. Factors like Heating Degree Days, HDD, and occupancy will be utilised to best quantify the project benefits.

11.3 Resourcing

11.3.1 Existing Resources Available

This plan will be owned and held for reference by the Trust's Utilities, Waste & Sustainability Manager. Planning and implementation will be led by the Director of Estates & Facilities. Financial resourcing will be dependent on the availability of grant funding and ultimate technical feasibility of the most economically advantageous decarbonisation options.

The Trust's capital budget is under pressure but the Trust's Investment Committee will be appraised of the situation and will govern further investment decisions. Furthermore, the Trust's project management resource is currently constrained below the expected scale demanded by works of this scope.

11.3.2 Anticipated Resources Required

It is anticipated that, in an effort to best assure prompt and successful delivery of the multiple projects outlined, a full time Project Manager, PM, would need to be hired. For a project manager within the NHS, this would typically require a budget of £60,000 per annum. When budgeting for this and other project costs, a rule of thumb will be applied for project costs calculated at 2.5% of the total capital expenditure, which for the projects outlined would come to approximately £158,000.

Initially, a master programme for the projects would need to be established by the PMs, to account for all project steps from kick off to completion. This would include, but not be limited to, engaging suppliers and tendering for the project works, ensuring continued operations of the heating and electrical infrastructure during project installation, commissioning and performance testing, plus sign off and handover to the estates department before the completion of projects.

It is also anticipated that the Trust will need continued external, expert consultancy support to ensure the delivery of selected design/build suppliers is critically assessed. This will ensure value for money for capital expended and ensure that decarbonisation targets are achieved.

11.4 Procurement & Funding

11.4.1 Funding Options

The Trust recognises that the significant capital costs involved with delivering the full scope of projects outlined in this report will not be available within the organisation's standard capital programme. On this basis, it is critical that alternative options for funding elements of the scope are considered and pursued.

Public Sector Decarbonisation Scheme (PSDS) – Phase 4 Onwards

Initially launched in September 2020, the PSDS is a grant funding scheme administered by Salix Finance. In phase 1 of the scheme, public sector bodies were eligible to apply for grant funding to deliver energy efficiency and heat decarbonisation projects. In subsequent phases of the scheme the eligibility criteria of the scheme were significantly narrowed to the funding of projects which could demonstrate a 'whole building' approach to heat decarbonisation.

Given the scale of the challenge of decarbonising heat across the public sector, both from a complexity and cost perspective, it is anticipated that there will be future phases of the PSDS or similar grant-based schemes. Without further PSDS phases (or equivalents) it is difficult to see how significant in-roads to can be made to the ambitious net zero targets set out by the NHS. It is therefore critical that the Trust maximises chances of successfully securing grant funding to deliver the schemes laid out in this plan. Key enabling steps to achieve this include;

- Ensuring a 'whole building' strategy is in place for all significant property (facilitated by this HDP)
- Prioritisation of projects based on wider Development Control Plan for site and commercial viability.
- Acting early when future funding phases are announced to ensure that funding bid is delivered at the 'front of the queue'.

Private Financing Options

Grant funding represents the most favourable route for the Trust to fund its heat decarbonisation programme but it is conceivable that this option will not provide all or any of the funding required to support the net zero agenda. In this case, the Trust must consider alternative funding mechanisms to deliver projects.

Schemes that will be considered include Energy Performance Contracting approaches which are outlined in further detail in Section 11.4.2, funds such as the Mayor of London Energy Efficiency Fund (MEEF) or local equivalents and also smaller-scale community funding initiatives which may be utilised to deliver specific elements of the projects.

Trust Capital Funding

Whilst it is clear that the Trust will not be able to deliver the entirety of the heat decarbonisation scope within its standard capital programme, the HDP will be used to inform where capital spend can be optimised to deliver energy efficiency and heat decarbonisation benefits within wider works. This will include ensuring that any significant new developments or deep refurbishment programmes allow for the additional marginal costs associated with ensuring these buildings meet Net Zero standards with particular focus on low temperature heating regimes and elimination of decentralised gas use.

