Carbon Reduction in Reigate and Banstead

Sponsored by the Reigate and Banstead Borough Council

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Abstract

This project used energy surveying protocols to identify opportunities for carbon reduction among small and medium enterprises in the borough of Reigate and Banstead. The team conducted energy surveys to discover the most common patterns of energy consumption, as well as areas for businesses to improve energy efficiency. Personalized reports were created for these companies, and separate recommendations were given to the Reigate and Banstead Borough Council regarding the replication of similar projects in the future. Additional recommendations were produced for the Council on how promote carbon reduction throughout the entire Borough.

Authorship

This report was developed through the collaborative efforts of Joe Lombardo, Kevin McCarthy, Nick Solarz, and Nicholas Mondor. All group members contributed equally to the completion of this project.

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Executive Summary

Research has shown that anthropogenic greenhouse gases (GHGs), or human sources of harmful gas emissions, are major contributors to the globe's increasing temperature and rising sea level (Hijioka, Masui, Takahashi, Matsuoka, & Harasawa, 2006). These findings have inspired many countries worldwide to take action to reduce GHG emissions, and in particular, carbon reduction. This includes the United Kingdom, which has set national goals to reduce carbon emissions by 80% by the year 2050 (Ek, Lattanzio, Leggett, & Parker, 2009). Local governments such as the Reigate and Banstead Borough Council are working to achieve this national goal.

The overall goal of our project was to assist the Reigate and Banstead Borough Council in developing energy auditing protocols used to identify carbon reduction opportunities among selected small and medium enterprises (SMEs) in the Borough. This overall goal was achieved through a series of objectives. The project team: (1) Characterized the best practices in energy auditing in the UK; (2) Identified patterns in energy consumption and carbon emissions among SMEs; (3) Developed overall strategies for achieving carbon reduction and created solutions specific to each SME; and (4) Recommended how the Borough should conduct future audits and outreach efforts with SMEs. These objectives were accomplished by reviewing the research literature, conducting a series of interviews with professional auditors and other appropriate personnel, conducting a series of energy audits with selected SMEs, analyzing the data to identify patterns of energy consumption and potential areas for carbon reductions, and preparing an action plan for each specific SME. Based on the results of the project, we have recommended how the Reigate and Banstead Borough Council might modify and expand the program in the future to reach out to other SMEs in the Borough.

Once we understood the goals of our project, the next step was to begin researching background information that would help us develop our auditing protocols and specific action plans for each business. During our research, we learned of numerous techniques and strategies for conducting energy audits. These techniques varied based on the time and data required to complete them, with the shortest and least intensive being a simple walkthrough audit. We also learned that a walkthrough audit provided the simplest energy saving solutions, as they tend to be based on building maintenance.

Once the type of energy survey was established, we looked into different recommendations that we could provide to SMEs. These solutions can be based on a number of different areas for potential savings. In our research, we learned about LED lighting and the savings it offers compared to normal fluorescent lighting. LED lights last significantly longer and consume less power than florescent lights. Next, we looked at the potential savings associated with adjusting boiler operation hours. The idea behind this was to turn off the boiler in a building one hour earlier. A well insulated building can retain enough heat to maintain a comfortable level until the occupancy hours have passed. The energy reduction associated with this can result in measurable savings. Finally, we looked at a number of smaller solutions associated with heating, ventilation, and air conditioning (HVAC). These solutions ranged from installing thermostatic radiator valves on radiators, to installing variable speed drives on the building's pumping system. All of these solutions are relatively simple fixes with a low payback period.

After we completed our research, we then developed a methodology for our project. The first thing we did was establish our energy surveying format. We decided that our audits would be in the form of a walkthrough audit. These audits were simple to conduct, yet provided a number of energy saving solutions for businesses. We also developed a checklist to aid with the surveying process. The checklist consisted of a variety of different key areas to look at and note during the actual audit. These key areas included heating, lighting, building envelope, and employee habits. The purpose of the checklist was to serve as a manual for conducting the audit, outlining and prompting all the areas of interest for the energy auditing team.

The next thing we did was recruit businesses to receive energy audits. Before we arrived on site, the Reigate and Banstead Borough Council had sent out a flier to a local industrial estate in order to generate interest in receiving a free energy audit. Unfortunately, only a few businesses responded to the flier directly. In order to recruit more SMEs, we contacted different businesses unaware of the free energy auditing program and directly asked them if they were interested in receiving an energy survey. We developed a standardized call prompt and went through a list of businesses within the industrial estate. This allowed us to create and schedule a total of eleven energy surveys.

After completing the audits themselves, we developed a standardized format for the actions plans, as well as numerous calculators to assist us in finding the possible savings associated with our recommendations. Our audit report format consisted of an introduction, summary of findings, possible savings (broken down into no-cost and cost solutions), top recommendations, and a conclusion. All of our audit reports followed this very simple and easy to read format. In addition to the report format, we also created or found different calculators to improve the accuracy of our recommendations. Using these calculators greatly improved our efficiency in writing the energy audit reports.

Finally, we created a feedback form for each business to complete after they had read through our report. This feedback form asked questions on what the business thought of the audit itself, as well as if they were planning on implementing any recommendations provided in the report. These reports allowed us to understand the social implications of our project.

After all of the audits were completed, we drew a number of conclusions. Through our analysis of energy consumption trends, we were able to conclude that lighting and heating provide the largest opportunity for carbon reduction in small and medium enterprises. From feedback, we determined that our method for conducting energy surveys was efficient, allowing us to produce high quality reports in a short amount of time. Additionally, businesses found that these energy surveys benefited their companies, and that our recommendations were feasible. As a result, the Reigate and Banstead Borough Council should continue targeting SME and public buildings to achieve local and national carbon reduction goals. While the efforts of Reigate and Banstead cannot lessen the impacts of anthropogenic carbon emissions alone, promoting energy awareness throughout the Borough and eventually throughout England has a significant influence.

In order to evaluate opportunities for carbon reduction in small and medium enterprises, we conducted a number of energy surveys to find general energy consumption trends. During these energy surveys, we came across challenges identifying an appropriate sample of SMEs to audit, as well as difficulty analyzing gathered data. We experienced further challenges during our personalized presentations regarding potential recommendations to improve energy efficiency. We found that there was some difficulty in getting companies to implement these solutions.

In addition to these challenges, we were also able to identify the limitations of our project. Our experiences revealed that members of the Reigate and Banstead Borough Council have been conducting similar energy surveys themselves, mostly for public schools and libraries along with residential housing. Moving forward, the Borough may not have the resources to continue conducting energy surveys targeting small and medium enterprises. In terms of the larger scope of the project, one borough in a single nation cannot make a significant impact. Globally reducing anthropogenic sources of carbon emissions will require the efforts of other boroughs in the United Kingdom, as well as efforts from other countries.

The final result of our project came in the form of recommendations for the Reigate & Banstead Borough Council. The first of these recommendations was to continue the free energy audit program within the Borough. Based on what we saw during our project, the energy audits were extremely beneficial to both the businesses within the Borough and the Borough itself. In order to continue this program, we recommended that the Borough Council look into working with a local university to establish a summer volunteer program. The next recommendation for the Borough Council was to create business outreach seminars. These seminars would be for local business owners and building managers in order to teach them about energy awareness within their buildings. During the seminar, they would learn about how to self-assess their energy use, as well as learn about different energy saving opportunities. These seminars would allow the Borough to continue its community outreach within the Borough if the free energy audit program wasn't able to continue. Finally, we recommended that the Borough Council increase its energy awareness. During our project, we developed a few promotional materials in order to spread information about energy savings. By having the Borough Council use these promotional materials, they will continue their community outreach for energy awareness in the most efficient way possible.

In closing, our project has successfully identified carbon reduction opportunities among small and medium enterprises within Reigate and Banstead. Our methods for identifying and analyzing these energy consumption trends were successful, as businesses found these energy surveys worthwhile and efficient. Additionally, businesses indicated that they would implement some of our recommendations, hence reducing their carbon emissions. We concluded that continuing outreach to small and medium enterprises is an effective way to achieve carbon reduction goals set forth by the Reigate and Banstead Borough Council, as well as England itself. To do this, we provided a few recommendations to modify and expand the current carbon reduction program. These recommendations included the continuation of free energy surveys through local students and volunteers, conducting carbon reduction seminars for businesses to learn how to self-assess energy usage, and finally, the use of promotional fliers, posters, and brochures to increase energy awareness. Even though our project was limited to the borough of Reigate and Banstead, the results and impact of this project can eventually spread throughout England. Reducing carbon emissions in small and medium enterprises throughout the nation can eventually lessen the impact anthropogenic sources of carbon emissions are having on our planet.

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1. Introduction

The international community has become increasingly concerned about the emissions of greenhouse gases (GHGs). Research has shown that anthropogenic GHGs, or human sources of harmful gases, are major contributors to climate change (Masui *et al.*, 2006). These findings have inspired many countries worldwide to take action to reduce GHG emission, and in particular, carbon reduction. The United Kingdom (UK) has been especially ambitious in setting carbon reduction goals. The UK is legally bound by the Climate Change Act of 2008 to cut carbon emissions by 80% by the year 2050 (Ek *et al.*, 2009). These goals have caused researchers to focus on the best methods for reducing carbon emissions on global, national, and local levels. Local governments, and more specifically the borough of Reigate and Banstead, are now beginning to target buildings as areas of interest, since buildings account a large portion of the Borough's carbon dioxide emissions.

In order to reduce carbon emissions in buildings, it is necessary to know which elements of a building cause energy loss. Energy audits provide an effective way of identifying how and where a building uses its energy, which leads to the creation of carbon reducing solutions. However, most energy audits have been performed on large businesses and on residential housing. As a result, these large businesses and residences have benefited from energy savings. Small and medium enterprises (SMEs) have received little attention in carbon reduction efforts. The majority of SMEs do not have the knowledge to conduct an audit themselves, nor do they have the resources to hire someone to conduct an audit for them. The Reigate and Banstead Borough Council aims to demonstrate the value of energy audits and carbon reduction efforts to SMEs.

The overall goal of our project was to assist the Reigate and Banstead Borough Council in developing energy auditing protocols used to identify carbon reduction opportunities among selected SMEs in the Borough. This overall goal was achieved through a series of objectives. The project team: (1) Characterized the best practices in energy auditing in the UK; (2) Identified patterns in energy consumption and carbon emissions among SMEs; (3) Developed overall strategies for achieving carbon reduction and created solutions specific to each SME; and (4) Recommended how the Borough should conduct future audits and outreach efforts with SMEs. These objectives were accomplished by reviewing the research literature, conducting a series of interviews with professional auditors and other appropriate personnel, conducting a series of energy audits with selected SMEs, analyzing the data to identify patterns of energy consumption and potential areas for carbon reductions, and preparing an action plan for each specific SME. Based on the results of the project, we have recommended how the Reigate and Banstead Borough Council might modify and expand the program in the future to reach out to other SMEs in the Borough.

2. Greenhouse Gas Emissions and Carbon Reduction Strategies

Climate change is a growing concern worldwide. As a result, many countries are actively seeking to reduce their greenhouse gas emissions, and in particular, their carbon emissions. This literature review discusses the adverse effects greenhouse gas emission can have, identifies global goals and goals within the United Kingdom to reduce carbon emission, identifies the main causes of carbon emissions in the United Kingdom, different techniques for gathering data regarding carbon emissions, and common solutions that have been recommended to reduce carbon emissions.

2.1 Nature of the Problem

Researchers, policy makers and scientists are becoming increasingly concerned about the possible impacts of climate change. While public opinion may waiver depending on recent weather events, researchers continue to identify a number of adverse effects that increasing GHGs (greenhouse gas) emissions[1] may cause in the coming decades. Such effects include extreme weather patterns, rising sea levels due to the thermal expansion of oceans and melting of continental glaciers, and the increased intensity and frequency of storms, all due to an increase in the earth's surface temperature (Matsui *et. al.*, 2006). Scientists claim that these adverse effects are becoming more and more apparent. According to the AS4 (Fourth Assessment Report) by the IPCC (Intergovernmental Panel on Climate Change), "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level" (Bernstein *et al.*, 2007).

