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Report for Meyrick Brentnall

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of Gloucester City Council

From CLS Energy Ltd

version 1.4

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With thanks to Meyrick Brentnall and all officers at Gloucester City, Aspire and Amey that kindly assisted in providing data and access to buildings, operations, and fleet.

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2030

Part I: City Council Plan 2050

Gloucester Greenhouse Gas Reduction Report

Introduction:

1. Background

As part of Gloucester's objective to Respond to Challenges to the Environment, as well as its 2019 public commitment to achieve net zero carbon emissions by 2030 and the same for the city by 2050, the Council is seeking to gain an understanding of its current carbon emissions from its principle consuming sites and has enlisted the services of CLS Energy (Consultancy) Ltd in order to do this.

2. Key Aims and Objectives

The Council aims to gain an understanding of its carbon emissions at these sites, as well as how and where they could expect to make large savings in energy use, and consequent reductions in Carbon equivalents ($CO2_e$) emissions.

3. Outputs

The Council have worked with CLS Energy (Consultancy) Ltd to carry out carbon emissions assessments at the following locations:

17th August 2020 (Day 1):

- GL1 Leisure Centre, Gloucester
- Plock Court
- Council Depot and fleet

25th August 2020 (Day 2):

- Gloucester Life (Folk) Museum
- Gateway Offices
- North Warehouse - and Enterprise car rental (EHI) fleet
- City Museum
- Coney Hill Crematorium
- Arbor Tea Room

11th September 2020 (Day 3):

- Guildhall
- Eastgate Market

29th September 2020 (Day 4):

- Blackfriars Priory
- Eastgate Complex

We have also visually inspected:

- Longsmith Street MSCP
- Kings Walk Multi-Storey Car Park (MSCP) (also referred to and Eastgate Complex upper car park)

Outputs include reports on the carbon emissions of the Council and, recommendations of where and how the Council can reduce their emissions. For example, through behavioural change or new technologies.

Project Scope

To conduct investment grade site energy audits and assessments at the 13 aforementioned sites to BS-EN 16247-1 and ISO 50001 guidance standards. These include (where data available), desktop assessments of billing data, normalisation of heating (gas or heating oil) data to permit the execution of regression analysis so as to remove variables such as weather, and to assess where heat is being wasted.

Comprehensive assessment of half hourly data (for electricity and gas where available/provided) at all code 5 (00 profile) sites to establish energy misuse as well as on-site plant and equipment assessment and profiling using technologies including data logging, infra-red thermography, visual assessment and meter calculations in order to provide a building baseline of energy use and carbon (CO_2e) emissions for the agreed 12-month reference period.

CLS Energy Ltd will identify and report where possible, on costed energy efficiency recommendations for areas of significant energy consumption within appropriate timeframes and payback periods and draw together a summary plan alongside a formal investment grade and detailed professional report, setting out these energy and cost saving measures. These visits will also include for an assessment of viability of appropriate renewable energy technologies.

- For each such measure and opportunity recommended, we will:
- Report on the typical capital cost
- Year one financial savings
- Year one energy savings (KWh)
- Year one CO_2e reductions
- Payback period for each significant opportunity also ranked as high, medium, and low
- Assess and rank the most cost-effective actions/opportunities.
- Assess and lay out case for renewable energy generation at these sites.

Background:

In compiling carbon (CO_2e) data, organisations are typically required to report on their scopes 1 and 2 emissions with an option to report on some of their scope 3 emissions.

Scope 1: Direct emissions. These are emissions from activities owned or controlled directly by the organisation. In the case of Gloucester, this includes gas used at its corporate buildings and fuel used by its own vehicles. Emissions from gas usage are calculated using gas meter reads. Emissions from fleet fuel usage are calculated using annual fuel usage reports.

Scope 2: Indirect emissions. These are emissions which are caused by the organisations energy use but are released at source, not at the location owned or controlled by the organisation. In the case of Gloucester, this covers the electricity used at its corporate buildings. Emissions from electricity usage are calculated using electricity meter reads, billing, and half hourly data.

Scope 3: Other indirect emissions. Emissions other than scope 2 emissions, that are caused by an organisations actions but do not occur at locations owned or controlled by the organisation. How this is factored when the Council owns but does not operate a facility may have impacts on where this is counted.

It is important to set out the scope and boundaries in any such report because what is included/excluded will impact on final figures. Scope 3 emissions are a particular example of this. Similarly knowing how much renewable energy generated is consumed on site or exported to grid will also impact. At the request of the Council, this report focusses on scopes 1 and 2.

In this instance, scope 1 is natural gas and transport fuel, and scope 2 is electricity. We have factored scope 1 and 2 data for all buildings that are owned and operated by the Council or operated on their behalf. The latter group includes depot (Amey) and GL1 (Aspire). Whilst these sites have their energy bills paid by the two private companies, at any time the Council may elect to take these properties and operations back in-house. Public perception is that a Council cannot wash its hands of a swimming pool or its waste services. We have not included the sites that the Council owns and leases to tenants such as B&Q as the Council has no direct ability to influence energy use at these sites. Similarly, the airport whilst 50% owned by the Council is neither operated nor controlled by the Council, the energy bills are paid for by others. There may be a local perception-based case for the sites such as the airport, as there is for the leisure centre and waste depot. In any event, these properties should all be considered priority in advancing the second stage of this report, namely, the 2050 City Plan. By acting to engage and work with local companies at this early stage, the Council puts itself in a strong position to meet its 2050 targets going forward.

Caveat

The site assessments conducted were carried out with the understanding that, due to Covid-19 and operational issues, we would not be able to conduct fully 'data-led' assessments. It is always preferable to assess sites and equipment with energy and data loggers in place so as to verify the actual energy consumption of plant and equipment. As such, the visits were carried out on the basis of fact-finding audits. Consequently, all of our calculations herein are conservative. We would expect to see greater savings than those set out in the report. Indeed, the Carbon Trust stipulate that up to 10% of savings can be derived from behavioural adjustments alone. Our behavioural savings are derived only from equipment led observations and half hourly data (HHD) analysis at certain sites where this is available. We would expect to see larger behavioural savings than these.

The data in this report constitutes the carbon baseline for the council based on information provided. It excludes aspects such as any remaining owned estate, 'Fluorinated' F gases, waste, water etc. This report and associated calculations are the property of CLS Energy and may not be copied or used without their written authorisation.

We would always recommend any organisation with a target to deliver net carbon zero to have a baseline that includes their total energy and fuel consumption measures in litres, kWh and have these converted to carbon in terms of greenhouse gas emissions (CO_2e).

Without an accurately produced baseline, it would be impossible to be able to demonstrate the achievement of a carbon zero figure in 2030. Emissions figures have been calculated based on Government data for green-house gases GHG (CO_2e) for the year 2019 and extrapolated by fuel type and then factored into appropriate scope.

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Baseline

A Council's carbon baseline should be established using carbon dioxide equivalents (CO_2e) which are the mix of seven gases making up the basket of greenhouse gases (GHGs) as agreed under the Kyoto Protocol, ratified by the UK in 2005. Gloucester's data has been scoped for the year 2019/20 and includes the following parameters:

- Electricity
- Gas
- Fleet Diesel
- Enterprise Hire Car (EHI) Fleet details
- Renewables (estimated where not known)

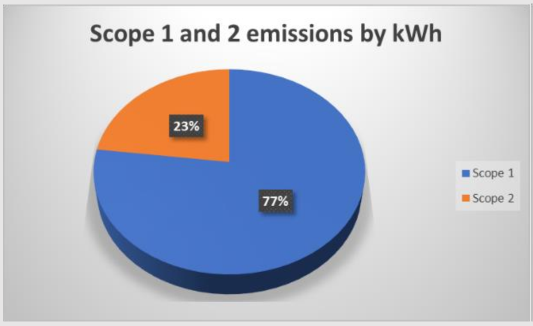
Aspects that should be considered going forward would include:

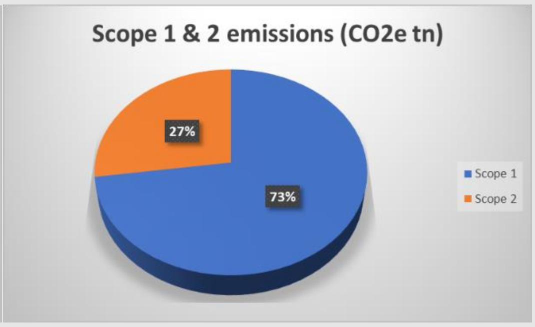
- Fleet unleaded petrol
- Electricity generation
- Heat generation
- Other heating or operational fuels (e.g. generator diesel, red diesel, LPG, or kerosene)
- Private Mileage Reimbursement (Grey Fleet) vehicles

Aspects that may also be considered would include

- Fluorinated (F) Greenhouse Gases
- Water Supply and Treatment
- Commuter travel
- Commercial Waste
- Owned but not operated properties

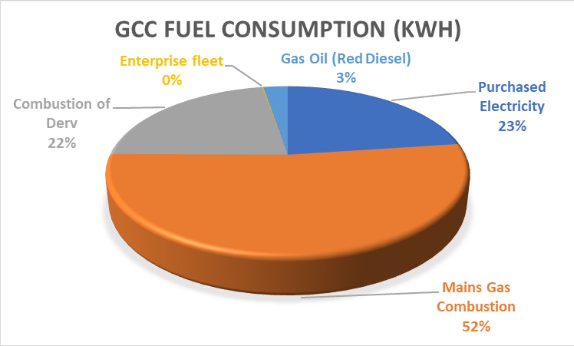
The tables below set out the total energy consumption (in kWh) and factors CO_2e emissions by percentage of the total in metric tonnes:

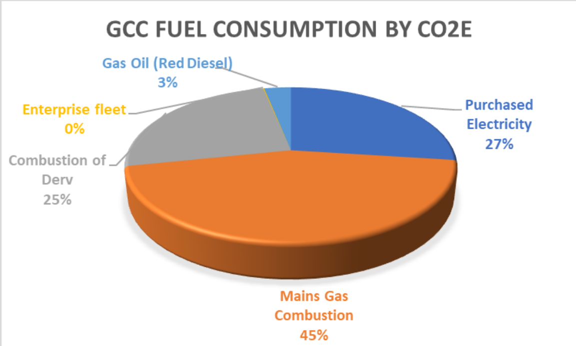




This equates to a Council Carbon (CO_2e) footprint for its sites and fleet of 3,461 tonnes for this baseline year which is reduced by 14 tonnes by the Council's renewables taking the figure to 3,447 tonnes.

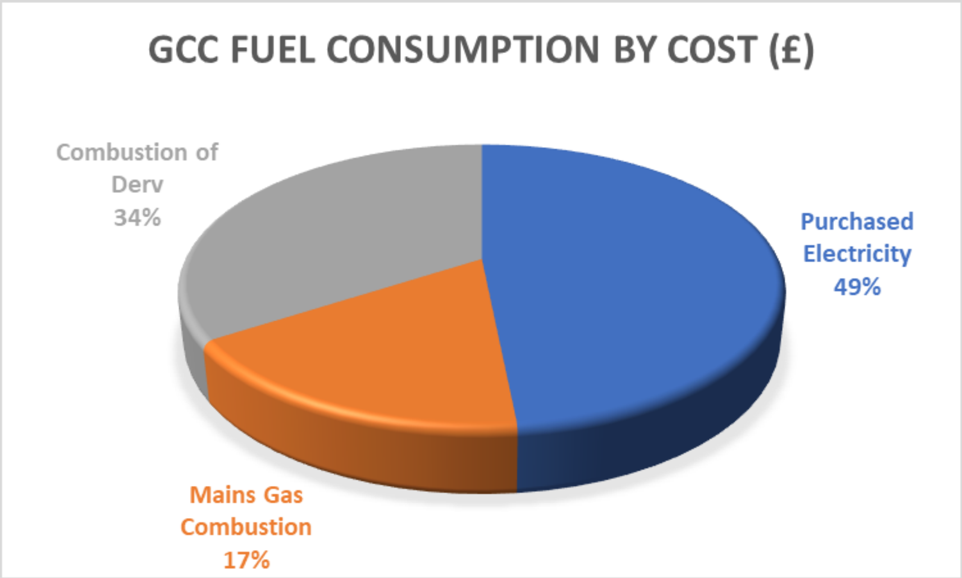
The split of Greenhouse Gas (GHG) emissions by fuels and measured in kWh can be shown as follows with gas (orange) amounting to 52%:





The graph alongside it alters subtly when measured by CO_2e emissions as the conversion factors for electricity and gas (orange), (like all fuels), is different and is adjusted annually in line with the national grid mix which is decreasing coal and increasing renewable energy. Gas in this graph is 45%.

A more striking difference is seen with energy fuel by **cost** where, as can be seen below, the graph compared to kWh broadly inverts due to the fact that the purchase price of gas (orange), 17% by cost at present, is a great deal less expensive than electricity.



Gas has become a large issue for Gloucester City Council, not least because of the Combined Heat and Power (CHP) Engine at Gloucester Leisure Centre (operated by Aspire) that generates heat and power through the consumption of gas, in large part for space and pool heating. The use of this CHP (whilst beneficial in many ways) has increased the Council's gas use (in the reduction of its electricity use). This makes it more difficult to find gas savings for the organisation. This in turn increases the Council's carbon footprint. It would be our view that as far as possible going forward, electrically powered heating technologies be considered which are allied to local electricity generation from allied and appropriate on-site renewable energy generating technologies. This way energy used can be provided by carbon free or low carbon generation.

The Council's vehicle fleet are also heavily $CO2_e$ emitting and it would be worthwhile addressing through a consideration of all options. These would include for example, telematic and fuel data assessment, fleet profiling, aerodynamics, controls, driver behaviour as well as technologies such as alternative fuels, battery electric vehicles (BEVs) and vehicle to grid (V2G).

Other areas may be worthwhile considering. These might include for example:

- Grey fleet (where this remains post Enterprise car club)
- Commuter fleet
- Water
- F Gases
- Waste and Recycling

Findings

Following site audits conducted at the 13 high consuming sites, we have established a number of opportunities which we would recommend are followed to permit energy and fuel savings to be made and which will lead to significant cost and carbon reduction.

Headline Consumption

The Council's building electricity use in kWh is set out below for the higher consuming sites for day, followed by night consumption. Where there are more than two rows, the site has more than one electric meter (green sites are those that were inspected):

Location	Address	Postcode	Total kWh
Gloucester Leisure Centre (GL1)	Bruton Way	GL1 1DT	532,470
Gloucester Leisure Centre (GL1)	Bruton Way	GL1 1DT	281,684
Docks Complex	Herbert Warehouse	GL1 2EQ	377,584
Docks Complex	Herbert Warehouse	GL1 2EQ	114,744
Plock Court (Oxstalls tennis)	Tewkesbury Road	GL1 3LR	285,995
Plock Court (Oxstalls tennis)	Tewkesbury Road	GL1 3LR	25,725
Oxstalls Sports Park Uni Sports Hall	Tewkesbury Road	GL2 9DW	226,045
Oxstalls Sports Park Uni Sports Hall	Tewkesbury Road	GL2 9DW	59,018
Eastern Avenue Depot	Eastern Avenue	GL4 6PG	198,412
Eastern Avenue Depot	Eastern Avenue	GL4 6PG	54,354
North Warehouse	The Docks	GL1 2EP	144,600
North Warehouse	The Docks	GL1 2EP	52,268
Gloucester Crematorium	Coney Hill Road	GL4 4PA	143,440
Gloucester Crematorium	Coney Hill Road	GL4 4PA	35,570
Eastgate Market	The Forum	GL1 1PL	144,461
Eastgate Market	The Forum	GL1 1PL	16,615
Guildhall Arts Centre	23 Eastgate Street	GL1 1NS	93,440
Guildhall Arts Centre	24 Eastgate Street	GL1 1NS	23,915
Eastgate Complex upper car park	Brunswick Road	GL1 1PL	61,519
Eastgate Complex upper car park	Brunswick Road	GL1 1PL	26,219
Gloucester Bus Station		GL1 1DG	69,401
Gloucester Bus Station		GL1 1DG	23,373
City Museum & Art Gallery	Brunswick Road	GL1 1HP	81,519
City Museum & Art Gallery	Brunswick Road	GL1 1HP	17,296
The Pumping Station	Inner Relief Road	GL1 2DA	3,990
Longsmith Street MSCP	Longsmith Street	GL1 2HH	51,014
Longsmith Street MSCP	Longsmith Street	GL1 2HH	19,442
Gloucester Folk Museum	Gloucester City Council	GL1 2PG	20,463
Gloucester Folk Museum	Gloucester City Council	GL1 2PG	6,091
Eastgate Complex upper car park	Brunswick Road	GL1 1PL	27,050
Eastgate Complex upper car park	Brunswick Road	GL1 1PL	6,731
Blackfriars Priory	Blackfriars	GL1 2HN	16,226
Blackfriars Priory	Blackfriars	GL1 2HN	15,236
Blackfriars Priory	Blackfriars	GL1 2HN	4,768
Blackfriars Priory	Blackfriars	GL1 2HN	1,118
Gateway	92 96 Westgate St	GL1 2PE	14,551
Gateway	93 96 Westgate St	GL1 2PE	14,034
Gateway	94 96 Westgate St	GL1 2PE	34,117
Gateway	95 96 Westgate St	GL1 2PE	7,800
King's House, Market Parade	Gloucester City Council	GL1 1RL	49,393
King's House, Market Parade	Gloucester City Council	GL1 1RL	25,733
Coney Hill Cemetery	Arbor Tea Rm Coney Hill	GL4 4PA	17,648
County Shire Hall			40,673
Robinswood Hill Rangers Hut	Reservoir Road	GL4 6SX	6,338
Robinswood Hill Rangers Hut	Reservoir Road	GL4 6SX	6,862
Eastgate Street		GL1 1PD	17,177

Set out below are the less energy consuming sites. Those highligthed in yelow are the market stall meters paid for by GCC, those in red look a little high forf public conveniences:

Christmas Lights			14,064
Tredworth Cemetery	Cemetery Road	GL4 6PA	11,931
Hampden Way		GL1 1SX	11,674
King George V Playing Fields Pavilion	Access via Upton Close	GL4 3EZ	10,719
Hempsted Meadows, Car Park Lighting		GL2 5LE	10,406
Streetcare UMS			10,273
St Michaels' Tower	Eastgate Street	GL1 1PD	10,268
Monument Basement Boots	New Site	GL1 1PA	9,846
63 Eastgate Market	Storeroom	GL1 1PL	9,199
Public Convenience Southgate Moorings Car Park		GL1 2DB	8,000
Permanent Meter Supplying The Bandstand		GL1 1XR	7,021
Westgate Street Car Park Public Toilets		GL1 2PA	5,874
38 The Forum		GL1 1PL	5,361
Car Parking UMS			5,138
5 Priory Place - Lighting		GL1 1TT	4,610
Streetcare UMS			4,574
Roman Bastion, Kings Walk	Kings Walk	GL1 1RY	4,490
18 The Forum		GL1 1PL	4,400
Baked Potato Stand	Eastgate Street	GL1 1NN	4,345
Council Environmental Services	The Park	GL1 1XR	4,301
Stall 41 Eastgate Market	Eastgate Street	GL1 1PL	3,862
Unit 22, Eastgate Market		GL1 1PL	2,624
Meter Cupboard Under Ramp		GL1 1RY	2,555
Tredworth Cemetery	Cemetery Road	GL4 6PA	2,290
26 The Forum		GL1 1XN	2,130
30 Eastgate Market		GL1 1PL	1,938
19 Eastgate Market		GL1 1XN	1,918
Stall 16, Eastgate Market		GL1 1XN	1,862
Stall 23a Eastgate Market		GL1 1PL	1,707
8 Grosvenor House	Station Road	GL1 1SZ	1,695
Mary Magdelan Chapel	London Road	GL1 3HN	1,456
Stall 36 Eastgate Market		GL1 1PL	1,431
Stall 24, Eastgate Market		GL1 1PL	1,142
7 The Forum		GL1 1PL	1,077
Unit 20, The Forum		GL1 1PL	929
Car Parking UMS			870
On Street Power - Outside St Michaels Tower	Eastgate Street	GL1 1PD	863
39 The Forum		GL1 1PL	800
Stockroom 48	Eastgate Market	GL1 1PL	754
25 The Forum		GL1 1PL	671
New Toilets And Stores	Little Meadow	GL1 2NW	626
3a The Forum		GL1 1PL	569
St Lucys Garden	Hare Lane	GL1 2BA	528
35 The Forum		GL1 1PL	375
Car Parking UMS			333
Streetcare UMS			285
37 Eastgate Market		GL1 1PL	212
Greyfriars Bowling Club	Constitution Walk	GL1 1TS	169
Park Store, New Inn Lane	New Inn Lane	GL1 1SD	47
The Lannett Changing Rooms	King Edwards Avenue	GL1 5DA	14
Kiosk (Opposite Sports Direct)	Northgate Street	GL1 1SL	9
The Fleece Hotel	19 Westgate Street	GL1 2UN	4
Kiosk, 1 Kings Walk	Northgate Street	GL1 1SL	1
Flood Lighting, Cathedral Grounds	Via Sacra, St Johns Lane	GL1 2AG	1
Floodlighting	Adjacent Telecom	GL1 2JF	1
Floodlighting Conservative Club	Conservative House	GL1 1TH	1
Unit 2 Southgate Street		GL1 2DH	1
Widden Street School		GL1 4AW	1
Side Of Boots Building	Eastgate Street	GL1 1NS	1
Ladybellegate House	Longsmith Street	GL1 2HT	1
27-29 Commercial Road		GL1 2ED	1
Cold Storeroom, 3 Eastgate Market	The Forum	GL1 1PL	1
11A Westgate Street		GL1 2NW	1
King's House, Market Parade	Gloucester City Council	GL1 1RL	1
23-25 Commercial Road - Lighting supply		GL1 2ED	1
Unit 11 Grosvenor House	Station Road	GL1 1SZ	1
Basement Store 17, Eastgate Market		GL1 1PL	1
Stall 3 Eastgate Market		GL1 1PL	1

Gas consumption is set out below. Where sites are repeated (as is the case with the Guildhall Arts Centre and Gloucester Life 'Folk' Museum), there are two gas meters:

Site	Postcode	Total kWh
Gloucester Leisure Centre (GL1)	GL1 1DT	4,314,265
Coney Hill Cemetery (and crematorium)	GL4 4PA	1,750,419
City Museum & Art Gallery	GL1 1HP	429,520
Docks Complex	GL1 2EQ	496,681
Plock Court	GL1 3LR	258,594
Oxstalls Sports Park Uni Sports Hall	GL2 9DW	243,849
North Warehouse	GL1 2EP	206,136
Blackfriars Priory	GL1 2HN	202,304
Gloucester Life (Folk) Museum	GL1 2PG	17,514
Guildhall Arts Centre	GL1 1NS	43,566
Guildhall Arts Centre	GL1 1NS	193,673
Gloucester Life (Folk) Museum	GL1 2PG	118,465
Greyfriars Bowling Club	GL1 1TS	0
County Shire Hall		64,696

The organisation consumes 15.96GWh of energy per year or 16.01GWh when renewables are included. This equates to $CO2_e$ emissions of 3,461 tonnes per year, reduced to 3,447 tonnes when savings from existing renewables are deducted:

Total Organisational Grid Energy Consumption (TEC) kWh:	15,958,449	kWh	15,958	MWh	3,461
Electricity	3,688,377	kWh	3,688	MWh	943
Combustible Fuel	8,339,682	kWh	8,340	MWh	1,538
Fleet Transport	3,930,390	kWh	3,930	MWh	966
Renewables	52,913	kWh	53	MWh	14
Total Energy Consumption (inc RE)	16,011,362	kWh	16,011	MWh	3,447

In assessing these 13 selected sites, we have effectively accessed 72.94% of electricity and 90.34% of gas. We have not extrapolated the remaining sites into our savings and as such the savings demonstrated only relate to the sites assessed.

Figures used are conservative, not least because we were unable to run data clamping surveys on equipment at times of visit due to Covid-19 closures. Whilst a substantial amount of savings found are from electricity (31.9% of total electricity at the 13 sites), overall savings (at 23.86%) are clouded by the large amounts of gas that the organisation consumes, predominantly by the CHP engine at GL1 and the Crematorium. The 22.7% of gas savings located are predominantly from significant change at the crematorium. Fleet savings amount to 18.8% of fuel use.

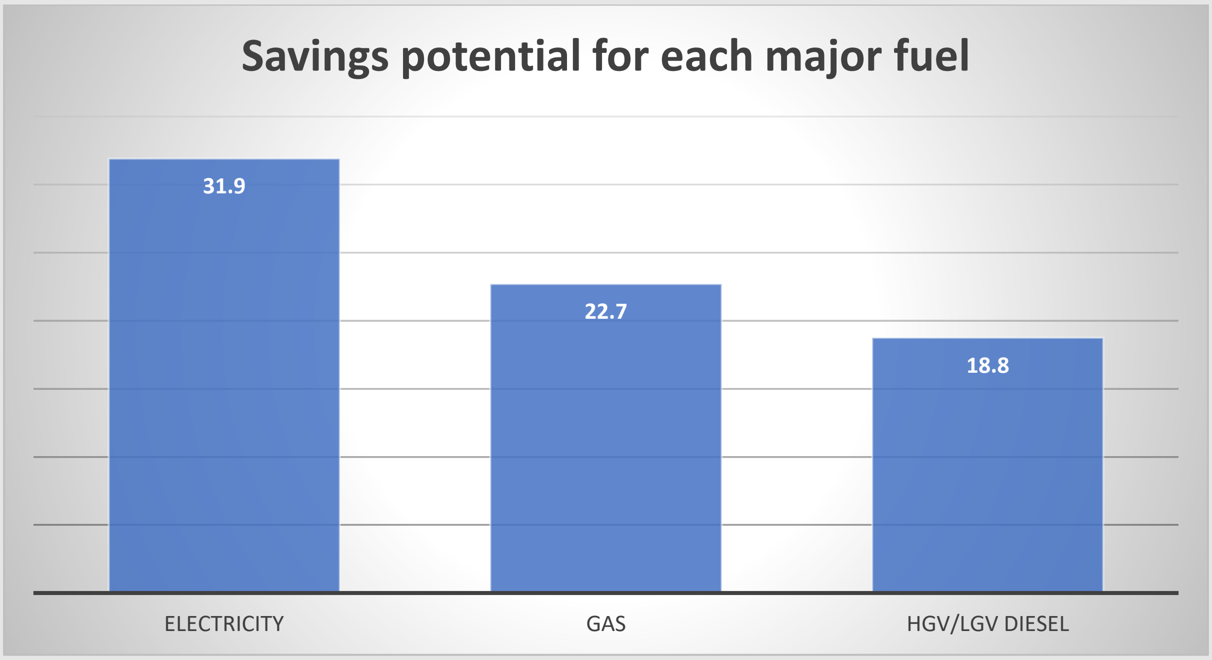
Summary of Savings:

Excluding renewable energy technologies, energy savings potential so far highlighted, amounts to around 19.24% of total consumption from the sites. This rises to 23.86% with fleet and 27.69% with renewables. These set of figures are conservative and in fact the renewables figure could be greatly increased, even at sites viewed, but more information would be required to demonstrate this.

	Electricity & Combustible Fuel	Fleet	Renewables	Total inc RE	No RE
Energy Saving potential identified kWh	3,070,472	737,293	610,454	4,418,220	3,807,766
Carbon reduction kg CO2e	658,079	180,357	537,717	1,376,152	838,435
%age saving from total consumption	19.24	4.62	3.83	27.69	23.86
Financial saving potential identified £	273,132	68,267	297,623	639,022	341,398

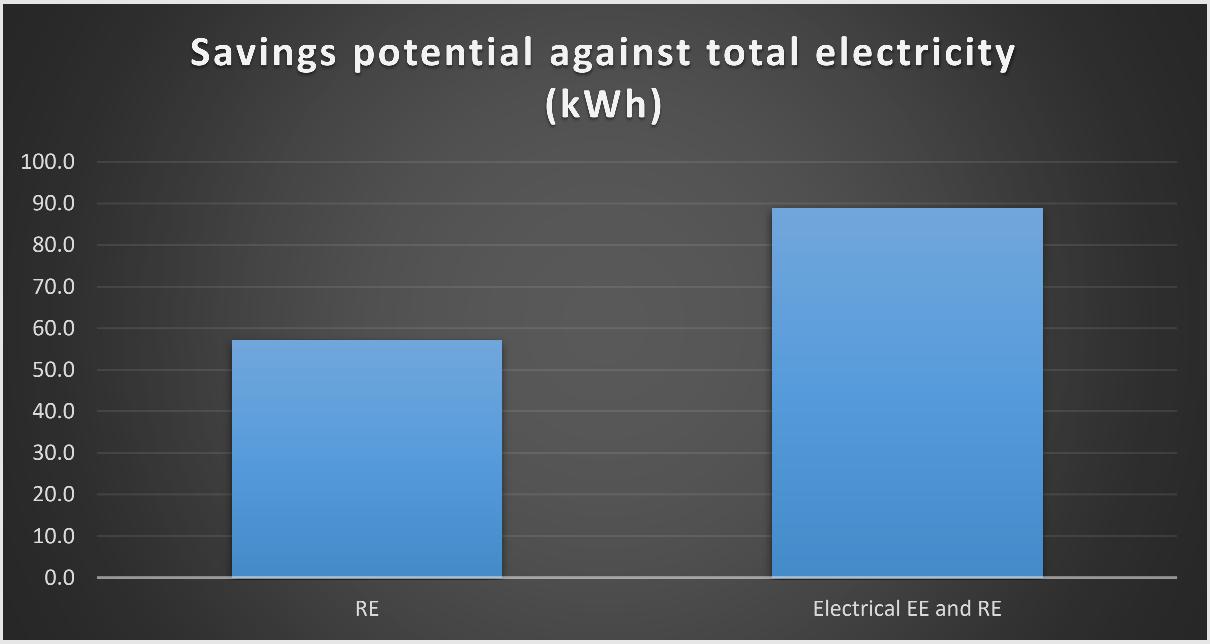
Savings from Resomation (a novel technology for the disposal of bodies – see later) at the crematorium have been captured under energy and combustible fuel rather than renewable energy to avoid double counting.

When broken down, it can be seen that savings per fuel, when viewed against total energy consumption for each fuel type, shows the following percentage potential for savings:



Clearly, the largest energy savings potential is energy efficiency incorporating the use of renewables. Renewable energy technologies can be designed to effectively meet the electrical demand of the Gloucester estate. Naturally, energy efficiency should always be addressed first because the ROI is almost always much higher. It is important to synchronise consumption against generation and plan for what is done with over supply. This is discussed more later with regard to the Oxstalls University site. Gas is more of an issue and as a consequence, we have placed a large focus on the gas use at the Crematorium. It is with this in mind that we have also placed a heavy focus in renewable energy and the future electrification of technologies that are currently using gas.

Renewable energy generation technologies at the sites visited could provide Gloucester City Council with around 58% of its electricity consumption. When factored alongside energy efficiency measures, it is likely to meet around 90% of the Councils electricity demands:



Naturally, matching generation to demand is crucial in this and as such we have factored where possible, at locations where these is potential to use of sell or otherwise distribute power.

