

Appendix 2 – Building/Site Heat Decarbonisation Background

The Heat Decarbonisation Roadmap, commissioned through Faithful and Gould (F&G) consulted on a number of sites in the Councils operational estate. Those sites and their calculated costs and actions to decarbonise are presented below as combined site and individual site case studies.

All figures, tables, data and attached analysis in Appendix 2 are derived from the Faithful and Gould (F&G) Heat Decarbonisation Roadmap.

A glossary of abbreviations has been provided below.

Appendix G. Glossary of Terms/Acronyms

- HDP - Heat Decarbonisation Plan.
- BSE - Building Services Engineering.
- HVAC - Heating, Ventilation, and Air conditioning.
- NZC - Net Zero Carbon.
- PV - Photovoltaic.
- kWh - Kilowatt hour.
- tCO₂ - One Tonne of Carbon Dioxide.
- ASHP - Air Source Heat Pump.
- Quick wins - Interventions that are easy, fast, and economical to implement.
- LED - Light Emitting Diode; type of lighting.
- KPIs - Key Performance Indicators.
- FM - Facilities Management.
- Soft landings - Government scheme adopting a strategy to ensure a smooth transition from construction to occupation ensuring optimal operational performance.
- Salix finance - non-departmental public body, wholly owned by the Government administering funds on behalf of the Department for Energy Security and Net Zero.
- DESNZ - Department of Energy Security and Net Zero.
- LCSF – Low Carbon Skills Fund.
- PSDS – Public Sector Decarbonisation Scheme.
- Climate emergency - A critical and urgent situation characterised by rapid and severe changes in global climate patterns, driven primarily by human activities, which pose significant threats to ecosystems, societies, and the planet's long-term sustainability.
- Decarbonisation (Built Environment) - The process of reducing or eliminating carbon emissions associated with construction, operation, or maintenance of buildings and infrastructure, typically through sustainable design, energy efficiency measures, and the adoption of low-carbon technologies.
- Retrofit – The process of enhancing or upgrading existing buildings, infrastructure, or systems to improve energy efficiency, sustainability, and functionality. Often done through incorporating innovative technologies and design principles.
- Building fabric – The physical components and materials that make up a building's envelope, including walls, roofs, floors, and cladding, which collectively determine the building's structure integrity, thermal performance, and weather resistance.
- GHG - Green House Gases.
- UK-GBC - UK Green Building Council.
- Climate Change Act - A legislative framework implemented by governments, aimed at addressing and mitigating the impacts of climate change through the establishment of binding policies and targets to reduce GHG emission and promote sustainable practices across industries.
- Carbon Budget Orders - These are regulatory measures and mechanisms established by governments, which allocate a specific allowable amount of carbon emissions over a defined period to different sectors or entities, with the goal of controlling and reducing overall GHG emissions to meet climate targets.
- SBTI – Science Based Targets initiative.
- M&E – Mechanical & Electrical.
- MEP – Mechanical, Electrical, and Plumbing.
- BMS – Building Management System.
- BEMS – Building Energy Management System.
- VRV/VRF - Variable Refrigerant Volume/Flow.
- Radiant electric - Refers to a heating system that utilises electric radiant heating elements, such as wires or panels, to emit infrared radiation for heating indoor spaces. Offering an efficient and direct method of heating without the need for traditional heating ducts, forced-air systems, or use of solid fuel.
- DX split - Refers to a type of air conditioning system where the cooling process is achieved through direct expansion (DX) of a refrigerant, typically in a split-system configuration, involving separate indoor and outdoor units. A DX split system that can work a reverse cycle to provide both heating and cooling is a heat pump.
- Point of Use - A system or device that provide specific services or functions (domestic hot water for the context of this report) at the location where they are needed, on a smaller scale and localised basis, enhancing energy efficiency while reducing resource wastage and distribution losses.
- DHW - Domestic Hot Water.