Furthermore, the Trust commits to reviewing which elements of the wider project can be delivered via Trust capital on a spend-to-save basis. I.e. where the commercial viability of the technology or approach lends itself to providing a strong return on investment.

11.4.2 Procurement Routes

It is anticipated that a fully compliant open tender will be carried out during the 2022-23 financial year to appoint a supplier to design and build the initial stage. This may also include operation and maintenance of the delivered solution. Suppliers are already showing interest in the future of the Trust's heating (and power) services.

NHS Shared Business Services (SBS) Framework Agreements

Established in 2005 by the Department of Health & Social Care (DHSC) in a partnership with Sopra Steria, NHS SBS host a variety of framework agreements which provide estates, facilities and capital teams a compliant route to market for the provision of a range of construction and facilities management services. SBS frameworks typically enable access to both SME and national providers who can provide design & build, build only, refurbishment and enabling services.

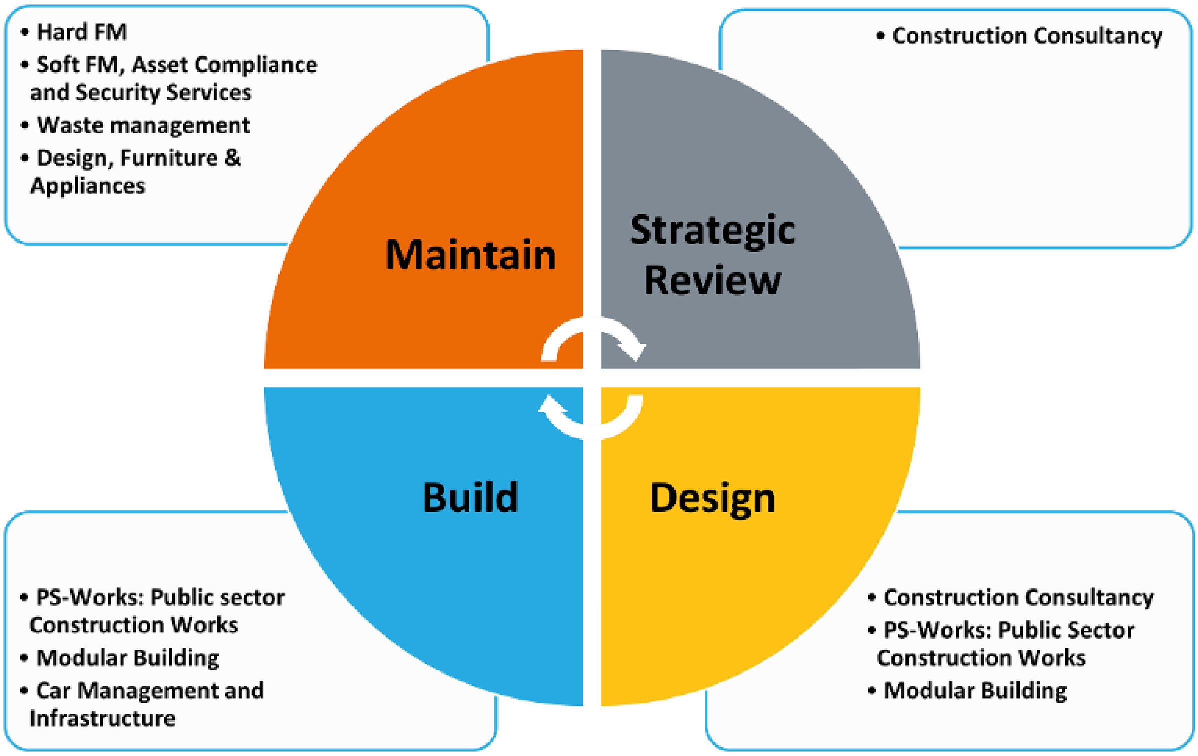


Figure 51: NHS SBS access to services for construction and estates (sbs.nhs.uk, 2022)

Crown Commercial Services (CCS) – Heat Networks & Electricity Generation Assets (HELGA) DPS

This Dynamic Purchasing System (DPS) launched in 2018 and can be utilised by any public sector organisation including NHS Trusts until November 2023. A DPS allows potential suppliers to join at any time and choose whether to compete for all, or any of the other work categories under the DPS. This has the benefit of shortening procurement times, as the advertisement in OJEU and PQQ stage has already been completed.