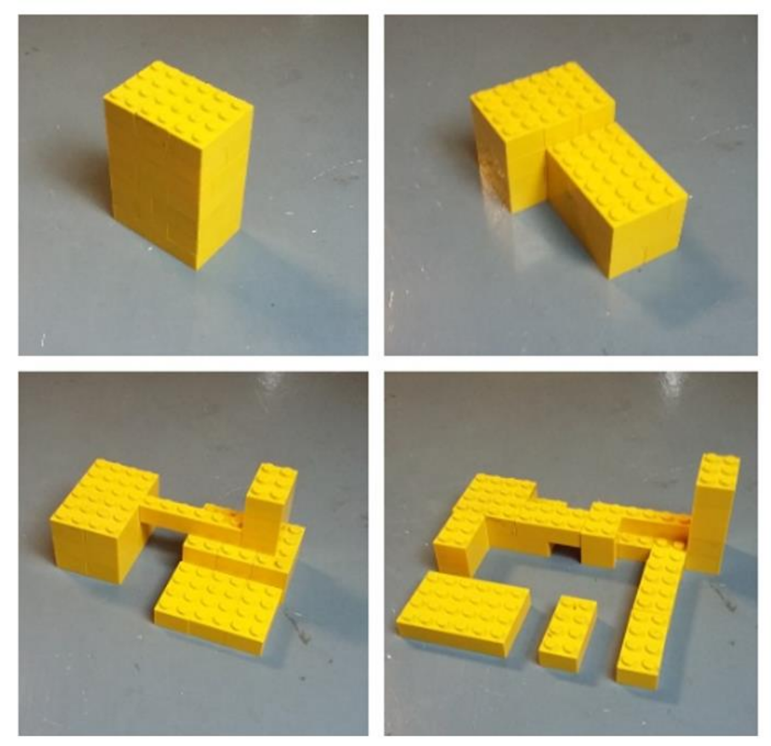
Further assessment of this at other sites is recommended to assist the Council to decarbonise its gas use, moving to electrical heating etc powered by renewable energy.

As discussed, the 58% RE figure of energy generated against total electricity consumed at these sites has the potential to be a great deal higher. We would also expect to see large and potentially linked savings opportunities for the Council’s fleet. We have factored for wind at the Crematorium, effectively removing the gas use there when combined with resomation.

General Benchmarking:

A Councils Carbon baseline can only be established with all of its Scope 1 and 2 emissions from its entire estate and fleet. The Council's sites appear to compare well to national benchmarks. National benchmarks for this sort of building are based on kWh/m2.

This is a rather blunt tool because the surface areas of a building can vary greatly for the same given volume as the example in Lego shows below, each image being constructed with the same number and volume of bricks but clearly with very different exposed surface areas at roof, walls and floor:



Half Hourly Data (HHD)

HHD has been assessed at various sites that have appropriate metering. An example of this is shown below for Plock Court during December 2019:

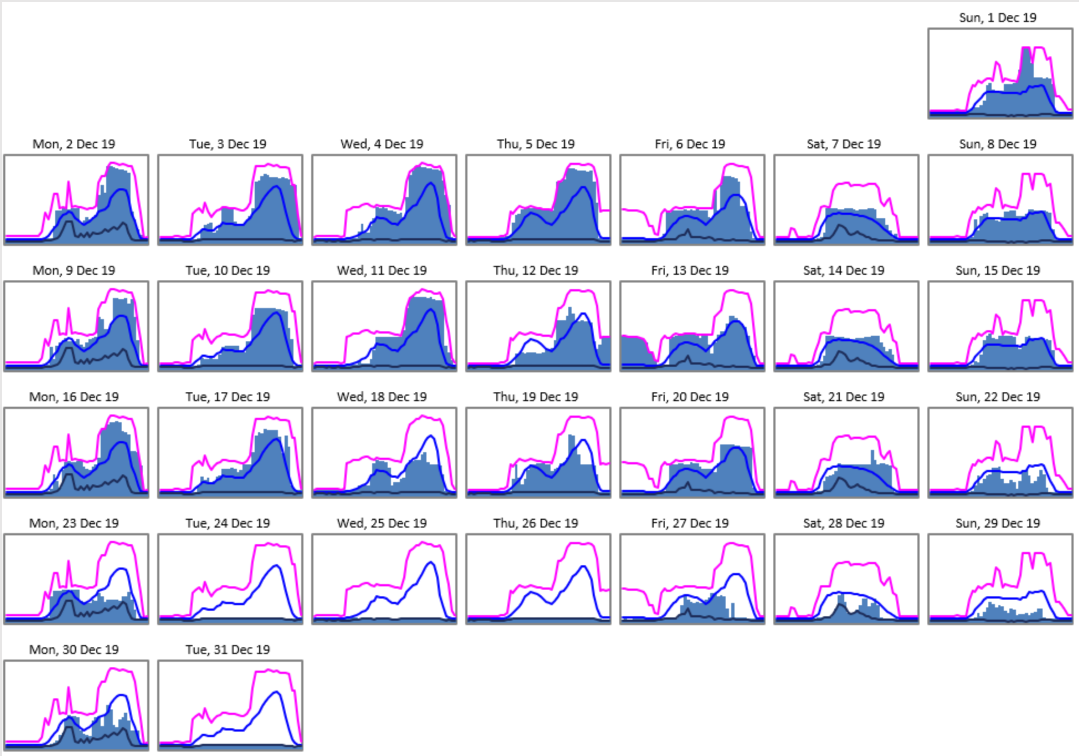
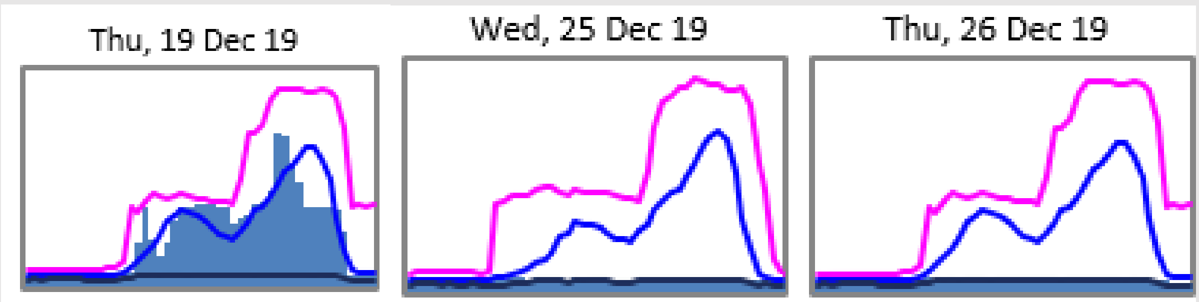


Image above shows December divided into 31 days and each box represents one day.

The pink line (top of the box) is the maximum electricity use on any given day (so for Christmas day below, any given Wednesday that year), the green line (bottom of the box) is the minimum and the blue line is the average (middle of the box).

The blue mass is electricity consumed per half hour throughout the day. As can be seen, at this site, the energy use typically commences around 07:00 and drops of at around 21:30. As can also be seen, night time use looks to be low during this month and during Christmas when we would expect to see site closure and little or no electricity use, this is indeed the case:



Heating Degree Days (HDD)

Regression Analysis:

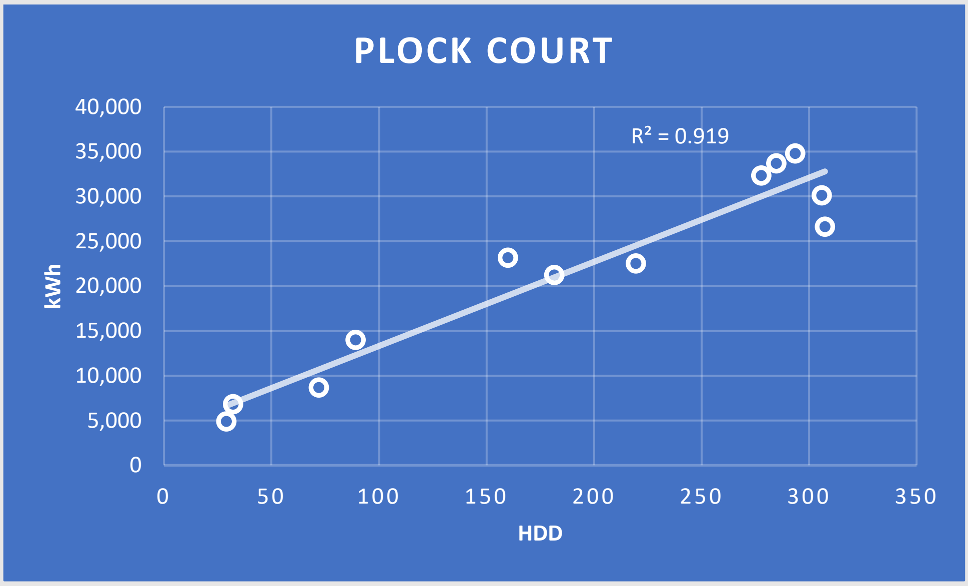
Degree day analysis allows us to compare heating (in this case gas central heating) use, with seasonal temperatures for the Gloucester area during the 12-month period observed.

An R^2 figure of 0.95 or higher shows statistical significance and a direct correlation between heat use when outside temperatures reach a certain pre-set level.

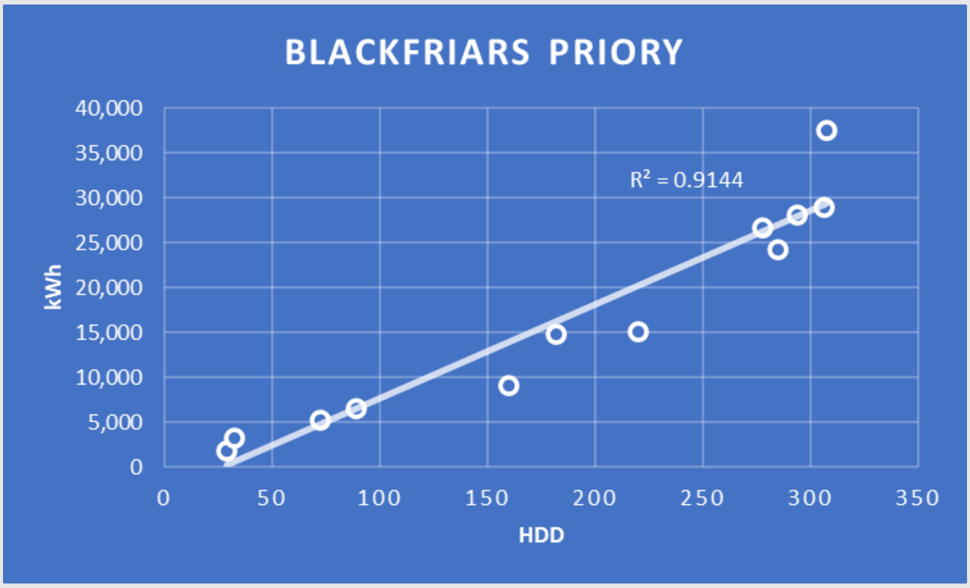
We have conducted regression analysis of the sites where there was sufficient gas data. This allows us to normalise the data and establish where heating is taking place at times when it need not have been. By assessing gas use data against local weather station data over the period, we can establish where heating systems have potentially been over-ridden and are providing heat when it ought not to be required:

The best controlled sites in terms of gas use set against outside weather temperatures were Plock Court and Blackfriars Priory, both of which have well operated BMS systems.

Plock Court has an R^2 of 0.919:



Blackfriars priory has an R^2 of 0.9144:



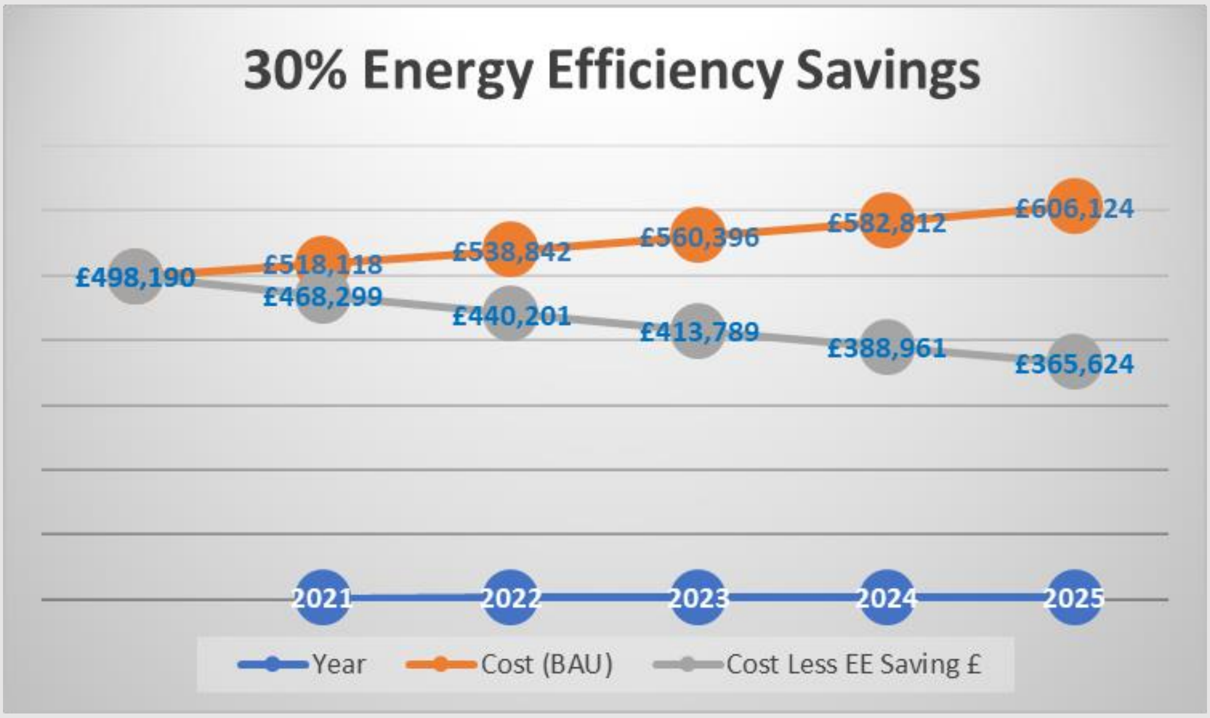
An R^2 figure of 0.95 would show significance and as can be seen at the two sites above, these figures are remarkably close. The Facilities Managers should be congratulated for this level of control.

More data is always beneficial in further investigations into regression analysis.

Value at Stake

The electricity consumption provided for the estate for a one-year period amounts to 3,688,377kWh. Averaging the cost per kWh across these sites give us a rate of £0.137206/kWh (13.7p/kWh). **Electrical** savings found through surveys amount to 1,177,173kWh or 31.9% - almost one third of total electricity used from the buildings assessed. Extrapolation to the remaining buildings would further increase this. We have factored for a conservative 30% and assessed the numbers for this below.

Excluding electricity charged at County Hall over which the City Council have no control, electricity consumption is 3,630,964kWh (3.63GWh) at an annual cost of £498,190. Were the Council to continue as normal (business as usual), then in 5 years-time they could expect to be spending £606,124 for the same electricity. This is because energy inflation increases the cost annually. We have factored this at 4% which is a reasonable industry standard. If by contrast, Gloucester acted on most of the recommendations put forward in this report and saved 30% of their energy use, then the costs for the electricity in 2025 would be £365,624. Figures exclude County Hall which is a rental allocation of 2.84% floorspace and consequently outside the control of Gloucester City Council.

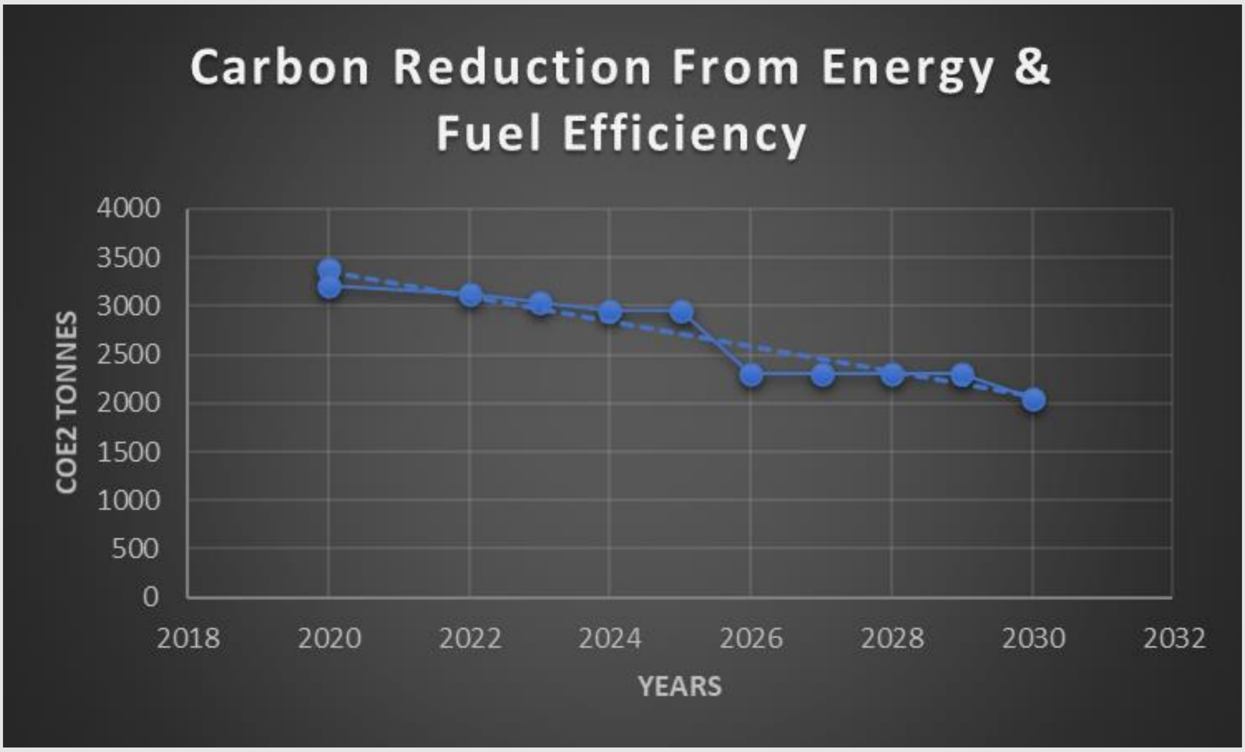


This is a cost saving of £240,501 and is the value at stake (VAS). The triangle formed between the orange and grey lines. Naturally, this could be expected to increase further if all actions were enacted and if the remainder of the estate were brought to bear. There is likely to be some synergy between opportunities. Whilst we appreciate that the Council is looking at this as a Carbon exercise, the financial saving available will help the council to enact future carbon saving measures and so should always be considered.

2030 Trajectory

Graph 1:

The council's ambition to be net carbon zero by 2030 is described below in three charts. The first shows the direction of travel if the Council integrates all of the 41 recommendations in this report.

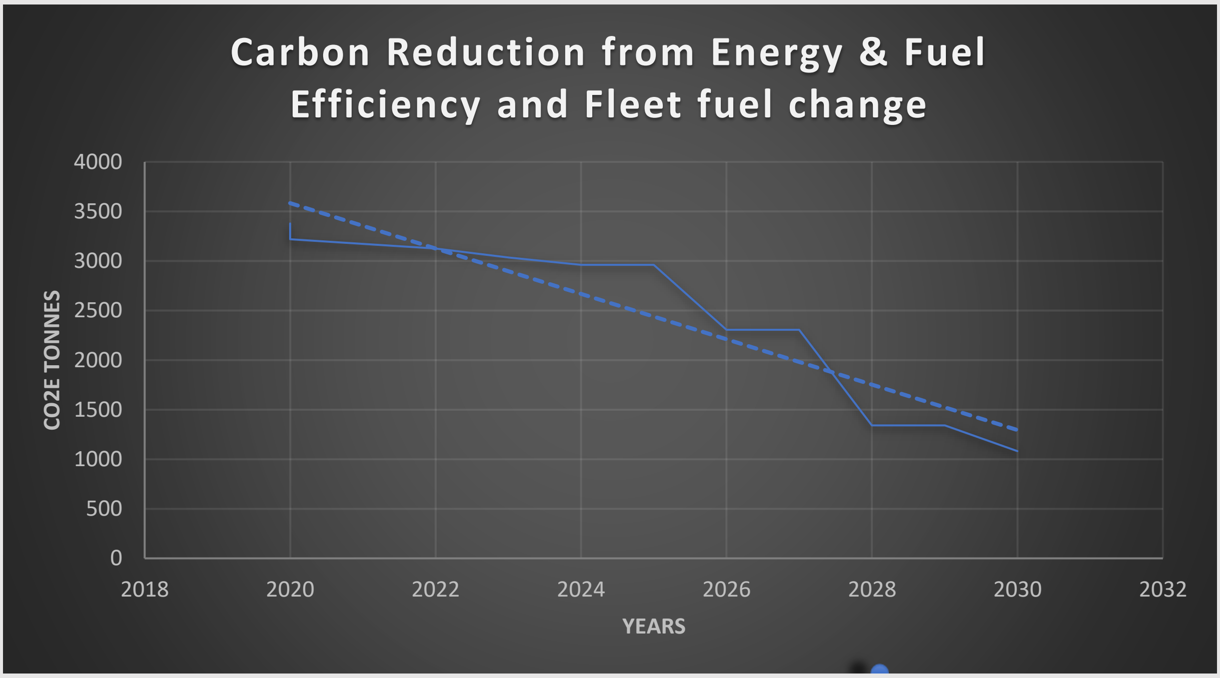


It must always be remembered that in certain instances, a recommendation may have impacts on another recommendation. As an example, whilst changing the belt type of a motor will make a saving, replacing the same motor with a more efficient one will make a greater saving. Only one of these options can be pursued for the gain to be made.

We do not normally advocate for planning in CO2e because the factors are affected each year by the way in which national power is sourced and generated.

Graph 2

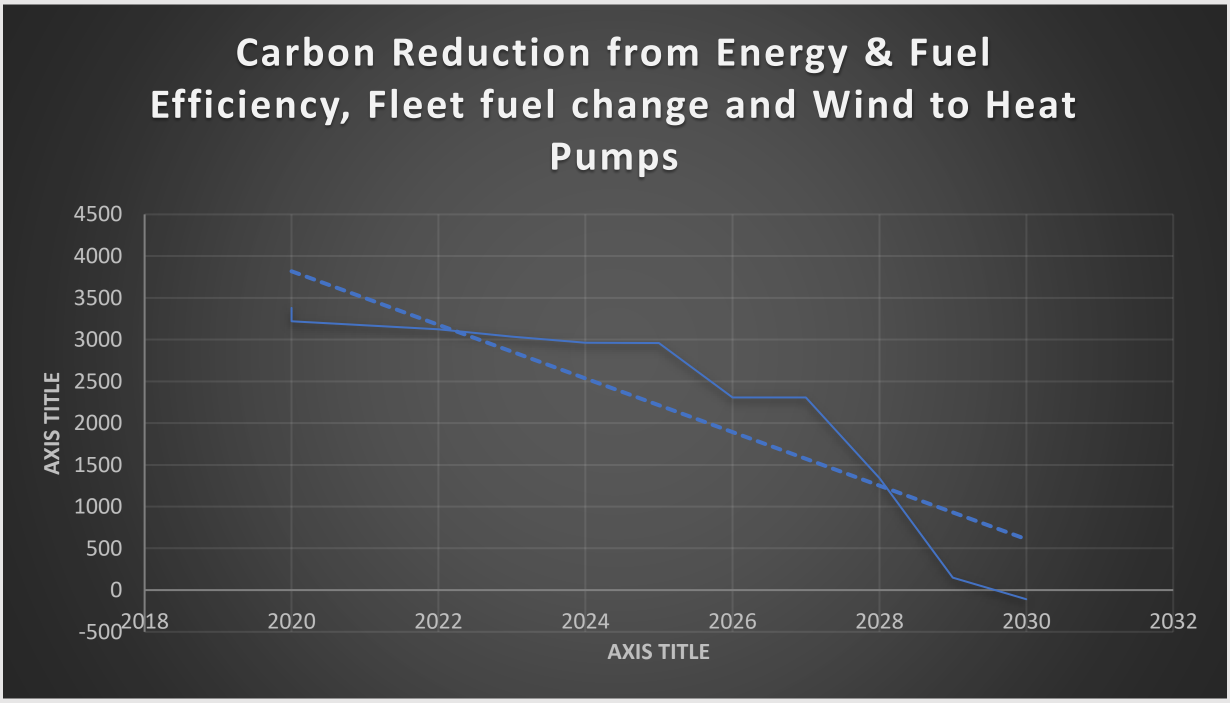
Graph two shows the same data as above alongside a replacement of refuse, recycling fleet and street cleaning and commercial van fleet with alternative zero carbon fuels:



The graph above is looking at technologies that are currently available but that are not yet financially viable.

Graph 3

Graph three shows the same data as above (the replacement of refuse, recycling fleet and street cleansing and commercial van fleet with alternative zero carbon fuels) and with the implementation of large wind (or solar) technology at a site or sites to be agreed (an example for the latter may be the airport) and the installation of heat pumps to provide electrified heat to replace that currently provided by mains gas:

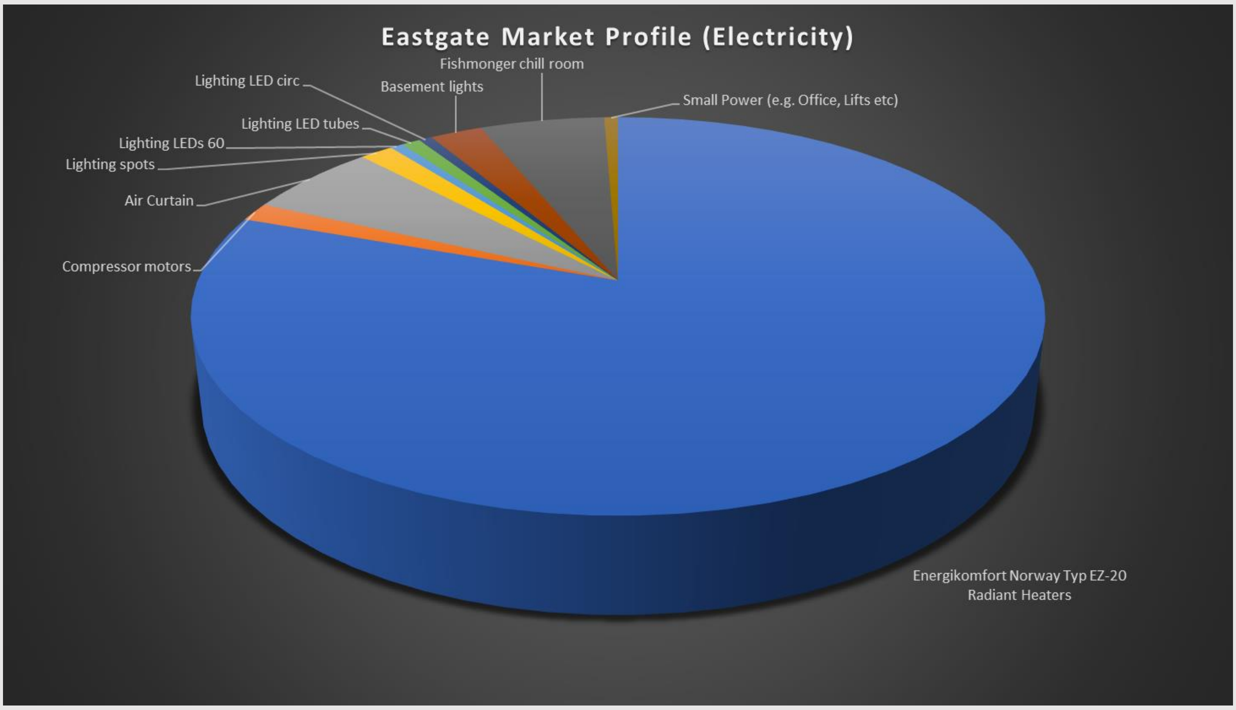


In this scenario, we have factored for a turbine of around 145m to tip as the most efficient route to generation. We have similarly factored for this energy to be used, appropriately distributed, or sleeved to power heat pumps which would be the most efficient method of heating carbon-free and powered by the appropriate renewable energy. These could be expected to achieve at least 2.5kW for every kW input. The above makes assumptions that, for example, heat pumps will be acceptable and viable at sites as yet unseen, that a site or sites may be available to install a large turbine or solar field and that it is appropriately grid connectable. At sites such as GL1, Ground Source Heat pump (GSHP) technology would be preferred and a comprehensive study would need to be conducted to establish whether or not the access and ground conditions around the rear of the site might be suitable. It also assumes that any remaining (too difficult to achieve) $CO2_e$ emissions that cannot be factored, are addressed via locally sourced sequestration.

All three of the above graphs are based on current (2019) carbon conversion factors that will change year on year going forward based on how the mix in the national grid is met.

Profile - Eastgate market

We have profiled the Eastgate Market because, as a single location, there is great potential for action here. It is also a long standing and recognised building to use by way of demonstration. Total consumption looks to be focussed around the 36# 2kW radiant heaters around the ceiling. Assumed to be on for 5 months of the year and for 12 hours per day, these look to represent just over 80% of the site's electricity consumption. The air curtains look to be around 6%. The fishmongers chilled waste room looks to be around 5.6%, vent compressors 1.5% and basement lighting 2.3% (this could be higher as several appear to be (red) on 24/7 – we have factored for 12 hours per day.



Lighting use across all Council sites observed look to be around 21% of total energy consumption which is high although more so due to sites such as Kings Walk MSCP that appear to have heavy duty light operating on the open air roof 24/7.

Recommendations

A full set of recommendations are broken down below into three tables setting out:

- energy (electricity and gas, where gas measures are highlighted in yellow),
- fleet - blue table
- renewables - pink table.