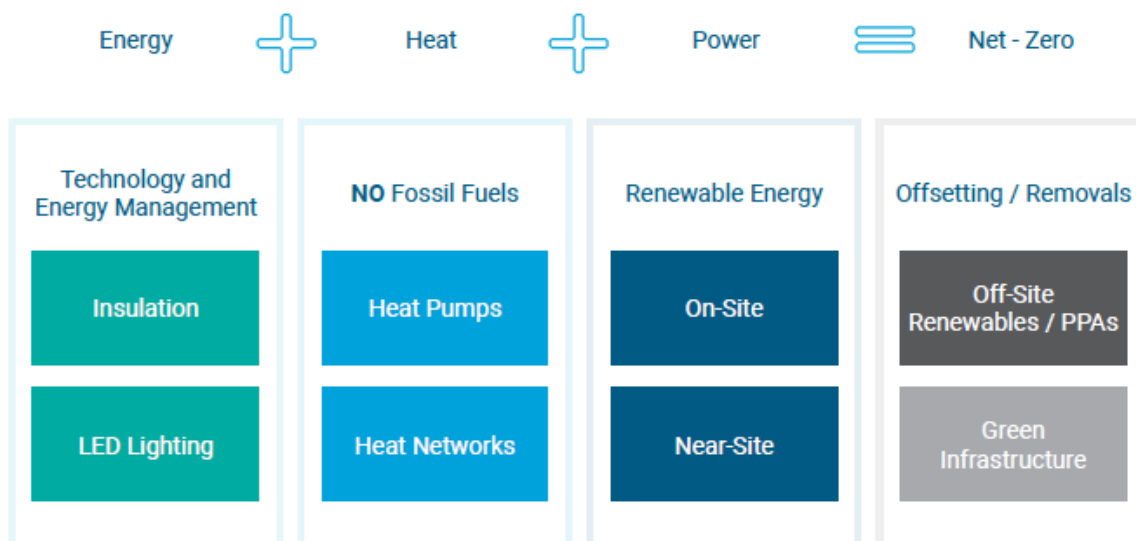
Combined Site Heat Decarbonisation Case Study:

This section presents and analyses the combined site heat decarbonisation data from Faithful and Goulds (F&G) commissioned Heat Decarbonisation Roadmap for the Council. The data below focuses on the cost, energy, carbon savings and intervention type for the combined built estate that was surveyed by F&G.

F&G were commissioned to deliver a roadmap to net zero for the Council. To explain what net zero meant in the case of this report F&G included Figure 2 (Pg.12) which shows that energy, heat and power decarbonisation technology and implementation of that technology will achieve Net Zero.

Figure 2

Process towards Net Zero Carbon buildings



Figures 3 and 4 below display the total annual consumption in kilowatt-hour and total carbon emissions in tonnes of carbon dioxide equivalent for gas and electricity consumption across the 7 of the sites that were reviewed by F&G. As seen in the tables below the J2 (Jubilee 2) Leisure Centre is the largest consumer of gas and electricity which makes it the largest emitter of greenhouse gas in the Council's operational estate. The more a site/building consumes in gas and electricity the more emissions we can expect to be associated with that site. Other notable mentions are the Bradwell Crematorium (labelled as Newcastle-under-Lyme Crematorium) and Knutton Lane Depot which both have high gas use and low electricity use. Compared to a building like Castle House which uses no gas whatsoever you can see how electrifying different buildings can decrease the relative emissions and impact.

