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Version Control:

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6. Queens' Building
1. POOLEY HOUSE

SITE INFORMATION

<table>
<thead>
<tr>
<th>Asset Name</th>
<th>Pooley House</th>
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<tr>
<td>Asset Type</td>
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<td>Floor Area</td>
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<td>Mile End</td>
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<td>Survey Date</td>
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SUMMARY OF OPPORTUNITIES

Through the baseline process, a number of specific actions for reducing consumption have been identified, combined with a range of strategic areas for energy performance improvement. Carbon Credentials believes that taking a strategic project based approach to specific areas of consumption will be the most effective way of achieving long term energy and carbon savings. Specific recommendations to achieve energy savings are shown in the table below.

<table>
<thead>
<tr>
<th>ENERGY CONSERVATION MEASURE</th>
<th>INVESTMENT REQUIRED</th>
<th>ANNUAL ELECTRICITY SAVING (kWh)</th>
<th>ANNUAL GAS SAVING (kWh)</th>
<th>ANNUAL COST SAVING</th>
<th>PAYBACK PERIOD (YEARS)</th>
<th>CARBON SAVINGS (TONNES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T8 LIGHTING UPGRADE TO LED</td>
<td>£19,700</td>
<td>53,400</td>
<td>0</td>
<td>£5,300</td>
<td>3.7</td>
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<td>CONTROL IMPROVEMENT FOR ELECTRIC HEATERS</td>
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<td>3.2</td>
<td>9</td>
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<tr>
<td>ENGAGEMENT STRATEGY</td>
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<td>53,800</td>
<td>0</td>
<td>£5,400</td>
<td>0.9</td>
<td>27</td>
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<td>TOTAL</td>
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<td>£15,400</td>
<td>£15,400</td>
<td></td>
<td></td>
<td>62</td>
</tr>
</tbody>
</table>

Carbon Credentials uses a tailored version of the ‘TM22’ methodology, developed by the Chartered Institute of Building Services Engineers (CIBSE). This industry standard methodology has been developed by Carbon Credentials to provide a prediction of typical consumption profiles for the building. If available these predicted profiles are reconciled with average profiles calculated using actual consumption data, resulting in confidence that the calculated consumption of each item is suitably accurate. Energy conservation measures are then calculated in the following way:
Lighting Opportunities:

Total kWh of lighting demand has been calculated through multiplying the amount of lamps counted during the site audit by the kW rating of the units (e.g. 10 x 58W T8s) multiplied by the burning hours which equates to the opening times of the site.

The cost saving opportunity is calculated by identifying the percentage reduction of the power rating of an LED lamp compared to the existing fitting. This percentage reduction is multiplied by the total kWh of electricity consumed by the inefficient lights in a year. The investment required is calculated by multiplying the count of all inefficient lights by the cost of the replacement fitting.

Control Improvement Opportunities:

- **Electric heaters** - The cost saving is calculated by applying a 15% consumption reduction due to improved controls.

Engagement Strategy:

Total usage of all items which are controlled manually by staff has been multiplied by a 15% reduction.

**TOTAL ENERGY CONSUMPTION**

Total consumption of Pooley House for the period January to December 2015 is shown in Figure 1 below:

![Figure 1: Annual consumption](image)

Total consumption has been broken down monthly by meter number for both electricity and gas usage and is shown in Figure 2 below. It can be seen that both electricity and gas usage follow a seasonal profile and on the whole, electricity consumption is consistently higher than gas consumption.
There are no half hourly electricity meters at Pooley House.

The survey identified that gas is only used for domestic hot water. Two meters were identified for the east and west block of Pooley House respectively. Figure 3 below shows the daily gas usage from the available half-hourly data. Each dot represents the total gas consumption for that day. Green dots represent weekdays and orange dots represent weekends. The graph below shows that at this site, weekend and weekday gas use is similar across the year. Peak usage is seen to take place in the winter month of February and daily consumption decreases during the summer months before increasing again in the early winter months. At the end of December, there are a few days with very low gas consumption and these are thought to correspond to the site being unoccupied over the Christmas period.
Figure 4 below shows average gas consumption over the 24 hour period for both half hourly gas meters at this site. The darker coloured lines represent the winter months, and show that for both meters, gas use during these months is higher than during the summer months which is in line with expectations. Peak usage for both meters occurs at approximately 12.00pm each day, and reduces slightly at 5pm. Consumption remains fairly consistent throughout the evening, until it begins to reduce at 12.00am to its lowest point at 6am in the morning. This trend is accentuated during the winter months when overall gas consumption for the meter is higher.
Figure 5 demonstrates the average daily electricity profile by weekday. The chart shows that average consumption during the week follows a consistent trend, reaching a maximum of approximately 400kWh. As expected, weekend consumption is significantly lower although consumption on Saturday appears to be slightly higher than consumption on Sunday.