Recommendations are ranked by payback (with the quickest to achieve returns at the top) and then as high, medium low in the final column using a RAG colour code. The table below sets out a summary of energy measures:

Assessment Findings:	Detail of Measure Identified	Assessed By	Applicability	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kg CO2e Reduced	Capital cost to instigate (£)	Ranked Payback Period
Energy Measures								
Measure ME1	Meter Reassociation	Site/Desk Assessment	EM	26,652	3,657	6,812	0	0.00
Measure ME2	ASC	Site/Desk Assessment	GL1, GBS, BP, GO	0	5,772	0	200	0.03
Measure ME3	Server Room AC	Site/Desk Assessment	EAD, GO, NW	72,020	9,882	18,408	900	0.09
Measure ME4	Air Curtains	Site/Desk Assessment	PC, G, EM	24,960	2,996	6,380	270	0.09
Measure ME5	BMS Control	Site/Desk Assessment	EAD, BP, ATR	54,838	1,673	14,017	400	0.24
Measure ME6	Chiller Control	Site/Desk Assessment	G, NW, EM	56,021	7,686	14,319	2,000	0.26
Measure ME7	HHD Assessment	Site/Desk Assessment	CHC, EAD, EM, NW	116,159	14,752	29,690	5,200	0.35
Measure ME8	VSD control on AHUs	Site/Desk Assessment	EM	6,599	905	1,687	450	0.50
Measure ME9	Site Behaviours	Site/Desk Assessment	FM, G, GO, GL1, AED	56,137	6,067	14,349	3,550	0.59
Measure ME10	Regression	Site/Desk Assessment	OxU, FM, NW, G, CM	143,482	3,088	26,379	1,960	0.63
Measure ME11	Comfort Zones	Site/Desk Assessment	GL1, PC, GO	5,780	793	1,477	820	1.03
Measure ME12	Radiants	Site/Desk Assessment	EM, EAD, BP	247,280	10,527	63,205	11,200	1.06
Measure ME13	Pipe Insulation	Site/Desk Assessment	GL1, PC, FM, NW, G, CM, BP	34,324	609	6,310	1,100	1.81
Measure ME14	F&V Lagging	Site/Desk Assessment	GL1, PC, FM, NW, G, CM, BP	37,130	591	6,826	1,210	2.05
Measure ME15	Cavity Insulation	Site/Desk Assessment	GL1, FM, GO	37,400	1,392	6,876	2,943	2.11
Measure ME16	Lighting	Site/Desk Assessment	GL1, PC, EAD, FM, NW, CM, CHC, G, EM, EGC, KW	271,279	44,925	49,875	103,214	2.30
Measure ME17	Boiler Optimisation	Site/Desk Assessment	GL1, PC, NW, CM, BP	137,348	3,116	25,252	10,050	3.23
Measure ME18	AHU EC Fans and Cogs	Site/Desk Assessment	GL1, NW, CM	239,449	30,860	44,023	114,520	3.71
Measure ME19	Compressors	Site/Desk Assessment	EM, EAD, BP	10,327	504	1,899	2,100	4.17
Total Energy Measures				1,577,183	149,796	337,783	262,087	1.75

The table below sets out a summary of fleet measures. Recommendations are again ranked by payback (with the quickest to achieve payback at the top) and then as high, medium low in the final column using a RAG colour code:

Fleet Measures RCV, Commercial Van and Car	Detail of Measure Identified	Assessed By	Applicability	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kg CO2e Reduced	Capital cost to instigate (£)	Ranked Payback Period
MF1	Eco Training using telematics	Site/Desk Assessment	All Fleet	116,041	10,731	28,386	5,100	0.48
MF2	Over revving	Site/Desk Assessment	RCVs and kerbsiders	99,127	9,167	24,248	5,100	0.56
MF3	Rolling Resistance	Site/Desk Assessment	All Fleet	59,450	5,498	14,543	4,200	0.76
MF4	Speed Restriction	Site/Desk Assessment	Commercial vans	46,628	4,312	11,406	4,900	1.14
MF5	EV Vans	Desk Assessment	2 vans	12,904	1,864	3,157	2,160	1.16
MF6	Idling reduction	Desk Assessment	RCVs and kerbsiders	33,042	3,056	8,083	5,100	1.67
MF7	Electrify Enterprise Fleet	Desk Assessment	6 cars	15,319	828	3,747	1,680	2.03
MF8	Maintenance Regimes	Site/Desk Assessment	All Fleet	17,485	1,617	4,277	4,200	2.60
MF9	Spec (Beacons/ Faring)	Site/Desk Assessment	Kerbsiders	21,081	1,950	5,157	5,600	2.87
MF10	CNG	Site/Desk Assessment	Kerbsiders	316,216	29,243	77,353	280,000	9.57
				737,293	68,267	180,357	318,040	4.66

The table below sets out a summary of renewable energy measures. Recommendations are once more ranked by payback (with the quickest to achieve payback at the top) and then as high, medium low in the final column using a RAG colour code, this time using yellow for long and red for extended payback:

Renewable Measures	Detail of Measure Identified	Assessed By	Applicability	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kg CO2e Reduced	Capital cost to instigate (£)	Ranked Payback Period
Renewables Current	Solar and Wind		Plock Court, Bus Station, Guildhall, Turbine	52,913				
Measure R1	Solar Array A	Desktop Assessment	GL1	500,202	64,306	127,852	336,157	5.23
Measure R2	Solar Array B	Desktop Assessment	Plock Court	325,471	50,028	83,190	251,073	5.02
Measure R3	Solar Array C	Desktop Assessment	Eastern Avenue Depot	335,093	44,327	85,650	225,197	5.08
Measure R4	Solar Array D	Desktop Assessment	Gateway	16,363	2,075	4,182	10,997	5.30
Measure R5	Solar Array E	Desktop Assessment	Crematorium	30,592	4,019	7,819	20,559	5.12
Measure R6	Solar Array F	Desktop Assessment	Guildhall	7,440	856	1,902	5,000	5.84
Measure R7	Solar Array G	Desktop Assessment	Eastgate market	75,684	10,057	19,345	50,863	5.06
Measure R8	Solar Array H	Desktop Assessment	Blackfriars Priory	12,450	1,521	3,182	8,367	5.50
Measure R9	Solar Array Car Port I	Desktop Assessment	Longsmith Street MSCP	187,000	25,085	47,797	290,000	11.56
Measure R10	Solar Array Car Port J	Desktop Assessment	Kingswalk MSCP and Eastgate Complex	519,680	69,997	132,830	828,800	11.84
Measure R11a	Wind 180kWp	Desktop Assessment	Crematorium and resomation	1,493,289	123,336	320,296	714,640	5.79
Measure R12	GSHP	Desktop Analysis	Depot	66,137	2,722	16,905	8,000	2.94
Measure R13	Plock Court	Assessment	Engineers Inspection Req'd	27,629	12,129	7,062	700	0.06
Measure R14	Plock Court	Assessment	Negotiation	0	10,500	0	0	0.00
Total Renewable Measures				2,103,743	420,959	858,013	2,750,354	6.53
Total All				4,418,220	639,022	1,376,152	3,330,480	5.21

Total for all three sections is in the green line above.

Renewables that are in place currently (red Line at the top of this table) above, represent the renewable energy that the Council is currently generating from operations at Plock

Court, Guildhall and Lock Cottage. There is also a solar array at the Gloucester Bus Station, and this has been assumed as a 20kWp array (similar to that at the Guildhall) as data was unavailable.

Applicability Key:

- GL1 GL1 Leisure Centre, Gloucester (contract change potentially 2022)
- PC Plock Court
- CD Council Depot and fleet
- FM Gloucester Life (Folk) Museum
- GO Gateway Offices
- NW North Warehouse (and EHI fleet)
- CM City Museum
- CHC Coney Hill Crematorium
- G Guildhall
- EM Eastgate Market
- BP Blackfriars Priory
- EGC Eastgate Complex
- LSS Longsmith Street MSCP
- KW Kings Walk MSCP

We would propose that any energy efficiency measure with a suitably long persistence factor (lifetime of the measure/equipment) should be enacted. Most private companies would tend to work on a maximum 3-year payback. However, technologies such as those above with over 3-year paybacks have long life expectancy and will deliver maintenance savings as well as quality and performance improvements.

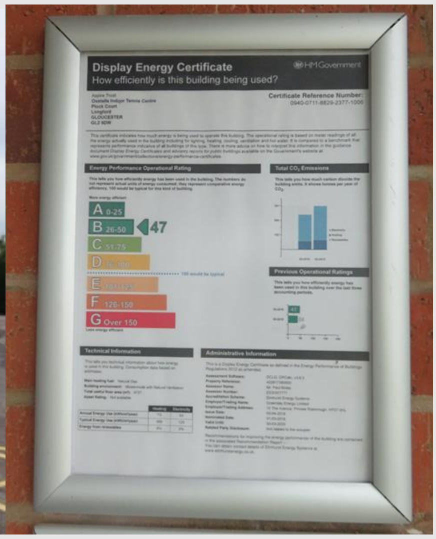
Summary of Sites Inspected:

GL1 GL1 Leisure Centre, Gloucester

Managed by Aspire with contract due to expire or extend potentially around 2022. Site is a leisure complex with pools.

PC Plock Court

Plock court attendance with Paul Dewsbery and Meyrick Brentnall. The DEC for the building shows a useful floor area of 4,727m2 and an encouragingly high B47 rating. This despite the fact that the DEC has neither recognised nor referred to the solar PV array on the roof.



The site is managed by a BMS system which operates boilers, reception and changing areas. There is an electric, gas and water meter on site. Readings below:

Opening hours (when not in Covid-19 operation) are 8:30 AM to 10:00 PM Monday to Sunday. Closing periods are Christmas Day, Boxing Day and New Year's Day and all bank Holidays with half day operation on Christmas Eve .

8# Powrmatic heaters (imaged above right) are in place in the tennis courts which are not used and ought to be disconnected from the mains gas. Controls for these are at either end east or west of the tennis courts.

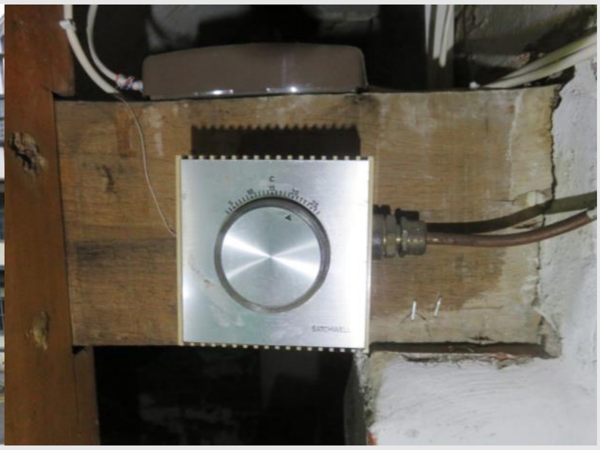
CD Council Depot and fleet

The Council depot site is operated by Amey. Windows are open with portable air conditioning units left on. These units are extracting through windows using 6-inch pipes this needs to be resolved using appropriate permanent AC units or extraction holes through walls. Distance from the site to the materials recycling facility (MRF) is short because the MRF is at the Depot and the disposal of waste is to the energy from waste site. Telematics have been provided. Operating hours at the site are 6:00 AM to 6:00 PM Monday to Friday. There is some Saturday working in the workshop .

The MRF has conveyor motors and also an 11kW compaction motor. The conveyor Motors are much smaller. Lighting throughout the building is fluorescent and should be replaced with LED, the server room is the only area that has its own air conditioning permanent unit and that should be adjusted given that it is a 24/7 operation.

FM Gloucester Life (Folk) Museum

The Gloucester Life (Folk) Museum Westgate Street is a Grade 2 listed building.



Much of the lighting has been replaced with LED spots. Rooms temperatures are controlled on thermostats. Boiler service is overdue since April 2019 as a result of Covid-19.

GO Gateway Offices

The building is 100% electrically powered with no gas on site.

The site has undergone a good standard of retrofit which has included windows with high quality argon filled double glazed units, re-lamping with LEDs and sensors, heating, and cooling with LG heat pumps. Lighting lux levels are particularly good.

NW North Warehouse (and Enterprise fleet)

The North Warehouse has floors 1 and 2 occupied by Regus. The basement and 3rd floor are occupied by the Council. Plant is stored in the basement.

Two of the three boilers appear to be operational

Metering in the building leads us to believe that the split of energy is not being carried out reasonably. The sub meter on the 3rd floor was not operational on day of visit and there is no obvious sub metering to floors. The Chiller unit outside the plant room, paid for by the Council at the basement is not being metered and is utilised by Regus at the cost of the Council.

CM City Museum

The museum is a grade 2 listed building. Unsurprisingly, it has a low DEC rating of G 165.

CHC Coney Hill Crematorium

The crematorium has three gas fired cremators fired from a single gas fired boiler. The site has a compressor, and the three cremators are managed externally and via on site BMS through Facultatieve Technologies. All three units are identical and can be used interchangeably.

G Guildhall

EM Eastgate Market

Opening hours: 0700 to 1800 Mon to Sat

December: Mon-Sun 0700 (0930 – 1700) 1800 public in brackets

Observation: Some of the stalls have meters paid for by GCC.

BP Blackfriars Priory

EGC Eastgate Complex

LSS Longsmith Street MSCP

KW Kings Walk MSCP

All lighting columns at the top floor of this site were found to be on in broad daylight.

Calculated together for the relevant sites and not extrapolated to the remaining sites, the report's specific recommendations are set out below on a technology by technology basis:

Energy Efficiency Recommendations

ME1 Transition – Repatriate stall meters

Some of the Eastgate Market stalls have meters paid for by GCC. In the year assessed, these consumed 26,652kWh of electricity at a cost to the Council of £3,657. From a fairness approach, it seems unreasonable that some stalls should receive free electricity when others do not. Whilst moving this cost to stall holders arguably simple moves the producer of the carbon, it is broadly accepted that when an owner is paying for their own electricity, they will be a good deal more careful in its use and the amounts of energy used are likely to reduce.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure E1	Meter	26,652	3,657	**6,812**	0	0.00

ME2 Available Supply Capacity (ASC) Adjustment

There is potential at GL1, Gloucester Bus Station, Blackfriars Priory and Gateway Offices to reduce the available supply capacity (ASC) at these sites. Whilst this would have no effect on carbon, it will reduce costs.

It must be understood that offering this capacity back to the grid and recovering income for the same must only be done if the operators are sure that they will not be expanding the sites or equipment in the future or otherwise increasing specific demand at key points of the day.

Once lost, there is no guarantee in the future that the grid can offer this capacity back and, if they can, there may be infrastructural costs levied. It is always good practice to run these assessments on at least two years of data before making a commitment.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure E2	ASC	0	5,772	**0**	200	0.03

ME3 Server Rooms

Depot

All cooling in the server room that is set at 20C or below should be allowed to rise to 22C.

It is also important to ensure that all rooms are set at the same temperatures.

Were units operating at x and y are in same room at different set points, they will be working much harder than necessary by fighting against each other to achieve an impossible dual set point.

North Warehouse Server room (3F)

It is understood that the Council server room is served by a Mitsubishi SRC63ZK-SAC unit adjacent the chiller. The unit has a 1.76kW input cooling capacity.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure E3	Server Room AC	72,020	9,882	**18,408**	900	0.09

ME4 Disconnect Door Warm Air Curtains

There are door curtains at various sites. Where door curtains are not covering the entire width of the door opening, warm air will escape from either side of the air curtain and no benefit will be achieved. At all of the sites below, this is the case. The curtain at Plock Court is serving no useful purpose and should be replaced or preferably removed/disconnected:

Plock Court

Guildhall

For similar reasons, we would recommend the removal of these two door curtains which are serving no real purpose and allowing warm air to escape either side and down the centre of these units:

Eastgate Market

Disconnect three front of Market Air Curtains that are currently all controlled from an on/off switch:

These curtains are switched on (one switch all three with no control over velocity, wattage, or temperature) when a trader complains. This provides no real advantage to anyone. The total door opening is 9.07m wide x 2.59m high. Each unit is less than 900mm wide.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure E4	Air Curtains	24,960	2,996	**6,380**	270	0.09

ME5 Building Management System (BMS) Control

Building management systems (BMSs) are computerised programmes and equipment designed to control the switching, timing and set points of electrical and in some cases, gas equipment. There is evidence of some good practice BMS control at some of the buildings visited.

We would propose that BMS systems be moved to remote desktop and ideally be web enabled where this is not currently the case (effectively at all sites except GL1).

Depot Trend BMS

The BMS is set incorrectly and needs to be adjusted.

Zone 1: 1st Floor LHS Optimiser Schedule

This is set to operate from 0600 to 1800 Monday to Friday which matches the stated operational hours of the site. There is no weekend usage as can be seen below:

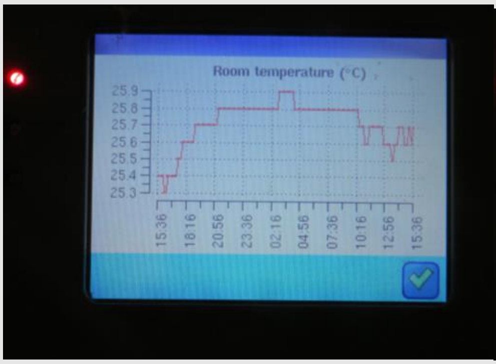
Zone 2: HWS Schedule

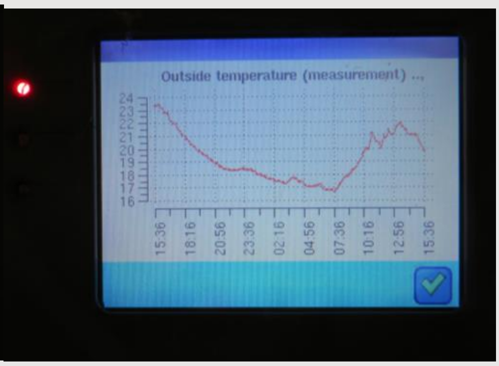
This schedule shows HWS operating from 0500 to 1800 Monday to Friday. However, it is also operating on Saturday and Sunday.

We would recommend that the BMS be interrogated and properly set up. The saving from addressing this alone will be significant.

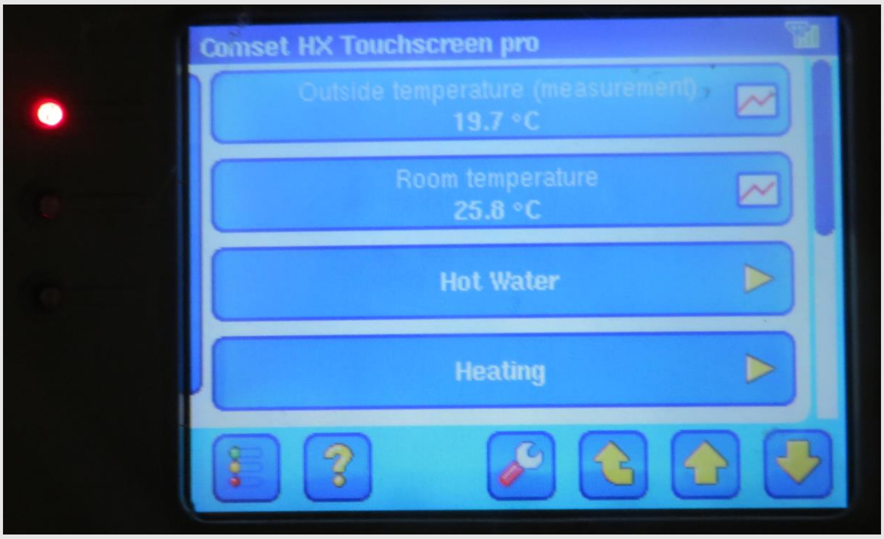
Crematorium Arbor Tea Room

Boilers are due for their next service in November 2020. Hot water and heating in the building is managed by a BMS.





Room temperatures look to have been set within a reasonable range. However, on considering outside temperatures over the most recent 24-hour period, with outside temperatures dropping over night to around 16.8C, internal temperatures overnight were typically over 25C suggesting that heating is being left on overnight. Indeed, at time of visit with outside temperatures at 19.7C, the internal room temperatures were 25.8C.



Blackfriars Priory

At this site, the BMS controls boiler heating and hot water.

Site is only open Fri, Sat and for ad-hoc events and marriages. It is typically, open then until 12 midnight.

- Mon 0700 – 1000 and 1700- 1900 (5)
- Tue 0600 – 1200 and 1730 – 2200 (8.5)
- Wed 1700 – 2200 (5)
- Thu 0600 – 2400 (18)
- Fri 0600 – 2400 (18)
- Sat 0700 - 0900 and 1800 – 2000 (4)
- Sun 0800 - 1100 and 1700 – 2100 (7)
- Total week: 65.5 hours (average 9.4hrs)

Recommend adjustment of controls – recognising the need to maintain heat on to remove damp and keep warm through hot pipes in floor but do not need heating on all of the time.

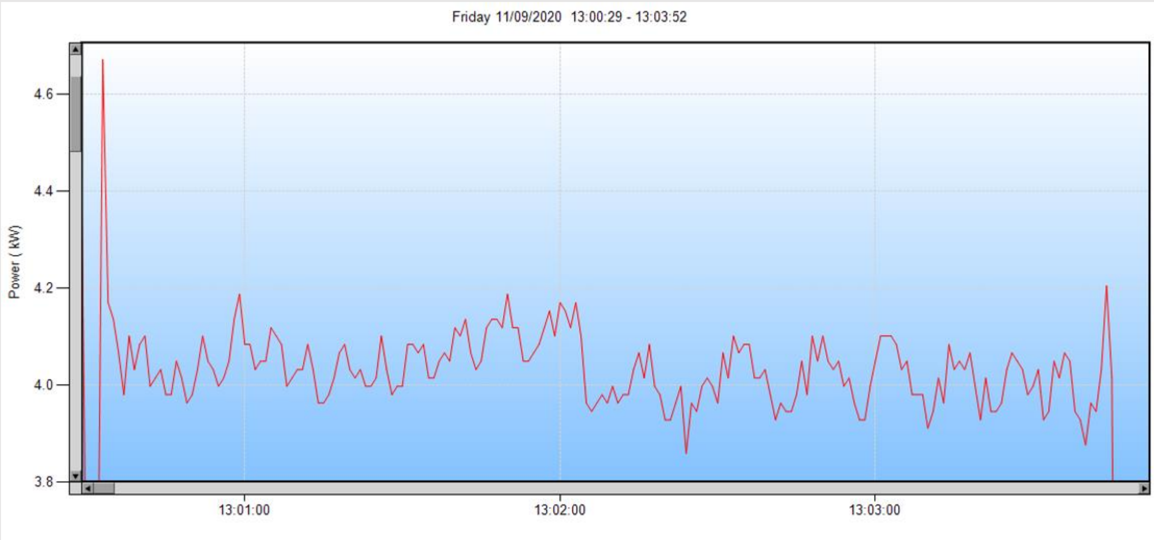
We would propose dropping Thu to Monday hours (18 becomes 5 and saves 13 hours) and dropping Sun hours to Sat hours (7 hours becomes 4 and saves 3 hours each week) 16 hours saved or 25%. This can be tweaked to optimise effects and results.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure E5	BMS Control	54,838	1,673	**14,017**	400	0.24

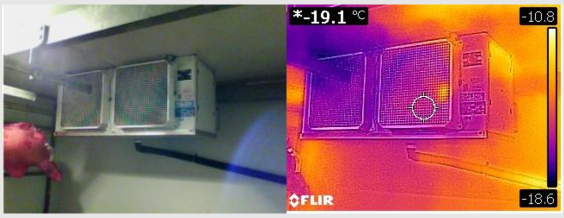
ME6 Chiller Control

There are a number of chillers that could be better controlled across the estate.

The 5 chill rooms (one of which not operating) all have meters. Clamping here on the butcher’s room (2) shows fan power input 290W with actual draw on meter in room at 4kW:



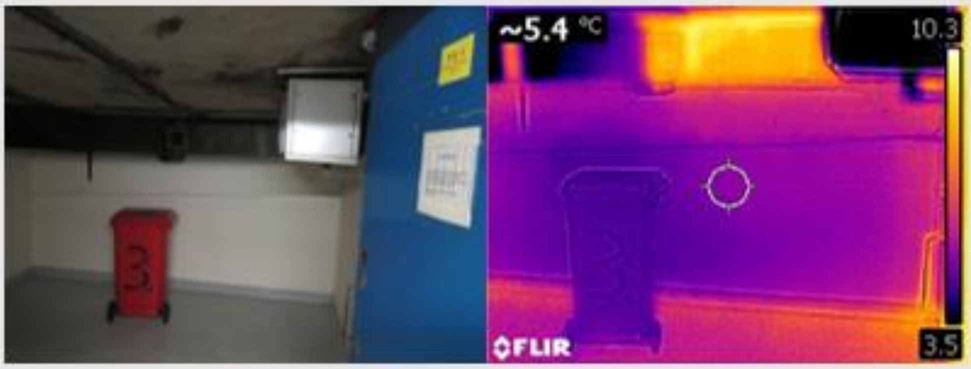
Chiller unit

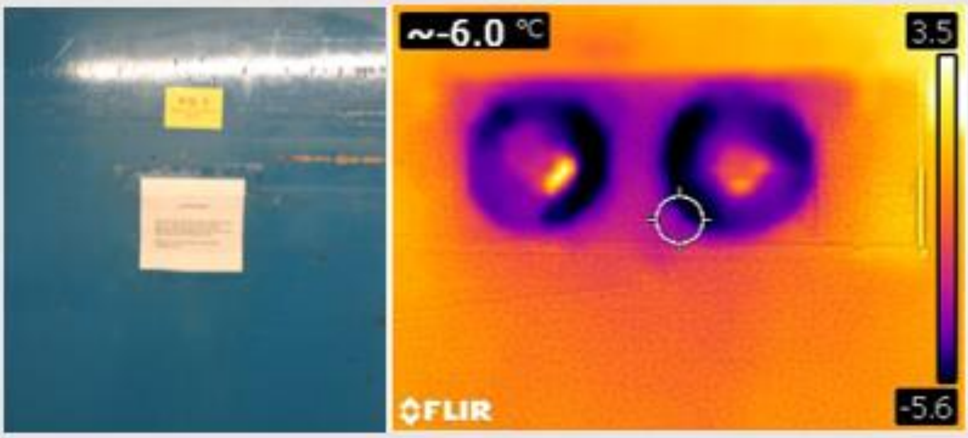


Eastgate Market Fishmongers

We would suggest that the room containing a 240lt wheeled bin of fishmonger waste is repatriated to the Fishmongers new walk-in chill room within an appropriate container.

This chill room (FS1) that is currently chilled at significant cost of the council 24/7/52 will make a significant saving. This chilled room for the fish monger shows 290W input & power draw and will be similar to the butcher’s unit. Assume cycles during 24-hour operation. The room contains only one 240 litre red wheelie bin with fish remains emptied weekly:





Variable Frequency Drive (VFD) on Chillers

North Warehouse

The air cooled Geoclima chiller in the basement foyer (VHA-C 116/66) has not been serviced or F gas tested since 28 Sep 2017. It is used by Regus for their server room, but it is not sub metered and it appears that the Council, are paying for its energy consumption. Third floor metering does not appear to be operational.

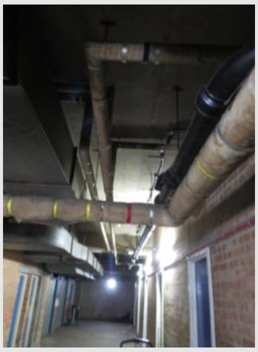
Chiller

The chiller unit mentioned above has a Vacon variable speed drive (VSD) installed. It was not possible to access the caged area to view this bit given lack of internal controls equipment and issues with AHU (see later), it is anticipated that this VSD needs to be correctly set and adjusted.

We would recommend that a meter is installed to remove these costs on the Council which will be significant. Naturally, movement of energy and carbon to Regus only improves the Councils 2030 target. However, if Regus have to pay for this power they will be more likely to better manage and reduce it. This is all discussed in more detail in chapter 2: the 2050 target.

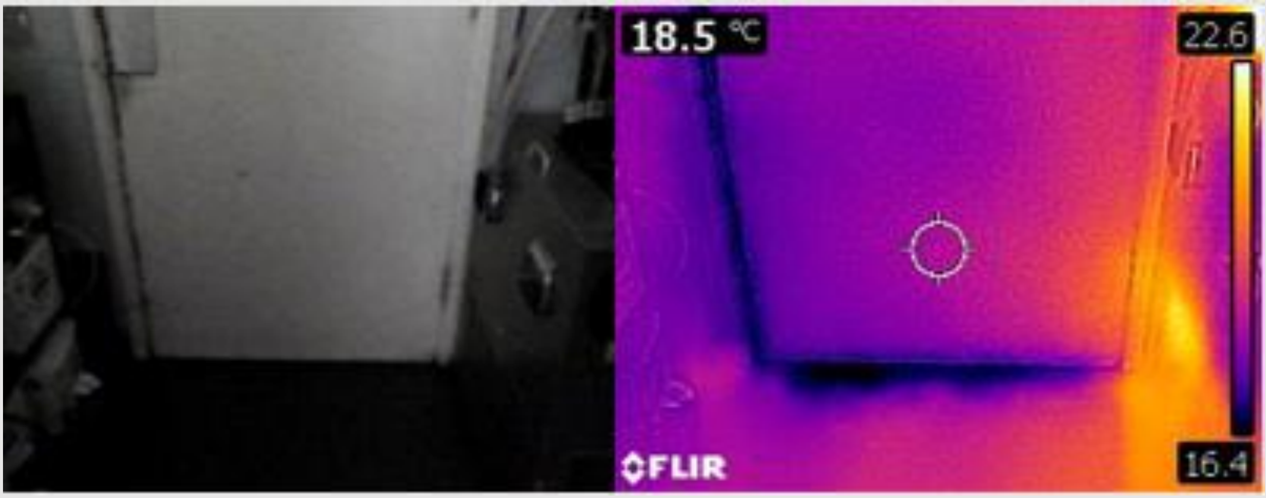
Eastgate Market – basement

Chiller rooms (Five – one not currently operational).



Guildhall

The chiller (1.03kW) serving the beer cask room should be turned off when not in use. When operational, install a VSD for times when is in use. It would also be worthwhile to seal around the chiller room door for reasons that can be observed below:



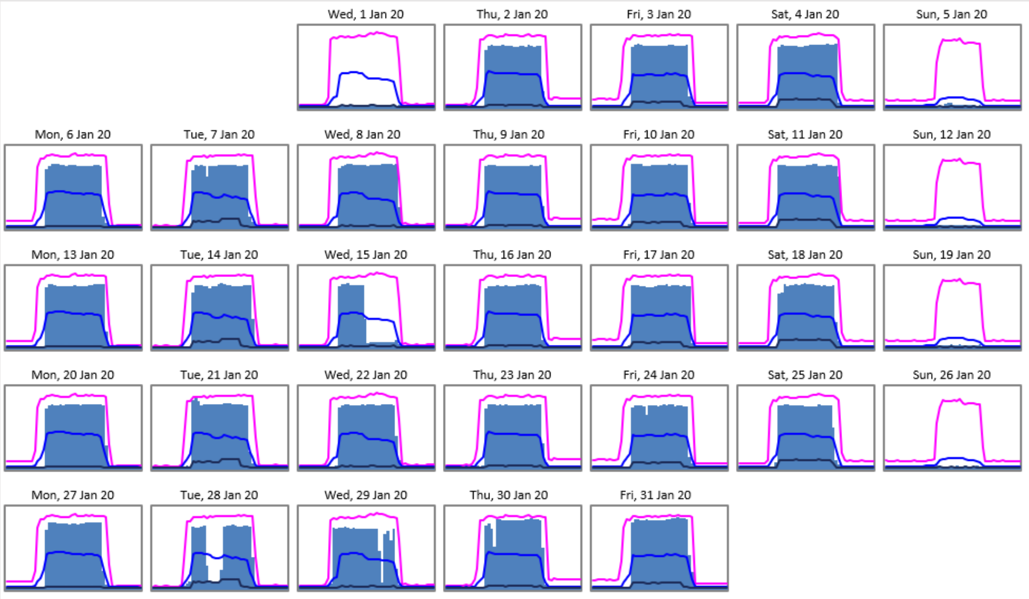
	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure E6	Chiller Control	56,021	7,686	**14,319**	2,000	0.26

ME7 Behaviours and Use of Half Hourly data to address energy wastage over time

Certain high energy consuming sites have electricity meters capable of recording consumption every half hour. This allows us to view when energy is being consumed at times when it should not be.

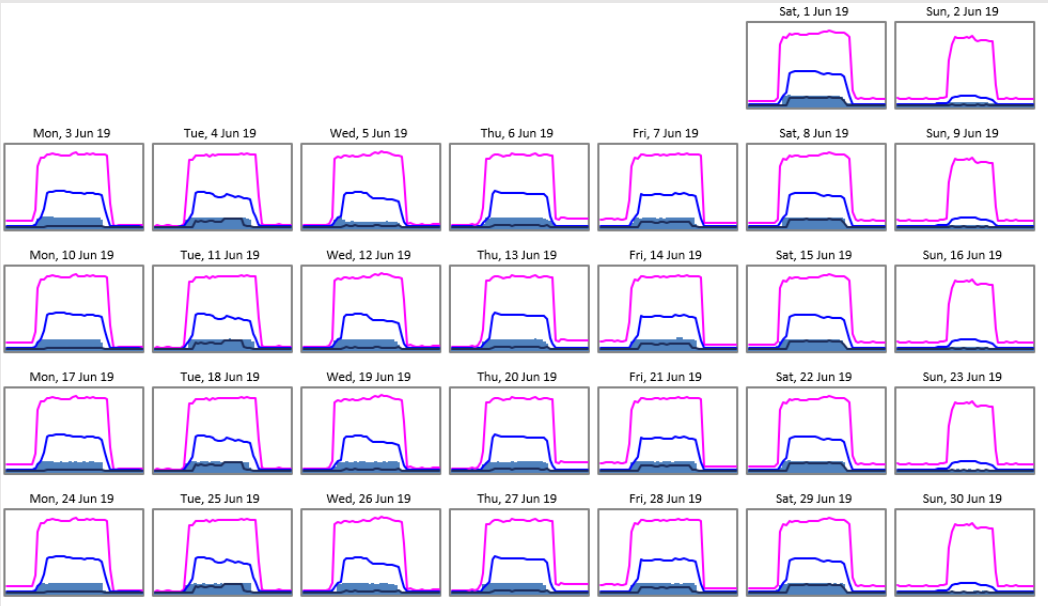
The site below is Eastgate market. As an indoor market, the site is in very regular use and rarely closes other than at night.