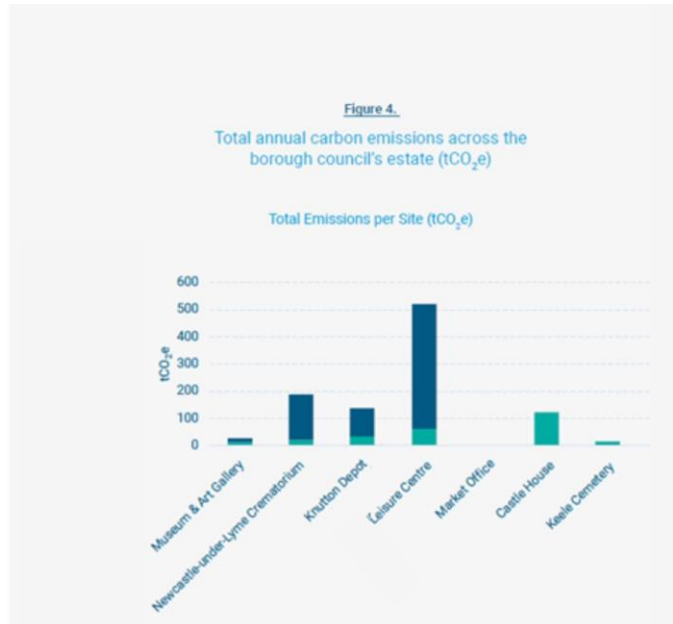
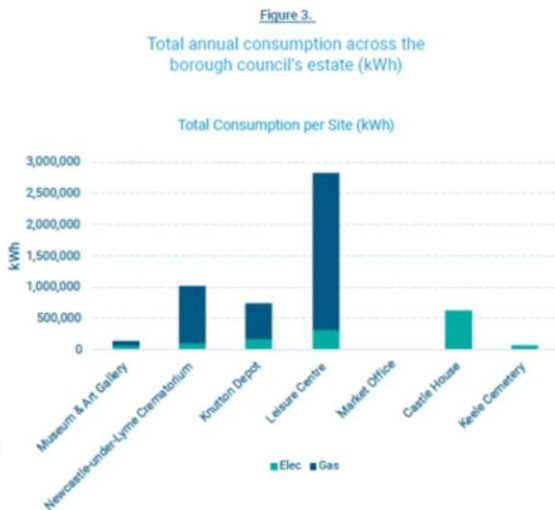
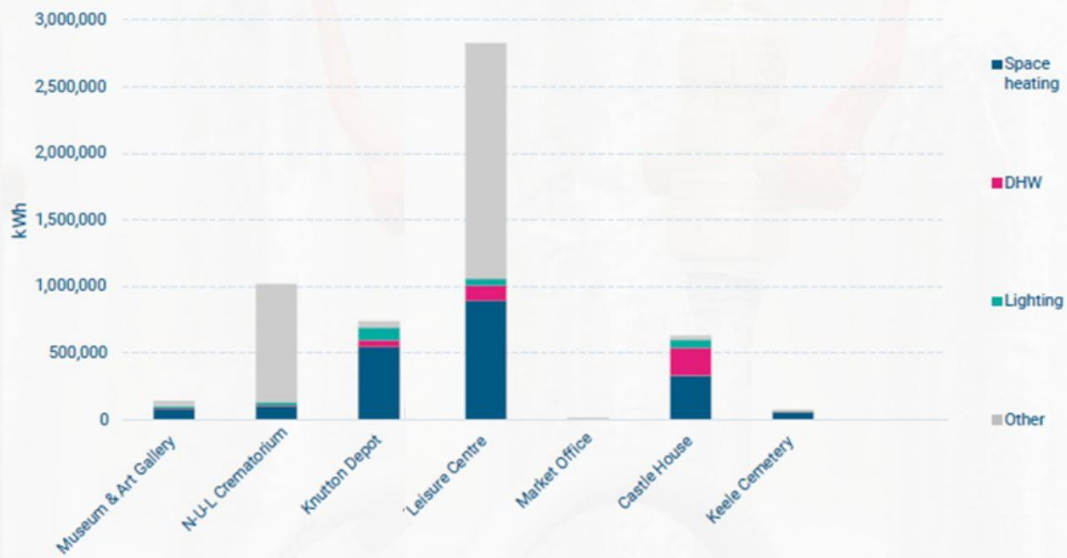


Figure 5 shows the breakdown of energy consumption at each site reviewed. It has been broken down by space heating, domestic hot water (DHW), lighting and other. "Other" is attributed to energy consumers such as the furnaces at the crematorium and the water heating for the leisure centre which as seen below are the main culprits for large amounts of energy consumption. Space heating as seen in the figure below also contributes to the significant amount of energy consumption from the council's operational estate, showing the need for decarbonisation methods especially for space heating and "other" energy consumers.

Figure 5.

Breakdown of energy consumption per site across the estate

Total On-Site Energy Consumption per Site (kWh)



Looking at the breakdown of energy consumption across the estate (Figure 5), space heating is the highest contributor to total energy consumption. Domestic hot water and lighting accounting for a smaller percentage. The remaining consumption is attributed to other services, such as furnaces at the crematorium, pool water heating and the leisure centre, and kitchen appliances. This breakdown has been estimated using certain percentages depending on building type.

Figure 11 shows the substantial decrease in energy use by 2030 from the recommended interventions, most notably in gas consumption. The reason electricity consumption increases is due to the decarbonising interventions like air source heat pumps that use electricity instead of gas. The leftover 666,236 kWh of gas at 2030 is due to the crematorium furnaces and some other consumers that still don't have the adequate technology to replace gas yet, which means that energy use which contributes to our emissions will have to be offset somewhere else until decarbonised replacements mature. However the great decrease in gas consumption means that even with an increase in electricity usage, the overall energy usage of the Councils operational estate decreases by almost half the original amount with these interventions by 2030.

Figure 11.