The Trust could use the DPS to identify a group of pre-qualified tenderers and access relevant qualification documentation held centrally by the framework administrator. This group could then be invited to tender for the works. The minimum time limit for return of tenders is 10 days and there is no option for Direct Award via this route.

The HELGA DPS enables access to a range of service from energy auditing through to complex installation projects. The lots that may be of interest to the Trust include;

- Lot 1 - Energy Advisory, Design and Technical Services: Technical services relating to the advice and design of any demand management or generation type
- Lot 2 - Delivery Services: Delivery services to install, manage and maintain any demand management or generation type

ETL Zero Carbon Delivery Framework

ETL (formerly Essentia Trading Limited) are a private company that was started in 2014 by Guy's & St Thomas' NHS Foundation Trust that provides consulting services predominantly to the public sector. The organisation manages a number of framework agreements accessible by Public Sector Bodies

(PSBs) including a Zero Carbon Delivery Framework Agreement which provides a fully OJEU-compliant route to procuring low/zero carbon technologies. This framework allows for both mini-competition and Direct Award. The lots that may be of interest to the Trust include;

- Lot 1 - All-encompassing Technologies: A 'one-stop' option for procuring holistic low/zero carbon technology solutions. All technologies are available through this lot, and project complexity and value can range from small to large.
- Lot 2 - Heating and Renewables: Access technologies including solar PV/thermal, ASHPs, GSHPs, low carbon heat networks, wind and biomass.

Fusion21 Heating & Renewables Framework

Fusion21 is a social enterprise that specialises in public sector procurement through a framework approach. This framework includes a selection of renewable technology applications from air and ground source heats pumps to solar thermal, electric heating and hot water systems. The commercial element of this framework can be utilised for a range of installations which includes district heating systems and the installation / servicing of Heat Interface Units.

The framework has flexible call-off processes including mini-competition and services can be procured on a supply & install basis, or supply/install only. The framework has 10 available lots of which the following may be of interest to the Trust;

- Lot 3 – Commercial Servicing, Maintenance and Installation of Heating Systems
- Lot 4 – Commercial Installations
- Lot 6 – Consultancy – Project Management and Principal Design
- Lot 7 – Installation of Ground and Air Source Heat Pumps
- Lot 8 – Installation of Electric Heating Systems

Carbon Energy Fund (CEF)

The Carbon Energy Fund (CEF) was launched in 2011 with the aim of funding, facilitating and project managing energy infrastructure upgrades, predominantly within the NHS but also for wider public sector organisations. The fund was co-created with the Department of Health as a special purpose vehicle allowing different parts of the Public Sector and NHS to work together.

CEF's purported advantages for its members include access to; advisory services, Energy Services Performance contracts, procurement via its framework, source funding where capex is limited and project and contractual management support. This fund has a track record of successfully delivering large energy infrastructure projects, however a significant proportion of these have focussed on use of CHP as a core design element. CHP systems have historically provided PSBs with cost and carbon savings and whilst the economics remain favourable, a gas-fired CHP system is now a carbon burden. The fund therefore may be suitable for some of the technology that will need to be deployed at the Trust (e.g. optimisation projects), but the core decarbonisation aspect – heat pumps – are not expected to deliver significant cost savings and therefore may have to be delivered via a different route.

RE:FIT Programme

The Re:fit programme is a procurement initiative for public bodies wishing to implement energy efficiency measures and local energy generation projects on their assets, with support to assist PSBs in the development and delivery of the schemes through an Energy Performance Contracting (EPC) approach. The scheme was initially developed by the Greater London Authority in 2009 but is available for use by PSBs across England & Wales.