![Average Daily Consumption Profile by Weekday](image)

**Figure 5**: Average daily gas profiles by day of the week
Carbon Credentials uses a tailored version of the ‘TM22’ methodology, developed by the Chartered Institute of Building Services Engineers (CIBSE). This industry standard methodology has been developed by Carbon Credentials to provide a prediction of typical consumption profiles for the building. If available these predicted profiles are reconciled with average profiles calculated using actual consumption data, resulting in confidence that the calculated consumption of each item is suitably accurate.

The combined modelled breakdown of Pooley House is demonstrated below.

The reconciliation of identified equipment and actual usage had identified a discrepancy of around 90%. Carbon Credentials have reason to believe that not all electricity meters of the building have been taken into account. It is recommend that a full meter review is undertaken for Pooley House to ensure that all meters are captured.

Figure 6: Combined modelled annual electricity consumption breakdown
2. HATTON HOUSE

SITE INFORMATION

<table>
<thead>
<tr>
<th>Asset Name</th>
<th>Hatton House</th>
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<tbody>
<tr>
<td>Asset Type</td>
<td>Halls of Residence</td>
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<tr>
<td>Floor Area</td>
<td>1,593 m²</td>
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<tr>
<td>Campus</td>
<td>Mile End</td>
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<tr>
<td>Survey Date</td>
<td>26/05/16</td>
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</table>

SUMMARY OF OPPORTUNITIES

Through the baseline process, a number of specific actions for reducing consumption have been identified, combined with a range of strategic areas for energy performance improvement. Carbon Credentials believes that taking a strategic project based approach to specific areas of consumption will be the most effective way of achieving long term energy and carbon savings. Specific recommendations to achieve energy savings are shown in the table below.

<table>
<thead>
<tr>
<th>ENERGY CONSERVATION MEASURE</th>
<th>INVESTMENT REQUIRED</th>
<th>ANNUAL ELECTRICITY SAVING (kWh)</th>
<th>ANNUAL GAS SAVING (kWh)</th>
<th>ANNUAL COST SAVING</th>
<th>PAYBACK PERIOD (YEARS)</th>
<th>CARBON SAVINGS (TONNES)</th>
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</thead>
<tbody>
<tr>
<td>PIR INSTALLATION</td>
<td>£400</td>
<td>1,300</td>
<td>0</td>
<td>£100</td>
<td>4.0</td>
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<td>ENGAGEMENT STRATEGY</td>
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<td>3,500</td>
<td>0</td>
<td>£400</td>
<td>12.5</td>
<td>2</td>
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<td>TOTAL</td>
<td>£5,400</td>
<td></td>
<td></td>
<td>£500</td>
<td>12.5</td>
<td>3</td>
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</table>

Carbon Credentials uses a tailored version of the ‘TM22’ methodology, developed by the Chartered Institute of Building Services Engineers (CIBSE). This industry standard methodology has been developed by Carbon Credentials to provide a prediction of typical consumption profiles for the building. If available these predicted profiles are reconciled with average profiles calculated using actual consumption data, resulting in confidence that the calculated consumption of each item is suitably accurate. Energy conservation measures are then calculated in the following way:

**Lighting Opportunities:**

The cost saving for the PIR installation opportunity is calculated by identifying the percentage reduction of the light usage, typically in common areas (corridors, kitchens, etc.). This percentage reduction is multiplied by the total kWh
of electricity consumed by the lights in a year. The investment required is calculated by multiplying the count of all inefficient lights by the cost of PIR fittings.

**Engagement Strategy:**

Total usage of all items which is controlled manually by staff has been multiplied by a 15% reduction.

## TOTAL ENERGY CONSUMPTION

Total consumption of Hatton House for the period January to December 2015 is shown in Figure 7 below:

<table>
<thead>
<tr>
<th>Total Consumption by Meter: 1/1/2015 - 12/31/2015</th>
<th>Total Energy Consumption</th>
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</thead>
<tbody>
<tr>
<td>Mpan</td>
<td>Fuel Name</td>
</tr>
<tr>
<td>17515906</td>
<td>Natural Gas</td>
</tr>
<tr>
<td>1200010153220</td>
<td>Electricity</td>
</tr>
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</table>

![Figure 7: Total annual consumption](image)

Electricity and gas consumption has been broken down monthly by meter number and is shown in Figure 8 below. It can be seen that gas demand follows a seasonal profile, with peak demand in January to March 2015. It is understood that the gas meter in Hatton House serves multiple sites including Lodge House and Chesney House.
DATA ANALYSIS - ELECTRICITY

No half-hourly data is available for the electricity meter "1200010153220" at Hatton House. It is recommended that a half-hourly meter is installed to gain further insight into the electricity demand. This will enable identification of further energy saving opportunities.