Looking at the graph below for January 2020, it can be seen that whilst there is good on/off control over evenings and Sundays, consumption throughout the day is solid. This is largely due to the fact that controls are simple on/off switches and so no thermostatic or other controls are in place. The graph below shows energy use with each box representing one day (24-hour period). The blue mass is energy consumed, the pink line is the highest energy consumed on any given day of the week throughout the period, green line is lowest on any given day and the blue line is average:



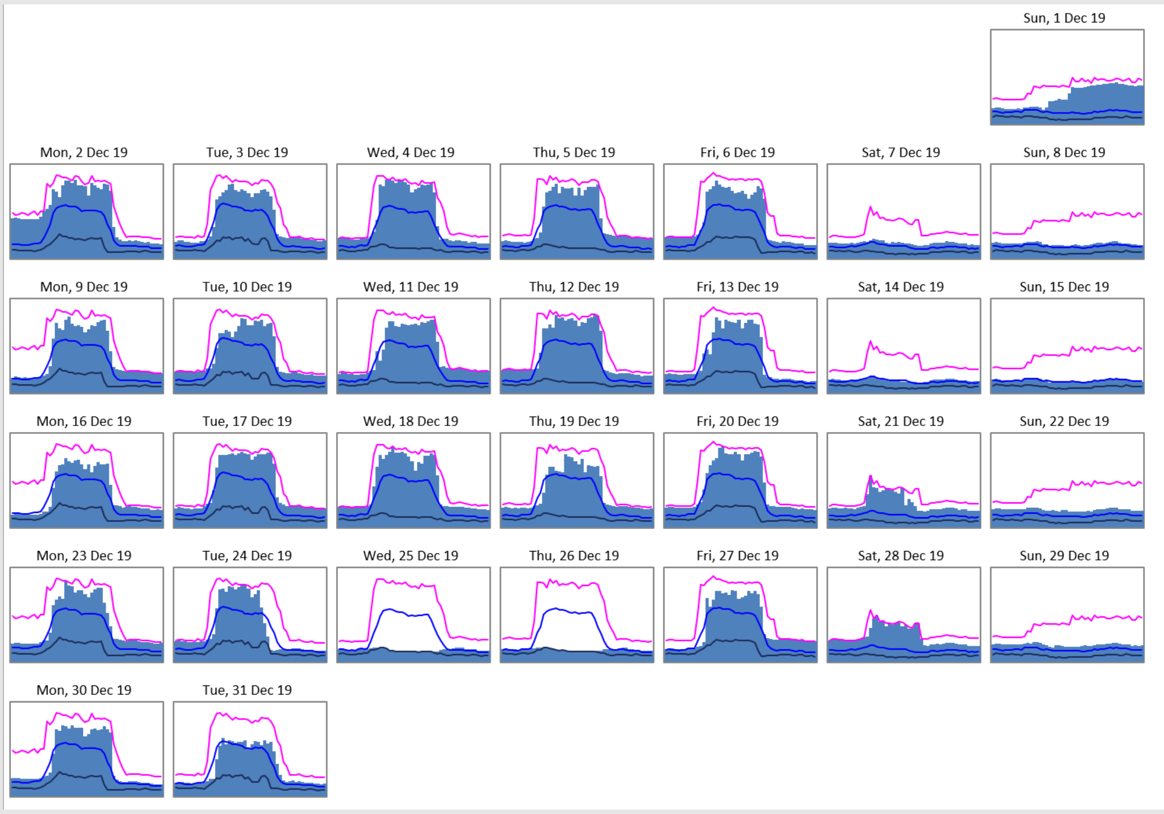
Energy consumption can be greatly reduced with better controls at this site.

As can be seen, energy use in the summer is a great deal less and this further demonstrates the effect of the all-day radiant heating and air curtain usage taking place during the winter:

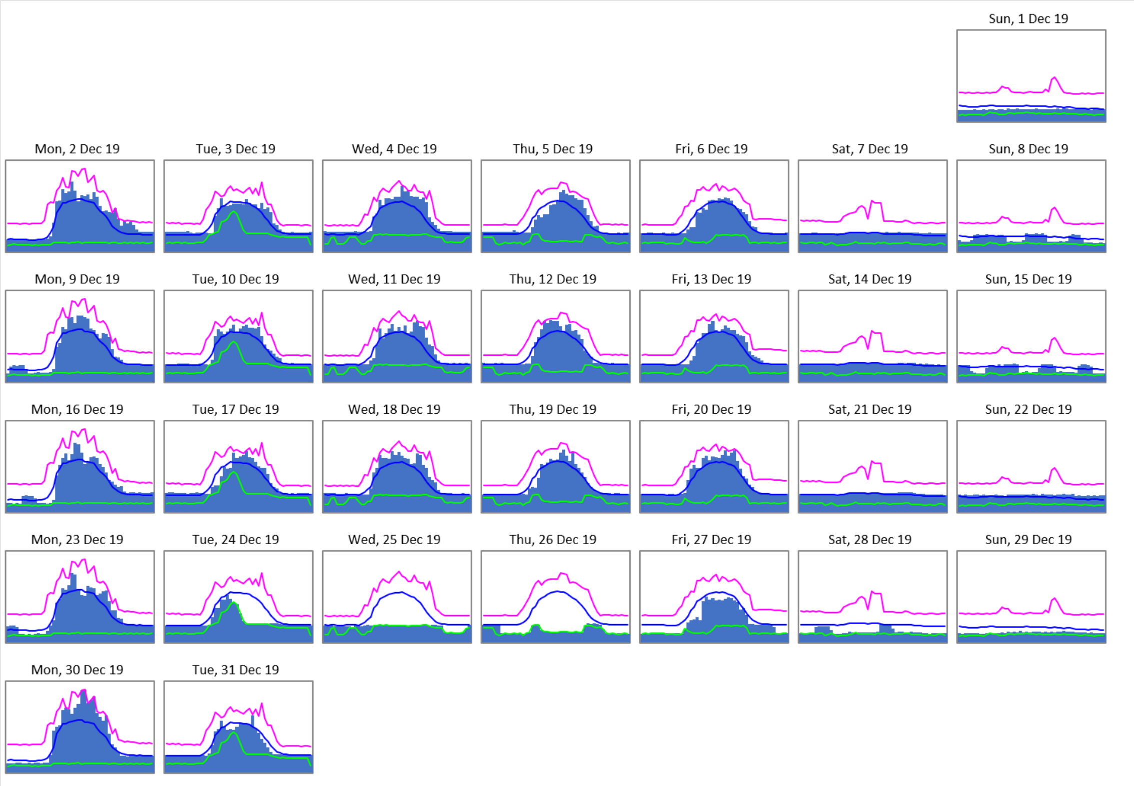


Eastern Avenue Depot energy use also is suggestive of relatively high night-time use which suggests equipment is being left running throughout the night. Even on Christmas Day, the midday load is around 13kW/hour.

This is equivalent to the constant boiling of around 9 kettles.

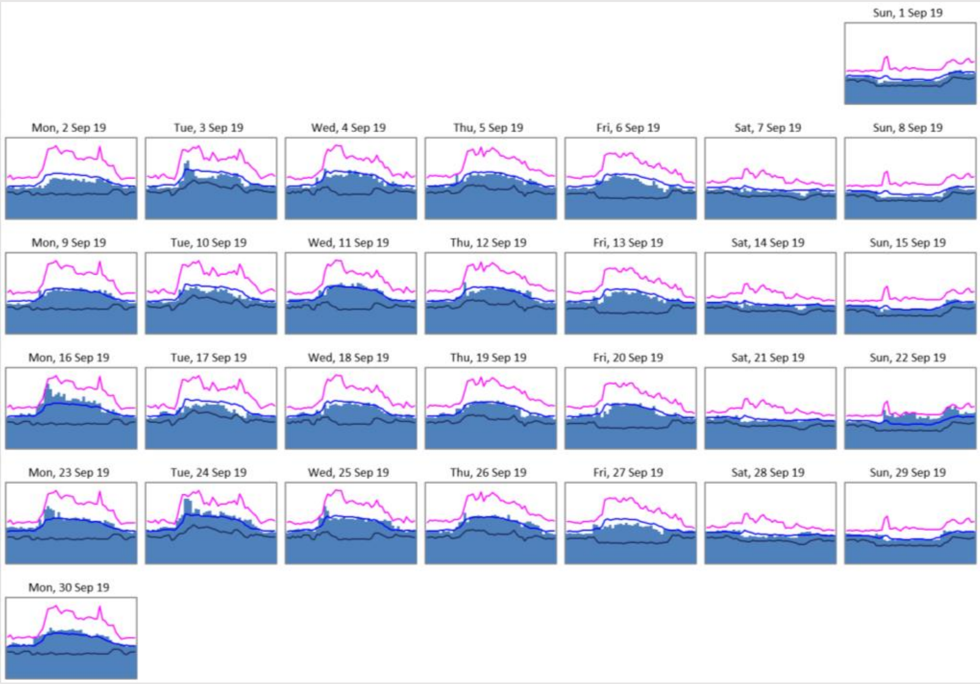


Similarly, the Crematorium's energy use is suggestive of relatively high night-time, weekend and Christmas baseline use which suggests equipment is being left running during these times. On Christmas day, the midday load is around 12.5kW/hour and typical Saturday loads are around 14kW/hour. This is equivalent to the constant boiling of around 10 kettles.


Sun, 1 Dec 19
Mon, 2 Dec 19
Tue, 3 Dec 19
Wed, 4 Dec 19
Thu, 5 Dec 19
Fri, 6 Dec 19
Sat, 7 Dec 19
Sun, 8 Dec 19
Mon, 9 Dec 19
Tue, 10 Dec 19
Wed, 11 Dec 19
Thu, 12 Dec 19
Fri, 13 Dec 19
Sat, 14 Dec 19
Sun, 15 Dec 19
Mon, 16 Dec 19
Tue, 17 Dec 19
Wed, 18 Dec 19
Thu, 19 Dec 19
Fri, 20 Dec 19
Sat, 21 Dec 19
Sun, 22 Dec 19
Mon, 23 Dec 19
Tue, 24 Dec 19
Wed, 25 Dec 19
Thu, 26 Dec 19
Fri, 27 Dec 19
Sat, 28 Dec 19
Sun, 29 Dec 19
Mon, 30 Dec 19
Tue, 31 Dec 19

Finally, the North Warehouse is showing significant consumption around the clock. There may be a metering issue here as it is accepted that Regus use the Council's Chiller and their operations may go beyond normal office hours. However, night-time profiles of 17 to 20 kW/h are much too high for this office environment and are deserving of further investigation.

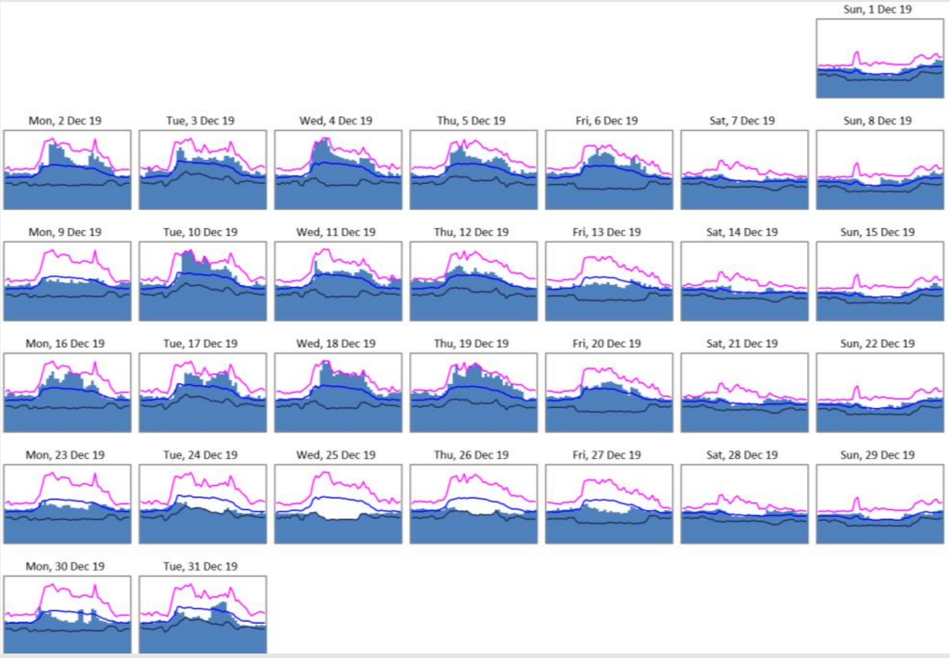
September 2019 shows little change between day and night consumption where peak daytime loads are around 28kW/h and night-time loads are around 17kW/h:



December 2019 shows what the baseload for this building looks like typically when we look at Christmas Day. The lowest energy consumption throughout the whole day is 15kW/h with 17kW/h at night. For context, one day, ‘Christmas Day’ at North Warehouse consumed 392kWh of electricity. Enough electricity to run an average house for five weeks.

If we could halve this base load, then the saving at this site alone for the year would be 71,540kWh which at average rates for GCC would amount to a saving of around £8,585 per year.

It is clear when comparing this to the savings in the table below, that, like all of our calculations herein, there is potential for a great deal more energy and cost saving:



As such, we would contend that there is potential for more control during night-time and to a lesser extent, during holiday periods. Conservatively we would expect to see the following savings from acting on the half hourly data:

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure E7	HHD Assessment	116,159	14,752	**29,690**	5,200	0.35

ME8 VSD to Air handling Units (AHUs) and control of existing AHUs and Extract fans

There is some evidence of VSDs in place on AHUs that are not being set or used appropriately. As with a number of aspects, it would be beneficial to install clamp data capture on some of this equipment when it is operating normally (outside of Covid-19 times) to get a clearer understanding of where energy is potentially being wasted.

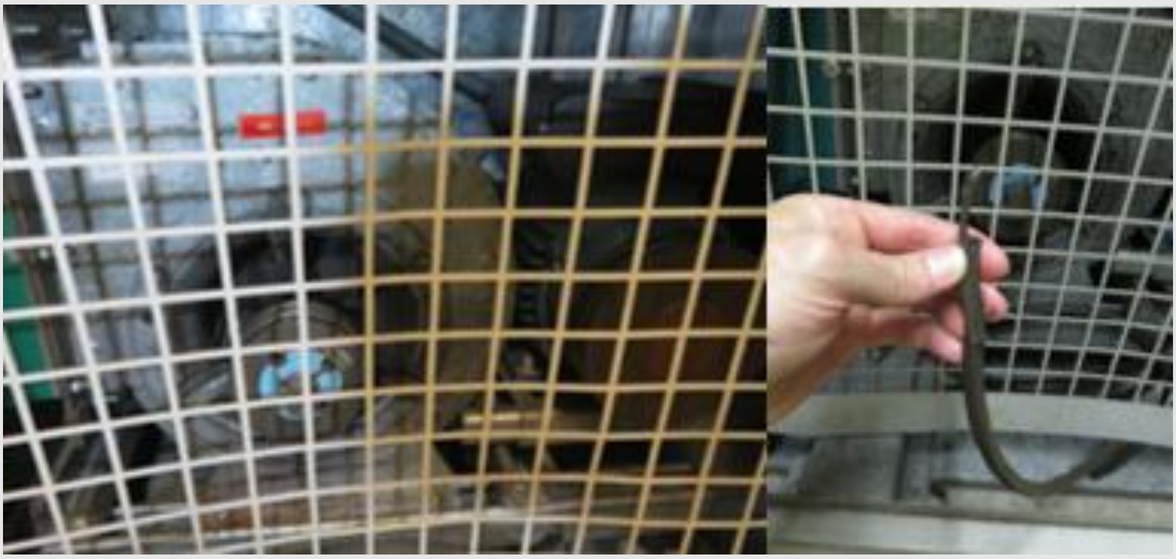
AHUs are all indirect v belt driven. We would ideally propose that these be replaced with direct drive EC fans or, at the very least, the belts be changed to cogged belts for enhanced efficiency and VSDs installed and controlled.

At GL1, North Warehouse and the City Museum, the AHU motors should be replaced with direct EC drive or cogged belts and VSDs. These recommendations are set out at ME18.

North Warehouse Air Handling Unit

The only AHU available to the Council on this site is a Carrier unit housed in the basement. We understand that this unit was serviced and repaired less than a year ago. However, there are some concerns:

On inspection of the fan motors, it was found that both belts had sheared and snapped meaning that although the unit was drawing power and motor spinning, the motor was not able to turn the fan and so no ventilation has been taking place since this occurred:

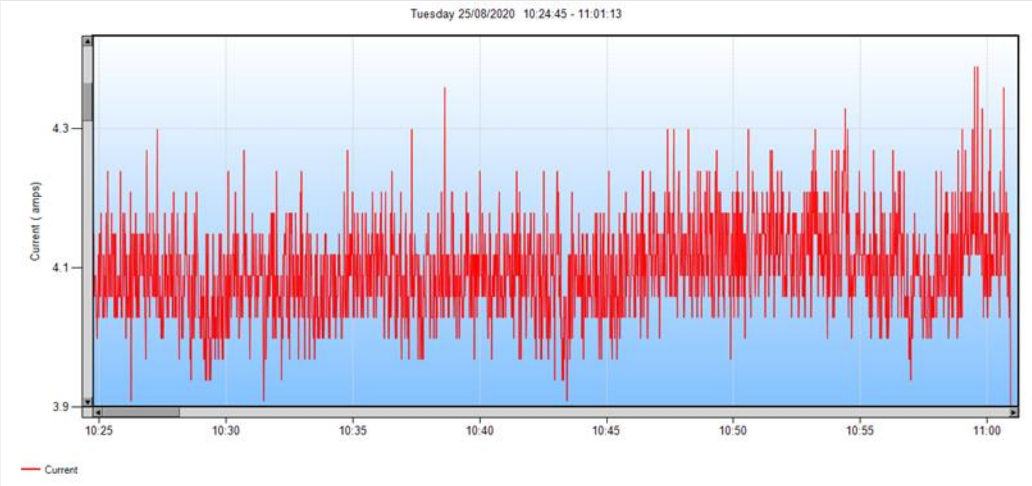


The belts themseves are a low quality/efficiency V belt and should be replaced with cogged belts for higher efficiency. The motor is old and if an investment could be made possible, it may be worthwhile replacing with a direct drive EC fan motor which, as well as being much more efficient, would not fail with the shearing of drive belts.

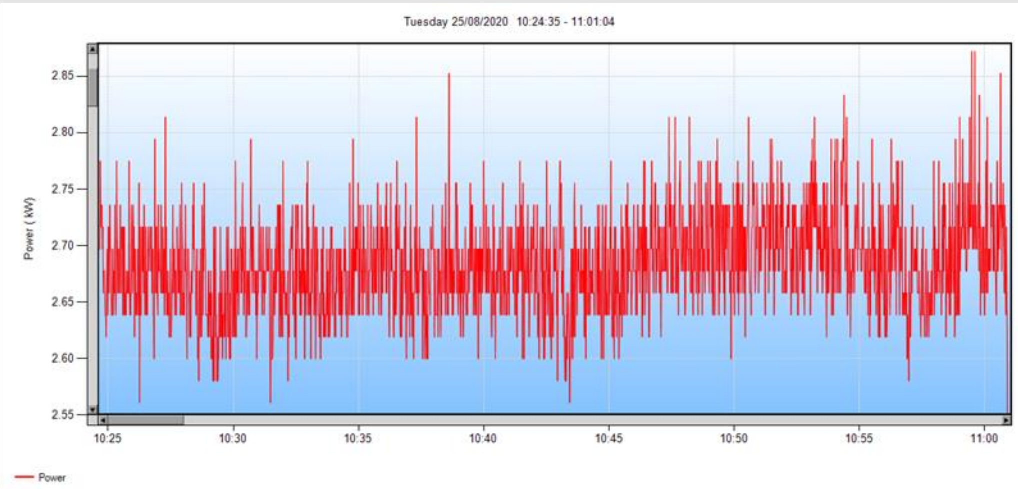
One of the two pre filters that stop dirty outside air from entering the ventilation system was not properly housed meaning that no real filtration was taking place. These are also dirty and have not been changed for some considerable time.

The pipework to this AHU should be more adequately lagged, particularly to flanges and valves:

On clamping the power supply to this AHU, we found a residual current of 4.2 amps.



It was understood from Paul (our guide on the day of visit) that this unit operates around the clock (24/7). With a mean rating of 2.75kW, even three months of operation with nthese broken belts would mean 6,138kWh of wasted energy.



Propose installation of a VSD to this unit.

City Museum AHU Ventilation

The site is ventilated from a large AHU and two extract fans. Vents are built into walls as seen below:


The air handling unit itself is housed in the upper areas of the building. It is a 4kW Brook Hansen fan motor and is belt driven with 3 V belts. Install cogged belts and a VSD.

Eastgate Complex

AHU to toilets (S and E) Both operate on indirect drives with cogged belts

Bag filters should be changed to a vertical position.

VSDs on each of the 4 motors (each look to be 1.5kW) Only Supply Fan 1 and Extract fan 1 are operating and at 50Hz and these should be adjusted and controlled.

Extracts fan VSDs all at 30Hz which is more encouraging.

Extract Fans

GL1

Control of extract fans is current via light switch in:

- Squash courts (EF 1-4)
- Creche kitchen area (EF 8)
- Office kitchen (EF 9)

Recommend that this changes to separate control at a cost of around £800.

Eastgate Market

Market hall extract fans 1-3. All are on VSDs.

Extracts 2 and 3 operate at 30Hz. These should be controlled by a BMS. Since they are not, all extracts (including #1 – image on right) should – as appropriate, be set to 30Hz for uniformity and energy reduction.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure E8	VSD control to AHUs	6,599	905	**1,687**	450	0.50

ME9 Site Behaviour Change

By addressing instances and causes of poor energy behaviours, there is potential for reasonable savings. The Carbon Trust contend that there are achievable savings of up to 10% through addressing staff behaviours. Addressing energy behaviour is never a quick fix and requires ongoing campaigns and actions to instil and then maintain changed behaviour.

As a consequence, it is recommended that staff are invited to volunteer to act as energy champions. They will need to be trained and given reasons to act but once on-board, they will ideally encourage their peers to do the right thing and point out when they are doing the wrong thing.

We would be happy to quote to provide energy or indeed environmental, waste, carbon, climate change, sustainability, fleet, or water management training to staff and/or members if this were deemed worthy of your consideration. Once trained, the energy champions will be able to deliver training in-house.

Points for behaviours include such issues as removal of portable devices such as under desk heaters and fans, particularly where buildings are heated and cooled with heat pumps and Chillers such as at the Gateway, Depot and North Warehouse.

Gateway

A well-appointed office such as this should not need windows opened or fans and heaters introduced.

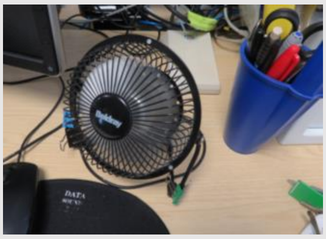
2,250W Hand dryers should also be replaced with efficient air blades.

North Warehouse

Other aspects to be addressed would include more frequent filter changes to the AHU at North Warehouse and at the AHUs on the roof of GL1.

In practical terms at Gloucester offices, we would recommend that the organisation removes all fans and heaters from above and under desks. Replace with only USB fans where absolutely necessary.

An example of a USB desktop fan:



Depot Heating

Heating in the workshop (11.88 wide by 21.74 long by 8.65m high) is all electric using radiant wall heaters (10#) at two kilowatts with 2# 15kW electric industrial fan heaters (now that propane gas blow heaters have been taken away for safety reasons):

Consider install of insulated suspended ceiling, wall cladding and the use of radiant Ambirad type heating. The roof of the workshop regularly drips water from condensation in that building so insulation would be beneficial.

Gloucester Life (Folk) Museum

Shelves (free standing) should be installed over radiators beside windows to allow the heat to be channelled into the room via convection rather than outside through single glazed and leaky framed windows. Boilers should also be serviced.

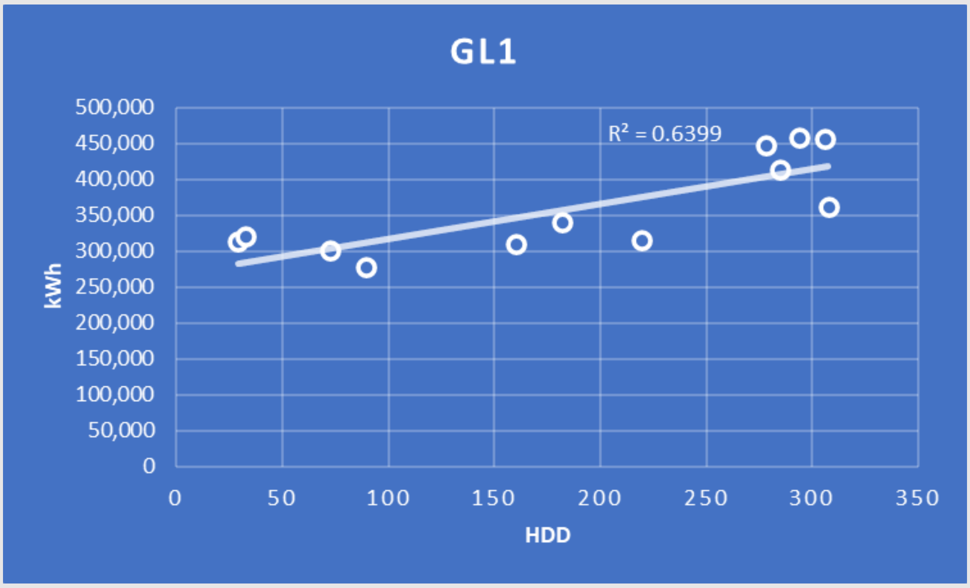
By enacting these measures, the organisation ought to be able to make the following savings:

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure E9	Site Behaviour	56,137	6,067	**14,349**	3,550	0.59

ME10 Regression Savings

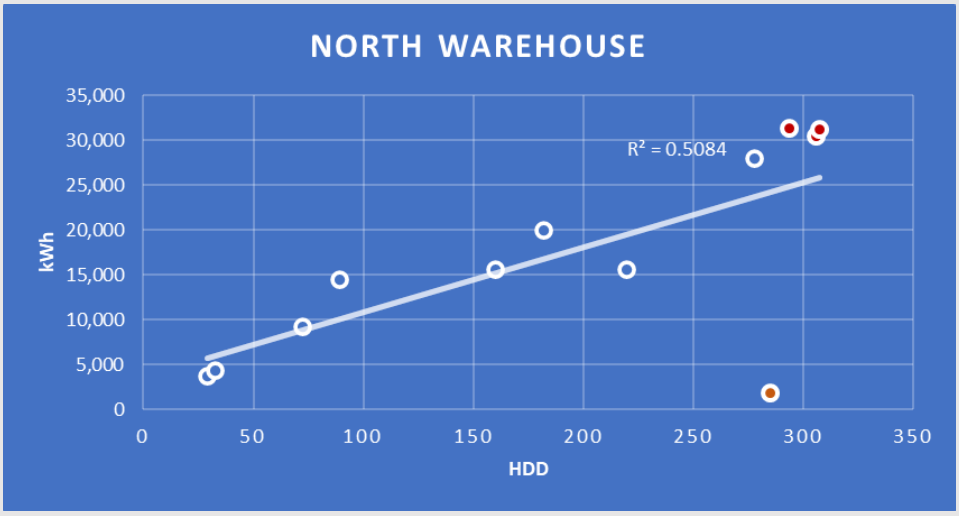
There are significant available savings apparent from better control of heating at certain sites. As discussed earlier, regression analysis is best conducted on 3 or more years of data. This is because gas billing can often be estimated, corrected, adjusted, and poorly recorded:

GL1 Data is skewed by the CHP use:

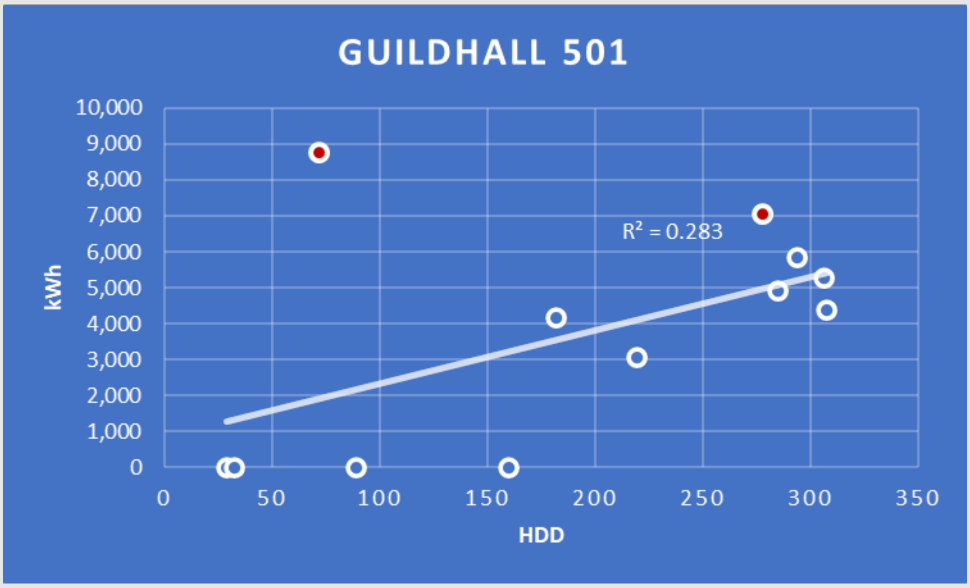


Sites that show some levels of concern as graphed below:

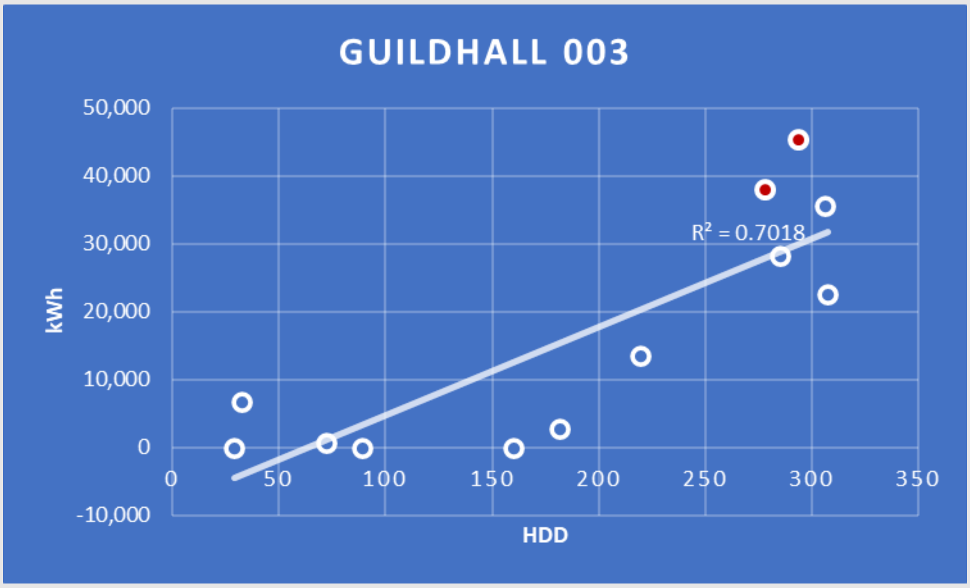
North Warehouse areas in red and orange should be investigated:



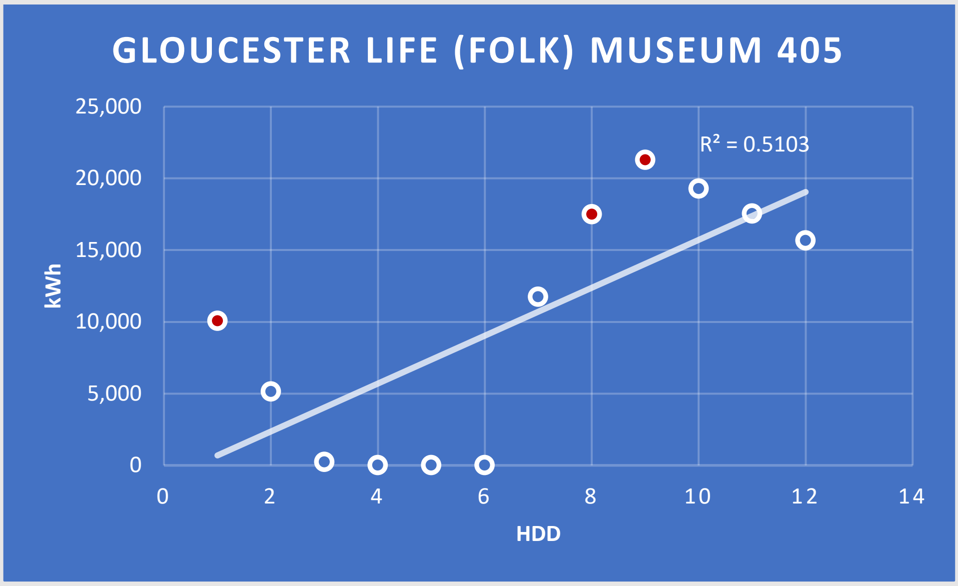
At the Guildhall and MPRN ending 501 data looks to be a case of poor billing but more information would be required to better understand and confirm this:



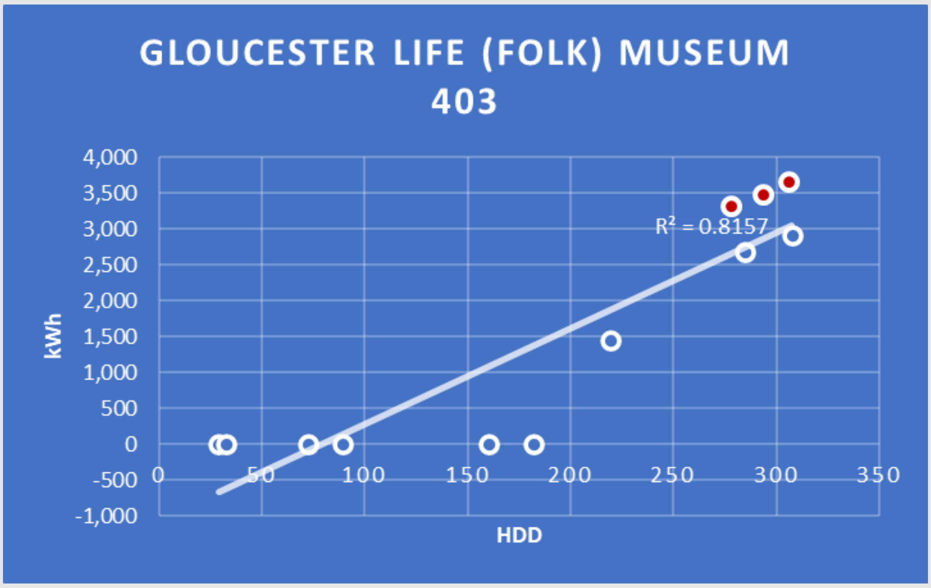
The Guildhall MPRN ending 003 looks better:



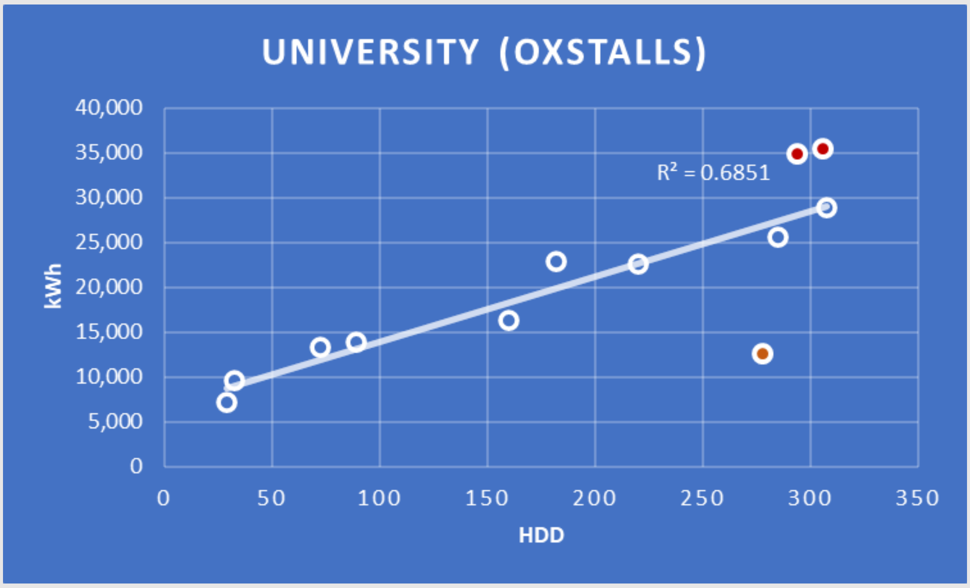
Gloucester Life (Folk) Museum MPRN ending 405 data looks to be badly billed:



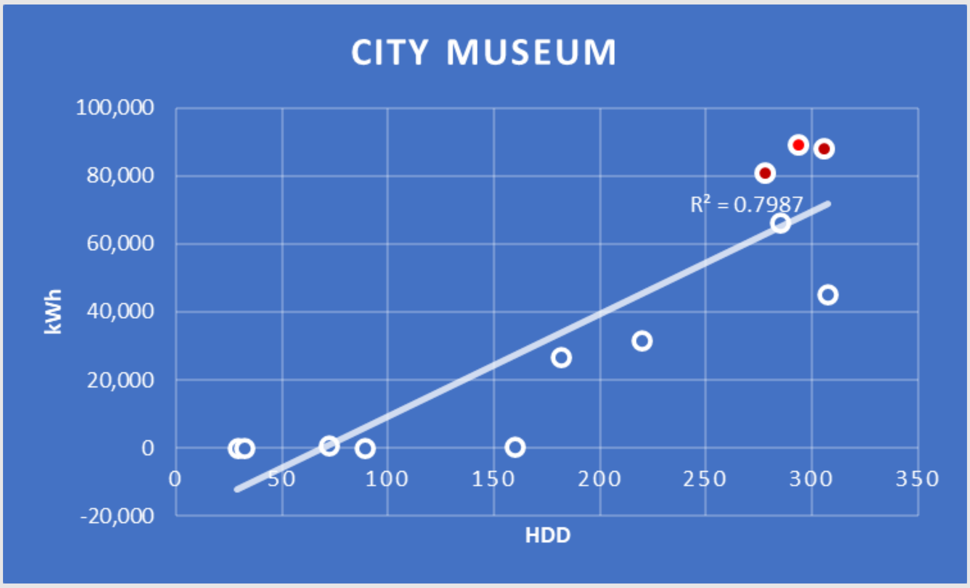
Similarly, to the Guildhall, the Gloucester Life (Folk) museum MPRN 403 looks to be more accurately billed:



The Oxstalls University building shows areas in red and orange which should be investigated:



There are some anomalies with the City Museum, but they do not look to be major:



By adjusting the points at seven sites where there is overuse against weather data, we have located an array of savings against reduced gas use and payments:

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure E10	Regression	143,482	3,088	**26,379**	1,960	0.63

ME11 Comfort Zones

GL1

Available settings on A/C controllers around the building can be as wide as between 18 and 30C.

We would recommend locking these within a small range and by adjusting to 1C either side and adding this adjustment in 0.5C increments. Experience states that as long as staff are able to feel that they are in control, they do not need to move the dial particularly far. Heating for the site is managed on a Trend 963 BMS with the A/C units being managed by FM on a separate centralised Daikin controller.

Many staff when cold (perhaps having just walked into the office from a frosty outside environment) will increase these settings to the highest level in the expectation of achieving more rapid change in temperature. This will not occur.

Instead, the temperature will rise at a fixed speed until this set point is achieved. As can be seen above, in several cases these units will allow temperatures of up to 28C or 32C. At some point, members of staff will decide that the room is now too warm and may drop the temperature to a lower level (potentially down to 16C). This will then again overshoot and cause the room to remain out of equilibrium throughout the day. In some cases, staff may open windows, further exacerbating the situation.

We would recommend that all controls are locked within comfort zones of between 19 and 21C. This will allow staff the ability to adjust, but not to adjust outside of a reasonable range that will cost the organisation excessively in energy costs. Electric heating and cooling, even with heat pumps is expensive.

Plock Court

Similarly, at Plock Court, controls allow for changes between 19 and 30C. This upper level should be brought down to around 21C to avoid unnecessary adjustments being made.

Depot

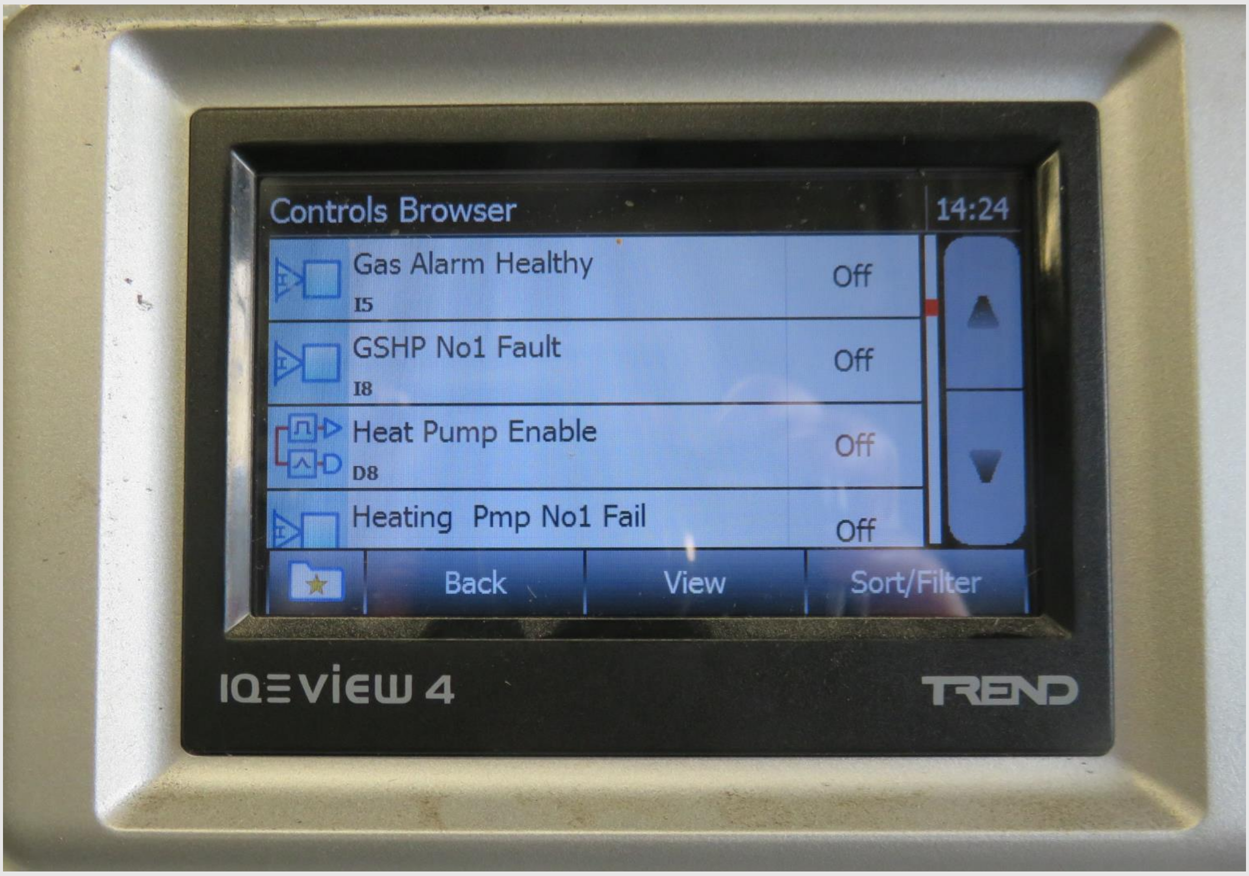
New Heat Pumps

The site has no gas and is electrically heated and cooled. Cooling is via portable air conditioning units which are typically rated at 1.5kW to 2.0kW.

The major problem with these is that there is no capacity for their heat outlet and so the c 6 inch (150mm) pipe that exhausts this heat is placed through open windows.This means that windows need to be wide open on hot days to expel the heat. Consequently the room never gets cool as the A/C unit attempts to cool the surronding world. Because of this, the installation of permanent heat pumps will lead to savings based on the building envelope being sealed so that the A/V unit does not need to work so hard and, if appropriate units are installed, the site will benefit from a higher coefficient of performance. Ground Soure Heat Pumps (GSHPs) can provide up to 4kW output for every 1kW input. If carried out before April 2021, the install would also potentially benefit form the RHI.

GSHP

We understand that the site had a Ground Source Heat Pump which is no longer operational. This was also observed on the BMS. It may well be worthwhile reintegrating, replacing or reinstalling this:



Gateway Comfort Zones

16-30 possible. Found at 27C. Ensure range is locked

Set Points

Ensure that open plan offices are not set at different temperatures. Images below show two DX wall mounted AC units with controls set at 16C and 18C in the same small open plan office. This means that the two units will be constantly fighting one another to reach a temperature set point that will never be met:

Eastgate Market Office

Electric wall heaters should, where possible be replaced with heat pumps

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure E11	Comfort Zones	5,780	793	**1,477**	820	1.03

ME12 IR Heating / Heating Control

Eastgate Market

The market has 36# 2kW Energikomfort radiant heaters in the roof and these are controlled in the suspended managers office with a simple on/off switch. Whilst there are slightly more efficient radiant heaters on the market, the easy saving here is control. By installing black bulb thermostats to the site, these heaters need not be on all day and could be operating only as required and not as a result of the first complaint by a trader.


	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure E12	Infra red Heating	247,280	10,527	**63,205**	11,200	1.06

ME13 Insulation to radiator pipework runs

Much of the radiator pipework around many of the buildings is not lagged. As such, when radiators are turned off at the thermostatic radiator valve (TRV), the pipework is still heating the room leading to windows being used as a control measure.

Plock Court

At Plock Court, radiator pipework around the building is observably unlagged.

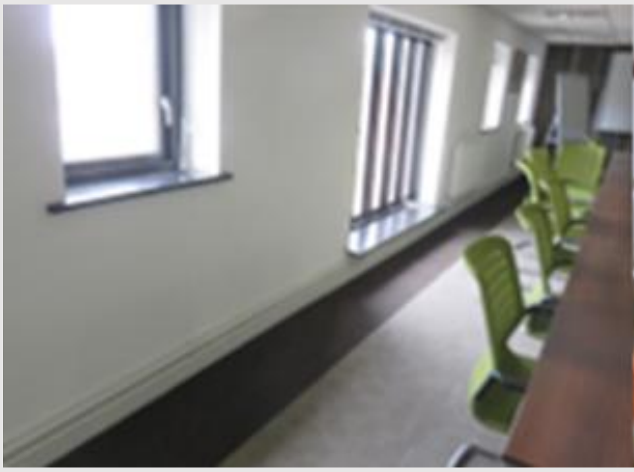
Gloucester Life (Folk) Museum

Pipework lagging to radiators should take place.

Build shelfs over radiators under windows to encourage convection currents and reduce losses through single glaze windows and insulated roof.

North Warehouse

Radiator pipework. There are long runs of exposed pipework on the third floor connecting radiators.



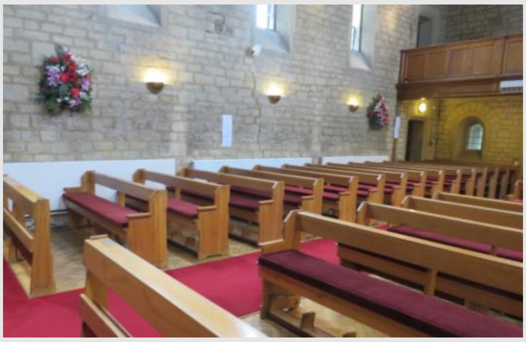
City Museum

The radiator system around the building is largely older cast iron units. There are runs of pipework that would benefit from being insulated so as to better control the heating in the building when radiator TRV valves are turned down.

Crematorium

Radiators

The radiators in the chapel are heating a large expanse through convection. Much of this will be lost to walls and high windows. We would recommend installing shelving above the radiators to permit the convection flow to enter the room.



Guildhall

Pipework lagging should be installed to radiators all around the building:

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure E13	Pipe insulation	34,324	609	**6,310**	1,100	1.81

ME14 Plantroom Flange and Valve (F&V) pipe lagging

There is a certain amount of pipework, but more importantly flanges and valves that are not lagged in certain of the plant rooms. This should be rectified to reduce heat loss and gas wastage.

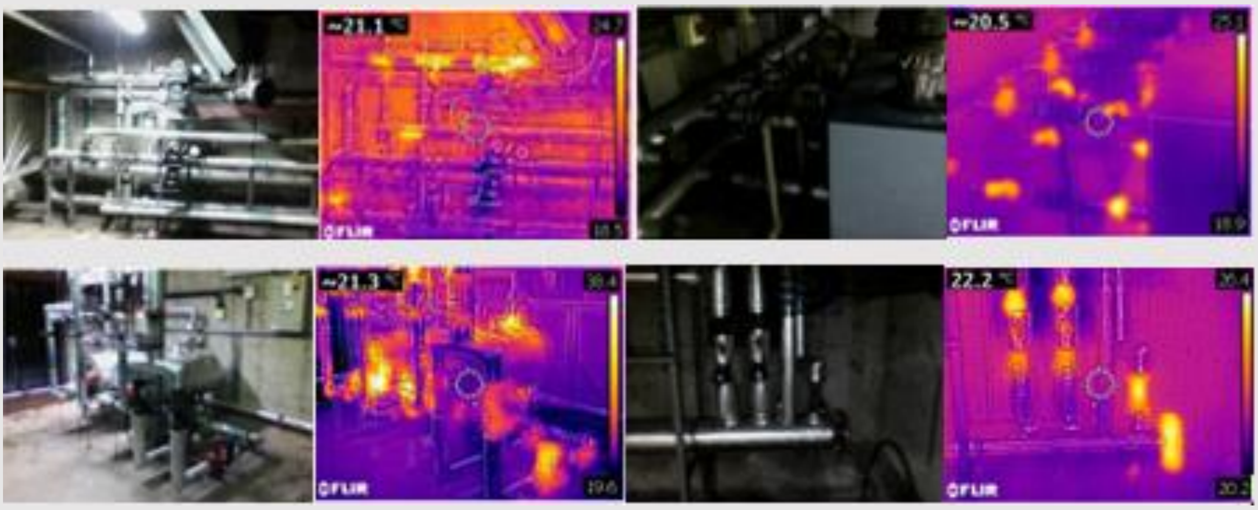
Plock Court and Depot

F&V insulation is required in plant room as can be seen below:

North Warehouse

F&V insulation to boilers

Boilers were not generally operational due to the audit taking place in August (summer). However, where they were, it is clear that there are areas where pipework is not properly insulated:



City Museum: Flange and Valve Insulation

Whilst the boilers were not operating (summer months), it was observed that the flanges and valves in the plant room have not been insulated. This means that there is a great deal of wasted heat before this heated water leaves the plant room. As a rule of thumb, due to its surface area, a flange or valve emits the equivalent heat of a one metre length of similar diameter pipe:



Similarly heating pipework serving the AHU should be lagged.

Crematorium

F&Vs should be lagged.



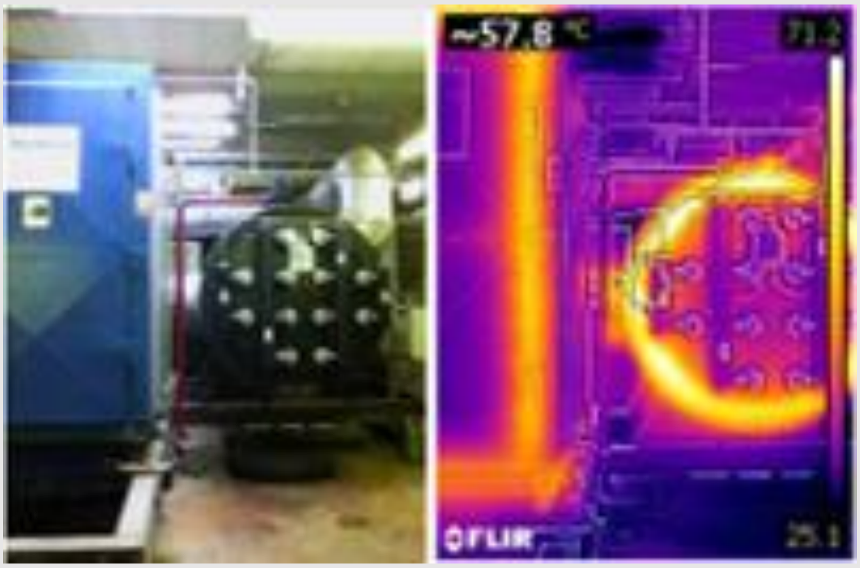
~28.9 °C
44.2
22.5
FLIR


~32.6 °C
48.2
22.5
FLIR


~39.8 °C
59.2
23.2
FLIR


~31.2 °C
68.9
25.2
FLIR

Boiler and tank lagging should be enacted:



Boiler (Cremators)

There is flue gas treatment present in the operation as would be expected in a facility of this type.

Crematorium Arbor Tea Room

Flange and valve insulation requirements can be seen below:



Guildhall

Pipework under 3 boilers requires insulation:




Pump room

Thermostat control

F&V lagging required in boiler rooms.

Move electric heaters in toilets to gas radiators on system or more preferably, to heat pumps.

Eastgate Market

Basement lagging is old and ineffective. Replace.

Also, lag hot water pipes.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure E14	F&V insulation	37,130	591	**6,826**	1,210	2.05

ME15 Cavity Wall Insulation (CWI)

The walls at the rear section building of GL1 do not appear to be cavity insulated:

Given the heat loss potential at this site, this should be investigated. The age of the site makes it unlikely that insulation was installed at time of construction. There is no evidence of these walls being insulated as a retrofit. We would recommend and endoscope survey be conducted and if required, insulation pumped into the cavity.

Gloucester Life (Folk) Museum

Similarly, there looks to be need for CWI to the cavity at the rear cafeteria area:

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure E15	Cavity wall Insulation	37,400	1,392	**6,876**	2,943	2.11

ME16 Lighting and Controls

Lighting across the Gloucester City estate is now predominantly LED. There are a few exceptions to this where LEDs are being phased in and where a plan is in place to replace.

GL1:

There is potential for replacing the current lighting at GL1 with LEDs and controls. Lighting that remains ready for change includes:

- T5 fluorescents
- Circular 2 x 326W 4Pin2D
- Underslung T8s
- 60cm x 60cm T8 18W tubes

Exterior lighting should also be addressed here.

Plock Court

On the courts, luminaires are angled to avoid glare and are 6# by 4 pin 2 D 55W T5 PL lamps. They are slung beneath the skylights to replicate natural light during the evenings or dark days when this is not available:

Lux levels measured at centre of court with no lights on at 12 noon read 284 to 344 lux.

With lights in, the lux levels ranged from 476 to 566.

Height to apex is 9.92m at eaves this height is 5.25m.

Each court length is 36.54m and the lengths of all courts (6 widths) is 95.57m

Number of luminaires in the tennis hall:

Ends 12 x 2 = 24 **Courts** 24 x 5 =120

There are 144# Luminaires with a total of 864 tubes each at 55W plus ballast.

Having sought advice from the Lawn Tennis Association LTA, with regard to their requirements, here is what they have advised:

“We recommend an average lighting level of 500 Lux (minimum 400 Lux) for the principle playing area (area within the lines) with of 0.7 Uniformity. For the total playing area the recommended level is 400 Lux (minimum 300 Lux) with a uniformity of 0.6”.

We have factored this into our calculations.

Currently, Lux with lights out at noon is 300, with lights in, this is around 400-500.

Replace the 30# 2 by 26 what CFL lamps all throughout the corridors. Soft play has dual T5 49W tubes and outer area has had its 4P2D lamps replaced with LEDs.

External floodlights to be replaced with controlled LEDs:

Floodlights look to be halides and are likely to be 400W each. The poles are able to be flexed at the bases with the right equipment which will save significantly in scaffold/access costs.

External wall lighting:

Depot Lighting

Reception has 5 x T5 tubes 49W

Reception office has 4# LED LG7

1F Offices has 30# 60 x 60 54W PL tubes on PIRs

External lighting is 250W halides

Workshop has 32# Dual 49W T5 tubes. We would propose that all be replaced with LEDs and sensors.

Gloucester Life (Folk) Museum

LEDs required to remaining main area fluorescent tubes.

North warehouse

Lighting

The top floor provides Cllr offices and meeting rooms. Lighting is dual 26W circular CFL PLs, 3 and 4 x T5 14W fluorescent tubes, 4 x T8 14W LG7 tubes, 28W 4pin 2Ds and 50W halogens.

Cabinet lighting in the Council Chamber Civic Suite is 7W LEDs. All lighting is controlled on a labelled switch bank:

Illuminance levels around the Civic Suite in daylight with all lights on are sub 100 lux. This is an insufficient light level for a room of this type.

There are 4# 400W external lights outside of the North Warehouse which should be replaced with LEDs.

Longsmith Street MSCP

Whilst we were not tasked to carry out an assessment at this car park, we did note during our visit that whilst most lighting had been changed to LED tubes, there remained T8 fluorescent tubes in the building. For reference, we also observed some damaged fittings as can be seen below

Roof area has controlled LEDs:

City Museum Lighting

The lighting in the museum is predominantly fluorescent with T5 tubes in the shop, 60 x 60 PLs and 58W T8 tubes, many of which with old style switch start ballasts:

Whilst most halogens spotlights have been replaced with LEDs; There remain lamps that would benefit from being converted to LED:

Crematorium

Lighting

Lighting varies around the building but included 4Pin2D (some of which converted to LED), 80W T8 Fluorescent tubes,

Tea room

Lighting in this building is a range of 18W dual PLs, high power 80-100w Erco spotlights, and T8 fluorescents:

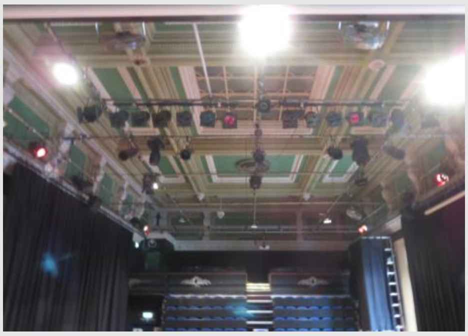





We would look to replace these tracked lights with another Erco product but LED such as this, which would be a 19W (23W) unit:

Guildhall

Suggest that the site opens the curtains in hall when not in use, so as not to need to leave lights on.



Lighting

Lighting

Main Hall Halogens

Film display posters (4 x 30W T8 SS x 9 posters).

Sitting behind these panels are 4# 30W T5 fluorescent tubes with switch start ballasts.

There would be benefit in replacing compact fluorescents:

As well as offices that were recently replaced with T5 fluorescent tubes:

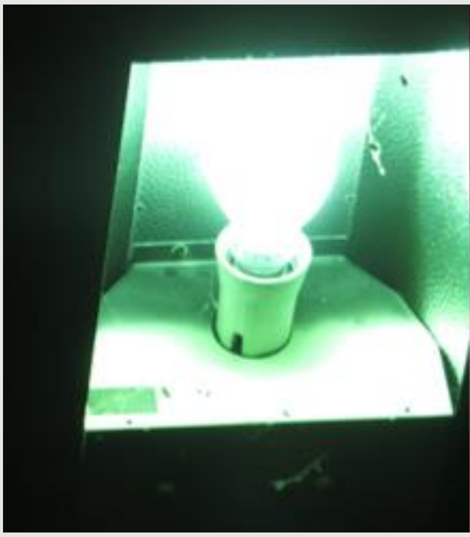
Broadly the site has fluorescents throughout.

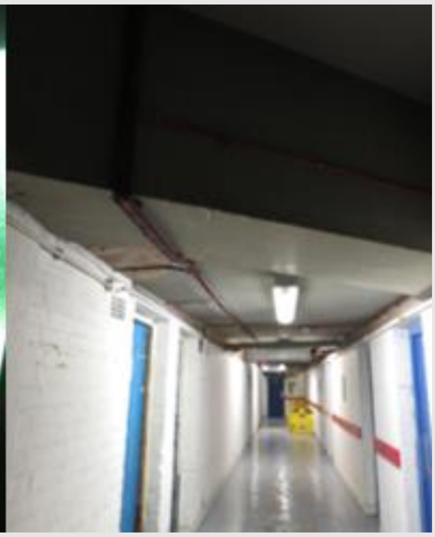
Eastgate Market

Lighting

Office lights are Cat 2 T8 fluorescents and should be changed to LED:

Basement and loading bay lights (3# 250W) on from 0700 to 1800 Mon to Sat. (7 days for December). Install sensors.





Red switches are left on 24/7. Install movement sensors on these fittings:

Front of market area new LED panels and circulars:

Kings Walk MSCP

Car Park over bridge (to Guildhall) Kings walk MS car park.

We were not tasked to attend this site but in a cursory visit, we found that on the open top floor, all of the lighting was found to be on, permanently.

Lamps are 5.4 m to lamp from car park floor. These will break for replacements

Eastgate Market

Lower floors are LED tubes. Lighting apart from LEDs at front and 13 x dual Cat 2 LED tubes over café area is all LED spots:

There are 11# Eastgate market stalls at which GCC are paying for electricity bills at 43,555kWh per year. Will be transferring carbon issues to tenants but if paying themselves they are more likely to reduce energy use. Stall #63 Eastgate market is consuming 9,199kWh per year (more than 2 houses worth).

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure E16	Lighting	271,279	44,925	**49,875**	103,214	2.30

ME17 Burner Optimisation

Plock Court

It may be worth considering dynamic burner optimisation for the boiler burners at Plock Court. Suggest cycling be controlled on the BMS as this should be less expensive than the option proposed within our calculations. Use of BMS requires that the in-house knowledge is in place and training is initiated and maintained:

North Warehouse

Boilers look to be 81.35 to 84.5% efficient and will not need servicing again until December 2020. Optimisation would again be beneficial here.

City Museum

There are eight Hamworthy boilers but only three are now operational and these have been serviced in November 2019 and have an efficiency of 85%. Optimisation would again be advantageous here.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure E17	Boiler	137,348	3,116	**25,252**	10,050	3.23

ME18 AHU fans to EC fans

GL1

The indirect driven fans on the eight major Air Handling Units (AHUs) at GL1 should be replaced with direct drive where possible and with cogged belts controlled with VSDs where not:

#	VSD	Location Served	Supply	Extract
AHU1	Y	Main Pool	37kW	37kW
AHU2	Y	Leisure and Learner Pool	15kW	15kW
AHU3	Y	Training Pool	11kW	11kW
AHU4	Y	Wet Changing	22kW	5.5kW
AHU5	Y	General Ventilation	37kW	37kW
AHU6	Y	Wet Health Suite	5.5kW	5.5kW
AHU7	Y	Aerobics and Multi Gym	7.5kW	5.5kW
AHU8	Y	Gymnasium	7.5kW	5.5kW
AHU9	N	Health Suite Supply	1.1kW	
AHU10	N	Soft Play Store	0.6kW	0.6kW
AHU11	N	Multi-Purpose and Event Change	0.55kW	0.55kW
AHU12	N	Sports Hall	7.5kW	
AHU13	N	Sports Hall	7.5kW	
AHU14	N	Sports Hall	7.5kW	

AHUs 1-3: Should be ramped down to 40% when not required.