The basis of an EPC approach is that participating PSBs can access guaranteed savings of minimum levels of generation via a contractual agreement which lasts for the payback period of the project. This has the benefit of de-risking new developments for the PSB. The drawback of this approach is that it typically predicated on technology selection that provides strong Return On Investment. Whilst examples of this technology will need to be deployed at the Trust (e.g. optimisation projects), the core decarbonisation aspect – heat pumps – is not expected to deliver significant cost savings and therefore may have to be delivered via a different route.

The latest iteration of the Re:fit EPC framework, Re:fit 4, has been now been launched and will run up until to April 2024. The programme is targeting delivering of £500m of contracts during the 4 years it will be in place. The framework itself is competitively tendered and OJEU-compliant.

Clear Futures – Partnership Procurement

Clear Futures is a partnership, established in 2017, between Eastbourne and Lewes Councils and strategic delivery partners AECOM and Robertson. Clear Futures operate an OJEU-compliant process to support PSBs deliver built environment projects. The strategic partnership allows provides the PSB with access to advisory services, standard contract models, project management support and access to their supply chain.

enFrame – Energy Performance Framework

enFrame are a Community Interest Company (CIC) that specialise in assisting PSBs in procuring a range of good and services. They operate three framework agreements including an OJEU-complaint Energy Performance Contracting (EPC) framework that enables organisations to procure services to design, install and finance the delivering of energy saving measures, renewable technology, energy generation and building system upgrades.

The Energy Services Partner (ESP) designs and implements energy conservation measures (ECMs) and guarantees the level of energy savings, offering a secured financial saving over the period of the agreement. The savings are used to fund the cost of improvements and services from the ESP. Once the costs have been repaid, the Trust should be able to keep the full savings generated from the improvements.

11.5 Risk Register

Risks associated with the delivery of individual projects themselves will be captured within the capital projects process. Identified risks at this stage are outlined in Table 80.

Table 80: HDP Risk Register

Description	Rank	Planned Mitigation
Lack of funding to complete the implementation.	High	As an alternative to Trust capital or grant funding, the Trust may opt for an energy as a service agreement whereby the equipment is fully owned and operated by the supplier. This comes with higher service costs but avoids the capital constraints.
DHN not being delivered or significant delay.	Significant	Exploration of potential ground-sourced heating will be carried out and a full re-evaluation of available technologies will be carried out before 2032.
Insufficient provision of internal human resourcing.	Significant	A resource is present to drive the energy strategy, more support will be sourced as needed.
Changes to the estates strategy necessitating changes to the design.	Significant	A Strategic Master Plan is in development which will include the energy centre and other key elements. Once finalised, the Trust will work closely with the chosen suppliers to adapt the design alongside further developments to the strategy.
Trust senior management not being engaged.	Low	The Green Plan recently passed the Board and will be reviewed annually. The various groups in place will continue to raise the profile of this agenda.

12. Recommended Next Steps

Kingston Hospital Trust plans to implement the above solutions in a phased approach, in line with the availability of capital through various means, including capital budgeting and external grants or loans for example Salix funding announcements to align to the Trust's carbon emission targets. In order to progress these opportunities further, other enabling actions will be carried out alongside securing the capital required, which are summarised below:

1) Conduct enabling activities that could be investigated whilst KHT awaits potential funding:
    a. Engage relevant parties within the potential Hogsmill district heating network project to aid in the development of this opportunity.
    b. Conduct ground surveys to assess viability of potential GSHP installation. If viable engage the Environment Agency to discuss permitting abstraction of water.
    c. Conduct ASHP studies to confirm suitability, infrastructure modifications and related performance.
    d. Engage the relevant District Network Operator, DNO, to confirm suitability of local electrical infrastructure for increase in consumption through heat pumps and potential of increasing supply limits to the Trust.
    e. Investigate PPA agreement for solar panels and battery energy storage (BESS) supplier agreement
    f. Create detailed submeter plan to obtain maximum visibility of consumption across Kingston Hospital. Connect existing and new meters to a M&T software to collect granular half hourly data for future analysis

2) Determine available funding routes for the optimisation and low carbon generation projects, utilising options outlined within the "Procurement and Funding" section of this report.
3) Engage potential suppliers relevant to all projects outlined, in order to obtain quotes and time-frames for works, thus enabling the creation of shovel ready project portfolios. The creation of this portfolio will best support applications to funding routes through swift and comprehensive applications.