DATA ANALYSIS - GAS

Figure 9 below shows the daily gas usage from the available half-hourly data. Each dot represents the total gas consumption for that day. Green dots represent weekdays and orange dots represent weekends. Generally there is little difference between gas use on weekdays and weekends throughout the year, with the exception of out-of-term summer months. Peak daily usage is seen in November. Gas use reduces during the summer months, likely due to the demand associated with hot water.
Figure 9: Total daily gas consumption

Figure 10 below shows how the monthly gas demand varies throughout the year, with darker coloured lines representing winter months. This graph shows that gas consumption is highest in winter months and lowest in summer months. In almost all months, there is consistent consumption throughout the day, with some slight peaks in winter months between 12 am – 2 am, and 10:30 am – 2 pm. Boilers remain enabled throughout the whole day. There may be opportunity here to change the strategy of how to the boilers are run to ensure there is minimised dry-cycling and that boilers are run only when there is heat demand.

Figure 10: Average daily gas profiles broken down by month
The combined modelled breakdown of Hatton House is demonstrated below.

![Combined modelled annual electricity consumption breakdown](image)

**Category**
- Air-Conditioning Systems
- Chiller
- Electric Heaters
- Incubators/Lab equipment
- IT - PCs, printers, TVs
- Lighting (External)
- Misc
- Unaccounted Baseload
- Catering/ Kitchen Appliances
- Pumps
- Lighting (Internal)
- Fridges/Freezers
- Air Handling Units/Fans

*Figure 11: Combined modelled annual electricity consumption breakdown*
3. LIBRARY

SITE INFORMATION

<table>
<thead>
<tr>
<th>Asset Name</th>
<th>Library</th>
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<td>Asset Type</td>
<td>Library</td>
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<td>Floor Area</td>
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<td>Campus</td>
<td>Mile End</td>
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<td>Survey Date</td>
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SUMMARY OF OPPORTUNITIES

Through the baseline process, a number of specific actions for reducing consumption have been identified, combined with a range of strategic areas for energy performance improvement. Carbon Credentials believes that taking a strategic project based approach to specific areas of consumption will be the most effective way of achieving long term energy and carbon savings. Specific recommendations to achieve energy savings are shown in the table below.

<table>
<thead>
<tr>
<th>ENERGY CONSERVATION MEASURE</th>
<th>INVESTMENT REQUIRED</th>
<th>ANNUAL ELECTRICITY SAVING (kWh)</th>
<th>ANNUAL GAS SAVING (kWh)</th>
<th>ANNUAL COST SAVING</th>
<th>PAYBACK PERIOD (YEARS)</th>
<th>CARBON SAVINGS (TONNES)</th>
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</thead>
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<tr>
<td>BMS OPTIMISATION</td>
<td>£10,000</td>
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<td>31,000</td>
<td>£6,200</td>
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<td>BOILER REPLACEMENT</td>
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<td>£2,800</td>
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<td>17</td>
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<tr>
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<td>TOTAL</td>
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<td>£11,600</td>
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Carbon Credentials uses a tailored version of the ‘TM22’ methodology, developed by the Chartered Institute of Building Services Engineers (CIBSE). This industry standard methodology has been developed by Carbon Credentials to provide a prediction of typical consumption profiles for the building. If available these predicted profiles are reconciled with average profiles calculated using actual consumption data, resulting in confidence that the calculated consumption of each item is suitably accurate. Energy conservation measures are then calculated in the following way:
Heating, Ventilation and Air-Conditioning Opportunities:

- **Plant replacements** - The cost saving is calculated by identifying the percentage reduction of the power rating of efficient plant replacements compared to the existing installation. This is multiplied by the total kWh consumed by the plant in a year.
- **Installation of variable speed drives** – The total consumption of pumps and air handling units which do not have an attached variable speed drive is multiplied by a 15% reduction.
- **Installation of temperature sensors** – 10% reduction of total annual gas usage was applied to calculate the cost saving.

Unaccounted Baseload Identification and Management:

A 10% reduction was multiplied against the total annual load which the model was not able to identify (i.e. unaccounted baseload).