As shown in Figure 1 below, between 1850 and 2000, the global average surface temperature has increased approximately 1°C, global average sea level has risen approximately 200 mm, and the northern hemisphere snow cover has decreased by roughly 1 million km. The authors of the AS4 Report also say that these observed increases in temperatures can be attributed to the steadily rising concentration of carbon dioxide in the atmosphere, which have been increasing more rapidly since the Industrial Revolution. NOAA (National Oceanic and Atmospheric Administration) has been tracking CO2 at its Mauna Loa Observatory for years. Figure 2 shows that CO2 shifts regularly with the season (red line), but the annual trend (black line) climbs upward continuously.

[1] Major GHGs include, in order of significance, water vapor, carbon dioxide, methane, and ozone (Kiehl,J.T. 1997)

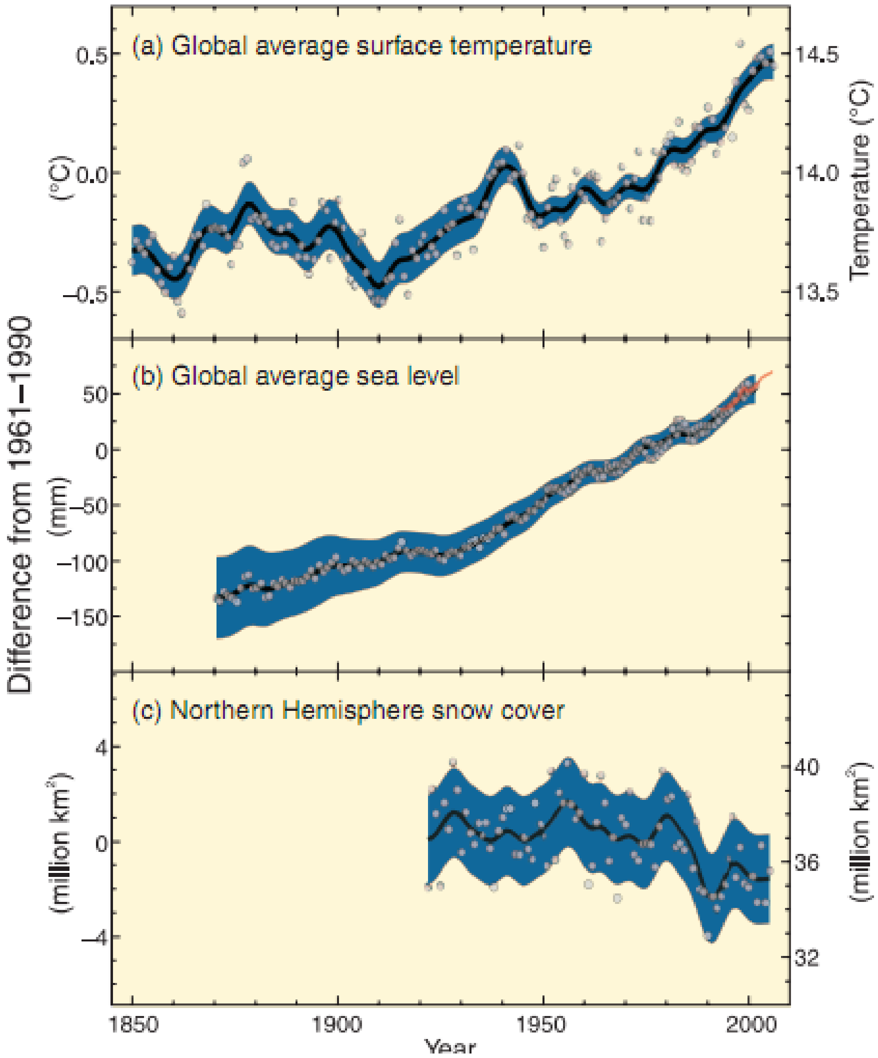


Figure 1 - Changes in Temperature, Sea Level, and Snow Cover in the Northern Hemisphere (Bernstein *et al.*, 2007)

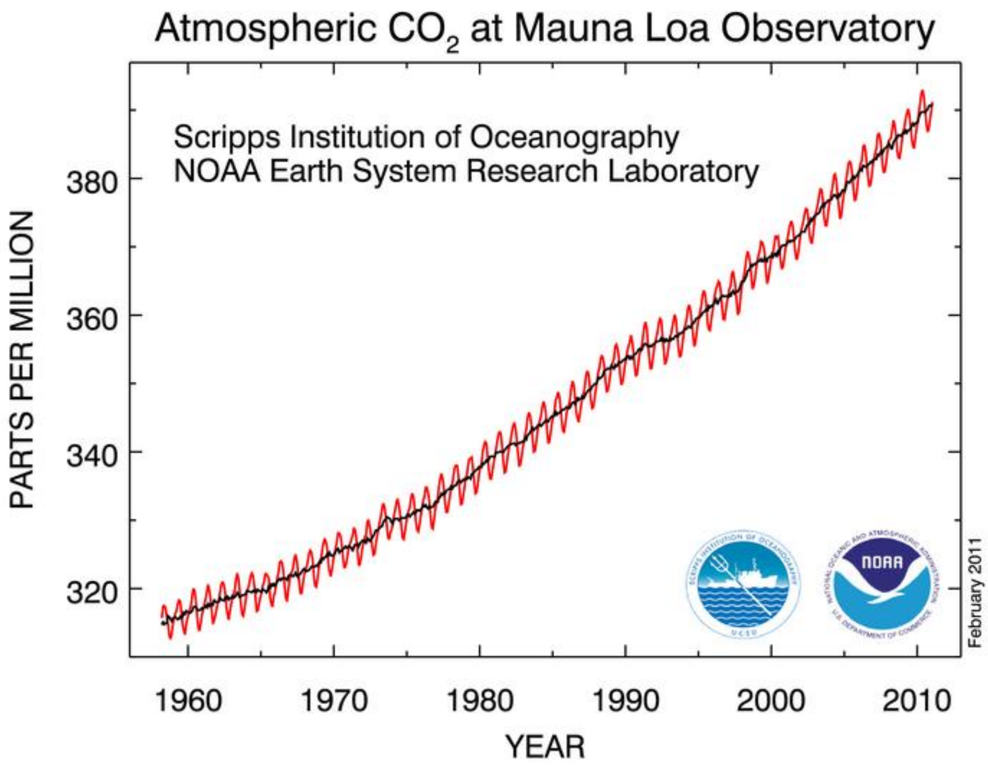


Figure 2 - Atmospheric CO2 at Mauna Loa Observatory (Mauna Loa Observatory, 2010)

Though there are skeptics, the majority of climate change scientists now agree that the most significant contribution to global warming and the greenhouse effect is anthropogenic sources of carbon dioxide emissions (Oreskes, 2004; Bernstein *et al.* 2007).

Since the increase in greenhouse gas emissions is tied to anthropogenic activity, various national and international organizations have set targets for the reduction of these gases, including carbon dioxide. The 1992 UN Conference on Environment and Development (UNCED) or “Earth Summit,” created an international treaty, the United Nations Framework Convention on Climate Change (UNFCCC) Treaty, in an effort to survey and control greenhouse gas emissions. This treaty sets limits and mandates certain levels of greenhouse gas emissions for all countries involved. The most recent update to this treaty is the Kyoto Protocol, adopted December 11, 1997 in Kyoto, Japan. It binds signatories to meet goals for greenhouse gas reduction. Overall, the Kyoto Protocol targets an average reduction of five percent of the levels in 1990 by the year 2012. Another notable mechanism of the Kyoto Protocol is the trading of emissions. Each nation is allowed a certain level of emissions. These emission units are then divided across all participants. If a particular nation has successfully reduced their carbon emissions below the required level and possess spare emission units, they may sell their excess units to other nations who may be experiencing greater difficulty reducing emissions to their allowable level. Nearly 200 nations have ratified the Kyoto Protocol since 1998 (Figure 3) and have established country-specific targets (UNFCCC, 14 January 2009).

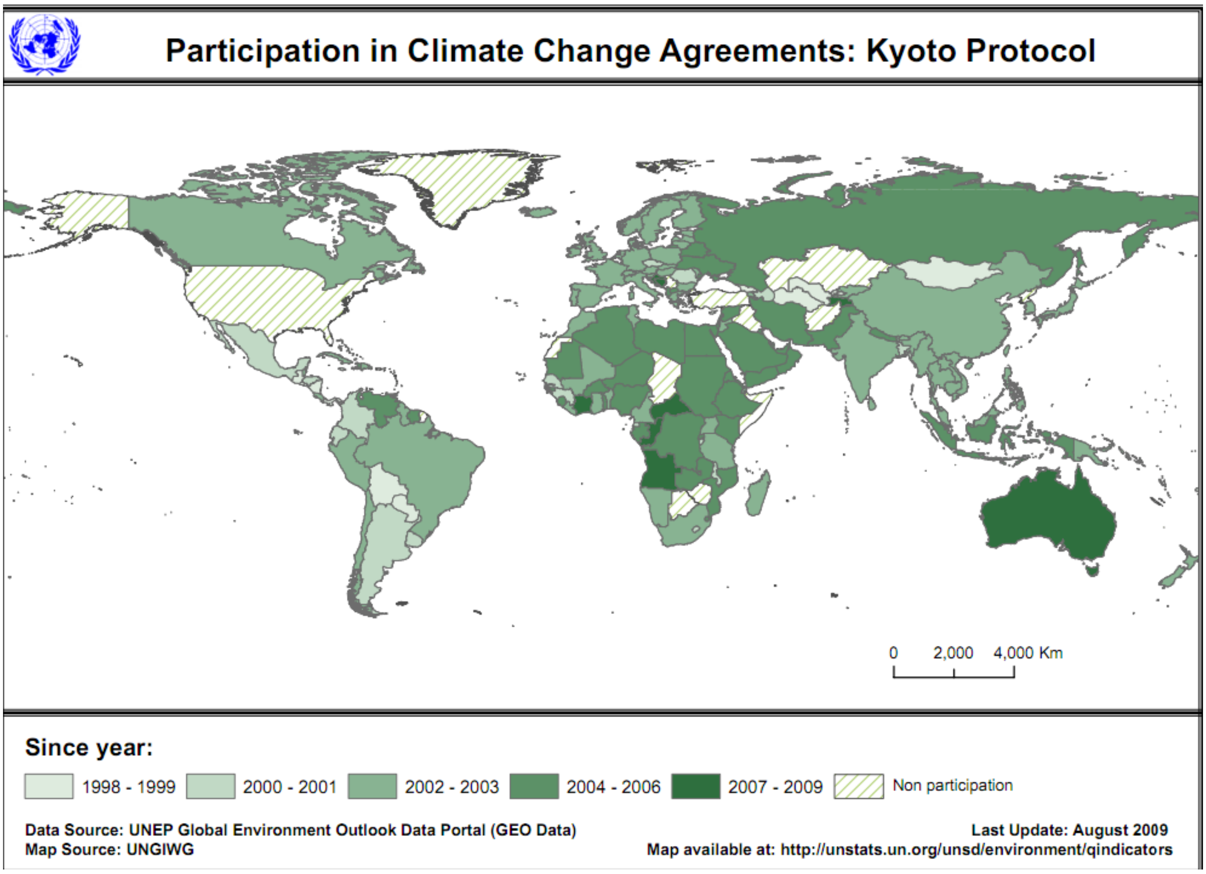


Figure 3 - Countries and their Kyoto Protocol Status (UNFCCC, 2009)

Additionally, Table 1 illustrates a timeline of major greenhouse gas reduction acts over the past 20 years.