Consumption changes after Net Zero interventions (all scenarios)

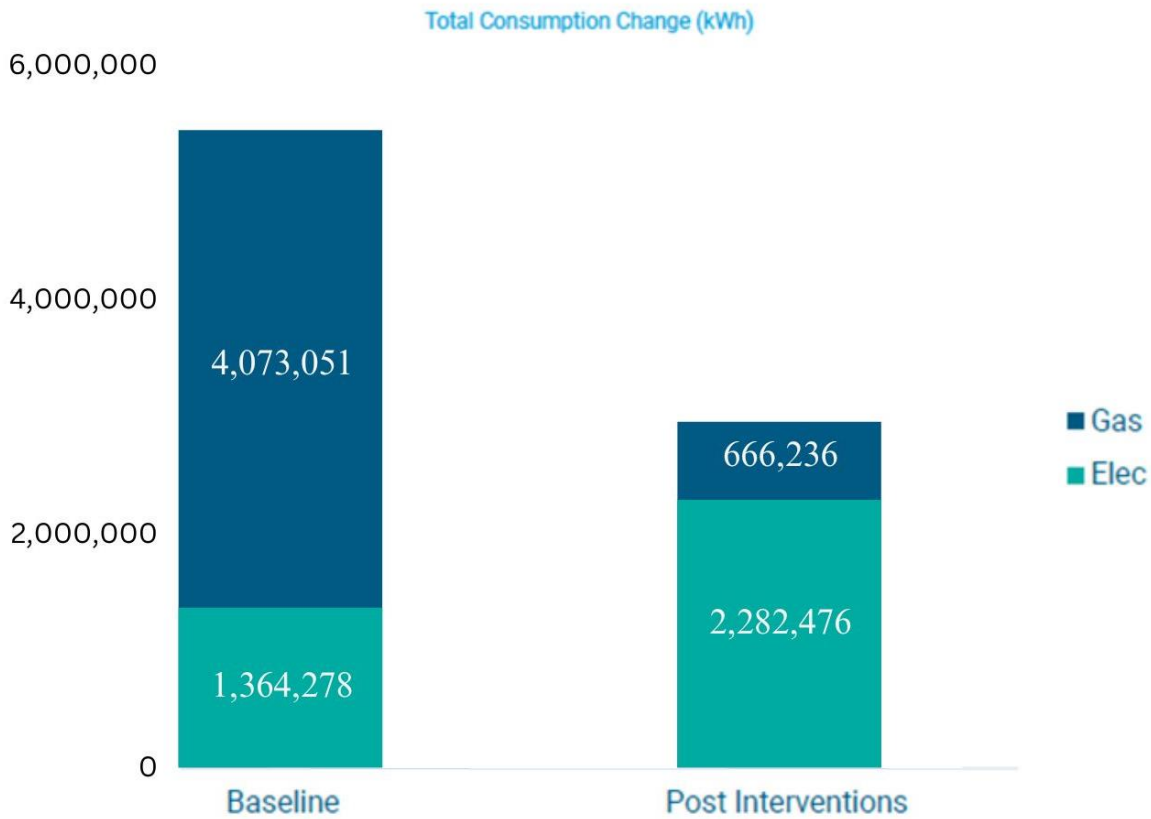


Table 17 breaks down the individual costs of all the installations of different interventions for each site needed by 2030. The most costly sites include Jubilee 2 Leisure Centre and Knutton Depot which together will cost the council over £6M to implement the below interventions. The total amount needed to decarbonise these operational buildings and sites reviewed below will cost a £7,396,287 by 2030. The largest contributor to the cost will be fabric upgrades (insulation, windows etc.) and heating and DHW installations.

Overview of Measures

Table 17 provides a site-by-site breakdown of the recommended measures across the 9 sites, highlighting the associated costs with each technological/fabric intervention.

Table 17. Site and cost breakdown of recommendations

Site Name	Behaviour Change	Fabric Up-grades	LED Install	Heating & DHW Install	PV Install	BMS/Controls Upgrade	Cooling Upgrade	Vent Upgrade	Total
Museum & Art Gallery	£178	£394,518	£17,056	£143,324	£0	£63,688	£0	£3,750	£622,514
Newcastle-under-Lyme Crematorium	£626	£283,633	£32,755	£211,564	£36,700	£52,632	£0	£7,500	£625,411
Knutton Depot	£632	£1,420,936	£44,664	£525,920	£42,000	£129,410	£0	£3,000	£2,166,561
Leisure Centre	£1,786	£0	£119,392	£3,438,300	£0	£106,600	£170,000	£10,000	£3,846,078
Market Office	£10	£1,335	£971	£4,853	£2,310	£607	£0	£750	£10,835
Castle House	£1,465	£0	£5,952	£0	£49,600	£0	£0	£0	£57,017
Keele Cemetery	£172	£0	£13,720	£0	£33,400	£20,580	£0	£0	£67,872
Total	£4,869	£2,100,420	£234,510	£4,323,961	£164,010	£373,517	£170,000	£25,000	£7,396,287