**TOTAL ENERGY CONSUMPTION**

Total consumption of the Library for the period January to December 2015 is shown in Figure 12 below:

![Figure 12: Total annual consumption](image)

Electricity and gas consumption has been broken down monthly by meter number and is shown in Figure 13 below. It can be seen that while both electricity and gas usage follow a seasonal profile, this can be seen more prominently for gas usage which reaches zero consumption in July and August.
DATA ANALYSIS - ELECTRICITY

Figure 14 below shows the daily electricity usage from the available half-hourly data. Each dot represents the total electricity consumption for that day. Green dots represent weekdays and orange dots represent weekends. On the whole, the graph below shows that weekend electricity use is lower than weekday electricity use, although this trend is not consistent between February and May, where weekend consumption is seen to be equal to weekday consumption. Peak usage is seen to take place between May and June and it appears that chillers kick in around this time to meet cooling demand.
Figure 14: Total daily consumption

The average electricity consumption over a 24 hour period is shown below in Figure 15. The darker coloured lines represent the winter months and the lighter colours represent the summer months. Each meter shows that electricity consumption during the summer is higher than during the winter and that there isn’t much variance between day and night consumption, although there is a slight increase in consumption from 8am to 8pm. Meter 1200010153123 shows least variance between months whereas meter 1200010153141 shows most variance, with approximately 25 kWh more usage during May than in December. The high baseload in meter 1200010153141 may suggest that cooling equipment and other major plant is left on throughout the night. It is understood that the library is operated for 24 hours during the summer prior to student exams.
Figure 15: Average daily electricity profiles broken down by month

Figure 16 demonstrates the average daily electricity profile by weekday. The chart shows that average consumption during the week follows a consistent trend. Electricity usage generally reaches a peak at around 4pm before reducing to its lowest point at 12am. On average, usage on Saturdays and Sundays appears to be slightly lower, particularly meter 1200010153132.

Figure 16: Average daily gas profiles by day of the week
DATA ANALYSIS - GAS

Figure 17 below shows the daily gas usage from the available half-hourly data. Each dot represents the total electricity consumption for that day. Green dots represent weekdays and orange dots represent weekends. While weekend gas use is slightly lower than weekday electricity use, particularly between January and April, on average there is little difference between the electricity usage between weekdays and weekends. Peak usage is seen in January and gas consumption reduces to zero in summer months before increasing in October.

Figure 18 below shows how the monthly gas demand varies throughout the year, with darker coloured lines representing winter months. This graph shows that gas consumption is highest in winter months and lowest in summer months. In almost all months, there is a significant reduction in gas use between 1am and 5am, before it peaks at 6am and at 12pm. Boilers start in the morning and remain enabled throughout most of the day. There may be opportunity here to change the strategy of how to the boilers are run to ensure there is minimised dry-cycling and that boilers are run only when there is heat demand.
Figure 18: Average daily gas profiles broken down by month
The combined modelled breakdown of the Mile End Library is demonstrated below.

Figure 19: Combined modelled annual electricity consumption breakdown
Figure 20: Modeled annual electricity consumption breakdown of the Library (Mile End) broken down by weekdays and weekends of periods showing significant change in average usage.
4. FOGG BUILDING

SITE INFORMATION

<table>
<thead>
<tr>
<th>Asset Name</th>
<th>FOGG Building</th>
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<tr>
<td>Asset Type</td>
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<td>Floor Area</td>
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<td>Asset Address</td>
<td>Mile End</td>
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<td>Survey Date</td>
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SUMMARY OF OPPORTUNITIES

Through the baseline process, a number of specific actions for reducing consumption have been identified, combined with a range of strategic areas for energy performance improvement. Carbon Credentials believes that taking a strategic project based approach to specific areas of consumption will be the most effective way of achieving long term energy and carbon savings. Specific recommendations to achieve energy savings are shown in the table below.