Table 1 - Timeline of Major Events Regarding Climate Control (UNFCCC, 2009)

1992	UNCED Earth Summit creates UNFCCC treaty. The purpose of this treaty is to stabilize the GHGs in the atmosphere (UN).
1995	IPCC releases its Second Assessment Report on Climate Change. It is concluded that GHG concentration continued to increase, likely for anthropogenic reasons (IPCC 2AR).
1997	Kyoto Protocol updates the UNFCCC treaty (UNFCCC).
2001	IPCC releases its Third Assessment Report on Climate Change, and finds there is stronger evidence that increased atmospheric GHG concentrations and global temperature is caused by human actions
2009	1. The European Union institutes the "20-20-20 Policy" to regulate GHGs and energy for the post-Kyoto period, which ends in 2012 2. France institutes a policy to reduce carbon emissions and to tax emissions 3. Germany, the UK, Australia, Brazil, Canada, China, India, Japan, Korea, Mexico, the Russian Federation, and the United States have all set similar goals for their nations, some more conservative than others.

The goals set by various policies to reduce greenhouse gas emissions in the United Kingdom are particularly ambitious compared to most nations. As a participant in the Kyoto Protocol, one such goal is to meet the obligatory five percent reductions of carbon levels in 1990 by the year 2012. In addition to the acceptance of the Kyoto Protocol, however, the United Kingdom has set a more ambitious policy of its own: the Climate Change Act of 2008. This states that the UK is legally bound to "cut emissions by at least 80% by 2050 and at least 34% by 2020 compared to 1990 levels… The act also requires that the government amend the act to include emissions from shipping and aviation by December 31, 2012. The act states that a reduction of power sector emissions by 40% should be achievable by 2020" (Ek *et. al*, 2009).

The United Kingdom has set its own national goals to reduce carbon emissions, and local governments are the driving force behind this reduction. The borough of Reigate & Banstead is one such example. The Reigate & Banstead Borough Council has established policies to cut down on carbon emissions, organized into their Sustainable Energy Strategy. For example, Reigate & Banstead aims to achieve ten percent of carbon reduction through the installation and utilization of renewable energy sources, such as solar- and wind-derived electricity. Of any of the involved goals, the most ambitious is to have all new housing and new commercial buildings have zero carbon emissions by 2016 and 2019, respectively. As for buildings that already exist, the Borough wishes to implement behavioral and technological changes to greatly improve energy efficiency and reduce carbon emissions. A strong focus appears to be directed at buildings, and for good reason; the Carbon Trust reports that buildings contribute to 40% of the EU's energy consumption. More specifically, the focus is directed toward buildings owned by businesses. The Sustainable Energy Strategy from the Reigate and Banstead Borough Council reports that, as of 2006, 34% of carbon emissions come from the "Industry and Commerce" sector (Reigate and Banstead Borough Council Sustainable Energy Strategy, 2009). Additionally, the United Kingdom Department of Energy and Climate Change reports that businesses contributed 184.6 million tons of carbon emission in 2009 out of 532.8 million tons total. The breakdown for carbon emission by industry is represented in Figure 4 below:

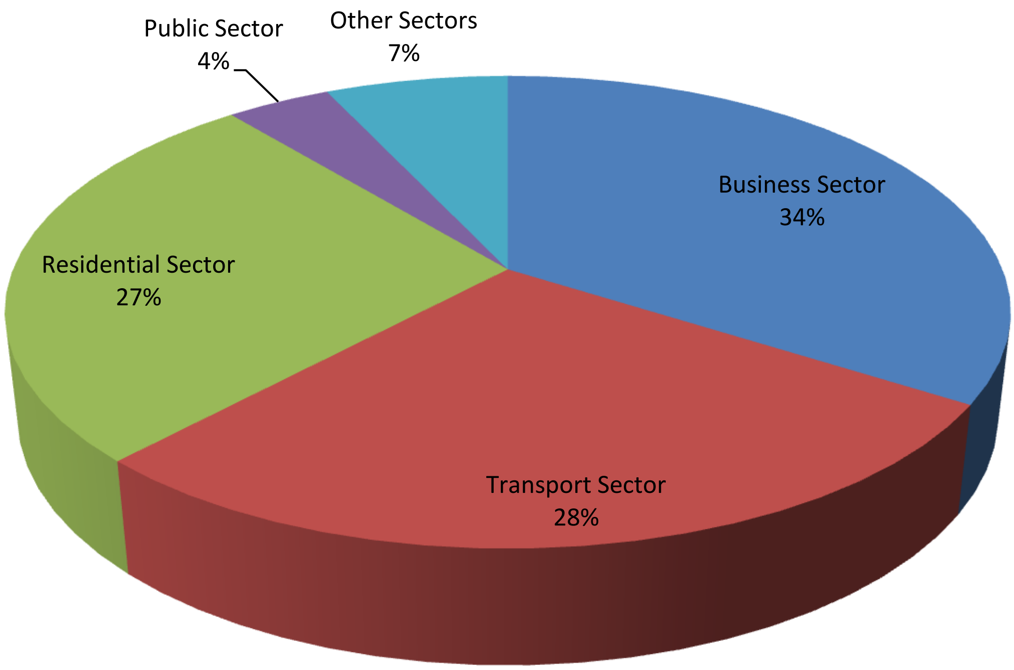


Figure 4 - UK Carbon Emission Totals by Sector (United Kingdom Department of Energy & Climate Change, 2009)

The business, transport, and residential sectors account for most carbon emissions in the UK with other sectors (public, agriculture, industrial, etc) accounting for the rest. According to the United Kingdom Federation of Small Businesses, there are roughly 4.8 million small and medium businesses in the United Kingdom. Small businesses employ anywhere from 10 to 50 people, whereas medium businesses employ 50 to 249 people. Those small and medium businesses account for over 59.8% of employment in the private sector. Of the 63.3 million people living in the UK, over 22.8 million people work for a small or medium enterprise

(SME). As a result, SMEs account for a major portion of the carbon emission caused from businesses. Businesses spending over £50,000 per year are eligible for a free energy audit from the Carbon Trust, which helps to identify where they can reduce carbon emissions. However, most small and medium enterprises spend below £50,000 per year and are ineligible for these audits. As a result, the Reigate and Banstead Borough Council is targeting SMEs in an effort to achieve part of their carbon reduction goal. Since the Council is in the early stages of developing a "Green Economy," focusing on SMEs will allow the borough of Reigate and Banstead to begin moving toward that goal (United Kingdom Federation of Small Businesses, 2010).

2.2 Energy Auditing

In order for the Reigate and Banstead Borough Council to achieve these carbon reduction goals, both the Council and the small and medium enterprises need to have a better understanding of current energy consumption patterns. A better understanding of current energy consumption patterns will allow for the implementation of effective energy saving controls and strategies. Energy audits provide an effective way to identify these energy consumption patterns and losses. An energy audit on SMEs involves analyzing their current energy usage, identifying where improvements can be made, and providing recommendations to reduce their carbon footprint. To further support this claim, Thumann (2008) states that an energy audit "serves the purpose of identifying where a building or plant facility uses energy and identifies energy conservation opportunities."

In the UK, energy audits are referred to as site surveys or energy surveys. While 'energy audit' and 'site survey' are interchangeable, the latter better expresses the UK's broader focus on both energy and carbon reduction (Carbon Trust, 2011). The methodology of a site survey is almost exactly comparable to that of an energy audit in the U.S. The main difference stems from the addition of a metric measure showing how much carbon is used and how much can be saved by implementing the recommended solutions. Once again this reflects the UK's broader focus on climate change through including both energy and carbon reduction measurements in their reports (Carbon Trust Hall & Woodhouse Case Study, n.d.).

There are three main types of energy audits; the walkthrough, the mini-audit (general or standard audit), and the maxi-audit (detailed audit). A brief overview of the advantages and disadvantages to each can be seen in Table 2 below:

Table 2 - Types of Energy Audits

Type	Advantages	Disadvantages
Walkthrough Audit	• Least amount of time to conduct • Requires an on-site visit only	• Least detailed and least comprehensive solutions for carbon reduction
Standard Audit	• More detailed and provides more specific solutions than walkthrough audit	• Takes more time to conduct • Requires more information (i.e. energy bills, meter data, etc.)
Detailed Audit	• Provides the most specific solutions designed strictly for the business being audited.	• Takes the longest time to complete • Requires the most data in order to provide solutions

2.2.1 Walkthrough Audit

The walkthrough audit is the simplest to conduct, as it involves going through a facility and conducting a visual inspection. Visual inspections allow the auditor to identify glaring issues and provide simple solutions on how to correct them. Additionally, a simple walkthrough audit will provide insight on whether or not the SME needs a more detailed audit (Thumann & Mehta, 2008). Similarly, Krarti (2000) says a walkthrough audit "consists of a short on-site visit of the facility to identify areas where simple and inexpensive actions can provide immediate energy use and/or operating cost savings. Some engineers refer to these types of actions as operating and maintenance (O&M) measures. Examples of O&M measures include setting back heating point temperatures, replacing broken windows, insulating exposed hot water or steam pipes, and adjusting boiler fuel-air ratio" (Krarti, 2000).

2.2.2 Standard Audit

The standard audit, or mini-audit, goes a step further than the walkthrough. The auditor collects data on energy usage in order to identify where energy losses are taking place. This allows the auditor to determine solutions that may not be apparent from a visual inspection. Mini-audits use data from past utility bills, as well as real-time, data collecting energy measurement tools. An analysis of the data allows for a much more detailed summary of possible energy reduction measures, as well as the ability to identify the cost-effectiveness of each measure (Krarti, 2000).

2.2.3 Detailed Audit

The detailed audit, or maxi-audit, continues along the same lines as the mini-audit. In addition to collecting data on energy usage in order to identify where energy losses are taking place, it also takes into account the specific areas (heating, lighting, computers, etc) where energy usage is occurring, and then factors that into the calculations. Maxi-audits may call for a computer model to simulate the yearly energy use of the entire building. This type of audit is the most time consuming, as it involves much more data collection and the creation of a simulation model. However, the maxi-audit provides the best set of energy reduction methods specific to the facility (Krarti, 2000).

2.3 Performing an Energy Audit

Once the type of energy audit is established, the audit itself consists of two main parts; data acquisition and data analysis.

Data acquisition involves collecting all necessary data in order to complete an energy audit. This consists of past energy bills as well as on-site energy measurements taken with portable measuring instruments. There are a number of instruments available to collect data on energy usage, ranging from light meters to portable watt-meters. Data acquisition allows the auditor to compile what energy goes in from electric and gas lines, and where the energy usage and loss takes place. Ideally, energy in should balance out with energy out (Thumann & Mehta, 2008). Since data acquisition relies on past utility bills, challenges may arise if the records kept by SMEs are not extensive. In this case, databases can be created to combine energy usage estimates with new information to acquire useful data for an energy audit.

Another aspect of data acquisition is taking inventory of all electrical devices and systems in use within the building. Auditors need to collect energy data on things such as lighting, heating, computers, as well as any business-specific equipment (Krarti, 2000). A walkthrough of the building with a checklist is one of the best methods for gathering this information. An example of a checklist from the Carbon Trust for typical office buildings can be found in Appendix A.

The next part of the energy audit is data analysis. Data analysis involves taking the data acquisition component and synthesizing and interpreting the results. After completing calculations, energy reduction solutions are found. It is important to take into account each type of energy used (electric, gas, etc.) as well as how and where it is used, since weather may affect energy usage (Thumann & Mehta, 2008). An example of this is that during winter, more gas is used for heating. On the contrary, heating may be turned off during the warmer months to conserve energy. An analysis of utility bills will reveal how the building is using energy, which may result in obvious recommendations such as turning off heat during warmer months. Additionally, due to the drastically different metering and billing techniques used in the United Kingdom, analysis of utility bills will also reveal if the company is being overcharged for gas and electricity. Meter readings in the United States typically happen once a month, and the electric and gas companies charge for the exact energy usage. In contrast, according to the staff at the Reigate and Banstead Borough Council, meter readings only need to be taken once every 2 years in the United Kingdom. As a result, monthly bills are often based on estimates, and companies are sometimes overcharged.