AHU's 4, 5, 6, 7 and 8 were set at on zero at time of visit due to Covid-19 lockdown and so not possible to see these operationally active.

Change AHUs 1-8 to EC fans direct drive all have variable speed drives controlled by the BMS all appeared to be well controlled.

Enact regular filter replacements to the pre filters on the GL1 roof which are excessively dirty (AHUs 12-14) – sports halls each with 7.5kW supply fans. These three AHUs (12-14) serving the Sports Hall should have VSDs installed and be changed to cogged belts:

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure E18	AHU EC Fans and Cogs	239,449	30,860	**44,023**	114,520	3.71

ME19 Compressor

Depot

The Worthington Cressona Decibar 100 7.5kW compressors used for air tools, tyres and the tyre removal clamp and is operating at 6.6 atmospheres. Suggest this is reduced and a booster installed if higher pressures are required for tyre pressures.

Depot MRF

Conveyor and compressor motors

11kW 3 phase. Not variable. Add VSD

Coney Hill Cemetery

Compressor

The 5.5kW Atlas Copco GA5 unit is set at 7.7 bar. We would advise reduction of this pressure. There appear to be some leaks.

Eastgate market

Compressor for extract fans

Significant pressurised air leakage is observable and audible in the office and is operating 24/7/52. Compressed air is an expensive commodity ad should be handled with extreme care.

Pipe leaks in managers office, even as vents are shut and not operating:


Two motors running round the clock operating alternate motors. Manufactured motors Dec 2016. TanAir B23B-BM-415. Ser No: 101823 and 101824. Both are 2HP.

Fire safety department have apparently stated that there is no longer a need for this and in fact, Council site management only open vents at the whims of one market trader. We have recommended replacement with mechanical controls.


Eastgate Market:

Compressor (7.7 bar) - remove and replace with mechanical vent opening.

Vents opened mechanically when café chef gets hot or if fire service still require this (the latter we understand from site staff is no longer the case).

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure E19	Compressors	10,327	504	**1,899**	2,100	4.17

Fleet Recommendations

MF1 Eco Training

Telematic data for the RCV and recycling fleet shows savings available here. There is only one person currently paying any attention to telematics and they are not doing this full time and not only looking at the poorest drivers.

There are invariably opportunities to improve on driver behaviour and deeper control of the telematics will facilitate this. There is significant evidence of improved miles per gallon (mpgs) through Driver Development Managers. We have included a bonus each week for most improved driver mpg and use of train the trainer following initial specialist training. We would be happy to propose excellent eco-trainers.

By instigating control over telematic data, beyond simply reporting on idling and over revving, the company should expect to make significant savings. Training the trainer (using your best drivers as the new trainers) avoids ongoing external trainer costs.

Using train, the trainer techniques and utilising Amey's consistently better drivers to train poorer drivers (acceleration, harsh braking and cornering, etc) as well as bringing drivers towards the fleet 's specific average, will also keep costs down and skills in house and deliver savings alongside safer and better skilled drivers.

	Detail of Measure Identified	**Identified Energy Savings Yr 1 (kWh)**	**Averaged annual savings (£)**	**kG CO2 Saving**	**Capital cost to instigate (£)**	**Ranked Payback Period**
Measure MF1	Eco Training (Telematics)	116,041	10,731	**28,386**	5,100	0.48

MF2 Over revving

Telematic data for the RCV and recycling fleet shows savings available here which could be established through more consistent use of telematics, driver training and awareness. Over revving on an RCV fleet can be as high as 40+Litres/hour on an RCV. By addressing and focussing on some of the other recommendations in this report, over revving (a significant cost to the company) will also be addressed.

	Detail of Measure Identified	**Identified Energy Savings Yr 1 (kWh)**	**Averaged annual savings (£)**	**kG CO2 Saving**	**Capital cost to instigate (£)**	**Ranked Payback Period**
Measure MF2	Over revving	99,127	9,167	**24,248**	5,100	0.56

MF3 Rolling Resistance

All tyres are available in a range of options to improve various aspects of their delivery. One of these is rolling resistance. The higher the rating, the better the efficiency. Higher rated tyres will typically be less robust and so care should be taken where vehicles are regularly travelling distances on construction type tracks as tyre damage may occur more frequently. We have factored for efficient but not the most efficient tyres at next natural change as ‘A rated’ tyres (which are less physically robust) may not meet the needs of the environment.

Selecting a good RR tyres mean that fuel efficiency is improved. We understand that the fleet do not enter landfill sites and are always on tarmacked or concrete hard standing. As such they would benefit from a move to more fuel-efficient tyres.

As such, B or C rated RR tyres (which are less robust than D or E rated tyres) ought to be acceptable for the application and would save significant fuel.

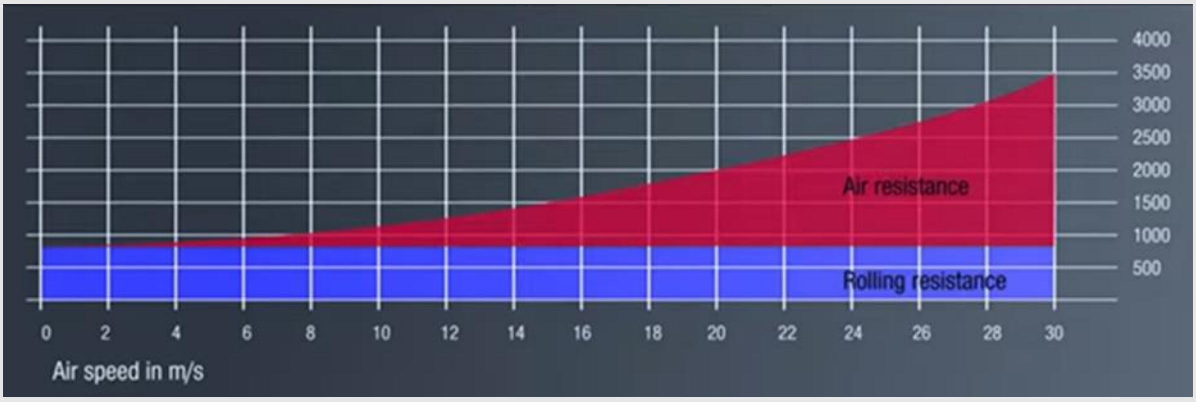
	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure MF3	Rolling Resistance	59,450	5,498	**14,543**	4,200	0.76

MF4 Speed Restriction

Whilst the RCV vehicles will not tend to get up to sufficient speed to justify adjustments here, the commercial vans do, and these should be restricted to reduce fuel wasted with speed. We have only run calculations on the smaller commercial vehicles, but speeding savings will apply across the fleet.

Vehicles that are not speed restricted use significantly more fuel than those that are. We understand that GCC, operate on A roads and dual carriageways and the presence of speed restrictions will remind staff of the importance of keeping within limits.

At average speeds above 60kph, wind resistance consumes more fuel than all other aspects of the vehicle put together. Once all vehicles are speed limited (around 53mph) the opportunities lie in reducing parasitic drag or wind resistance.



As can be seen in the graph above, a doubling of speed leads to 4-fold increase in air resistance (red). The highest point here - 30m/s equates to 67.1mph.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure MF4	Speed restriction	46,628	4,312	**11,406**	4,900	1.14

MF5 EV Vans

There is potential for a move to electric vans from the current diesel vans. We have factored for two of these where these is sufficient information, but it is likely that the numbers here could be increased.

From an assessment of fleet movements and costs, we have established that there look to be at least two company vehicles that would readily lend themselves to replacement with battery electric vehicles (BEVs). For the purposes of this exercise we have elected to replace with Nissan Leaf Mk2s or eNV200 – other alternatives are available.

A more exact assessment using actual miles driven per day will ensure that these vehicles will cope with the range delivered by these EV models. Savings from EVs are most especially made in terms of fuel costs. Further to this, the changes to benefit in kind (BIK) recently announced, make EVs an attractive company car option. With around half of all new cars obtained by companies, and because benefit in kind (BIK) makes a significant difference to an individual's monthly wages, BIK represents a very potent lever available to government to encourage adoption of the lowest emitting vehicles.

In July 2019, following consultation, HM Treasury announced their intent to strongly incentivise full (BEVs) using these rates, and offer a more modest incentive on plug-in hybrid electric vehicles (PHEV).

The changes incentivise companies and employees to purchase BEVs, effective from 6th April 2020. At this point, these new lower rates are effective (all BEVs will pay no company car tax in 2020-21, just 1% in 2021-22 and 2% in 2022-23). Current BIK rates for zero emission vehicles are up to 16%.

Inevitably, some of the messaging around the running costs of EVs tends to be quite general in order to reduce complication.

Positive messages tend to focus on the fact that EVs could cost as low as £0.02 per mile whereas the more pragmatic messages use a default £0.04 per mile (the HMRC Advisory Electric Rate for business mileage).

However, it is important to remember that, just like petrol and diesel cars, not all EVs are the same in terms of their cost per mile and so it is important to understand and be able to calculate the differences before making your choice.

Like any car, the larger / heavier it is the less efficient it is likely to be. There will also be differences between the technologies incorporated by different manufacturers.

The types of journey, season, driving style, load weight, passengers, temperature, and weather will all affect these indicative figures together with the use of public charge points.

A constant and incorrect perception around EVs which is repeated by the media and suppliers within the automotive sector is around annual mileage.

A recurring message is that EVs are best suited to short journeys and this then translates into a message that EVs are only suitable for people who do low annual mileage or as a second urban car.

This perceived annual mileage threshold at which an EV becomes unsuitable varies but it is usually 10,000 or 15,000 miles per year.

However, if you drive 110 miles a day for work, 5 days a week for 46 weeks of the year this equates to 25,000 miles. When you factor in extra weekend private mileage this could easily be 30,000 miles a year.

The real-life average range of EVs on the market today is approximately 190 miles. Most are more than capable of achieving 110 miles a day. We have factored on the safe side using an average 100 miles per day as we do not have granular data for driving at GCC.

Of course, this also ignores the fact that on longer journeys you can always charge up for extra range and rapid chargers at all UK motorway service stations can charge a car from dead to 80% within 40 minutes (broadly the time it takes to drink a cup of coffee).

In short, EV range is no longer an issue and it is important to question anyone who tries to suggest otherwise.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure MF5	EV Vans	12,904	1,864	**3,157**	2,160	1.16

MF6 Idling Reduction

The telematics data evidences higher than expected idling by the refuse and recycling fleets.

Idling is an index that demonstrates driver behaviour. Reducing the instances of idling will affect a range of driving attitudes and bring down fuel use and emissions.

Whilst idling is not the biggest fuel user it is the easiest aspect to engage drivers on. Speeding will be the fleet's biggest issue even with short distances travelled. By focussing on the idling (relentlessly) drivers know that managers are watching and speeding drops along with idling. Short of restrictors (which we have not factored for this heavy fleet), going after speeding alone would take up too much management time with disciplinary issues; the aim is to get drivers to save fuel within the limited (management) resources available. Once engaged they can focus on over revving which is liable to be ten times as high as idling on an RCV.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure MF6	Idling Reduction	33,042	3,056	**8,083**	5,100	1.67

MF7 Enterprise Fleet

The fleet operated by Enterprise would benefit from a review. The 6 vehicles (from the ten assessed) cumulatively only travelled around 18,000 miles over the year to end March 2020 (so broadly Covid-19 unrelated). They would also benefit from an assessment for a wholesale move to Battery Electric Vehicles (BEVs) – cars and a van, rather than the one on the fleet currently.

Vehicles observed:

Make	Model	Type	Fuel	Registration	Colour
Nissan	Leaf	Car	BEV	DV69 GVA	White
Toyota	Yaris	Car	Hybrid petrol	FL68 WUW	White
Vauxhall	Vivaro	Van	Diesel	DL69 AGO	Silver
Hyundai	Ionic	Car	Hybrid	EA68 UKV	Silver
Hyundai		Car		EF67 AEY	Blue
Toyota	Yaris	Car	Hybrid petrol	FP68 ACX	Grey

From the data provided for the year, it appears that these six vehicles are the only ones on the contract. The four vehicles within the data provided have been replaced with some of these.

Our calculations have only factored for a move to one electric van, 3 electric cars and 1 e-bike. As such, we have 'greened', and reduced the fleet by one. The use of daily hire cars should also be reviewed alongside the pool fleet for potential savings as there look to be savings available here.

	Detail of Measure Identified	**Identified Energy Savings Yr 1 (kWh)**	**Averaged annual savings (£)**	**kG CO2 Saving**	**Capital cost to instigate (£)**	**Ranked Payback Period**
Measure MF7	Adjust EHI Fleet	15,319	828	**3,747**	1,680	2.03

MF8 Maintenance regimes

If tyre pressures are not regularly checked and maintained, then there is significant space for improvement. For example, a five PSI underinflation has the drag effect equivalent to an additional cab-mounted extremity with consequent increase in fuel consumed of 0.2-0.5%. We would expect extremely fast payback on such measures. We understand that vehicles are maintained on site and by local dealerships, frequency and level of checking should be investigated along with assessments by drivers. As with HGVs, it is common amongst fleets that tyre pressures and tracking are not checked and adjusted as often as necessary. We would recommend at least monthly, before driving at high speed and more ideally, weekly. Appropriate engine oil and tappit checks etc should also be regularly addressed.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure MF8	Maintenance	17,485	1,617	**4,277**	4,200	2.60

MF9 Specification

In specifying future vehicles, there are improvements that can be made that will enhance fuel efficiency and keep down costs and carbon emissions. An example would be built-in beacons into installed cab farings. It is encouraging to note that certain of the beacons are housed within the cab or shell of the Refuse Collection Vehicles (RCVs). However, there are commercial vehicles and kerb-siders with protrusions that should be designed into the vehicle.

As a rule of thumb, vehicles that have protruding beacons or similar, demonstrate relevant aerodynamic losses for any such protrusion. Roof racks have a far more detrimental effect. Whilst beacons are required, future vehicles can be procured with these built into the bodywork (see RCV in image above) and we would advise this for future leasing and procurement of vehicles.

Whilst the RCVs generally do not travel fast enough to justify significant investment in aerodynamics, some of the commercial fleet do. Installation of cab fairings on vehicles such as cage trucks and box vans will make a large difference in fuel consumption and reduce emissions significantly.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure MF9	Spec	21,081	1,950	**5,157**	5,600	2.87

MF10 Compressed natural gas (CNG)

Due to the capital cost and limited distance travelled and fuel consumed by the fleet, it is difficult to justify electric recycling vehicles at this time.

Whilst Hydrogen as a fuel is available today, it is not yet commercially viable. Nor are there adequate numbers of filing stations to make this viable for GCC. A short to mid-term solution for the Council may be CNG.

As the world of heavy goods looks to alternative fuels following net zero emissions targets by 2050 climate emergencies and 'diesel-gate', considerations for viable low emission alternatives to diesel are required.

CNG offers an attractive 40% discount in fuel cost per kWh at a roughly 20% reduction in combustion efficiency, the net gain in real world conditions is approximately 20% reduction in fuel cost for the same work/distance.

This can and is being produced from sustainable biofuels and has significantly lower emission than diesel and less cost per litre. We are currently conducting trials on these vehicles and would be pleased to work with you on our independent findings following these tests and perhaps more specific assessment for GCC at a later date.

Importantly, as the world moves to more and more low emissions zones (LEZ), dramatic reductions in harmful emissions (NOx, SOx, PMs, CO etc) are available using CNG. This will enable entry to low emission zones and avoidance or reduction in congestion charges. CNG in use is Renewable, Sustainable Biomethane, 100% sourced from waste, independently verified, and approved by the Department for Transport's Renewable Transport Fuel Obligation (RTFO).

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure MF10	CNG	316,216	29,243	**77,353**	280,000	9.57

Renewable Energy

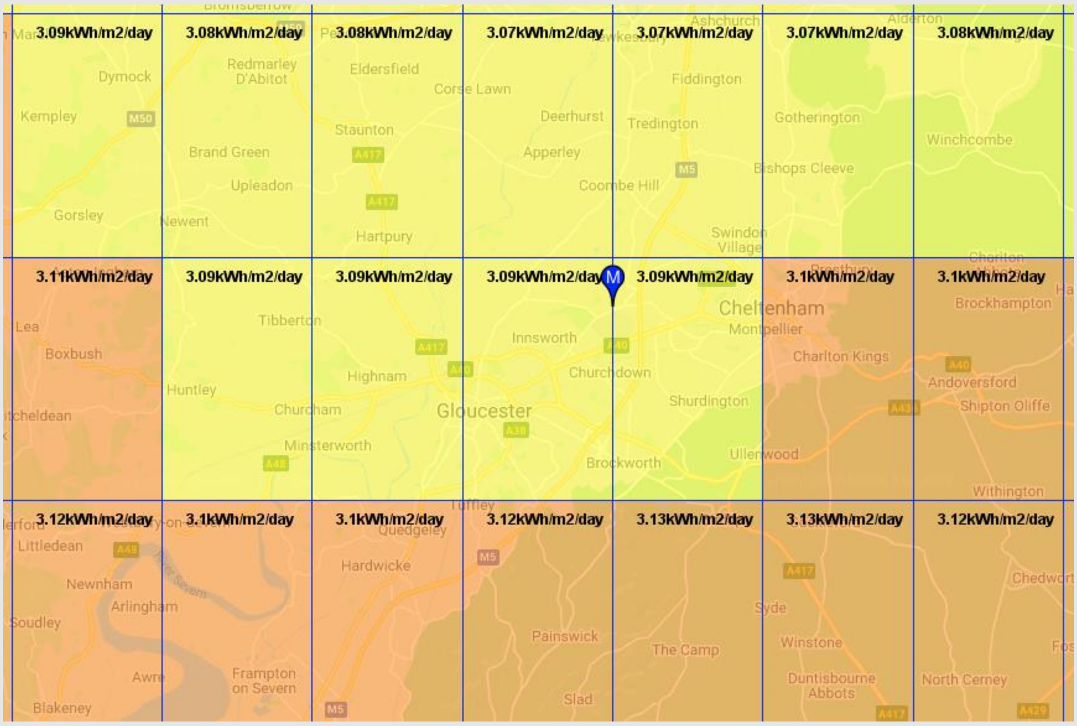
Solar PV

The installation of solar arrays at certain of the sites visited would provide significant benefits including:

- Guaranteed energy costs for the next 20-25 years
- Payback on investment in around 5-6 years
- Security of supply
- Strong return on investment (ROI) potential
- Environmental and reputational credentials
- Greenhouse gas reduction

Solar irradiation around Gloucester is around 3.09kWh/m2 per day.

Solar plan of area below shows solar irradiance levels at Gloucester for key oriented buildings of significantly over 900kWh/kWp All of these are suitable locations for the right oriented roofs to be installed with solar arrays.



Source: Google Earth

Table 6.1: Specific photovoltaic power output – hourly averages [Wh/kWp]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 - 1	-	-	-	-	-	-	-	-	-	-	-	-
1 - 2	-	-	-	-	-	-	-	-	-	-	-	-
2 - 3	-	-	-	-	-	-	-	-	-	-	-	-
3 - 4	-	-	-	-	-	-	-	-	-	-	-	-
4 - 5	-	-	-	-	1	9	2	-	-	-	-	-
5 - 6	-	-	-	3	37	50	38	10	-	-	-	-
6 - 7	-	-	0	55	112	127	110	69	21	-	-	-
7 - 8	-	0	55	153	212	229	210	161	106	30	0	-
8 - 9	8	54	145	255	303	319	302	258	199	124	42	6
9 - 10	62	128	221	334	370	386	376	328	272	192	105	56
10 - 11	120	196	290	394	417	420	414	374	338	255	164	110
11 - 12	161	251	353	439	454	461	454	412	372	313	196	142
12 - 13	174	272	373	446	460	464	465	423	373	282	195	147
13 - 14	151	231	323	413	434	444	448	401	341	242	159	123
14 - 15	109	186	275	364	401	424	419	364	285	192	111	78
15 - 16	50	134	221	302	341	366	361	307	231	133	43	18
16 - 17	1	54	138	214	255	279	279	229	149	31	-	-
17 - 18	-	0	40	110	156	186	183	134	49	0	-	-
18 - 19	-	-	0	18	65	93	90	43	0	-	-	-
19 - 20	-	-	-	-	8	25	21	1	-	-	-	-
20 - 21	-	-	-	-	-	0	-	-	-	-	-	-
21 - 22	-	-	-	-	-	-	-	-	-	-	-	-
22 - 23	-	-	-	-	-	-	-	-	-	-	-	-
23 - 24	-	-	-	-	-	-	-	-	-	-	-	-
Sum	**835**	**1507**	**2434**	**3498**	**4027**	**4284**	**4172**	**3515**	**2735**	**1795**	**1013**	**680**

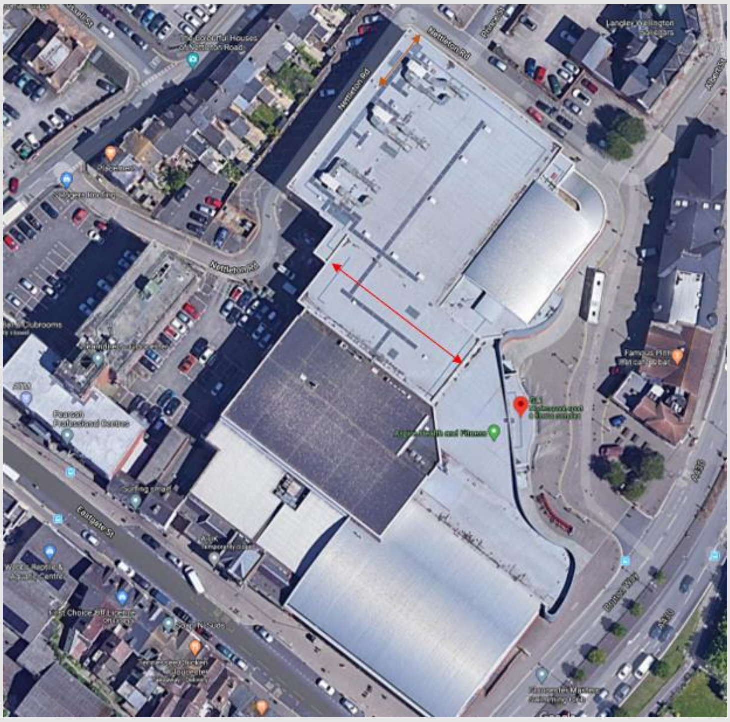
Solar Arrays would typically be designed to match site consumption whilst electrical energy storage costs remain high.

A professionally installed solar roof array should be delivering 80% of its initial yield at 20 years into the future. We would always recommend a minimum of three quotes, sizing of array to meet consumption load and the inspection of array post install to ensure proper stringing and cabling. This is something we would be happy to assist with.

With all recommendations discussed below, it is always worth recognising that energy efficiency measures should be enacted before investment in renewables as the ROI is far greater.

MR1 GL1

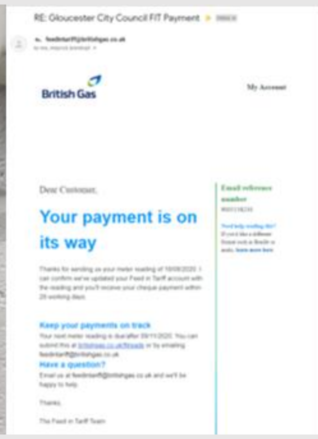
There is potential to install Solar PV arrays to large areas of these roofs, as with all recommendation, a structural engineers reports should be sought and there are roofs we have ignored on this site due to advice from Aspire. As such we have factored for only two roof areas. More may well be possible.



	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure R1	PV GL1	500,202	64,306	**127,852**	336,157	5.23

MR2 Plock Court

The site has a small array of 45 modules installed shortly after the feed in tariff came into being. Electricity generation since install amounts to 54,392kWh. Solar PV existing was installed in 2011 with over 44 Pence per kWh feed in tariff rate and the array is 9.81 kilowatt peak we have a reading from the metre for generation to date. See below. More information is provided on this array later in the report:


RE: Gloucester City Council FIT Payment

British Gas

My Account

Dear Customer,

Your payment is on its way

Email reference number

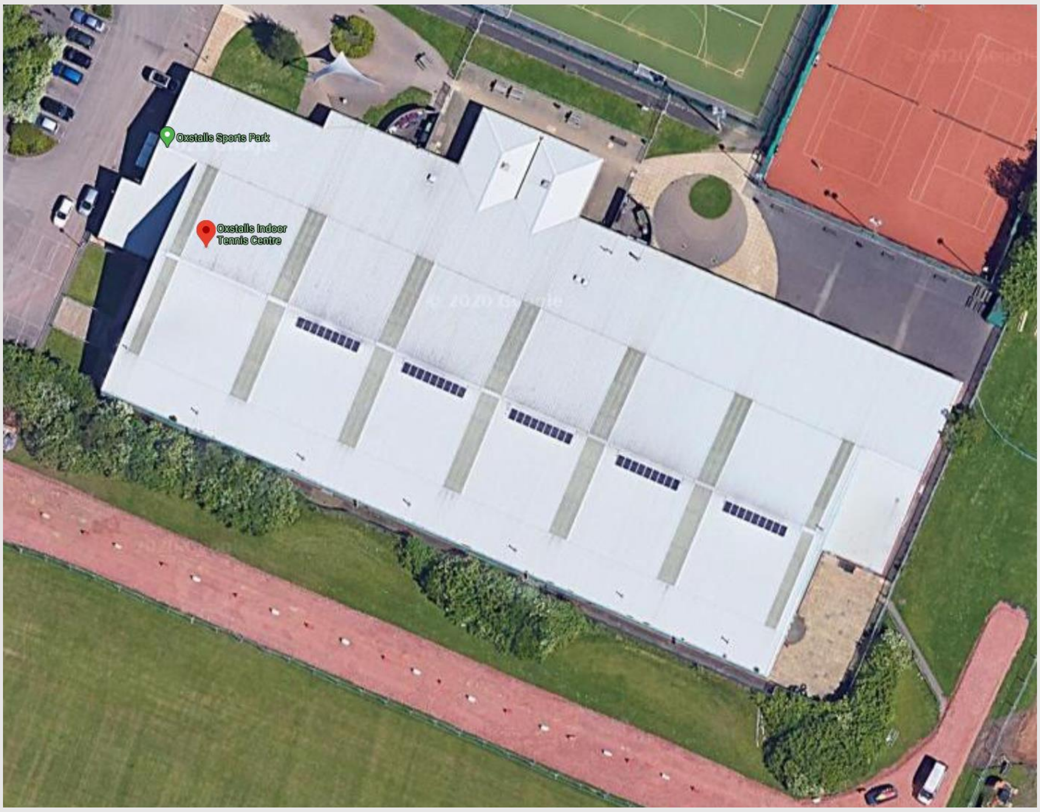
Keep your payments on track

Have a question?

Thanks,

The Feed in Tariff Team

There is potential for a far greater array at this site which would provide the daytime load of the site. There may be potential to look at energy supply to Oxstalls University Building.



Provided that it is structurally sound, there is potential for a significantly large array to be installed on this large SSW facing roof.

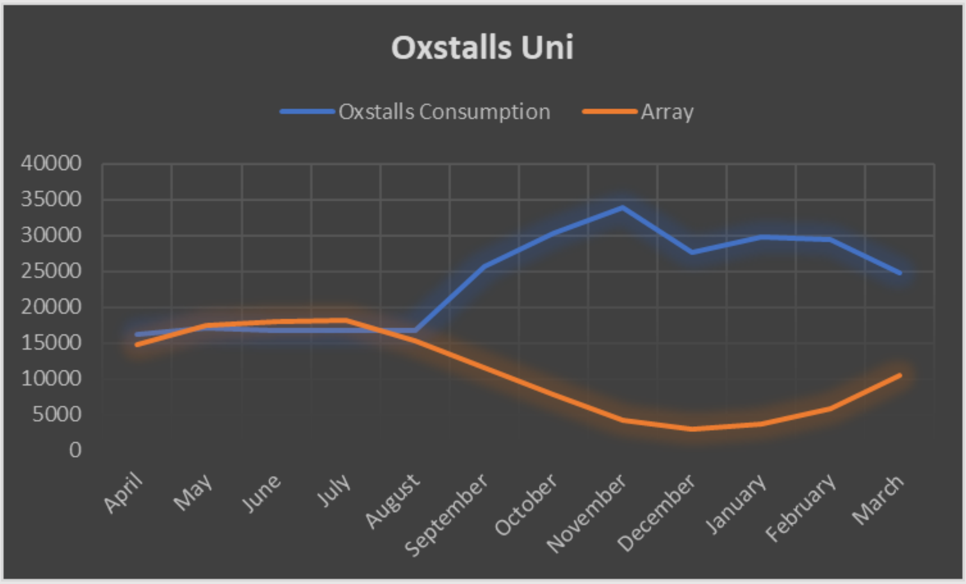
We have calculated irradiance (sunlight falling) on this SSW facing roof and it is shown as 929kWh/kWp which is excellent for this part of the Country.

Given that the pitch of this roof is only 12-14 degrees, it may be possible to more than double this array using the larger NNE facing roof space. Having calculated irradiance for this roof, we are seeing a lower, but still credible irradiance level of 749kWh/kWp.

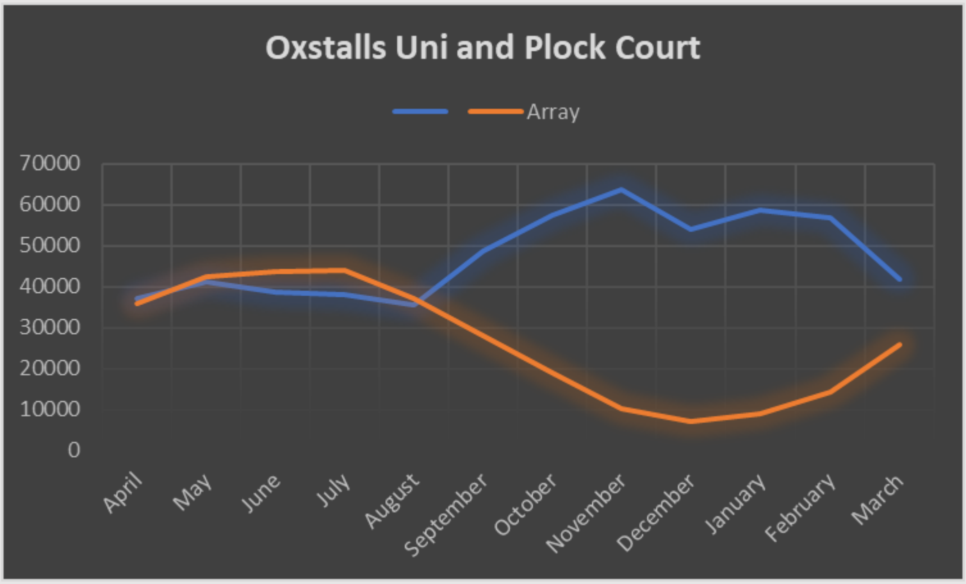
There may be an option for a soft dig trench and cable supply of energy generated to the university sports building (lighting, air handling, cooling etc). It is understood that University roof itself would not take this additional structural load.