Table 21 shows the carbon reduction opportunities across the operational sites studied, focusing on how much total carbon was saved by installing the interventions from the roadmap. The most costly sites are the Leisure Centre (Jubilee 2) and Knutton Depot, however as seen below they will contribute the most carbon savings out of all the sites.

Table 21.

Carbon reduction opportunities across the estate

Site	Floor Area (m ²)	Total Carbon Saved (tCO ₂ e today's factors)	Cost of Interventions
Museum & Art Gallery	1,061	14	£622,514
Newcastle-under-Lyme Crematorium	877	31	£625,411
Knutton Depot	2,571	96	£2,166,561
Leisure Centre	4,264	280	£3,846,078
Market Office	24	1	£10,835
Castle House	4,960	14	£57,017
Keele Cemetery	343	9	£67,872

A decarbonisation plan which centres around the properties would require an investment of circa £7,396,287 and would save a total of 502 tonnes of CO₂e. Targeting the 'worst offending buildings' could be an effective tool for the Council as they push towards Net Zero.

Individual Site 2030 Heat Decarbonisation Case Study:

This section breaks down the data from the Faithful & Gould (F&G) Heat Decarbonisation Report for each of the operational sites as individual cases. It breaks down the cost, energy, carbon savings and intervention type for each site with short analysis.



= Not Applicable



= No Data

Acronyms Glossary:

- ASHP = Air Source Heat Pump
- VRV = Variable Refrigerant Volume
- RE = Radiant Electric
- DX = Direct Expansion
- POU = Point of Use Water System

When an **N** is used after the mention of a certain intervention, this means that this intervention has already been installed and is working on the relevant site OR the intervention is not needed on the site for it to become net zero.

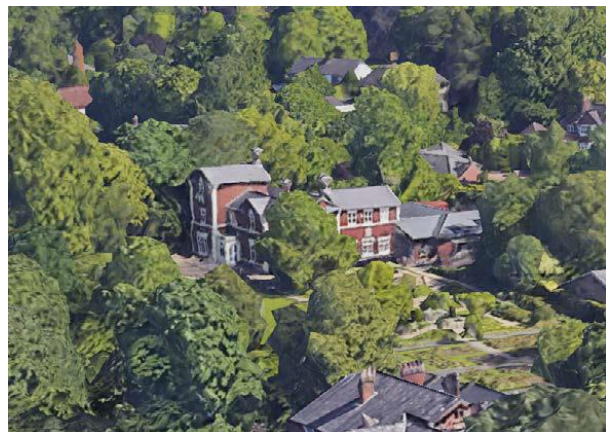
The carbon saving data in this section is derived by adding all carbon saving data located in the table below (Appendix C in the F&G report) in which the total is derived from subtracting the "Additional Elec from Htg & DHW Upgrade" as these upgrades decrease the carbon savings of interventions as they increase electricity usage. Total amounts may differ from calculations made with data presented as they are totals are rounded.

Appendix C. Carbon Saving of Implementation Measures (2022 Carbon Conversion Factors)

tCO ₂ e Savings by Building (today's factors)										
Site	Behaviour Change	Fabric Upgrades	LED Install	Htg & DHW Upgrade	Additional Elec from Htg & DHW Upgrade	PV Install	BMS Upgrade	Chiller Upgrade	Vent Up-grade	Total
Museum & Art Gallery	1.32	5.06	0.74	7.68	3.71	0.00	2.83	0.00	0.36	14.27
Newcastle-under-Lyme Crematorium	9.36	4.39	3.04	8.28	3.70	6.03	3.67	0.00	0.26	31.32
Knutton Depot	6.85	40.14	6.35	52.89	28.94	6.90	10.54	0.00	1.42	96.16
Kidsgrove Townhall	2.86	15.08	1.89	12.06	2.40	4.49	5.19	0.00	1.95	41.12
The Guildhall	1.31	5.01	1.23	6.30	1.69	0.00	2.62	0.27	0.82	15.87
Leisure Centre	25.99	0.00	5.35	418.05	197.45	0.00	21.94	3.94	2.09	279.92
Market Office	0.04	0.04	0.06	0.30	0.00	0.38	0.06	0.00	0.04	0.93
Castle House	6.09	0.00	0.25	0.00	0.00	8.15	0.00	0.00	0.00	14.49
Keele Cemetery	0.72	0.00	0.48	0.00	0.00	5.49	1.97	0.00	0.00	8.65
Total	54.53	69.72	19.39	505.55	237.89	31.45	48.83	4.21	6.94	502.75