Building size and building envelope are also important aspects of data analysis. Comparing the collected data to standards for similarly sized buildings allows for a better understanding of the building undergoing the energy audit. After completing the data analysis portion of the energy survey, an auditor is able to find possible energy reduction solutions (Krarti, 2000).

One method for performing data analysis is through the Carbon Trust's "Energy Analyser Tool." The Energy Analyser Tool uses data gathered from metering devices and allows the user to create graphs and charts based on this data. This allows the user to identify areas where energy loss is taking place based on numerical data. Auditors may also use self created Microsoft Excel spreadsheets to do calculations. For example, a self created Microsoft Excel spreadsheet for lighting may include the amount of light fixtures, amount of lights per fixture, wattage of each light, the amount of kilowatt hours used per year, and the cost expenditure on lighting per year. Additionally, the auditor can also identify areas of high carbon emissions if a walkthrough is conducted and a checklist is used. These checklists have the auditor examine types of light bulbs, boiler settings, thermostat settings, and old and worn out areas of the building, allowing for simple solutions based off of observations.

2.4 Energy and Carbon Reduction Efforts

Analyzing data from site surveys provides the auditor with the ability to create feasible solutions that make a difference in carbon reduction efforts. Energy audits reveal what sort of solutions will be most effective for specific situations. From these solutions, the ones with a small payback time and a large benefit to cost ratio are generally the most feasible solutions.

The ideal solution is one that provides a high carbon reduction, requires little initial capital, and has a quick payback time. However, these solutions will vary based on the type of business. Solutions may vary substantially depending on the nature of the small business (office buildings, manufacturing, restaurants, retail, etc.) due to the different equipment needs of each business sector. Figure 5 below shows the total carbon emissions from energy use in public and commercial buildings in 2002.

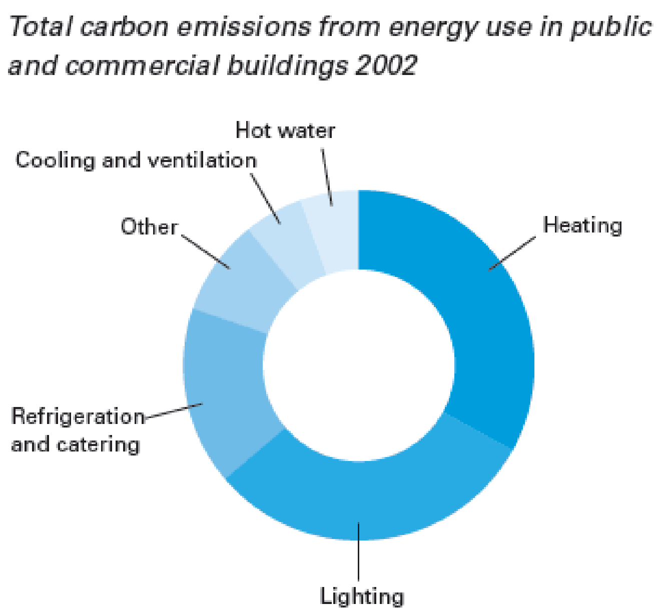


Figure 5 - Breakdown of Carbon Emissions within Commercial Buildings (Carbon Trust Heating, Ventilation and Air Conditioning Overview, 2006)

Lighting and heating are the two largest causes of carbon emissions in public and commercial buildings and provide the largest opportunity for carbon reduction. As a result, behavioural changes and more efficient technology are two of the more common recommendations following an energy survey.

2.4.1 Behavioural Changes

Behavioural changes are solutions that reduce energy consumption with little to no monetary costs. These changes include, but are not limited to: (1) Turning off unused lighting and equipment; (2) Switching off computers and copiers at night; (3) Lowering thermostat settings to a comfortable temperature; and (4) Turning equipment on energy saver or standby mode. Things like turning off computers and copiers at night will save a surprisingly large amount of money and reduce carbon emissions. The Carbon Trust estimates that shutting down computers, laser printers, and monitors at night and during the weekend can lower the annual energy consumption of these devices by 75%. These changes can also help to lengthen the lifespan of the electrical equipment. While this is a behavioural change, it can also be accomplished by purchasing cheap, seven-day timers programmed to automatically switch off equipment at certain times during the day. Another energy saving technique is to enable standby mode on unused electronics. Since screensavers can use more energy than some normal computer applications, enabling a standby mode will reduce energy use if the electronic device is not used for a certain period of time. However, employees will need to wait for the equipment to start up again if it is turned off. Though the wait is often a short period of time, the challenge lies in getting people to change their behaviours. People may be resistant to this change. Reducing lighting when appropriate is another technique that the Carbon Trust has identified to reduce carbon emissions. According to the Carbon Trust, there is an optimal point for lighting and productivity. Figure 6 illustrates this optimal point.

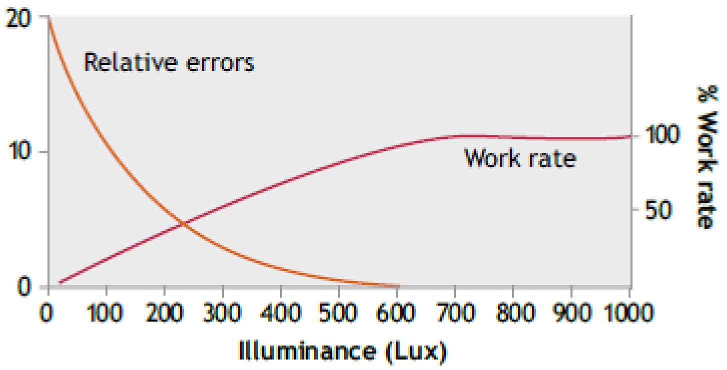


Figure 6 - Work Rate versus Illuminance (Carbon Trust Lighting Technology Overview, 2007)

Reducing the amount of lighting in the building during periods of high sunlight requires little to no behavioural changes on the part of the employees. In some cases, lights can be completely turned off to make use of ambient light, hence saving kWh and money while reducing carbon emissions.

The Carbon Trust suggests that the best way to get people to change their behaviours to promote energy efficiency is to get them involved in the process. One such example is assigning people the responsibility of turning off lights at night. Giving people a sense of responsibility may cause them to be more open and willing to change. The Carbon Trust also suggests explaining increased energy efficiency to employees in the context of how it can benefit the company, such as cultivating good public relations for taking a green initiative.

2.4.2 Incandescent and Fluorescent Lighting versus Light Emitting Diodes

As shown in Figure 5, lighting accounts for approximately 33% of carbon emissions in the public and commercial sector. Additionally, according to the Carbon Trust Good Practice Guide on lighting, lighting can account for up to 40% of a company's electric bill. This is due to the large number of light bulbs used throughout buildings, as well as the various different kinds of light bulbs used.

The different lighting types include incandescent and compact fluorescent lighting (CFL), as well as T-12, T-8, and T-5 fluorescent lights. Incandescent and compact fluorescent lighting have screw or bayonet caps and fit into the same light fixtures, allowing them to be directly compared. On the other hand, T-12, T-8, and T-5 fluorescent lights are tubular and come in a variety of different sizes. The numbers 12, 8, and 5 refer to the diameter of the tube—T-12s have a 1.5" (inch) diameter, T-8s have a 1" diameter, and T-5s have a 5/8" diameter. These tubes also vary in length, ranging anywhere from 2' (feet) to 8'. These fluorescent tubes cannot be compared to incandescent or compact fluorescent lights, but can be compared to each other.

Compact fluorescent lights are much more efficient than regular incandescent bulbs. Incandescent bulbs use electricity to "heat a filament inside the bulb; the heat makes the filament white-hot, producing the light that you see." On the other hand, compact fluorescent lights contain a gas that reacts to the flow of electricity rather than a tungsten filament. This reaction causes the production of ultraviolet (UV) light, which is then emitted through the white coating surrounding the bulb. As a result, CFLs are more 4-6 times more efficient due to the lack of heat needed to produce light. Additionally, CFLs have similar lumens per watt, meaning that CFLs and incandescent bulbs produce comparable amounts of light (General Electric Compact Fluorescent Light Bulb (CFL) FAQs, 2011).

Similar to CFLs, T-5 tubes are much more efficient than T-8 and T-12 tubes. However, due to the difference in tubular diameter, the pin base size at the end of each tube varies. T-5 tubes have a small, bi-pin base, whereas T-8 and T-12 tubes have a medium bi-pin base, as seen in Figure 7:

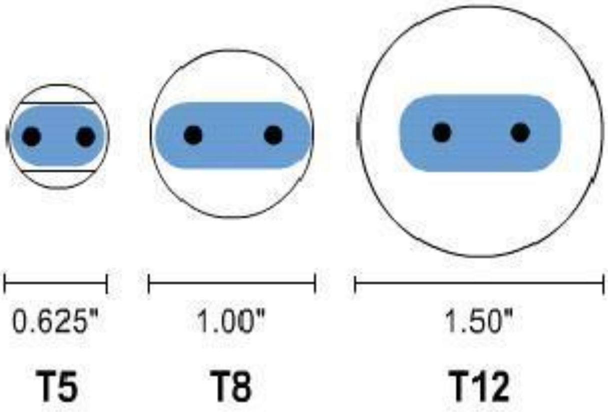


Figure 7 - Fluorescent Tube Pin Base Sizing (Lighting Research Centre, 2002)

As a result, switching from T-8 or T-12 tubes to T-5 tubes requires the replacement of the fluorescent tubes and the physical light fixture itself. This results in a higher cost for replacement. However, as shown in Figure 8, T-5 tubes use less wattage and have higher lumens per watt than T-8 and T-12 tubes, resulting in energy savings.

(From manufacturers' catalogs; Philips Lighting 2001/2002; GE Lighting 2001/2002)

Lamp Type	Nominal Length (in)	CCT (K)	Light Output* (lm)		Lamp Efficacy** (lm/W)
			Initial	Mean	
T5 14W	22	3,000-6,500	1,350	1,269-1,275	96
T5 21W	34	3,000-6,500	2,100	1,974-2,000	100
T5 28W	46	3,000-6,500	2,900	2,726-2,750	104
T5 35W	58	3,000-6,500	3,650	3,431-3,450	104

(From manufacturers' catalogs; Philips Lighting 2001/2002; GE Lighting 2001/2002)

Lamp Type	Nominal Length (in)	Phosphor*	CCT (K)	CRI	Light Output** (lm)		Lamp Efficacy** (lm/W)
					Initial	Mean	
T12 40W	48	RE70	3,000-6,500	70-75	3,050-3,250	2,775-2,950	81
	48	RE80	3,000-5,000	80-82	2,200-3,400	1,775-3,090	85
T12 34W	48	RE70	3,000-6,500	70-75	2,650-2,800	2,430-2,520	82
	48	RE80	3,000-5,000	80-82	2,025-2,900	1,775-2,610	85
T8 32W	48	RE70	3,000-6,500	75-78	2,700-2,850	2,550-2,710	89
	48	RE80	3,000-5,000	86	2,800-2,950	2,660-2,800	92

Figure 8 - Fluorescent Lighting Efficiency (Lighting Research Centre, 2002)

As a result, one of the common lighting suggestions after an energy survey is to replace T-12 and T-8 fluorescent tubes with T-5 fluorescent tubes.