The distance between the nearest walls of the tennis Centre and university building is 78m and the majority of this would be soft dig. The additional distances between plant rooms must be considered.

Limited consumption data provided by the University shows that an array to broadly cover the south facing roof of Plock Court with electricity exported to the University building would broadly serve their daytime* summer demand. In the three graphs below, the blue line is site consumption and orange line show PV energy generation:



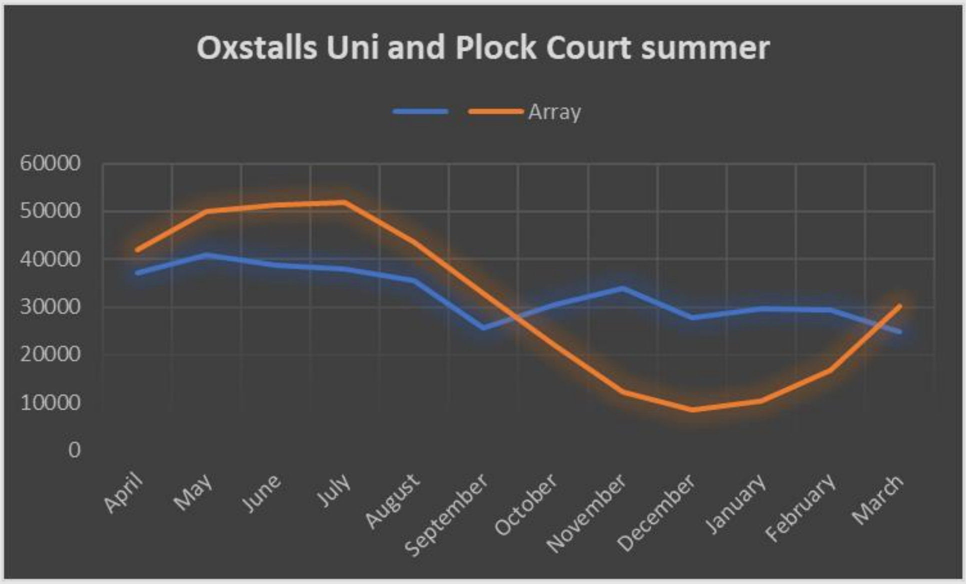
Maximising the array across all Plock Court roofs could potentially achieve all of Plock Court and Oxstalls University's daytime summer demands.



*Data provide by Oxstalls was total electricity, not split by day/night tariff. Nor was HHD supplied so that actual daytime/sunlight consumption is unknown. Data provided also included five months of CV-19 lockdown period. Energy data for Plock Court should be significantly reduced with changes as proposed in this report, in particular with regard to lighting, albeit this will be broadly night-time savings. This is all dependent on whether such a venture is allowable as a process between separate MPANs.

Calculations can be provided with more accuracy with a more real time period and half hourly data provision.

A scenario whereby all Plock Court roofs are maximised with PV and energy is provided to both sites from March until August and then only to Oxstalls thereafter might look like this (previous caveats apply):



An array of this size could provide around much of the current energy demand of the site. If there were interest in this going forward, we would suggest a more comprehensive assessment looking at, for example, energy efficiencies available at Oxstalls, demand time against solar delivery times and options to link to EV charging vehicle to grid opportunities.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure R2	PV Plock Court	325,471	50,028	**83,190**	251,073	5.02

MR3 Eastern Avenue Depot

There are several roofs that would lend themselves to Solar PV at this site.

The site consumes a relatively high amount of electricity and we have factored our array based on an oversupply of energy which would factor for an element of renewable EV charging in future fleet or sale of electricity to properties in the linked industrial estate.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure R3	PV Depot	335,093	44,327	**85,650**	225,197	5.08

MR4 Gateway

As a pure electric building, this site would benefit greatly from a solar array to power the pumps of the heat pumps.

We have factored for an array that would generate around 1/3rd of annual daytime electricity consumption.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure R4	PV Gateway	16,363	2,075	**4,182**	10,997	5.30

MR 5 Crematorium

There are relatively small roof areas at the crematorium and the nearby on-site Arbor tea rooms that would lend themselves to solar PV arrays. It would be particularly important at the latter site to ensure that the energy efficiency measures, specifically lighting, be undertaken before embarking on this as a change to the main 'Erco' spotlighting in the two major event rooms will make a substantive reduction to the electricity consumed on site.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure R5	PV Crematorium	30,592	4,019	**7,819**	20,559	5.12

MR6 Guildhall

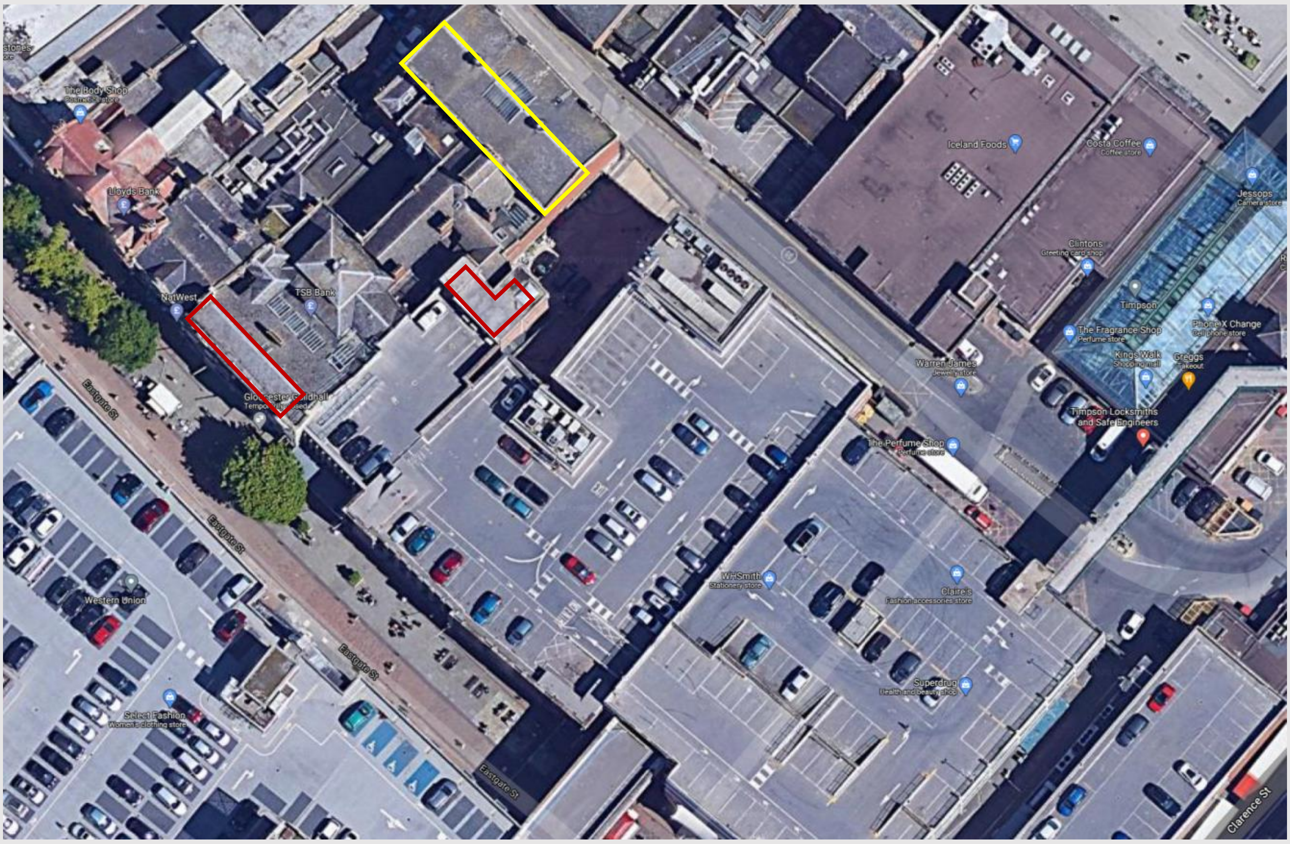
The Guildhall has a 20kWp array that was installed in February 2020. It is delivering significant yields in its first seven months. Meter below shows 14,549.5kWh

PV Generation meter:

For the PV generation on this roof to have delivered 14,550kWh since installation on 5th February 2020 from a 19.5kWp array, is both impressive and further evidence (where it needed) of the fact that the 9.91kWp array at Plock Court is not delivering what it should be in a similar part of the country.

Solar Car ports are a possibility for the car park adjoining the Guildhall.

Areas marked in red may lend themselves to additional PV roofs, albeit the front building is currently occupied by Nat west bank.



	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure R6	PV Guildhall	7,440	856	**1,902**	5,000	5.84

MR7 Eastgate Market

PV south facing upper roof


Area in question:

Triangle areas would need to be on raised platforms and with solar edge technology to avoid adverse shading affects

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure R7	PV Eastgate Market	75,684	10,057	**19,345**	50,863	5.06

MR8 Blackfriars Priory

Proposed installation of PV array to new roofs (SE) and portable IR panels in main hall to make the room viable for more events – can then move panels for other locational events

Specifically:


	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure R8	PV Blackfriars Priory	12,450	1,521	**3,182**	8,367	5.50

MR9 Longsmith Street MSCP Upper level


Provided the site is considered secure, there is potential here for PV car ports that could generate 3.5 times the daytime demands of the site. Power could be sold/shared/sleeved locally for other sites and used for EV charge points. Local connection points may need to be upgraded if larger systems are to be fed into them. Full planning will be required for car ports. This may not be the case for a ballasted array that would effectively close the top floor of the car park.

The Carports considered exclude development works such as structural investigation / Civils, DNO costs and upgrade works.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure R9	PV Car Port Longsmith Street MSCP	187,000	25,085	**47,797**	290,000	11.56

MR10 Kings Walk MSCP

There is potential here for PV car ports on the 4th (top) floor that could generate 5.8 times the daytime demands of the site. Spare power could be sold/shared/sleeved locally for retail sites and used for EV charge points. Local connection points may need to be upgraded if larger systems are to be fed into them. Full planning will be required for car ports. This may not be the case for a ballasted array that would effectively close the top floor of the car park.

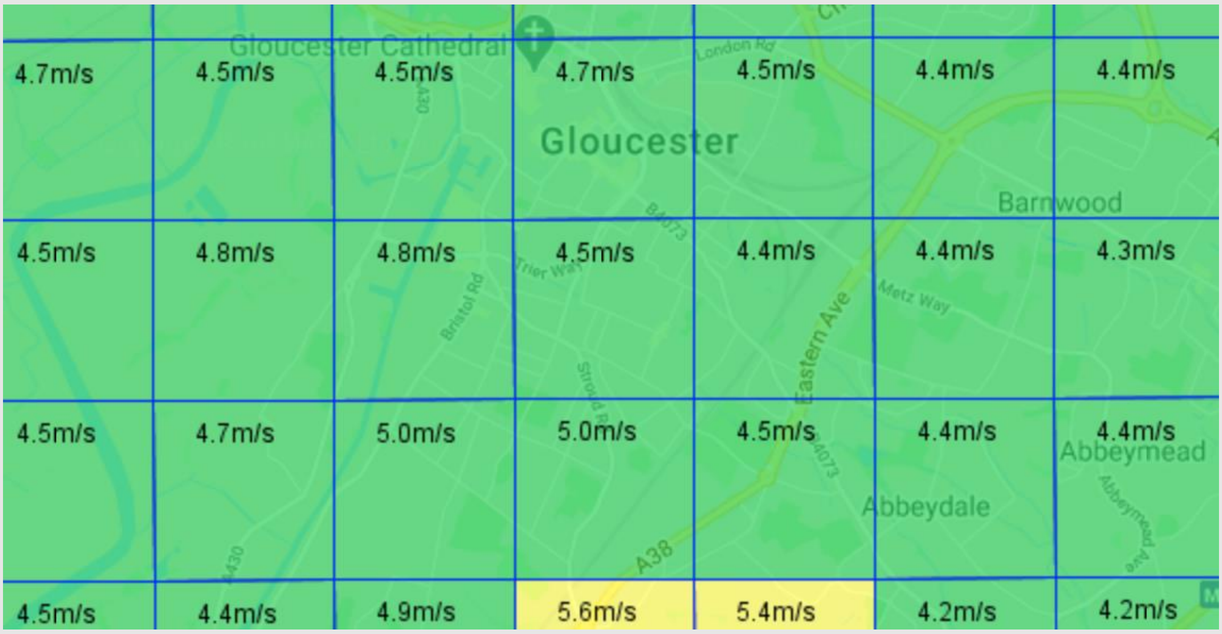
The Carports considered exclude development works such as structural investigation / Civils, DNO costs and upgrade works. Lighting controls should be implemented before any further action takes place as the daytime top floor light use is skewing and increasing the energy use of this site dramatically.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure R10	PV Car Port Kingswalk MSCP	519,680	69,997	**132,830**	828,800	11.84

MR11 Crematorium

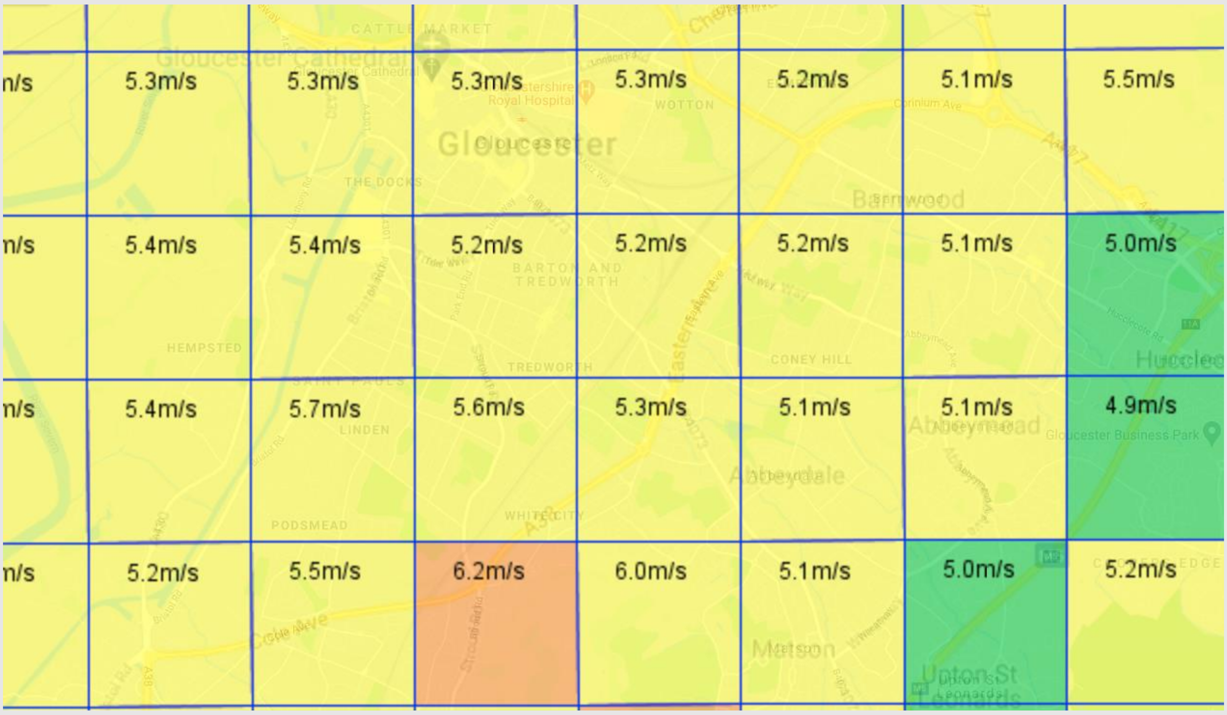
Wind Turbine linked to Electrical Cremation (Resomation)

A more contentious opportunity might be a wind turbine. Even at a low hub height of 10m, wind speeds of around 4.5m/s are reasonably good and the Coney Hill site which has a reasonable amount of land onto which a moderately sized wind turbine could be installed.

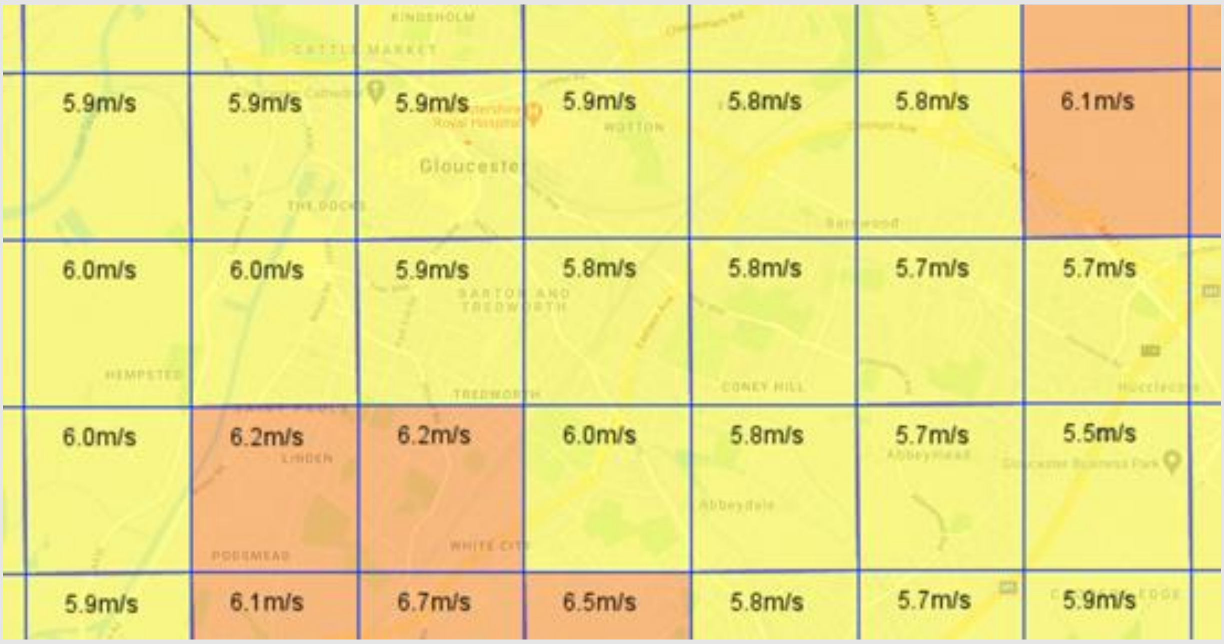


Source: Google maps

A taller tower (25 metre) which we would recommend given energy demand requirement, would provide wind speeds in excess of 5.2m/s which, with suitable frequency becomes viable.



A hub height at 45m shows speeds at 5.8m/s:



Source: Google Earth

An 80kW wind turbine at this site could provide around all of the current electrical energy demand of the site. If there were interest in this going forward, we would suggest a more comprehensive assessment looking at, for example, actual energy demand time against a more precise assessment of wind speeds and an accurate assessment of local wind frequency. There are options to link to EV charging vehicle to grid opportunities.

We have factored for a small solar array at the crematorium building and tea rooms. If resomation were to be taken seriously, we would recommend a wind turbine to this site.

An 180kW wind turbine at this site could provide around all of the current electrical energy demand as well as future Resomation demands of the site. We would suggest a more comprehensive assessment looking at, for example, actual energy demand time against a more precise assessment of wind speeds and an accurate assessment of local wind frequency.

We appreciate that this is cemetery is surrounded on all sides by residential and retail properties and so will not have an easy route through the planning process.

Resomation - Crematorium

It is widely assumed that heat created through the burning of bodies at a Crematorium can be distributed to heat nearby premises. Typically, the Crematorium at Coney Hill will cremate 8 bodies per day, during the Covid-19 pandemic, this figure was significantly higher.

A problem with piping heat over long distances is heat loss, although this can be ameliorated to some extent with good quality pipe insulation. However, the main problem is that cremations occur year-round and only Monday to Friday during office hours, to make use of the generated heat, there needs to be an all year-round demand.

Space heating is only required during winter months. Consequently, without a sump load such as a swimming pool nearby, there is no viable payback opportunity for piping waste heat.

Cremation uses significant volumes of natural gas which produces high levels of global warming gases. Since electric heat pump technology cannot achieve the temperatures required, the obvious solution is to power the process using renewably delivered electricity. This then needs a whole new method of body disposal.

By installing renewable electricity generation technologies at the crematorium site at Coney Hill, the site would have the option of becoming electrically powered. Installation of a roof mounted solar PV array and 180kW of wind turbines would provide the site with its aggregate demand, connected to the electrical grid for peaks in demand and sale of energy to the national grid during hours of closure.

If electrical 'cremation' technology is introduced to replace gas cremators over time, then the site becomes largely self-financing, close to zero carbon, non-polluting, requiring of no gas scrubbing and has no need for chimney stacks.

Introduction – Gas Solution

A resomator can handle 4 bodies per day. As such, understanding that the site currently cremates an average of 1,800 bodies per year or 6.92 bodies per day, we have factored for two resomators that together should be able to handle 8 bodies per day or 2,080 per year.

Gas use on site currently amounts to 1,750MWh at a cost of over £40,500 per year.

Industry analysis suggests that gas energy prices are expected to increase by a minimum 1% year on year for the foreseeable future and likely much more than this as the Government attempts to move away from gas.

Electrical demand for pre-heating cremators amounts to 150kWh/week or 7,800kWh/year at a cost of **£1,000**/year.

The gas scrubbing technology involved in traditional gas-powered cremation (to ensure that the emissions leaving the chimney do not contain furans and dioxins) costs in the region of **£10,000** every ten years (£1,000 per year).

A Site Powered by Renewables

Clearly the single gas cremator on site operating as follows would see a doubling of gas and electricity use with the introduction of the second cremator in the future (see table below):

The case is founded on the fact that the site becomes electrically powered and that the site is well located for both Solar PV energy generation and likely wind turbine energy generation. NOABL wind speed database shows speeds of over 5.0m/s which would be more than adequate if they are of reasonable frequency. In order to test this, a Wiebel Distribution test should be performed with a mast of around 15 to 20 metres on site for 3 months +.

The fact that the electric cremators could operate almost entirely from this on site renewable energy would mean that it will also be expected to pay for itself within around 6 years and the site can then become financially sustainable beyond its 7th year of operation. The savings in electricity purchased from the grid (which will have increased by min 4% each year) will be very real.

Wind technology is effectively twice as efficient as solar PV. The combination of the two will help to balance intermittency of load. There is expected to be some requirement for grid electricity or stored electricity, but more analysis will be required here. Sale/sleeving of excess power should be able to offset this.

The use of electrical cremation will result in the removal of scrubbers and effectively remove the need for hazardous and carbon emissions to air. The liquid solution at the Resomation end of the process is an alkali which can be treated with CO_2 or mild acid to neutralise.

Electrical Solution

Total electrical demands 257MWh to operate two units each year. Predominantly delivered by renewable means.

This excluding for peaks in demand which could be levelled out with the electrical grid connection which would be required anyway to export power when not required (weekend and during the hours of night for wind) this could be largely covered with a suitably sized solar array wind turbines.

UK Government Position

The UK Ministry of Justice (MoJ) (Coroners, Burial, Cremation) have been aware of technologies such as Alkaline Hydrolysis (AH) and Resomation (AH based in Scotland operating on higher temperatures and pressures), as well as Gasification/Pyrolysis since at least 2008.

The technology is not regulated (because it is not burning and falls outside the scope of burials and cremations). Therefore, it is neither legal nor illegal in England and Wales. As such, a Resomation (Alkaline Hydrolysis) unit could be installed today but if it could not satisfy the relevant departments as to its disposals and effluents, then it could not be operated for the purposes of human disposals.

Operations Elsewhere

These technologies have been in operated, licenced, and proven in the US and Canada for human disposal in direct replacement for burial or cremation since before 2011.

The technology has been used for body part disposal in hospitals and universities for decades across the UK, Europe and beyond.

The image below shows the unit in operating position alongside two standard gas cremators: In terms of Alkaline Hydrolysis, assuming sufficient space, the technology can be retrofitted on-site inside a day.

Alkaline Hydrolysis (aka Resomation or Dissolution)

A flameless process that uses water instead of fire. A gentle and respectful process. No emissions of mercury or other harmful greenhouse gases to the atmosphere. 90% less energy use than gas cremation. A fraction of the carbon footprint of burial or cremation.

Capital Costs:

US $235,000 U.S. for a high temperature unit (4 bodies per day)

£183,300 (Oct 2020 prices) + shipping + 1 day install cost.

Caustic Alkalines required (ca 10kg for average sized body)

The predominant (75%) alkali known as NaOH (sodium hydroxide, or caustic soda) is derived by electrolysis of salt (NaCl) water into sodium hydroxide. Earth has abundant quantities of sodium chloride (salt) to produce this alkali. (NaOH is commonly used in making hard soap and other personal hygiene products). After the process of hydrolysis, sodium chloride (table salt) reforms as one of the end products.

The remaining 25% alkali known as KOH (potassium hydroxide, caustic potash, or potash lye) is derived by electrolysis of potassium salt water into potassium hydroxide. Earth has abundant quantities of potassium chloride to produce this alkali. KOH is commonly used in the making of soft soap among other products, many of which are used for personal hygiene. Potassium (K) is an essential nutrient for plant growth; found in every bag of fertilizer. After the process of hydrolysis, potassium remains as one of the end products.

The Funeral Service

The traditional funeral ceremony and returning of remains is unchanged. In both cases, mourners see their loved one go behind a curtain. In the case of flame cremation, the body is put into a cremation device (retort), in the case of dissolution (alkaline hydrolysis) the body is placed in a water vessel. The remains from dissolution (alkaline hydrolysis), like fire-based cremation, are returned to the family in an urn. In AH, the body does have to be input outside of a coffin using a body bag so this might have to be disposed of separately.

There appears to be sufficient space in front of the cremator exit area (imaged below) is 2.78m x 11.18m. There is also a courtyard directly outside of this (right of the image) that is of a similar size and could potentially be adapted/expanded into which would effectively double the width of this area to over 5m x 11.18m. The area at the far end of the image by the Hi Vis jackets is access to the front (input) end of the cremators

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure R11	Wind and Res'n Crematorium	1,493,289	123,336	**320,296**	714,640	5.79

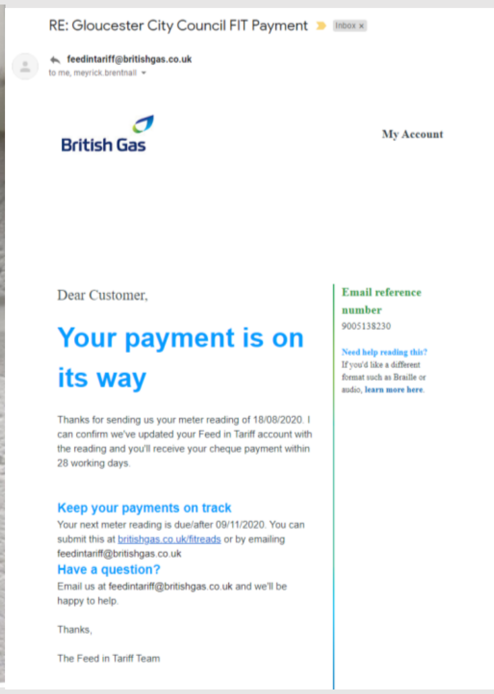
MR12 GSHP

The depot at Eastern Avenue already has a GSHP installed which is not operational. Much of the cost of a GSHP is in its installation of pipework. It would be worthwhile investigating the reinstatement of this unit as the cost of cooling and heating the site right now is excessive, not least due to the use of portable AC units exhausting through open windows.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure R12	GSHP Depot	66,137	2,722	**16,905**	8,000	2.94

MR13 Plock Court

The site has a small array of 45 modules installed shortly after the feed in tariff came into being. Electricity generation since install amounts to 54,392kWh:



RE: Gloucester City Council FIT Payment Inbox ×

feedintariff@britishgas.co.uk
to me, meyrick.brentnall

British Gas

My Account

Dear Customer,

Your payment is on its way

Thanks for sending us your meter reading of 18/08/2020. I can confirm we've updated your Feed in Tariff account with the reading and you'll receive your cheque payment within 28 working days.

Keep your payments on track
Your next meter reading is due/after 09/11/2020. You can submit this at britishgas.co.uk/fitreads or by emailing feedintariff@britishgas.co.uk

Have a question?
Email us at feedintariff@britishgas.co.uk and we'll be happy to help.

Thanks,

The Feed in Tariff Team

Email reference number
9005138230

Need help reading this?
If you'd like a different format such as Braille or audio, **learn more here**.

On meeting at this site, CLS Energy were given to understand that the Council had not received Government FIT payments for the solar array at this site since 2012. Following conversations and emails and information being located, we were able to establish that payments are still available to the Council and CLS Energy were successful in resurrecting these.

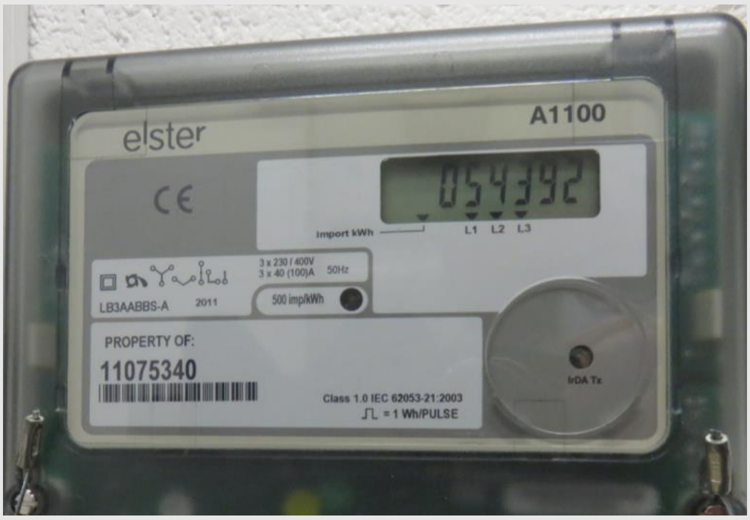
We understand that a cheque for £10,500 has now been received by Gloucester City Council.

Our capex cost here relates to point R14. It is based on an engineer's investigation and the expectation that any fault found can be held against the installer. The cost of a new inverter installed, and strings properly attached is likely to be under £2,000. In our view, despite the inverter now being out of warranty, where a fault is found, this should not fall on the Council.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure R13	PV Repair Plock Court	27,629	12,129	**7,062**	700	0.06

MR14 Plock Court

The site has an existing small array of 45 modules installed shortly after the feed in tariff came into being in 2011. Electricity generation in the nine years since this install amounts to 54,392kWh:



The amount of energy generated according to the meter above is low in comparison to what we would expect at a site with a 9.81kWp array in this location of the UK.

We have queried this as, over the 9 years since install, we would expect to see this array delivering at least 82,000kWh, meaning that the Council may have missed energy savings and generation payments from 28,000kWh. At an arbitrary £0.11/kWh grid electricity cost over the period and a FIT rate of £0.48/kWh and lost deemed export payments. Total of lost revenue to the Council from this yield loss is around £17,000.

Following our query, the install site to inspect and report back in October. We will be pleased to provide expert independent analysis and inspection should this be required.

Important

Our observation on assessing Plock Court was that the meter reading showing energy generated since the solar PV install and commissioning on 16th September 2011 did not match our expectations for solar yield on an array of this size in this part of the UK. On challenging this, the installer has visited site and claims that the Fronius inverter is faulty and the Council should purchase a new one to rectify this problem. From what we have seen, this inverter appears to have been operating only 2 of its 3 strings from installation. This would account for why it has only generated 2/3rds of what we would have expected from this array. The cost of this loss of yield to the Council over its 9-year life is as follows:

82.021MWh- 54.392MWh = 27,629kWh

Generation tariff: (£0.4829/kWh – rate paid 1 Aug to 29 Sep 2011) £13,342.04

Grid energy not purchased: (say £0.11/kWh average) £3,039.19

Deemed Export Tariff: 50% of energy generated at £0.045/kWh £621.65

Estimated loss of income to the Council over the 9 years of: £17,002.88

https://www.ofgem.gov.uk/environmental-programmes/fit/fit-tariff-rates

It would be our view that recovery be sought over this. In order to make a claim on this, the Council would need to evidence its case against the installer. If our belief over the case of this is correct, then an independent engineer's inspection of the inverter should demonstrate this. We can arrange this on a day rate if the Council wishes to pursue it.