13. Appendices

Appendix I

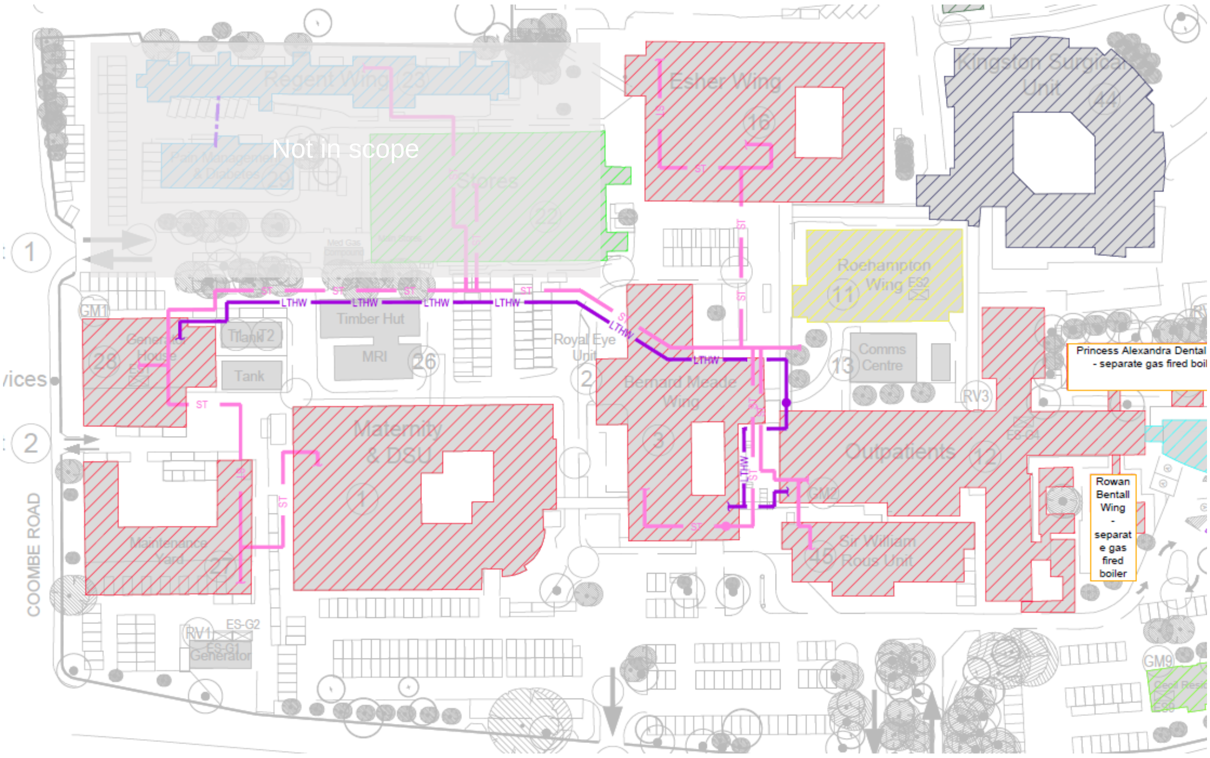


Figure 52 Existing LTHW and