The newest and most efficient technology is light emitting diode (LED) technology. This is relatively new, but provides a much greater efficiency than even T-5 fluorescent tubes. An

LED light uses electricity to excite atoms within a semiconductor chip, causing these atoms to release electrons as energy in the form of light. Due to their increasing popularity, LEDs come in sizes and shapes that can replace CFLs, as well as T-5, T-8, and T-12 fluorescent tubes. According to Philips, LEDs have a very long life and can cut energy costs by up to 50% (Philips What are LEDs?, 2011). Additionally, according to NetLED Lighting, a typical 4' T-5 LED uses 14 W, which is over 50% more efficient than the 28 W used by the T-5 fluorescent tube shown in Figure 7 (NetLED Lighting, 2011). In addition to massive energy savings, LEDs also mitigate the need to replace the physical light fixture. While it's possible to switch T-8 fluorescent tubes with T-5 LED tubes in a new light fixture, the energy efficiency of LEDs allows the user to simply switch T-8 fluorescent tubes with T-8 LED tubes and gain similar savings. These LED tubes are beginning to replace the recommendation of switching to T-5 fluorescent tubes due to their high energy efficiency.

2.4.3 Heating, Ventilation, and Air Conditioning

Research shows that poor heating, ventilation, and air conditioning (HVAC) is another major cause of carbon emissions. The chart provided from the Carbon Trust in Figure 5 shows that HVAC accounts for almost 33% of the total carbon emissions from energy use by public and commercial buildings. As a result, there are many opportunities for SMEs to save money and reduce carbon emissions through adjusting HVAC.

Boilers contribute to a large portion of the total carbon emissions from heating, ventilation, and air conditioning. There are a variety of different reasons why boilers contribute to energy loss including, but not limited to: (1) Type of fuel; (2) Method of pumping; (3) Hot air circulation and radiation system; and (4) Building management.

Two of the more common types of fuel used to heat boiler systems are oil and natural gas. Older boilers tend to be heated by oil, whereas new, more efficient boilers tend to be heated by natural gas. According to the Environmental Protection Agency, natural gas is the cleanest of all fossil fuels, releasing lower levels of carbon dioxide and other harmful greenhouse gases. Table 2 compares the pollutants emitted from natural gas, oil, and coal.

Table 3 - Fossil Fuel Emission Levels (NaturalGas, 2010)

Fossil Fuel Emission Levels
- Pounds per Billion Btu of Energy Input

Pollutant	Natural Gas	Oil	Coal
Carbon Dioxide	117,000	164,000	208,000
Carbon Monoxide	40	33	208
Nitrogen Oxides	92	448	457
Sulfur Dioxide	1	1,122	2,591
Particulates	7	84	2,744
Mercury	0.000	0.007	0.016

Source: EIA - Natural Gas Issues and Trends 1998

Switching from oil to natural gas will not only reduce carbon emissions, but will also provide significant monetary savings. Energy consumption calculation sheets used by the Surrey County Council estimate the price of natural gas to be £0.023 per kWh, as opposed to the £0.525 per litre for oil. Using additional conversion factors, 1 litre is the equivalent of 11.69 kWh. Taking this information and the changing prices for gas and oil into account, replacing an oil-fuelled boiler with a natural gas boiler can save around 50% on energy consumption costs. As a result, this is a common carbon reduction solution suggested after energy surveys.

Another less popular, yet energy efficient method used for heating is biomass fuels. Biomass refers to a number of substances, ranging from animal waste to purpose grown energy crops. Among the more popular materials used are wood chips and wood pellets. Wood chips are simply small chunks of untreated wood, whereas wood pellets are small, manufactured items made with dried wood. Water content determines how much usable heat is released upon combustion. Lower water content results in the release of more usable heat. As a result, wood pellets release more usable heat than wood chips.

The biggest selling point for biomass fuels is their low net carbon cycle, since burnt biomass materials can be recycled and used to produce new biomass materials. On the contrary, fossil fuels release carbon dioxide that is unable to be recycled. Low net carbon emissions for wood chips and wood pellets results in up to a 90% increase in energy efficiency over natural gas for the same amount of energy used (Carbon Trust Biomass Heating, 2009). Additionally, the cost of biomass fuel is significantly cheaper than fossil fuel and has little market fluctuation.

Conventional natural gas and oil boilers use fuel to heat water, which is subsequently circulated throughout the building by a number of pumps. These pumps work near 100% of their max operating power while pumping hot water through pipes. Once water has left the pump, the flow rate is dampened down to its required rate of about 70-80% by a special valve. Variable speed drives (VSDs) alter the way that the flow rate is dampened. Instead restricting flow rate using a valve, VSDs reduce the power input of the motor itself to achieve the same results. The Affinity Laws help to explain potential energy savings from reduced power usage; "The Affinity laws state [that] Flow is directly proportional to speed, torque is directly proportional to speed squared, [and] power required is proportional to speed cubed. Therefore, this means that if 100% flow requires full power, 75% flow requires 0.753= 42% of full power, [and] 50% flow requires 0.53= 12.5% of the power… A variable speed drive saves energy by reducing the actual speed of the motor when full flow is not required" (Lloyd, 2009). Savings from the installation of variable speed drives can be easily calculated using an energy savings calculator from ABB. This calculator uses kilowatts (kW), operating hours, and the desired flow rate to produce expected annual savings, initial cost, and payback period. The calculator can be view in Appendix B.

Radiators are a common method for dispersing heat produced by boiler systems. Older systems use a single pipe circuit, which is less efficient than double pipe radiation circuits. Single pipe circuits circulate hot water through a single pipe to each radiator in the circuit. Due to the lack of a return pipe, the temperature of the hot water drops as it flows to each successive radiator. This causes the radiators at the beginning of the circuit to disperse warmer steam than radiators toward the end of the circuit. Double pipe circuits ensure equal water temperature throughout all radiators in the system. The second pipe returns water to the pump for reheating, resulting in less heat loss and a higher efficiency (Home Heating Systems and Solutions, n.d.). While changing a radiator system can be expensive, reducing heat loss through this method can be a valid recommendation after an energy survey.

Radiators can be regulated through thermostatic radiator valves (TRVs). TRVs are easily installed and fit onto each individual radiator. As a result, this allows for more control over each individual room. The user can set the thermostatic radiator valve higher or lower in each room depending on the temperature. TRVs are a cheap option to regulating heat throughout the building, and can be recommended after an energy survey to buildings that do not have them (BBC, 2008)

Lastly, poor building management can also result in energy loss. Poor building management includes things like setting timers to irregular hours and setting thermostats to high temperatures, thus overheating the building. One recommendation to remedy poor building management is to install a building management system (BMS). BMS is a computer system that connects an entire building and allows for easier regulation of timers and thermostats. The system allows the building managers to control which plant services are on through remote access. These systems are generally seen in new buildings, but can prove to be a viable option for buildings experiencing poor building management.

. These different methods of carbon reduction are used nationally throughout the United Kingdom. As a result, they provide a solid base for our carbon reduction project on small and medium enterprises within the Borough. Energy surveys help reveal where energy loss is taking place, and these different recommendations can reduce the amount of energy loss in those areas. Identifying opportunities for carbon reduction among SMEs provides a potential target for the Reigate and Banstead Borough Council to meet the national goals set throughout the United Kingdom, as well as goals set by their Sustainable Energy Strategy.

3. Identifying Carbon Reduction Opportunities

The overall goal of this project was to assist the Reigate and Banstead Borough Council in identifying carbon reduction opportunities among small and medium enterprises (SMEs) within the Borough. In order to accomplish this goal, the project team identified four different objectives:

- Characterize the process of energy auditing and identify some of the best practices in energy auditing in the United Kingdom (UK)
- Identify patterns of energy consumption and carbon emissions among small and medium enterprises
- Develop overall strategies for reducing carbon emissions and develop specific action plans for each small and medium enterprise
- Recommend how the Borough should conduct future audits and outreach efforts to small and medium enterprises within the Borough

In order to accomplish these objectives, the project team used a variety of data collection methods. These methods included performing additional research on energy efficient technologies, interviews with building managers, conducting an energy survey on each building, and quantifying data using carbon calculators and spreadsheets. Table 4 represents the thought process that lead to the creation of the desired goals and objectives, and also outlines the method of data collection for each of these goals and objectives.

Table 4 - Outline of Goals and Objectives, Data Needed, and Methods of Data Collection

Question	Data Needed	Method of Data Collection
What are the best practices in energy auditing in the United Kingdom?	Identify general approaches to energy auditing. Identify specific practices to energy auditing in the United Kingdom. Identify specific practices to energy auditing in Reigate and Banstead.	Perform a basic literature review. Supplement the basic literature review with additional materials available in the United Kingdom. Conduct interviews or shadow professional energy auditors. Conduct interviews with the Reigate and Banstead Borough Council staff.
What are some patterns of energy consumption and carbon emissions among small and medium enterprises?	Identify an appropriate sample of SMEs. Determine how to perform an energy audit. Determine how to identify patterns of energy consumption for potential carbon reductions.	Contact SMEs located in the Holmethorpe Industrial Estate and other locations using an online directory. Develop auditing protocols based on checklists and shadowing professionals. Conduct audits to gather data on carbon emissions. Analyze gathered data to identify common trends.
What are some overall strategies for achieving carbon reduction and how do we develop specific plans for each small and medium enterprise?	Identify carbon reduction options available for each SME. Assess technical and economic feasibility of carbon reduction options.	Perform a cost benefit analysis and identify payback periods for each solution. Prepare an action plan for each SME and prioritize recommended solutions.
How should the Borough expand and modify the program to outreach to SMEs in the future?	Identify the usefulness of energy surveys for SMEs. Identify challenges faced during the energy auditing process. Identify methods for further outreach to SMEs.	Send feedback forms to SMEs that have been audited. Analyze some of the barriers faced during energy audits and the recommendation process. Create flyers and brochures for the Council's use.

3.1 Objective 1: Characterizing the Best Practices in Energy Auditing

The first step in our methodology was to characterize the process of energy auditing and identify some of the best energy practices in the United Kingdom. We accomplished this objective by shadowing Ian Sharpe, an experienced energy manager from the Surrey County Council, conducting a series of unstructured interviews with Raymond Dill, another experienced energy manager from the Reigate and Banstead Borough Council, and performing additional research on new, energy efficient technologies.

The project team shadowed Ian Sharpe of the Surrey County Council on a walkthrough energy survey of the Wray Park Fire Complex, as well as a tour of the highly energy efficient Surrey County Council building. During the shadowing process, we were able to identify how long a typical energy survey takes, what to bring to an energy survey, some of the difficulties encountered, and important topics of interest. Additionally, we were also able to physically view some of the newer, more energy efficient technologies, which helped to identify some of the best energy practices in the United Kingdom.

The walkthrough survey of the Wray Park Fire Complex took around an hour to complete. Depending on the size of the building, we concluded that a basic walkthrough audit on small and medium enterprises could last anywhere from 15 minutes to an hour. Since Ian was an experienced energy manager and knew what to look for, he took notes on a blank sheet of paper rather than using a checklist. While we encountered no difficulties during our audit of Wray Park Fire Complex, Ian revealed that not having access to the boiler room or a building manager could cause some problems. From our observations, we made a list of different topics of interest to consider during energy surveys. This list can be viewed in Appendix C. Additionally, Ian confirmed our original research from the Carbon Trust regarding the two biggest areas of energy loss, which were heating and lighting.

During the energy survey of the Wray Park Fire Complex, Ian explained how some of the older technology found in the building worked. He explained the technology behind boiler systems and hot water calorifiers, the difference between forced air and atmospheric boilers, single pipe versus double pipe radiator systems, and so on. We used this information to gain a better understanding of what to look for during our own energy surveys. Subsequently, Ian took us on a tour of the Surrey County Council building where he explained some of the more energy efficient technology. This included hot air compensation, building management systems, variable speed drives, and many more. By viewing the plant equipment in the Surrey

County Council building, we were able to create a list of different technologies which we used to supplement our literature review.