Museum & Art Gallery

The Brampton Museum is a 1061m² building comprising a 2 storey 1854 solid brick building and a large 2020 single story extension. The Brampton Museum will cost £622,514 to retrofit for net zero but would reduce its energy use by 77,864 kWh which saves a total amount of 14.27 tCO₂e per year based on the interventions implemented.



Total Cost of Interventions: **£622,514**
 Total Energy Use Reduced: **77,864 kWh**
 Total Carbon Saved: **14.27 tCO₂e**

Heat Decarbonisation Recommendations	Relevant Actions (Y/N) Y = YES N = NO	Cost of Relevant Actions (£)	Total Cost (£)	Energy Consumption Before (kWh)	Energy Consumption After (kWh)	Carbon Saving (tCO ₂ e)
Behaviour Change	Y	£178	£178	Gas 77,864	Gas 0	1.32
Fabric Up-grades	Wall N Roof Y Glazing Y	0 £14,595 £379,922	£394,518			5.06
LED Install	Y	£17,056	£17,056	Electric 62,682	Electric 62,682	0.74
Heating & DHW Install	Heating ASHP Y VRV RE DX DHW POU Y ASHP	£142,324	£142,324			7.68 -3.71 = 3.97
PV Install	N					
BMS/Controls Upgrade	Y	£63,688	£63,688			2.83
Cooling Upgrade	N					
Vent Upgrade	Y	£3,750	£3,750		0.36	
Total		£622,514	£622,514	140,546 kWh	62,682 kWh	14.27 tCO₂e

Table 1. Museum & Art Gallery site heat decarbonisation, energy and cost breakdown

Newcastle-under-Lyme (Bradwell) Crematorium

Bradwell crematorium comprises the chapel and crematorium building, and a remote site which has been converted to an office and accommodation at the site entrance. Bradwell Crematorium will cost £625,411 like the Museum to retrofit for net zero but would reduce its energy use by around 168,459 kWh which saves a total amount of 31.32 tCO₂e per year based on the interventions implemented. Due to the gas furnaces and currently having no decarbonised equivalent the gas usage that could be eliminated will have to remain until the technology is available to replace them.



Total Cost of Interventions: **£625,411**

Total Energy Use Reduced: **168,459 kWh**

Total Carbon Saved: **31.32 tCO₂e**

Heat Decarbonisation Recommendations	Relevant Actions (Y/N) Y = YES N = NO	Cost of Relevant Actions (£)	Total Cost (£)	Energy Consumption Before (kWh)	Energy Consumption After (kWh)	Carbon Saving (tCO ₂ e)
Behaviour Change	Y	£626	£626	Gas 913,765	Gas 798,269	9.36
Fabric Up-grades	Wall Y Roof Y Glazing N	£40,015 £243,618 0	£283,633			4.39
LED Install	Offices Y Chapel Y	£11,760 £29,995	£32,755	Electric 105,518	Electric 52,555	3.0
Heating & DHW Install	Heating ASHP Y VRV Y RE DX DHW POU Y ASHP	£211,564	£211,564			8.28 -3.70 =4.58
PV Install	Y	£36,700	£36,700			6.03
BMS/Controls Upgrade	Offices Y Chapel Y	£17,640 £34,992	£52,632			3.67
Cooling Upgrade	N					
Vent Upgrade	Y	£7,500	£7,500			0.26
Total		£625,411	£625,411	1,019,283 kWh	850,824 kWh	31.32 tCO₂e

Table 2. Newcastle-under-Lyme (Bradwell) Crematorium site heat decarbonisation, energy and cost breakdown

Knutton Depot

Knutton Depot is a large property constructed in the 1960s which contains large unheated factory style units, a heated vehicle workshop area and a two-storey office accommodation. Knutton Depot will cost £2,166,561 to retrofit for net zero but would reduce its energy use by a significant 529,308 kWh which saves a total amount of 31.32 tCO_{2e} per year based on the interventions implemented. It is the 2nd most costly of site surveyed however one of the most impactful on our net zero goals.