<table>
<thead>
<tr>
<th>ENERGY CONSERVATION MEASURE</th>
<th>ELEC SAVING TOTAL (KWH)</th>
<th>GAS SAVING TOTAL (KWH)</th>
<th>ANNUAL COST SAVING</th>
<th>INVESTMENT REQUIRED</th>
<th>PAYBACK PERIOD (YEARS)</th>
<th>CARBON SAVINGS (TONNES)</th>
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<tr>
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<td>6,700</td>
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<td>£700</td>
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<td>2.7</td>
<td>3</td>
</tr>
<tr>
<td>T8 Lighting Upgrade to LED</td>
<td>50,800</td>
<td>0</td>
<td>£5,100</td>
<td>£23,300</td>
<td>4.6</td>
<td>25</td>
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<td>T12 Lighting Upgrade to LED</td>
<td>7,500</td>
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<td>£700</td>
<td>£1,700</td>
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<tr>
<td>BMS Optimisation</td>
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<tr>
<td>Unaccounted Baseload Identification and Management</td>
<td>26,200</td>
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<td>£2,600</td>
<td>£10,000</td>
<td>3.8</td>
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<td><strong>215</strong></td>
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</table>
Carbon Credentials uses a tailored version of the ‘TM22’ methodology, developed by the Chartered Institute of Building Services Engineers (CIBSE). This industry standard methodology has been developed by Carbon Credentials to provide a prediction of typical consumption profiles for the building. If available these predicted profiles are reconciled with average profiles calculated using actual consumption data, resulting in confidence that the calculated consumption of each item is suitably accurate. Energy conservation measures are then calculated in the following way:

**Lighting Opportunities:**

Total kWh of lighting demand has been calculated through multiplying the amount of lamps counted during the site audit by the kW rating of the units (e.g. 10 x 58W T8s) multiplied by the burning hours which equates to the opening times of the site.

The cost saving opportunity is calculated by identifying the percentage reduction of the power rating of an LED lamp compared to the existing fitting. This percentage reduction is multiplied by the total kWh of electricity consumed by the inefficient lights in a year. The investment required is calculated by multiplying the count of all inefficient lights by the cost of the replacement fitting.

**Heating, Ventilation and Air-Conditioning Opportunities:**

- **Plant replacements** - The cost saving is calculated by identifying the percentage reduction of the power rating of efficient plant replacements compared to the existing installation. This is multiplied by the total kWh consumed by the plant in a year.
- **Installation of variable speed drives** – The total consumption of pumps and air handling units which do not have an attached variable speed drive is multiplied by a 15% reduction.
- **Installation of temperature sensors** – 10% reduction of total annual gas usage was applied to calculate the cost saving.

**Engagement Strategy:**

Total usage of all items which is controlled manually by staff has been multiplied by a 15% reduction.

**Unaccounted Baseload Identification and Management:**

A 10% reduction was multiplied against the total annual load which the model was not able to identify (i.e. unaccounted baseload).
TOTAL ENERGY CONSUMPTION

Total consumption of the FOGG building for the period January to December 2015 is shown in Figure 21 below:

Electricity and gas consumption has been broken down monthly by meter number and is shown in Figure 22 below. It can be seen that while both electricity and gas usage does not follow a seasonal profile. No electricity data was available for January and March 2016.

Figure 21: Total annual consumption

Figure 22: Total monthly consumption broken down by fuel and meter
No half hourly data was available for the meter 12000061047130 which serves the FOGG building. The survey had identified the meter to be a half-hourly meter but half-hourly data was not available in the Engie data portal. Carbon Credentials recommend to investigate the why half-hourly data is not being sent to the portal and to rectify this issue. With the availability of half-hourly data and through intelligent analysis a comprehensive insight of operational activity may be understood.

**DATA ANALYSIS - GAS**

Figure 23 below shows the daily gas usage from the available half-hourly data. Each dot represents the total gas consumption for that day. Green dots represent weekdays and orange dots represent weekends. Seasonal variation cannot be seen in the below chart and usage appears to be higher during warmer months. While a number of lab equipment had been identified to be use gas throughout the year, no items would suggest higher usage over a warmer period. This could imply that a significant amount of gas waste is occurring, and that boilers may be running at a high load throughout most of the year.

Figure 23: Total daily gas consumption
Figure 24 below shows how the monthly gas demand varies throughout the year, with darker coloured lines representing winter months. This graph shows that gas usage is quite erratic with no clear overnight baseload and daytime peak load and suggests that gas is consumed all day. It is highly recommend that the control strategy of the boilers are investigated to minimise waste. No temperature sensors have been identified to be installed around the building which could result in a significant amount of overheating and as a consequence waste.

Figure 24: Average daily gas profiles broken down by month
The combined modelled breakdown of the FOGG Building is demonstrated below.