Our unstructured interviews with Raymond Dill yielded additional information on the best energy practices in the United Kingdom. Raymond provided us with some information on solutions that he had personally implemented. This included information on biomass fuelling, LED lighting, and the adjustment of boiler operation hours. Since Raymond had access to meter readings, he was able to show us the amount of savings since these solutions were implemented. In addition to showing us results, Raymond also brought us on site to a location where he implemented LED lighting. We concluded that LED lighting and fluorescent tubes had a similar light output, yet LED lighting was significantly more efficient.

Using the information gained from Ian and Raymond to extend and supplement the literature review helped us to further identify some of the best energy auditing practices in the UK. We researched additional information on the Carbon Trust website, as well as large manufacturing websites, such as General Electric and Philips. We also researched common practices found in the United States. This information came from a few books, most notably Thumann and Mehta's *Handbook of Energy Engineering*, Krarti's *Energy Audit of Building Systems: An Engineering Approach*, and Doty's *Commercial Energy Auditing Reference Handbook*.

3.2 Objective 2: Identifying Energy Consumption Patterns among SMEs

Having identified the range of audit practices, we accomplished our next goal of identifying energy consumption patterns among SMEs. Identifying energy consumption patterns among SMEs involved four primary tasks: (1) Identifying an appropriate sample of SMEs; (2) Developing energy audit protocols; (3) Conducting energy audits for each specific SME; and (4) Analyzing gathered data to identify common trends. Figure 9 provides an overview of the steps and methods we used to accomplish our objectives.

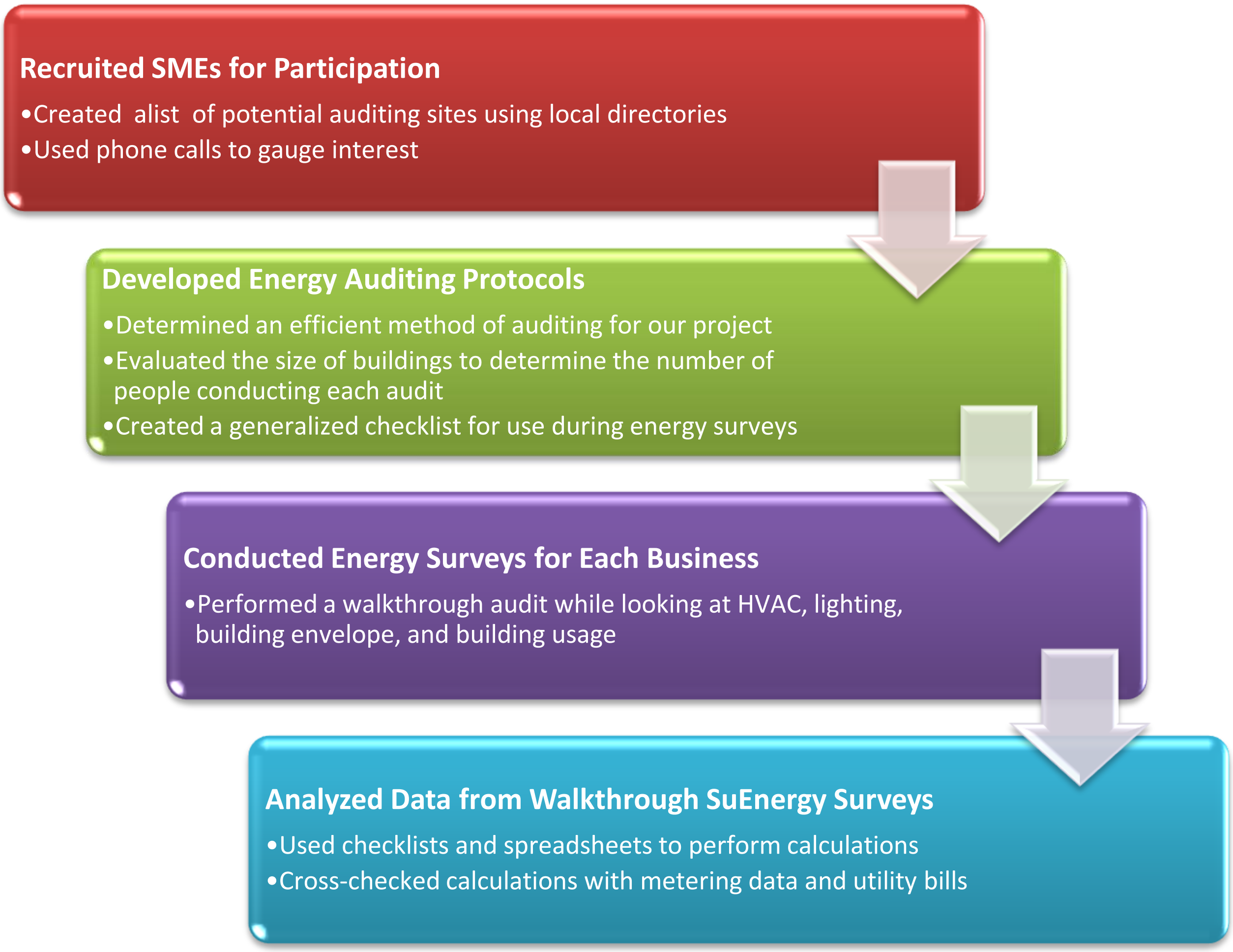


Figure 9 - Identifying Energy Consumption Patterns

The project team recruited a sample of 4 public buildings and 7 SMEs in the borough of Reigate and Banstead to participate in these energy audits. The public buildings included a school, library, and fire complex, while the recruited SMEs ranged from a restaurant to YMCA athletic and residential facilities. While the Reigate and Banstead Borough Council provided an initial list of interested SMEs, we built on this initial list of by using local directories. This allowed us to target businesses in a defined geographic area that were interested in receiving an energy survey. The town of Redhill, and more specifically the Holmethorpe Industrial Estate, was one of these areas since it is an area where new development was taking place.

After creating a substantial list of companies from these target areas, we made a series of phone calls to gauge interest. Prior to calling these companies, we made a call prompt, which can be view in Appendix D. We encouraged SMEs to participate by explaining that the energy survey is free, takes up very little time, and can result in significant and immediate cost savings. Contacts from some of these companies were not available during our initial phone calls. As a result, we made multiple phone calls in an effort to reach these individuals. We also faced difficulty in having companies agree to be audited. Some companies wanted to know how they could improve energy efficiency, whereas other companies thought that they were either very energy efficient already, or just weren't interested.

With these difficulties in mind, we scheduled times and dates to conduct energy surveys for interested companies. During the scheduling process, we explained how having access to a building manager and the boiler room would help us generate helpful and accurate results. All eleven energy surveys were scheduled over a 3-4 week period.

After successfully recruiting 3 public buildings and 8 SMEs to participate in a free energy survey, we developed protocols for conducting the energy audits. We decided to follow the same style of walkthrough audit that Ian conducted during the shadowing process. This type of audit is what we called a "walkthrough plus" audit, which combined a typical walkthrough audit with a mini-audit. The walkthrough plus audit consisted of a normal walkthrough audit, plus any supplemental information available to us, such as energy bills and metering results provided by the building manager. We decided to use this type of audit since it provided an adequate amount of knowledge with relative efficiency for the amount of time required. It also allowed us to determine whether or not this audit model could be used by the Borough Council in the future.

Evaluating the size of each building before performing an energy survey helped us to determine how many people we would need to be able to conduct each individual survey. We first visited the Holmethorpe Industrial Estate, which provided us with a more accurate sense of the size of the buildings we would be surveying. For buildings that we were not able to visit and evaluate beforehand, we utilized Google Maps and company websites to help us determine the building's size. From these preliminary size evaluations, we found that a group of two would usually be sufficient for conducting energy audits, with the exception of a larger four-story office building. This system was efficient and beneficial to our overall work flow, as it allowed us to work on reports while still conducting energy surveys. We created a rotating schedule so each group member would share in both tasks: when one team was out conducting an energy survey, the other team worked on the analysis and writing of the reports. We would then alternate, which allowed the team that had just preformed an energy audit to work on the report for that specific building, while the other team conducted the next scheduled audit.

Another component of developing energy auditing protocols was creating a checklist for the walkthrough audit. We found that the checklists on the Carbon Trust website were too specific for our walkthrough plus audits. An example of a checklist from the Carbon Trust for office buildings can be viewed in Appendix A. Another member of the Surrey County Council energy team, Gonzalo Jimenez, referred us to the Green Impact checklist. We used a modified version of this checklist to include the number of lights, power input of the boiler system, hot water calorifier data, and a few miscellaneous questions regarding the building's usage. The completed versions of these checklists can be found in Appendices E, G, I, K, M, O, Q, S, U, W and Y.

During the eleven energy surveys, we utilized our modified checklist and looked at a few key areas: HVAC, lighting, building envelope, and building usage. Building envelope included whether or not the buildings were insulated, checking for any obvious open-air leaks, and looking at the age and types of windows installed. Lighting included examining what types of lighting was being used, how many lights were used, and determining if unpopulated areas were being lit. For HVAC, we looked at thermostat settings, boiler systems, pumping systems, and different types of radiator systems throughout the buildings. The building usage portion of our energy audit had us looking at if the boilers, lighting, and any other equipment were kept on during unnecessary times, such as hours where no one is in the building.

In order to provide carbon reducing solutions to SMEs, we quantified and analyzed data procured from energy audits. We used data from our filled out checklists to create spreadsheets calculating the annual running cost of lighting and heating throughout the buildings. Lighting was calculated through a series of equations using operation hours, number of lights, wattage, and price of electricity. Similarly, the annual cost of heating was calculated using the input power of the boiler in kilowatts, operating hours per year, boiler efficiency, which is found by taking the output of the boiler over the input of the boiler, and the cost of natural gas or oil, depending on the type of boiler. From these annual costs, we were able to see how much money each building was spending on lighting and heating. If the building had metering and utility bills, we were able to cross-check our calculations with the cost expenditure from gas and electric companies to see if it was consistent. If our calculations were not consistent, we determined that the gas or electric companies may be overcharging for utilities.

These spreadsheets also allowed us to calculate savings from technological upgrades. For example, we calculated the amount of savings from switching current lighting to LED lighting solutions for many companies. This involved taking the investment cost for LED lighting, calculating the amount of kilowatt hours used from these LED lights, and calculating the kilowatt hours and money saved per year. From this, we were able to calculate the payback period by taking the investment cost over the annual savings.

Additionally, we were also able to analyze qualitative data gathered from our checklists. This included things like leaving windows open when heating was on, not taking advantage of ambient light during the day, and over lighting areas of low traffic. Quantifying qualitative data involved taking a percentage of the annual heating and lighting cost expenditures, such as 5 or 10%, and using that number as estimated savings from behavioural changes. For example, lowering the thermostat settings by 1° Celsius can result in an 8-10% savings according to the Carbon Trust. As a result, we calculated the total expenditure for heating per year, and took 8% of that cost to calculate savings. Examples of these calculations can be seen in the "Calculations" section of our reports, which are found in Appendices F, H, J, L, N, P, R, T, V, X, and Z.

3.3 Objective 3: Developing Carbon Reduction Strategies Specific to Each SME

Once we completed the audit and data analysis, we created reports specific to each public building and small and medium enterprise. These reports were broken down into different sections: (1) Introduction; (2) Summary of Findings; (3) Potential Savings; (4) Recommendations; (5) Conclusion; and (6) Calculations. We scheduled follow up meetings to present our findings, and emailed our reports for the companies to review prior to these meetings. Additionally, we created a feedback form for companies to evaluate the usefulness of our energy surveys. Figure 10 illustrates an overview of our strategy for developing carbon reduction reports, as well as presenting our findings and receiving feedback.