Total Cost of Interventions: **£2,166,561**

Total Energy Use Reduced: **529,308 kWh**

Total Carbon Saved: **96.16 tCO_{2e}**

Heat Decarbonisation Recommendations	Relevant Actions (Y/N) Y = YES N = NO	Cost of Relevant Actions (£)	Total Cost (£)	Energy Consumption Before (kWh)	Energy Consumption After (kWh)	Carbon Saving (tCO _{2e})
Behaviour Change	Y	£632	£632	Gas 571,342	Gas 0	6.85
Fabric Up-grades	Wall Y Roof Y Glazing Y	£1,015,232 £51,178 £354,526	£1,420,936			40.14
LED Install	Offices Y Workshop N	£44,664	£44,664	Electric 169,351	Electric 211,386	6.35
Heating & DHW Install	Heating ASHP VRV Y RE Y DX DHW POU Y ASHP	£525,920	£525,920			52.89 -28.94 =23.95
PV Install	Y	£42,000	£42,000			6.90
BMS/Controls Upgrade	Offices Y Workshop Y	£111,660 £17,750	£129,410			10.54
Cooling Upgrade	N					
Vent Upgrade	Y	£3,000	£3,000			1.42
Total		£2,166,561	£2,166,561	740,694 kWh	211,386 kWh	96.16 tCO_{2e}

Table 3. Knutton Depot site heat decarbonisation, energy and cost breakdown

Leisure Centre (Jubilee 2)

Jubilee 2 is a multipurpose leisure complex which incorporates a main pool, learner pool, fitness centre, dance studios and café. It was constructed in 2011 and includes ground, first and second floor levels with a combination of single and double height spaces. Jubilee 2 (J2) will cost £3,846,078 to retrofit for net zero but would reduce its energy use by around 1,588,192 kWh which saves a total amount of 279.92 tCO_{2e} per year based on the interventions implemented. J2 is the largest emitter of all sites and should be a priority when it retrofitting NuLBC's built estate due to the vast paybacks those would provide.



Total Cost of Interventions: **£3,846,078**

Total Energy Use Reduced: **1,588,192 kWh**

Total Carbon Saved: **279.92 tCO_{2e}**

Heat Decarbonisation Recommendations	Relevant Actions (Y/N) Y = YES N = NO	Cost of Relevant Actions (£)	Total Cost (£)	Energy Consumption Before (kWh)	Energy Consumption After (kWh)	Carbon Saving (tCO _{2e})
Behaviour Change	Y	£1,786	£1,786	Gas 2,510,080 Electric 318,422	Gas 0 Electric 1,240,310	25.99
Fabric Up-grades	Wall N Roof N Glazing N					
LED Install	Y	£119,392	£119,392			5.35
Heating & DHW Install	Heating ASHP Y VRV RE DX DHW POU ASHP N	£3,438,300	£3,438,300			418.05 -197.45 =220.6
PV Install	Y	£280,000	£280,000			
BMS/Controls Upgrade	Y	£106,600	£106,600			21.94
Cooling Upgrade	Y	£170,000	£170,000			3.94
Vent Upgrade	Y	£10,000	£10,000			2.09
Total		£3,846,078	£3,846,078			2,828,502 kWh

Table 6

Table 4. Leisure Centre (Jubilee 2) site heat decarbonisation, energy and cost breakdown

Market Office

The Market offices is a 24m² single storey with brick walls and a pitched roof over, built in 2002. The Market Office will cost £10,835 to retrofit for net zero but would reduce its energy use by around 4,798 kWh which saves a total amount of 0.93 tCO₂e per year based on the interventions implemented. Of the 9 sites the Market Office costs the least however would be a 'quick win' for NuLBC to accomplish.