**Figure 25: Combined modelled annual electricity consumption breakdown**
5. ARTS ONE BUILDING

SITE INFORMATION

<table>
<thead>
<tr>
<th>Asset Name</th>
<th>Arts One</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset Type</td>
<td>Lecture/Office space</td>
</tr>
<tr>
<td>Floor Area</td>
<td>5,481 m²</td>
</tr>
<tr>
<td>Asset Address</td>
<td>Mile End</td>
</tr>
<tr>
<td>Survey Date</td>
<td>26/05/2016</td>
</tr>
</tbody>
</table>

SUMMARY OF OPPORTUNITIES

Through the baseline process, a number of specific actions for reducing consumption have been identified, combined with a range of strategic areas for energy performance improvement. Carbon Credentials believes that taking a strategic project based approach to specific areas of consumption will be the most effective way of achieving long term energy and carbon savings. Specific recommendations to achieve energy savings are shown in the table below.

<table>
<thead>
<tr>
<th>ENERGY CONSERVATION MEASURE</th>
<th>INVESTMENT REQUIRED</th>
<th>ANNUAL ELECTRICITY SAVING (kWh)</th>
<th>ANNUAL GAS SAVING (kWh)</th>
<th>ANNUAL COST SAVING</th>
<th>PAYBACK PERIOD (YEARS)</th>
<th>CARBON SAVINGS (TONNES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T8 LIGHTING UPGRADE TO LED</td>
<td>£200</td>
<td>3,000</td>
<td>0</td>
<td>£300</td>
<td>0.7</td>
<td>2</td>
</tr>
<tr>
<td>PIR INSTALLATION IN CORRIDORS</td>
<td>£1,800</td>
<td>9,100</td>
<td>0</td>
<td>£900</td>
<td>2.0</td>
<td>5</td>
</tr>
<tr>
<td>PUMP UPGRADE</td>
<td>£3,000</td>
<td>100</td>
<td>0</td>
<td>£600</td>
<td>5.0</td>
<td>0</td>
</tr>
<tr>
<td>ENGAGEMENT STRATEGY</td>
<td>£5,000</td>
<td>18,400</td>
<td>20,600</td>
<td>£2,500</td>
<td>2.0</td>
<td>13</td>
</tr>
<tr>
<td>TOTAL</td>
<td>£10,000</td>
<td></td>
<td></td>
<td>£4,300</td>
<td></td>
<td>19</td>
</tr>
</tbody>
</table>

Carbon Credentials uses a tailored version of the ‘TM22’ methodology, developed by the Chartered Institute of Building Services Engineers (CIBSE). This industry standard methodology has been developed by Carbon Credentials to provide a prediction of typical consumption profiles for the building. If available these predicted profiles are reconciled with
average profiles calculated using actual consumption data, resulting in confidence that the calculated consumption of each item is suitably accurate. Energy conservation measures are then calculated in the following way:

**Lighting Opportunities:**

Total kWh of lighting demand has been calculated through multiplying the amount of lamps counted during the site audit by the kW rating of the units (e.g. 10 x 58W T8s) multiplied by the burning hours which equates to the opening times of the site.

The cost saving opportunity is calculated by identifying the percentage reduction of the power rating of an LED lamp compared to the existing fitting. This percentage reduction is multiplied by the total kWh of electricity consumed by the inefficient lights in a year. The investment required is calculated by multiplying the count of all inefficient lights by the cost of the replacement fitting.

**Engagement Strategy:**

Total usage of all items which is controlled manually by staff has been multiplied by a 15% reduction.

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**TOTAL ENERGY CONSUMPTION**

Total consumption of the Arts One for the period January to December 2015 is shown in Figure 26 below:

![Figure 26: Total annual consumption](image)

Electricity and gas consumption has been broken down monthly by meter number and is shown in Figure 27 below. Gas usage follows a seasonal profile, and reaches near-zero consumption from May to August. Electricity consumption appears to vary inconsistently throughout the year.
Figure 27: Total monthly consumption broken down by fuel and meter

DATA ANALYSIS - ELECTRICITY

Figure 28 below shows the daily electricity usage from the available half-hourly data. Each dot represents the total electricity consumption for that day. Green dots represent weekdays and orange dots represent weekends. On the whole, the graph below shows that weekend electricity use is much lower than weekday electricity use. Peak usage is seen to take place in January and May.
The average electricity consumption over a 24 hour period is shown below in Figure 29. The darker coloured lines represent the winter months and the lighter colours represent the summer months. Baseload electricity consumption is higher during the summer than the winter, but daytime consumption is higher during the winter months. The day-night variance is much more pronounced during winter months because of this. The high baseload in the summer months may suggest that cooling equipment is left on throughout the night.
Figure 30 demonstrates the average daily electricity profile by weekday. The chart shows that average consumption during the week follows a consistent trend. Electricity usage generally reaches a peak at around 2pm before reducing to its lowest point at 12am. On average, usage on Saturdays and Sundays is much lower.