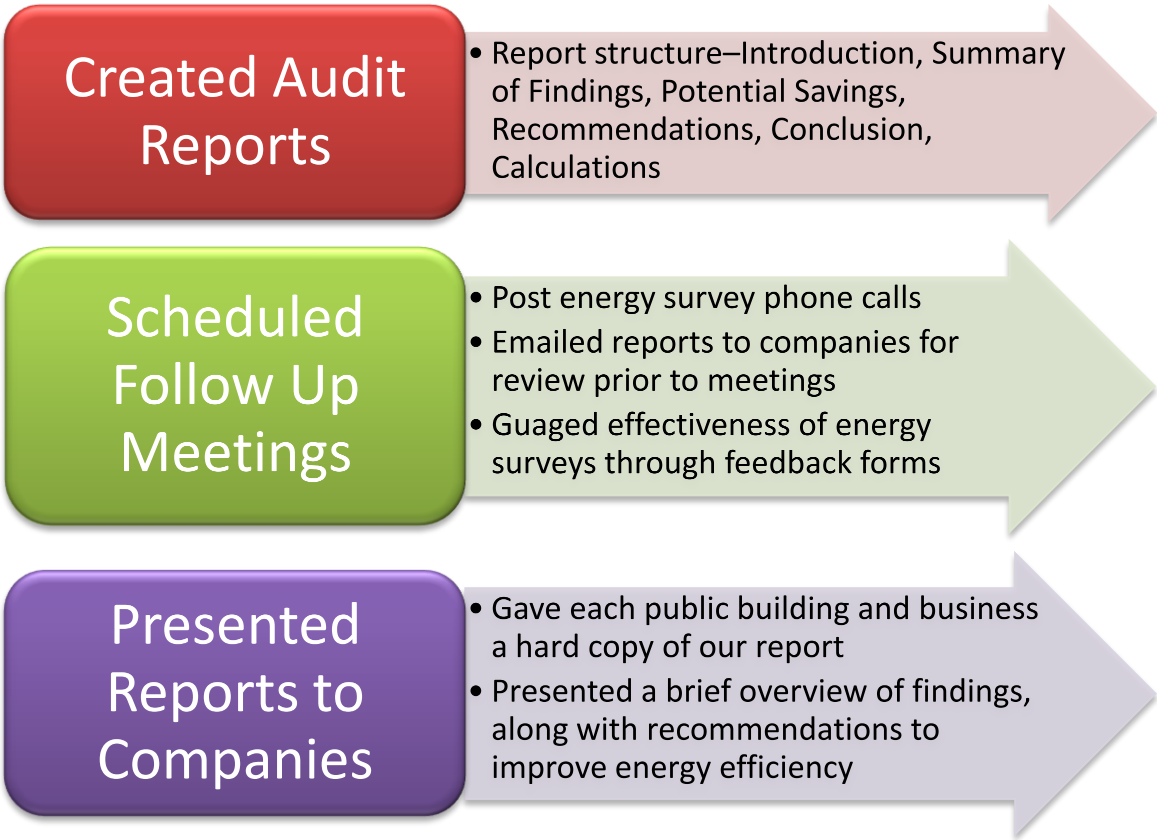


Figure 10 - Energy Survey Follow Up Plan

The "Introduction" section provided basic information about the building and the company itself, as well as the type of auditing method used. This included a variety of information, namely the type of building (school, factory, etc.), the operation hours, and the size of the building.

The "Summary of Findings" section gave an overview of our findings during our energy surveys. These findings normally didn't include positive aspects regarding energy efficiency, but rather areas of interest on where energy efficiency could improve. This provided the basis for the potential savings section, as we were able to identify areas of low energy efficiency. These findings helped the reader understand recommendations made later in the report.

The "Potential Savings" section took into account all areas where the SME could improve energy efficiency. We broke down the section into "No Cost" solutions and "Cost" solutions, which we thought would give companies a variety of options for implementation. "No Cost" solutions were energy reducing solutions that required no initial capital, whereas "Cost" solutions were energy reducing solutions that required some initial capital. We utilized tables to provide a clear understanding of the energy efficiency problem, the area where this problem was taking place, the solution, and a brief overview of the annual savings.

The “Recommendations” section used the data provided in the potential savings section to prioritize energy efficiency improvements. We wanted to recommend the most feasible solutions based on annual savings, investment, and payback period, and as a result, a typical recommendations section contained our top three priorities. Our thought was that only recommending the top three priorities would keep the reports relatively short, meaning that companies might be more likely to read these reports in their entirety. These priorities contained a detailed breakdown of everything that our recommendation entailed, as well as additional information on why we recommended the particular solution. Deciding the order of priorities involved a cost-benefit analysis and involved many different factors. In general, we decided to recommend the “easiest” solutions to implement first, followed by solutions that are feasible, but not necessarily easy to implement. An example of this is recommending behavioural changes over changing all current lighting to LED lighting. The behavioural changes have no initial cost and an immediate payback period, whereas changing lighting has an investment, but is generally feasible. An example of a solution that would not be as feasible is a solar panel that costs £10,000 to install and only saves £300 per year. In this case, the payback period dramatically outweighs the savings benefit. Our ideal solutions were ones that were relatively cheap, but had a high amount of annual savings and quick payback period while reducing carbon emissions.

The “Conclusions” section brought our reports to a close and summarized our top recommendations. This section served as a more succinct version of the “Recommendations” section for companies unable to read the entire report. In addition to the “Conclusions” section, we also included a “Calculations” section for companies to see the math behind our recommendations. The “Calculations” section contained editable spreadsheets so that companies could do their own calculations in the future. All eleven reports that we generated can be viewed in Appendices F, H, J, L, N, P, R, T, V, X, and Z.

After finalizing our reports, we then made follow up calls to these public buildings and SMEs to present our results. Contrary to the initial scheduling process, we did not encounter as many difficulties setting up times and dates to present our reports. We were unable to reach a few contacts initially, but followed up with additional phone calls and scheduled these meetings. In addition to making these phone calls, we also emailed the reports to each individual company for them to review. All buildings that we audited read the full report, or at the very least read the recommendations section.

During these individual presentations, we printed out a paper copy of our report for the company to keep. Rather than going through the entire report, we decided to give a brief overview of our findings, as well as our energy saving recommendations. This allowed the reports to be short, yet also provided an adequate explanation for why we recommended certain solutions. These presentations were more like discussions, as the representative from the company would stop us to ask pertinent questions they had.

Lastly, we also created a feedback form that was attached to our email with the report. These feedback forms allowed us to get a better sense of if these energy surveys were useful. Additionally, the forms also provided insight into how professional our reports were and whether or not businesses would recommend an energy survey to other businesses. These feedback forms can be viewed in Appendix AA.

3.4 Objective 4: Recommendations for the Borough

Although one of our objectives was to provide useful recommendations for each specific SME, our overall goal involved providing the Council with recommendations on how the Borough can modify and expand the program in the future. To accomplish this goal, we analyzed common trends found in our data to create a top three energy savers for SMEs, as well as headline figures for the Council to promote energy savings. The top three energy savers were the most common recommendations found throughout our reports. To supplement the top three energy savers, we also created headline figures, which included the average annual savings, the average payback period, and the average amount of carbon reduction from the top three. Carbon reduction was calculated by taking the kWh saved and using conversion factors from the Carbon Trust (see Appendix BB) to produce the amount of carbon reduction in kilograms (kg). We then divided this number by the amount of kilograms in a tonne, producing the reduced emissions in tonnes. Since behavioural changes were a mix of both heating and lighting improvements, we used an average of the natural gas and lighting conversion factors.

We also suggested to the Council whether the carbon reduction program was worth the time and effort. We did this by analyzing the feedback forms given to us by companies. Additionally, we created content for promotional materials for the Council to use if they choose to extend the energy surveying program. This included using headline figures for a promotional flyer, as well as creating content for an informational brochure on how SMEs can reduce carbon emissions themselves.

4. Energy Consumption Trends and Future Outreach Efforts

An analysis of general energy consumption trends allowed us to identify carbon reduction opportunities among small and medium enterprises. Examining these trends also lead to the creation of recommendations on how the Borough should conduct future audits and outreach efforts to small and medium enterprises within the Borough.

The development of energy consumption patterns involved using data from our eleven personalized reports to generate headline figures, as well as the top three recommendations for small and medium enterprises to improve energy efficiency. We found that the top three most common recommendations were changing current lighting to LED lighting solutions, increasing energy awareness, and adjusting the operating hours of boilers and hot water calorifiers. From this, we concluded that the greatest opportunity for small and medium enterprises to improve energy efficiency was through changes to heating and lighting, which was consistent with our background research from the Carbon Trust. Additionally, we concluded that continuing to target small and medium enterprises would allow the Reigate and Banstead Borough Council to achieve part of the goal set forth by the Sustainable Energy Strategy, as well as the Climate Change Act of 2008.

Data from feedback forms used in conjunction with headline figures provided additional data used to determine whether or not the Borough should continue an energy surveying program for small and medium enterprises. Despite the small sample size, our data showed that small and medium enterprises found these energy surveys helpful, and that they would implement some of the solutions we recommended. These feedback forms also revealed that our method of energy auditing was efficient given the small timeframe. To further promote energy efficiency among small and medium enterprises, we created materials for the Reigate and Banstead Borough Council to use. This included a flyer with the total monetary savings, average payback period, and total carbon reduction for each of our top three recommendations, as well as an informational brochure on these top three energy savers.

4.1 Benefits from Carbon Reduction

An analysis of the recommendations from our eleven reports yielded headline figures that provided statistical evidence for the benefits of carbon reduction. These recommendations resulted in over £109,000 in monetary savings per year, along with a carbon reduction of 437 tonnes. Figures 11 and 12 illustrate the breakdown of these savings organized by business.