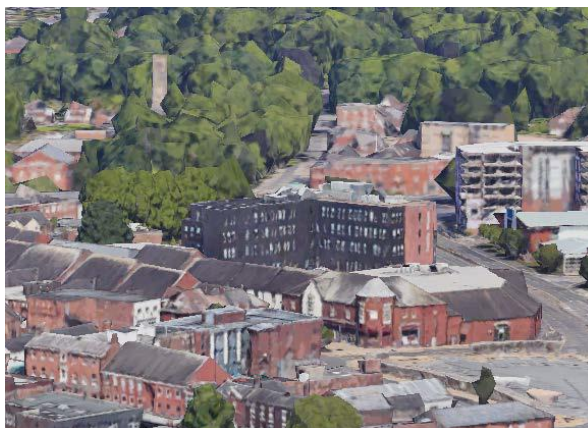
Total Cost of Interventions: **£10,835**
 Total Energy Use Reduced: **4,798 kWh**
 Total Carbon Saved: **0.93 tCO₂e**

Heat Decarbonisation Recommendations	Relevant Actions (Y/N) Y = YES N = NO	Cost of Relevant Actions (£)	Total Cost (£)	Energy Consumption Before (kWh)	Energy Consumption After (kWh)	Carbon Saving (tCO ₂ e)
Behaviour Change	Y	£10	£10	Gas 0	Gas 0	0.04
Fabric Up-grades	Wall N Roof Y Glazing N	£1,335	£1,335			0.04
LED Install	Y	£971	£971	Electric 4,279	Electric -519	0.06
Heating & DHW Install	Heating ASHP VRV RE DX Y DHW POU N ASHP	£1,335	£1,335			0.30
PV Install	Y	£2,310	£2,310			0.38
BMS/Controls Upgrade	Y	£607	£607			0.06
Cooling Upgrade	N					
Vent Upgrade	Y	£750	£750			0.04
Total		£10,835	£10,835	4,279 kWh	-519 kWh	0.93 tCO₂e

Table 5. Market Office site heat decarbonisation, energy and cost breakdown

Castle House

Castle House is a 4,960m², four storey, modern building constructed in 2017. Castle House will cost £57,017 to retrofit for net zero but would reduce its energy use by around 74,927 kWh which saves a total amount of 14.49 tCO₂e per year based on the interventions implemented. As a newer development Castle House is already independent of gas and would only need some basic net zero interventions.



Total Cost of Interventions: **£57,017**
 Total Energy Use Reduced: **74,927 kWh**
 Total Carbon Saved: **14.49 tCO₂e**

Heat Decarbonisation Recommendations	Relevant Actions (Y/N) Y = YES N = NO	Cost of Relevant Actions (£)	Total Cost (£)	Energy Consumption Before (kWh)	Energy Consumption After (kWh)	Carbon Saving (tCO ₂ e)
Behaviour Change	Y	£1,465	£1,465	Gas 0	Gas 0	6.09
Fabric Up-grades	Wall N Roof N Glazing N					
LED Install	Y	£5,952	£5,952	Electric 629,920	Electric 554,993	0.25
Heating & DHW Install	N					
PV Install	Y	£49,600	£49,600			8.15
BMS/Controls Upgrade	N					
Cooling Upgrade	N					
Vent Upgrade	N					
Total		£57,017	£57,017	629,920 kWh	554,993 kWh	14.49 tCO₂e

Table 6. Castle House site heat decarbonisation, energy and cost breakdown

Keele Cemetery

Keele cemetery is a 343m², single storey, modern building constructed in 2010. Keele Cemetery will cost £67,872 to retrofit for net zero but would reduce its energy use by around 44,753 kWh which saves a total amount of 8.65 tCO₂e per year based on the interventions implemented. Like castle house the cemetery is a newer development so only needs basic interventions to become net zero.



Total Cost of Interventions: **£67,872**

Total Energy Use Reduced: **44,753 kWh**

Total Carbon Saved: **8.65 tCO₂e**

Heat Decarbonisation Recommendations	Relevant Actions (Y/N) Y = YES N = NO	Cost of Relevant Actions (£)	Total Cost (£)	Energy Consumption Before (kWh)	Energy Consumption After (kWh)	Carbon Saving (tCO ₂ e)		
Behaviour Change	Y	£172	£172	Gas 0	Gas 0	0.72		
Fabric Up-grades	Wall N Roof N Glazing N							
LED Install	Y	£13,720	£13,720	Electric 74,108	Electric 29,355	0.48		
Heating & DHW Install	N							
PV Install	Y	£33,400	£33,400			5.49		
BMS/Controls Upgrade	Y	£20,580	£20,580			1.97		
Cooling Upgrade	N							
Vent Upgrade	N							
Total		£67,872	£67,872			74,108 kWh	29,355 kWh	8.65 tCO₂e

Table 7. Keele Cemetery site heat decarbonisation, energy and cost breakdown