DATA ANALYSIS - GAS

Figure 31 below shows the daily gas usage from the available half-hourly data. Each dot represents the total gas consumption for that day. Green dots represent weekdays and orange dots represent weekends. Weekend gas use is consistently lower than weekday use. Peak usage is seen in February, and consumption reduces to near-zero in summer months before increasing in October and December.
Figure 32 below shows how the monthly gas demand varies throughout the year, with darker coloured lines representing winter months. This graph shows that gas consumption is highest in winter months and lowest in summer months. In all months, there is a significant reduction in gas use between 9pm and 7am, before it peaks at 9am and at 7pm. Boilers start in the morning and remain enabled throughout most of the day. There may be opportunity here to change the strategy of how to run the boilers to ensure there is minimised dry-cycling and that boilers are run only when there is heat demand.

Figure 32: Average daily gas profiles broken down by month
The combined modelled breakdown of Arts One Building is demonstrated below.

![Combined modelled annual electricity consumption breakdown](image)

Figure 33: Combined modelled annual electricity consumption breakdown
6. QUEENS’ BUILDING

SITE INFORMATION

<table>
<thead>
<tr>
<th>Asset Name</th>
<th>Queens’ Building</th>
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</thead>
<tbody>
<tr>
<td>Asset Type</td>
<td>Office</td>
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<tr>
<td>Floor Area</td>
<td>13,300 m²</td>
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<tr>
<td>Campus</td>
<td>Mile End</td>
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<tr>
<td>Survey Date</td>
<td>02/06/2016</td>
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</table>

SUMMARY OF OPPORTUNITIES

Through the baseline process, a number of specific actions for reducing consumption have been identified, combined with a range of strategic areas for energy performance improvement. Carbon Credentials believes that taking a strategic project based approach to specific areas of consumption will be the most effective way of achieving long term energy and carbon savings. Specific recommendations to achieve energy savings are shown in the table below.

<table>
<thead>
<tr>
<th>ENERGY CONSERVATION MEASURE</th>
<th>INVESTMENT REQUIRED</th>
<th>ANNUAL ELECTRICITY SAVING (kWh)</th>
<th>ANNUAL GAS SAVING (kWh)</th>
<th>ANNUAL COST SAVING</th>
<th>PAYBACK PERIOD (YEARS)</th>
<th>CARBON SAVINGS (TONNES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T8 LIGHTING UPGRADE TO LED</td>
<td>£9,200</td>
<td>74,300</td>
<td>0</td>
<td>£7,400</td>
<td>1.2</td>
<td>37</td>
</tr>
<tr>
<td>PL-L UPGRADE TO LED</td>
<td>£3,700</td>
<td>10,000</td>
<td>0</td>
<td>£1,000</td>
<td>3.7</td>
<td>5</td>
</tr>
<tr>
<td>HALOGEN UPGRADE TO LED</td>
<td>£5,800</td>
<td>47,700</td>
<td>0</td>
<td>£4,800</td>
<td>1.2</td>
<td>24</td>
</tr>
<tr>
<td>PUMP UPGRADE</td>
<td>£24,000</td>
<td>39,800</td>
<td>0</td>
<td>£4,000</td>
<td>6.0</td>
<td>20</td>
</tr>
<tr>
<td>BMS OPTIMISATION</td>
<td>£15,000</td>
<td>37,500</td>
<td>69,100</td>
<td>£5,800</td>
<td>2.6</td>
<td>31</td>
</tr>
<tr>
<td>ENGAGEMENT STRATEGY</td>
<td>£5,000</td>
<td>43,600</td>
<td>0</td>
<td>£4,400</td>
<td>1.1</td>
<td>22</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>£62,700</strong></td>
<td><strong>£27,400</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>138</strong></td>
</tr>
</tbody>
</table>
Carbon Credentials uses a tailored version of the ‘TM22’ methodology, developed by the Chartered Institute of Building Services Engineers (CIBSE). This industry standard methodology has been developed by Carbon Credentials to provide a prediction of typical consumption profiles for the building. If available these predicted profiles are reconciled with average profiles calculated using actual consumption data, resulting in confidence that the calculated consumption of each item is suitably accurate. Energy conservation measures are then calculated in the following way:

Lighting Opportunities:

Total kWh of lighting demand has been calculated through multiplying the amount of lamps counted during the site audit by the kW rating of the units (e.g. 10 x 58W T8s) multiplied by the burning hours which equates to the opening times of the site.