This will aim to establish whether the stringing of the inverter is at fault. We would also recommend that if the Council is to make a case, the installer is not permitted to remove/dispose of the old inverter.

	Detail of Measure Identified	Identified Energy Savings Yr 1 (kWh)	Averaged annual savings (£)	kG CO2 Saving	Capital cost to instigate (£)	Ranked Payback Period
Measure R14	PV FIT recover Plock Court	0	10,500	**0**	0	0.00

Over and above the detail above, CLS were able to negotiate unpaid feed in tariff (FIT) payments since 2012, between CLS Energy and the energy supply company. This has resulted in a £10,500 cheque payed to Gloucester City Council which more than covers the cost of this report. These FIT payments have now been resurrected and payments will be paid quarterly on the installed FIT rate plus RPI inflation rates provided that the Council continue to provide meter readings until the year 2031.

It is important to bear in mind that while the array continues to yield at only 2/3rd of its capacity, the Council, will continue to receive underpayments for the remaining 11 years of the FIT scheme. Action is recommended on this array to avoid a further £20,000+ of lost income and carbon savings.

General

Loft Insulation

Depot - Office (1F) loft insulation

There was found to be no insulation above the suspended ceiling. Suggest this be installed to avoid heat being contained beneath insulated metal profile roof as part of a warm roof design.

Guildhall

Loft insulation looks to be absent in certain roof spaces. It was not possible to access a reasonable number of areas to accurately assess this. Such works should be conducted as loft insulation is one of the least expensive and easy to implement savings opportunities for a site such as this and could save up to around 25% of space heat.

Renewable energy is a good technology and would assist the Council towards achieving zero carbon. However, given that energy that is not consumed by their sites will be exported to the national grid and payment for this is currently low, it makes sense to get the Council's estate in order first. Specifically, by addressing energy efficiency measures laid out earlier in this report, energy consumption is reduced along with carbon emissions and cost and the investment required to fill, or part fill the remaining energy use is reduced meaning less renewable energy required and less cost. There are opportunities to utilise vehicle batteries going forward as storage for excess renewable energy generated and we would be pleased to discuss such opportunities with you.

Gloucester Specific Next Steps:

The Council may like to consider the following additional related services:

Commuter assessment

An assessment of the carbon emissions produced by staff commuting to and from the workplace. Formal Commuter carbon assessment.

Waste and Water assessment

Assessment of council water use and how to reduce it; assessment of in-house waste and recycling and improvements to be made.

Electric Vehicle Infrastructure Assessment

An assessment of our current Electric Vehicle Infrastructure and where future infrastructure would be most effective.

Owned Sites assessment

Properties owned but not operated by the Council such as Gloucester airport and various commercial and retail buildings.

Beyond this is a list of potential next steps and opportunities to enact or move the savings agenda forward. We would be pleased to discuss any aspect of these.

- Set up a route-map to zero carbon by an agreed year.
- Assistance with working up Salix grant project
- Assist with instigation of any of the measures recommended in this report.
- Assessment of quotes received for technologies and or renewable energy.
- Assistance with public or business consultation events.
- Drafting, updating checking, or writing of policies and strategies (for example: Carbon Management Plan, Energy Strategy, Travel Plan, Travel Action Plan, Low Carbon Impacts Profile, data normalisation etc).
- Support at Cabinet and Member briefings.
- Provide Staff and member training.
- Work up proposals and/or specifications for solar arrays based on consumption vs generation, roof area, storage, and vehicle to grid (V2G) storage options.

- Assess and work up consideration of CNG or Hydrogen for next refuse truck purchase.
- Assessment and independent advice on renewable energy, specification provisions and engineer's inspection of final installation.

2050

Part II City-Wide Plan 2050

Gloucester City Council has made a commitment to achieving net zero carbon across the city of Gloucester by 2050.

To understand how it will achieve this, as with part I of this piece of work (set out above), there is a need for a baseline to be produced.

The UK Government hold baseline data for regions of the UK and we have used this as a starting point for this exercise.

The most recent data available is more than a year older than the baseline used in part I and it must be decided how best to address this. We would propose utilising the most recent data until such time as comparable data can be accessed.

The most recent data (2018) extrapolated for Gloucester City local authority region is set out below.

Electricity

Gloucester City has around 57,000 domestic electricity meters and around 4,000 commercial property electric meters.

Domestic electricity consumption is around 196GWh with commercial at 361GWh meaning that total electricity consumption is around 557GWh.

Domestic mean consumption is around 3,463kWh per household compared with 2,895kWh as a median figure. In matters such as this, we would tend to use the mean figure as more reliable.

Commercial mean consumption is around 80,505kWh per business compared with 8,098kWh as a median figure. In matters such as this, we would tend to use the median figure as more reliable.

Mains Gas

Gloucester City has around 52,000 domestic gas meters and around 1,000 commercial property gas meters.

Domestic gas consumption is around 596GWh with commercial at 406GWh meaning that total gas consumption is around 1,001GWh.

Domestic mean gas consumption is around 11,436kWh per household compared with 10,375kWh as a median figure. In matters such as this, we would tend to use the mean figure as more reliable.

Commercial mean consumption is around 770,093kWh per business compared with 151,725kWh as a median figure. In matters such as this, we would tend to use the median figure as more reliable.

Transport Fuel

Gloucester City is a local authority area consumes the following fuel for transport within its borders:

Transport Type	Tonnes of Oil	kWh	CO2e kg	CO2e Tn
Personal (car)	26,342	306,357,456	71,617,182	71,617
Freight	8,570	99,669,099	24,686,042	24,686
Total	**34,913**	**406,038,184**	**96,303,225**	**96,303**

Residual Fuel (the remaining elements of non-electric, non mains gas and non-transport fuels)

This final section picks up the residual fuels not captured in the data above.

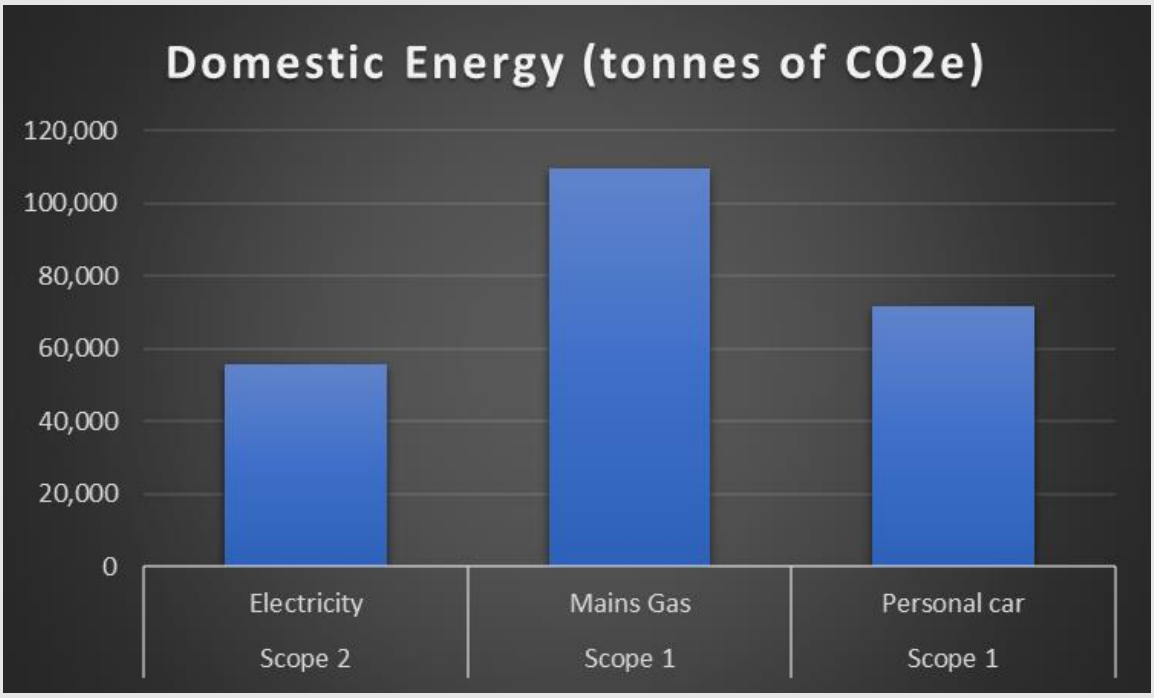
	Industrial	**Domestic**	**Rail**	**Public Administration**	**Commercial**	**Agricultural**
Petroleum based	5.2	0.4	0.9	0.1	0.1	0.2
Coal based	-	0.5	-	-	-	-
Manufactured Solid Fuels	0.5	0.5				
Bioenergy and wastes	-	5.9				
Total	14.0 ktoe (thousands of tonnes of oil equivalents					

Totals:

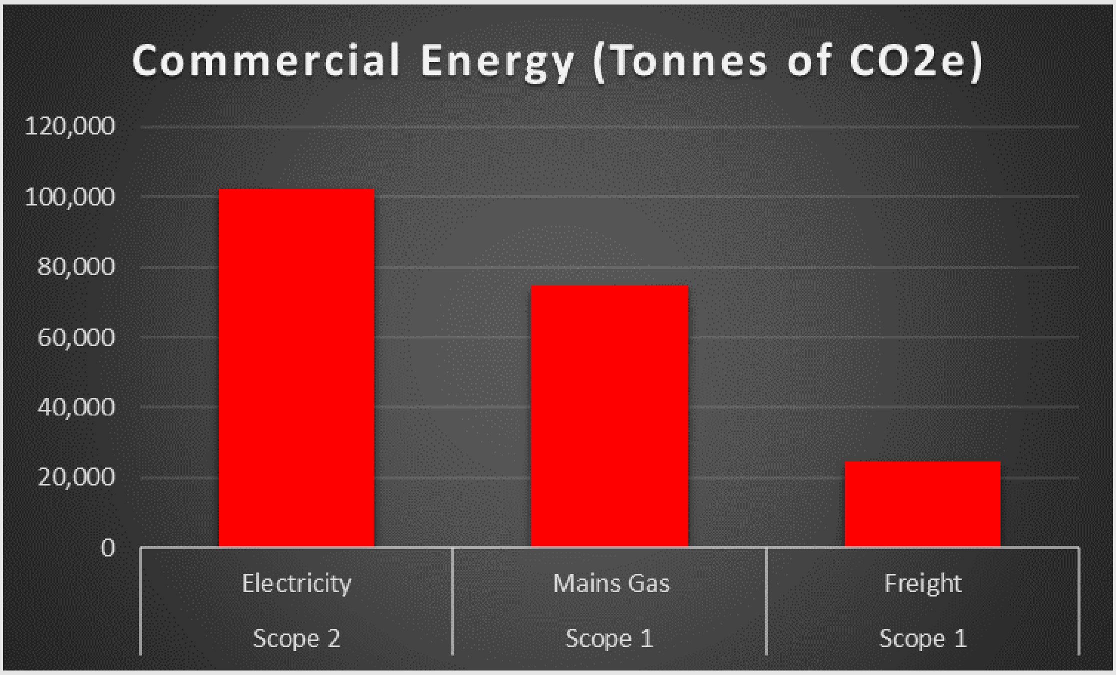
Total figures for Gloucester City are set our below:

Fuel Type	Tonnes of Oil equivalent	CO2e Tn
Electricity	Domestic	55,482
Electricity	Commercial	102,188
Mains Gas	Domestic	109,640
Mains Gas	Commercial	74,688
Personal (car)	26,342	71,617
Freight	8,570	24,686
Total	**34,913**	**438,301**

Graphically, domestic consumption for Gloucester City this can be shown as follows:



And commercial:



Naturally, there are aspects missing from this figure including residual fuels which is why it does not add up to the 468,530 tonnes of CO2e in the later table.

Consumption data such as that above can be used by and on behalf of local authorities and for targeting and monitoring a range of carbon reduction and energy efficiency policies.

In this case it is being used to provide a reasonable starting point for a baseline from which to plan methods and means of reduction against Gloucester’s 2050 target.

There are many caveats contained within the use of these data.

For example, data contains estimates of the number and proportion of properties without a gas meter across Great Britain. Estimates of properties without a gas connection are calculated by subtracting the number of domestic meters from the number of properties in a region. Other assumptions include that all gas meters with consumption of 73,200 kWh or below assumed to be domestic when in fact a house with a gas heated swimming pool is likely to have consumption figure far greater than this. Similarly, electricity consumption below 100,000kWh is deemed to be domestic.

The data does not include companies that generate their own energy on site. With the exception of half hourly data, meter reads will not all be actual, and estimates will be included at around 20% of the totals.

Residual fuel data is not weather corrected.

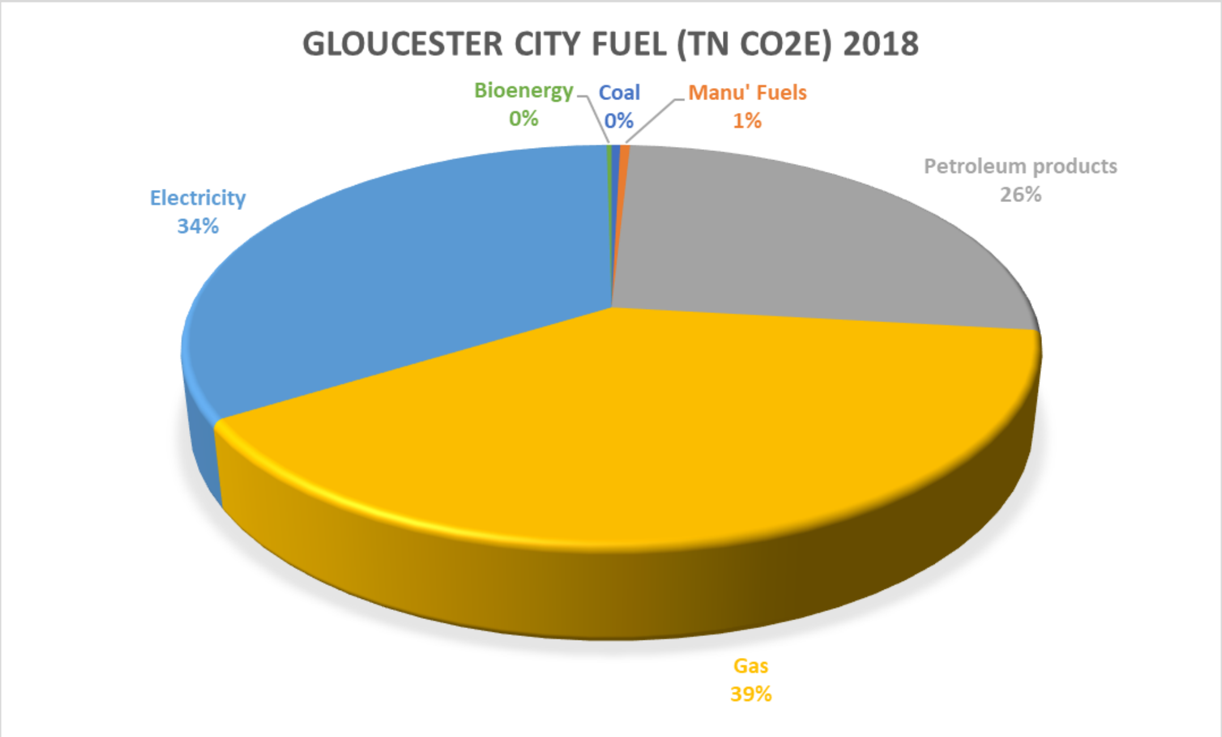
Data coverage for 2018 is:

Gas mid May 2018 to mid-May 2018

Electricity: Start Feb 2018 to end Jan 2019

Road Transport: Start Jan 2018 to 31 Dec 2018

Residual fuels: Start Jan 2018 to end Dec 2018



The pie chart above shows the split of fuel use in CO2e by tonnes for Gloucester City.

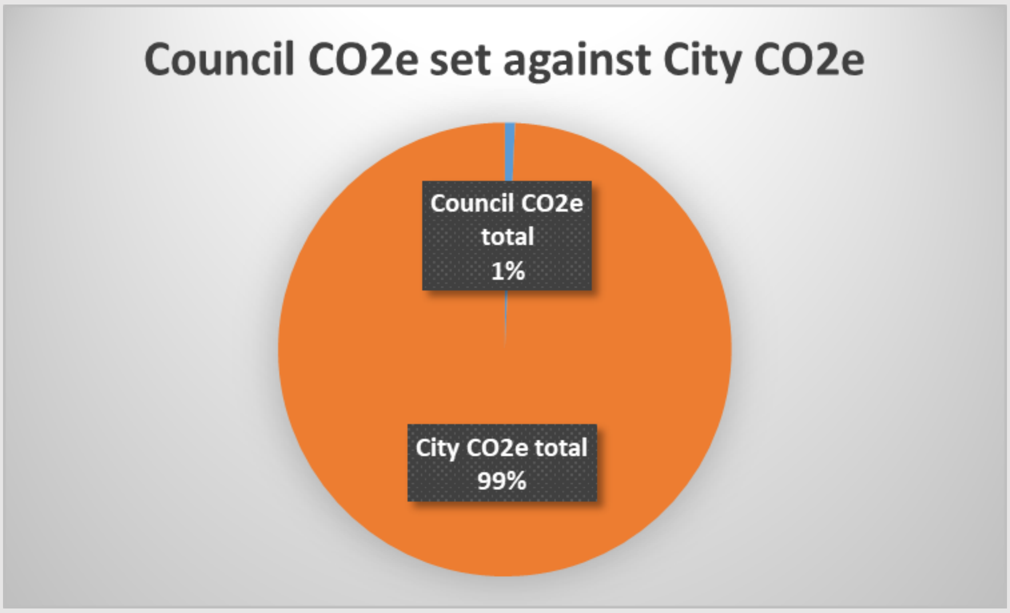
In tabular format, this looks like this:

Fuel	Scope	Tn CO2e	%age
Coal	Scope 1	1,827	0.4
Manufactured Fuels	Scope 1	2,080	0.4
Petroleum products	Scope 1	121,799	26.0
Mains Gas	Scope 1	184,199	39.3
Electricity	Scope 2	157,585	33.6
Bioenergy	Scope 1	1,039	0.2
Total (2018)		468,530	100

This data has been weather corrected and is not calendar year data.

By contrast to the data above and for context, the City Council’s estate, fleet, and operation amounts to 3,461 tonnes of CO2e less renewable contribution of just under 14 tonnes takes this to 3,447.

This Council emissions figure is shy of three quarters of one percent (0.73%) of the 468,530-tonne city total above. Whilst the Councils contribution may seem an insignificant amount in comparison to Gloucester City, the figure can be seen in the context of a microcosm of the UK’s contribution to CO2e across the world.



This figure is also around 1% but it is through leadership that the UK has demonstrates what can be done globally, and the same concept applies locally to GCC. As well as control over its buildings, operations and fleet, the Council has half ownership of an airport, it has huge influence over tenanted properties and by its actions, it will encourage business and residents to follow suit. The Council operates joint ventures and arms-length companies who will be encouraged by the Councils example to address and act on its estates energy efficiency and meet its challenging 2030 target with ambitious and the sort of tangible approaches, set out in part one of this report.

The Council's move to a pool fleet with Enterprise sets a trend for other businesses to follow. Further addressing this to reduce the size of the fleet and implement pure electric vehicles will further extend this. By installing EV charge points (for which the Council can currently claim grants) across its appropriate car parks the city, the Council will encourage BEV car ownership amongst its residents and business owners and this will reduce carbon emissions, as well as air pollution, thereby reducing the incidence of lung and heart disease.

By linking renewable energy with electric charge points, the Council will permit the storage of energy going forward through BEVs and the potential for revenue streams. This will also provide the impetus for investment in electric vehicle technology. There will be a need to move to alternative fuels for the Council's heavy RCV fleet and this could potentially be achieved within the 2030 target.

The benefits of the Council's 2030 plan are that in terms of electricity through energy efficiency and renewable energy technologies, the Carbon ambition looks to be achievable currently. In regard to fleet, this looks to be achievable within the 10-year timeframe. The gas ambition may need the adjustment to renewably powered electric heat solutions and potential for sequestration to pick up any remaining emissions. We would suggest a heat strategy is produced to pick up on gas use and move towards electrification of heat along with various allied available solutions. We would be happy to produce or provide consultancy advice on all of this.

By displaying the achievement of this 2030 goal, the Council is demonstrating to others what can be done and what must be done. It is likely that the Council will need to borrow extensively to fund many of these projects. However, with interest rates at an all-time low and Public Works Loan Board (PWLB) loans available at historically low rates, energy efficiency technologies along with the renewable and fleet technologies highlighted in this report, will provide ROIs far in excess of these figures and ensure that loans can be comfortably repaid in full.

Summary of Potential Opportunities moving forward

In order to bring the City of Gloucester, its residents, business, third sector and educational institutes on this journey to net zero carbon by 2050, the Council will need to target a number of key areas:

- Get the message across
- Talk up its actions and explain the benefits in financial savings, as well as carbon reduction terms
- Address climate change in the city, parishes, and wards
- Link up to local groups
- Set out a list of top tips for things that residents can do right now such as:
    - Insulate
    - Buy A* rated goods
    - Minimise, repair, reuse, recycle
    - Switch to renewable energy provider
    - Install renewable energy generation
    - Drive electric
    - Car clubs
    - Travel actively
    - Reduce draughts
    - Install energy efficient technologies
- Encourage campaigns such as “Shop local – think global”
- Address Fuel poverty so as to allow those at the less affluent end of the spectrum the opportunity to act
- Explain all the benefits of resource efficiency
    - Recognise that for a variety of reasons, some people do not wish to believe in man-made climate change. The concept of finite natural resources, fossil fuel reserves or animal extinction, may be more of an acceptable argument for some of these people.
- Augment community recycling
    - Recognising that waste sent to landfill or energy from waste is lost forever and leads to further methane and carbon dioxide emissions, respectively.
- Express and set out the need to adapt to climate change and link this to 5,000 properties affected by flooding in the 2007 flood Gloucestershire event and those events in Tewkesbury in 2019
- Set and continually revise a series of climate challenges for the whole community
- Invest in community renewables

- Celebrate successes as they occur both within the Council and across the City.
- Be an exemplar city for Carbon Reduction.

The Council will be expected to consult with its stakeholders as it progresses on this journey. The planned and systematic achievement of its targets through measures set out in this report will help it to lead by example and set a precedent for others to follow. It will be important to keep local media and businesses on board with this project and ensure that carbon reduction messages are portrayed in a positive light and to address all the reasons that the Council is embarking on this ambitious and necessary plan

End.

Author: Alan Asbury

- Fellow of the Energy Institute (FEI)
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- European (Advanced) Energy Manager (EurEM)
- Chartered Member of the Institute for Logistics and Transport (CMILT)
- Member of the Institute of Car Fleet Manager (MICFM)
- Chartered Environmentalist (CEnv)
- Fellow of the Institute of Environmental Management and Assessment (FIEMA)
- Chartered Resource and Waste Manager (CRWM)
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Alan Asbury CV. Profile:

With a background in construction site management, CLS Energy Ltd.'s Company Director Alan Asbury has been a Sustainability Manager since 1997 and an Energy Manager since 2006. A **Chartered Energy Manager**, **Chartered Fleet Manager**, **Chartered Environmentalist** and **Chartered Wastes Manager**, Alan was trained by the Energy Institute to its highest **European (Advanced) Energy Manager** level in 2010 and has been a full member (**MEI**) of the Energy Institute from 2011 until 2018 when was awarded Fellowship (**FEI**). He has been an Energy Institute Professional Interviewer and Assessor since 2018. Alan has been an **Associate of the Institute of Environmental Management and Assessment (IEMA)** since 2002, upgraded to **Practitioner (PIEMA)** in 2016 and elected to Fellow in 2020.

Academic Qualifications:

MSc in Environmental Management from the University of Nottingham. 1998/9
BSc 2:1 (Hons) Environmental Science & Management St John's College, University of Leeds. 1995/8.

Professional Qualifications:

Elected to **Fellow** of the Institute of Environmental Management and Assessment (**FEIMA**) 9th June 2020
Elected to **Fellow** of the Energy Institute (**FEI**) 5th September 2018.
Chartered Member of the Institute of Logistics and Transport (**CMILT**) since 2018.
Corporate member of the **Freight Transport Association** (FTA)
Association of Energy Engineers **Certified Measurement and Verification Professional** Jul 2014 & July 2017
Providing guaranteed savings using EVO IPMVP global industry standard software. Recertified in July 2017.
Full **Member of the Institute of Car Fleet Managers** (**MICFM**) since July 2017.
Announced and trained in the first 20 **ESOS** (EU Energy Efficiency Directive 2012/27/EU) **Lead Assessors** in October 2014 by virtue of his Chartered Energy Manager status.
Experienced EED (Article 8) Energy & Fleet Assessor in **Denmark** & **Sweden** (No: 2015-5368) since 2015.
Certified RELUX Lighting Assessor, CIBSE and LIA, March 2014.
Courses Direct; Instructional Skills Training Distinction. Jun '12 to Feb 2014
Elected as 65th **Chartered Energy Manager** (No: 0043209) in the world in Oct 2013.
Trained by the **Energy Institute** to its **European EurEM – [Advanced] (AEM) Energy Manager** level in 2010/11.
Full Member of the Energy Institute (**MEI**) since 2010 (No: 43209).
Completed TREND 963 Operators Course July 2009.
Chartered Wastes Manager (No:1002143) since 2004.
Chartered Environmentalist: (**CEnv**) Society for the Environment (**SocEnv**) since its inception.
Associate of the Institute of Environmental Management and Assessment (**AIEMA**) since 2002 (No: 002347).

Commercial Experience:

Alan has personally completed more than 20 EED (2012) ESOS Phase 1 Audits to full compliance/completion to companies including: Titan Airlines, Harvard Engineering, Ultraframe, AW Jenkinson, Uniserve, Landmark Trust, Missguided, Beiersdorf (Nivea), Regatta, ProCam, Oxford Airport and was joint Lead Assessor for Qatar Airways. Alan has conducted 41 ESOS phase 2 Audits, including 70% of returning (Phase 1) customers. Alan is registered to lead and conduct EED Article 8 (ESOS) Assessments through the Swedish Energy Agency, the Irish (Eire) Government, and the Danish Energy Agency. All assessments factored the additional use of renewable energy generation solutions. In fact, we assisted AW Jenkinson to install large arrays on their roofs in Cumbria and are currently working with Regatta and Craghoppers in Manchester to install large solar roof arrays and to achieve carbon neutrality within a 5-year plan. He is working with VW group UK on their "5-year carbon challenge". We are currently conducting a comprehensive EV fleet conversion solution for Aico.

Alan conducts energy assessments, audits, and presentations. As a qualified trainer, he provides training on behalf of CLS Energy Ltd lecturing on Sustainability to MSc Built Environment & H&S students at 2 Universities. Alan is a Critical Friend Panellist to UK Power Networks and to Western Power Networks (Distribution Networks Operators). Alan is a full member of both the Institute of Car Fleet Managers (**MICFM**), the Freight Transport Association (**FTA)**, and Chartered with the Chartered Institute of Logistics & Transport (**CMILT**).

Delivering up to 47% savings for corporate fleets; He has authored professional guides to fleet assessment for the **Energy Managers Association** and the Grey Fleet Toolkit for the **Energy Savings Trust** launched on 29.1.18.

Local Authority Experience:

Alan has consulted for **Rother** DC under the LGA Expert programme which included scoping and assessing all estate and commercial roofs for renewable energy opportunities. Two of these sites were installed under Alan's guidance in 2019. He is now delivering a carbon neutral plan for Rother for 2030. In 2017, Alan consulted for **Hastings** BC on an Energy Options Study, addressing their built estate and land holdings with the result that they have unlocked £9m for such projects. For **Maidstone**, Alan provided consultancy advice on a series of solar arrays that were all enacted. Along with **Gloucester Council**, Alan is currently working with **Oxford**, **Copeland**, **South Northants**, **Wokingham**, **North Herts**, and **Stevenage** Councils to assist them with their route to zero carbon following their respective Carbon Emergency announcements. He has recently been invited by the LGA Expert programme to deliver similar works to **Cumbria Councils** which he began in early 2020.

A local authority sustainability manager since 2000, Alan understands how Councils operate and has delivered energy efficiency and renewable energy solutions across the Aylesbury Vale estate including Solar PV, GSHP, CHP and an Absorption Chiller. He over achieved on delivery of both Carbon Management Plans, hitting 22% a year early in 2012 and achieving 36%, 4 years early in 2016.

Energy and Fleet Presentations:

- Speaker for Cambridge Cleantech at Tech Days Europe Munich 15th June 2020
- Chairing Low Carbon Scotland (Edinburgh) 4th June 2019
- Presenting at Low Carbon Britain (Westminster) 8th November 2018
- Presenting at Low Carbon Scotland (Edinburgh)15th May 2018
- Presenting at Low Carbon Britain (Westminster) 8th November 2017
- Keynote speech at Low Carbon Workspaces event on energy and Fleet 4 July 2017
- Presented energy and fleet solutions at Low Carbon Scotland, Edinburgh on 23 May 2017
- Presented at Buying Business Travel (BBT) 12.5.17, Grange City Hotel, London and 14.6.17, Dublin
- Fleet presentation to Government Departments (DEFRA, EA, DWP, Police, Fire Service) at Portcullis House, Houses of Parliament 3 Nov 2016.
- Fleet presentation to major Welsh Public Bodies at Cardiff City Hall 27 April 2016.

Awards:

Awarded **National Sustainability Manager of the Year in Dec 2012** by the National PSSA Journal.
Awarded Silver at **10th National Energy Savings Trust Fleet Hero Awards** Nov 2015 (grey fleet).

Career Summary:

Director	CLS Energy (Consultancy) Ltd	2014 to Date
Chairman	Low Carbon Club	2015 to Date
Visiting MSc Lecturer EIA	University of Middlesex (H&S Dept)	2020 to Date
MSc Lecturer Sustainability/Climate	University of Greenwich (Built Env't Dept)	2018 to Date
Senior Consultant	Incgen Ltd and Novae Ltd	2015 to 2017
Sustainability Team Leader	Aylesbury Vale DC	2005 to 2017
Waste Strategy Manager	South Beds DC	2002 to 2005
Sustainability Team Leader	Warwick DC	2000 to 2002
CSV Environment	Waste Resource Development Manager	1999 to 2000
Far East Travel and University	Far East; (BSc) and (MSc)	1992 to 1999
Asst Contracts Manager	Forbes West	1990 to 1992
Site Manager/Site Engineer	J S Bloor Housebuilders	1988 to 1990

Alan has been a professional environmental and sustainability manager since the mid-1990s. He is passionate about the subject. He lives with his wife and two children in Oxford, England and enjoys canoeing, rowing, rugby, travel, reading and learning Chinese (Mandarin).

Alan Asbury - **Company Director** CLS Energy (Consultancy) Ltd

MSc, BSc (Hons), CEnv, FEI, CMVP®(IPMVP), EurEM (AEM), FIEMA, MCIWM, Chartered Energy Manager, MICFM, CMILT, ESOS Lead Assessor, ISO 50001 EnMS Assessor, Energy Institute Professional Assessor, AEMA.
Linked In: https://www.linkedin.com/in/alanasbury/ Twitter: @AA_CLS