Steam Network

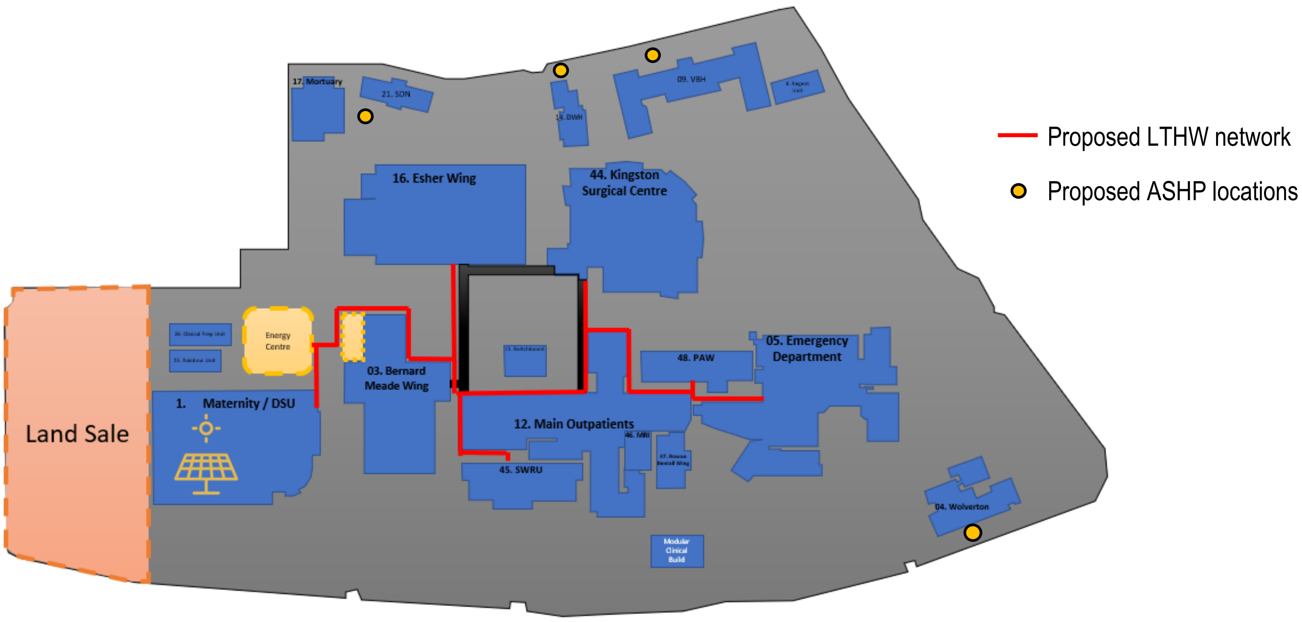
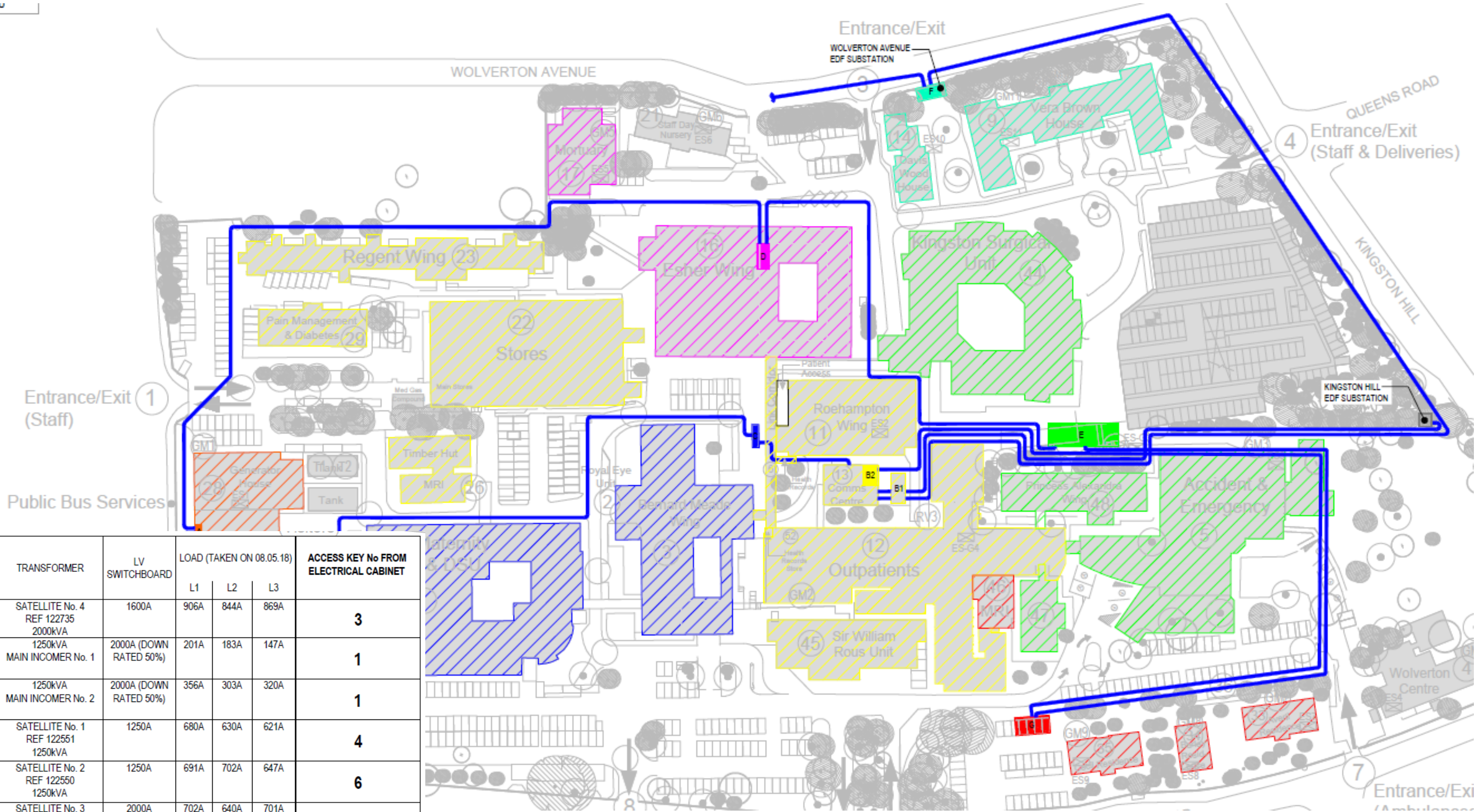