The cost saving opportunity is calculated by identifying the percentage reduction of the power rating of an LED lamp compared to the existing fitting. This percentage reduction is multiplied by the total kWh of electricity consumed by the inefficient lights in a year. The investment required is calculated by multiplying the count of all inefficient lights by the cost of the replacement fitting.

Heating, Ventilation and Air-Conditioning Opportunities:

- **Plant replacements** - The cost saving is calculated by identifying the percentage reduction of the power rating of efficient plant replacements compared to the existing installation. This is multiplied by the total kWh consumed by the plant in a year.

- **Installation of variable speed drives** – The total consumption of pumps and air handling units which do not have an attached variable speed drive is multiplied by a 15% reduction.

- **Installation of temperature sensors** – 10% reduction of total annual gas usage was applied to calculate the cost saving.

Engagement Strategy:

Total usage of all items which is controlled manually by staff has been multiplied by a 15% reduction.

**TOTAL ENERGY CONSUMPTION**

Total consumption of the Queen’s Building for the period January to December 2015 is shown in Figure 34:
During the site audit, it was noted that there is potential that not all three electricity meters serve Queens Building. From annual consumption, it is thought that only meter number 1200010153337 serves the building. Electricity and gas consumption has been broken down monthly by meter number and is shown in Figure 35 below. It can be seen that both electricity and gas usage follow a similar seasonal profile.

**Figure 34: Total annual consumption**

<table>
<thead>
<tr>
<th>Mean</th>
<th>Fuel Name</th>
<th>kWh</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>8616040710</td>
<td>Natural Gas</td>
<td>1,362,491</td>
<td>£41,475</td>
</tr>
<tr>
<td>1200010153337</td>
<td>Electricity</td>
<td>1,014,651</td>
<td>£101,465</td>
</tr>
<tr>
<td>1200010153346</td>
<td>Electricity</td>
<td>1,687,008</td>
<td>£168,701</td>
</tr>
<tr>
<td>1200010153355</td>
<td>Electricity</td>
<td>922,042</td>
<td>£92,294</td>
</tr>
</tbody>
</table>

**Figure 35: Total monthly consumption broken down by fuel and meter**

**DATA ANALYSIS - ELECTRICITY**
Figure 36 below shows the daily electricity usage from the available half-hourly data. Each dot represents the total electricity consumption for that day. Green dots represent weekdays and orange dots represent weekends. On the whole, all three meters see lower electricity use at the weekend. Peak usage for two of the meters (1200010153346 and 1200010153355) is seen to take place between January and March.

![Figure 36: Total daily consumption](image)

The average electricity consumption over a 24 hour period is shown below in Figure 37. The darker coloured lines represent the winter months and the lighter colours represent the summer months. Each meter shows that electricity consumption and day-night variance is higher during the winter than during the summer. In particular the baseload is significantly higher indicating there are a number of electrical items Meter 1200010153337 shows least variance between months whereas the other two show much greater variance.
Figure 37: Average daily electricity profiles broken down by month

Figure 38: Average daily electricity profiles by day of the week

Figure 38 demonstrates the average daily electricity profile by weekday. The chart shows that average consumption during the week follows a consistent trend. Electricity usage generally reaches a peak at around 2pm before reducing to its lowest point at 12am. On average, usage on Saturdays and Sundays is much lower.
Figure 39 below shows the daily gas usage from the available half-hourly data. Each dot represents the total gas consumption for that day. Green dots represent weekdays and orange dots represent weekends. Weekend gas use is often zero. Otherwise it is usually lower than weekday use. Peak usage is seen in January, and gas consumption falls to near-zero in summer months before increasing in October.

![Figure 39: Total daily gas consumption](image)

Figure 40 below shows how the monthly gas demand varies throughout the year, with darker coloured lines representing winter months. This graph shows that gas consumption is highest in winter months and lowest in summer months. In almost all months, there is a significant reduction in gas use between 8pm and 4am, before it peaks at 7am. Boilers start in the morning and remain enabled throughout most of the day. There may be opportunity here to change the strategy of how the boilers are run to ensure there is minimised dry-cycling and that boilers are run only when there is heat demand.
Figure 40: Average daily gas profiles broken down by month
The combined modelled breakdown of Queens’ Building is demonstrated below.

The reconciliation of identified equipment and actual usage had identified a discrepancy of around -75%. Carbon Credentials believe that the electricity meters capture more buildings in addition to the Queen’s Building. It is recommend that a full meter review is undertaken to ensure that all meters are captured and assigned to the correct buildings.

**Figure 41: Combined modelled annual electricity consumption breakdown**