Figure 53 Proposed new LTHW network, Energy centre and ASHP

Kingston Hospital
NHS Foundation Trust

Appendix II

Figure 54 HV and LV network



SUBSTATION	HV ENCLOSURE	TRANSFORMER	LV SWITCHBOARD	LOAD (TAKEN ON 08.05.18) L1	L2	L3	ACCESS KEY No FROM ELECTRICAL CABINET
A	RING MAIN UNIT	SATELLITE No. 4 REF 122735 2000kVA	1600A	906A	844A	869A	3
B1	RING MAIN UNIT	1250kVA MAIN INCOMER No. 1	2000A (DOWN RATED 50%)	201A	183A	147A	1
B2	RING MAIN UNIT	1250kVA MAIN INCOMER No. 2	2000A (DOWN RATED 50%)	356A	303A	320A	1
C	RING MAIN UNIT	SATELLITE No. 1 REF 122551 1250kVA	1250A	680A	630A	621A	4
D	RING MAIN UNIT	SATELLITE No. 2 REF 122550 1250kVA	1250A	691A	702A	647A	6
E	RING MAIN UNIT	SATELLITE No. 3 REF 122627 1600kVA	2000A	702A	640A	701A	5
F	UKPN/EDF PROPERTY, NO ACCESS	UKPN/EDF PROPERTY, NO ACCESS	UKPN/EDF PROPERTY, NO ACCESS				N/A
G	RING MAIN UNIT	SATELLITE No. 5 REF 122854 1500kVA	2500A	N/A	N/A	N/A	8
TOTAL RUNNING LOADS:				3536A	3302A	3305A	
SITE MAXIMUM DEMAND (TAKEN ON 08.05.18): 2.33MVA							