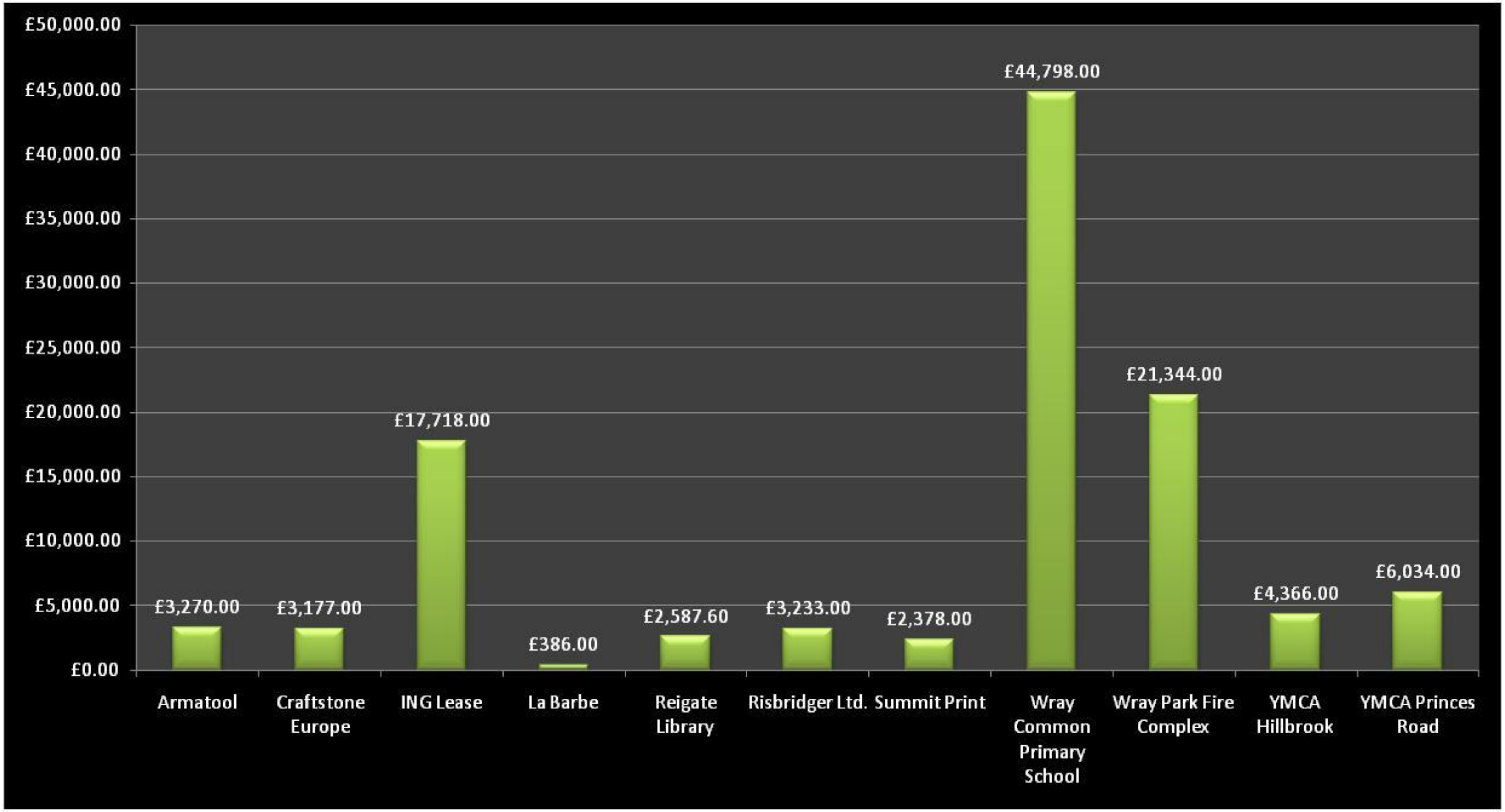


Figure 11 - Annual Monetary Savings from Recommendations

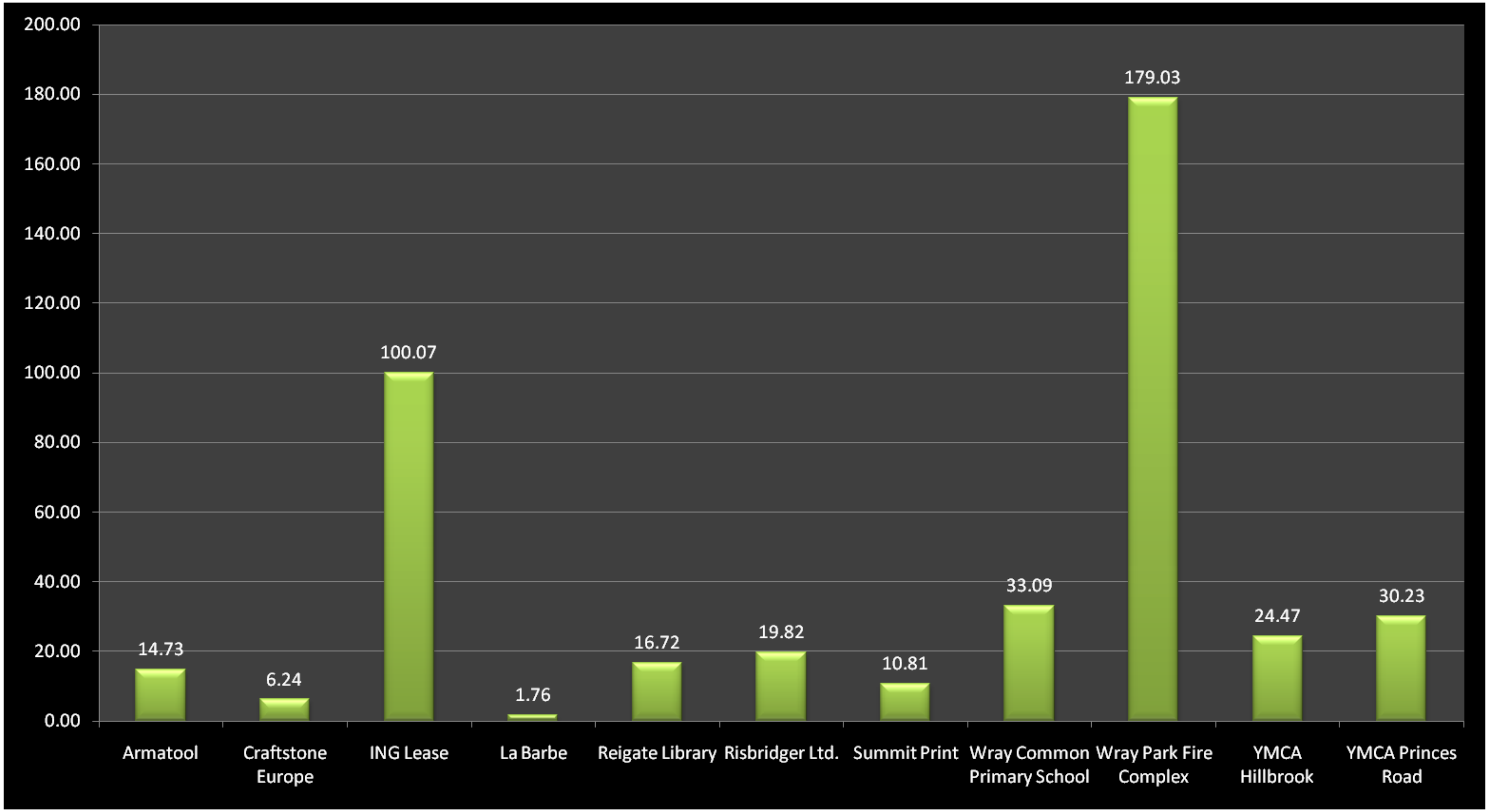


Figure 12 - Energy Savings (Tonnes of CO2) from Recommendations

Data in Figures 11 and 12 for Craftstones Europe is misrepresentative of the potential monetary and energy savings resulting from our recommendations. This inaccurate data was caused by the need for a professional estimate for insulating storage rooms throughout the building. Insulating these rooms would result in a higher number of savings, but we were unable to calculate these savings without a professional quote. Additionally, we were also unable to calculate the carbon reduction from recommending the installation of a wood-chip boiler in the Wray Common Primary School. This resulted in a much lower carbon reduction number for the school.

Despite this inaccuracy, our data suggested a clear statistical incentive for small and medium enterprises to participate in energy surveys. Every business that we audited can benefit from monetary and energy savings through our recommendations, with an average savings of just under £10,000 and just over 58,000 kWh per year, along with 32 tonnes of reduced carbon emissions. The total payback period for all recommendations was just less than 1.3 years. This was calculated by taking the total overall investment over the total annual savings across all businesses.

$$Payback\ Period = \frac{Total\ Invested}{Total\ Annual\ Savings}$$

After completing the payback period, small and medium enterprises could allocate annual savings, displayed in Figure 11, to different aspects of the company.

In order to calculate these numbers, we took the total amount of savings from the recommendations listed in the "Recommendations" section of Appendices F, H, J, L, N, P, R, T, V, X, and Z. In total, we recommended seven different solutions across all of these companies, only six of which required a set of calculations. These suggestions were:

- Switching Current Lighting to LED Lighting Solutions
- Adjust Boiler and Hot Water Calorifier Operation Hours
- Improve Energy Awareness
- Install Variable Speed Drives
- Install Thermostatic Radiator Valves
- Change Boiler from Oil to Natural Gas or Biomass

4.1.1 Calculations for LED Lighting

We counted the amount of light bulbs, figured out the wattage of each bulb, and figured out how many hours these lights were on. Multiplying these figures yielded the total kilowatt hours (kWh) used by the bulbs.

$$Kilowatt\ hours\ (kWh) = (\#\ of\ lights) \times (wattage) \times (hours)$$

From this, we were able to generate the total annual cost by multiplying kWh and the cost of electricity, which we said was 10p/kWh based on information from the Reigate and Banstead Borough Council.

$$Total\ annual\ cost = (kWh) \times (Cost\ of\ Electricity)$$

We then calculated the total cost of installing LED lights using the price guide found on Net LED Lighting (Net LED Lighting, 2011). Typically, one current light bulb was replaced with one LED light bulb, with the exception of areas that were over lit. Again, we took the total number of light bulbs, the wattage of each bulb, and the number of hours each bulb was on to calculate the total amount of kilowatt hours used. The total annual cost for these new LED lights was found by taking kWh times the cost of electricity. We took the total annual cost for the current lighting subtracted by the total annual cost for these new LED lights, which gave us annual monetary savings.

$$Annual\ Monetary\ Savings = Total\ annual\ cost\ (Current) - Total\ annual\ cost\ (LED\ )$$

We also took the total amount of kWh used by current lighting subtracted by the total amount of kWh used by LED lighting to find the annual kWh savings.

$$Annual\ kWh\ savings = kWh\ (Current) - \ kWh\ (LED)$$

The total carbon reduction was calculated by taking the annual kWh savings and multiplying it by the Carbon Trust conversion factor for electricity (.54522) found in Appendix BB.

$$Total\ carbon\ reduction = Annual\ kWh\ savings\ \times (0.54522)$$

4.1.2 Boiler Adjustment Calculations

Boiler adjustment savings were calculated by taking the boiler input (kW), the hours it runs per day, days it runs per week, weeks it runs per year, the boiler efficiency, and a few constants provided by the Surrey County Council to calculate the annual energy input in kilojoules.

$$Annual\ Energy\ Input\ (kJ) = \frac{(kW \times hours \times days \times weeks \times 3600 \times 0.6)}{(efficiency \times 0.8)}$$

This number was then converted to kilowatt hours by conversion factors.

$$Annual\ Energy\ Input\ (kWh) = \frac{(kJ \times 0.278)}{1000}$$

The annual cost was then calculated by taking the kWh multiplied by the cost for natural gas or oil, depending on the type of boiler. These costs were provided by the Surrey County Council or came directly from the gas bills of the company. Most of the time, we used 2.23 pence/kWh for natural gas, and 52.5 pence/litre for oil. If oil was being used, we converted kWh to litres through conversion factors.

$$Annual\ Cost = kWh \times Cost\ of\ Gas\ or\ Oil$$

The adjustment was calculated by reducing the number of hours in the annual energy input calculation by one. The annual costs prior to reducing the number of hours were then subtracted from the new annual costs to produce the annual monetary savings. The same process was done for kWh savings. After finding kWh savings, we then multiplied by conversion factors from the Carbon Trust (Appendix BB), which was 0.18523 or 0.24683 depending on whether the boiler was natural gas or oil.

$$Total\ Carbon\ Reduction = (kWh\ Savings \times 0.18523)$$

4.1.3 Energy Awareness Calculations

Savings for improving energy awareness were calculated by totalling the total cost of electricity and heating and multiplying it by a percentage. This percentage represented potential savings from behavioural changes. We used percentages lower than ones found in Carbon Trust case studies to provide conservative estimates to companies.

$$Annual\ Savings = Total\ Utility\ Bill\ Cost \times Percentage\ of\ Possible\ Savings$$

4.1.4 Variable Speed Drive Calculations

Calculations for installing variable speed drives (VSDs) were done through the ABB calculator seen in Appendix B. The required inputs were the kW of the boiler, the number of boilers, and the number of hours these boilers were on. The calculator did the rest of the work to produce monetary savings, investment, payback period, and tonnes of carbon reduced.

4.1.5 Thermostatic Radiator Valve Calculations

Similar to calculating energy awareness savings, thermostatic radiator valve (TRV) savings used data from energy bills. We calculated the total annual expenditure for heating and multiplied this expenditure by a percentage of savings. According to BBC (2008), installing TRVs can save up to 17% on energy bills each year. As a result, we used a 15% savings.

$$TRV\ Savings = Annual\ heating\ cost \times 0.15$$

The total kWh savings was also calculated by taking 15% of the annual kWh used for heating. Additionally, BBC (2008) also said that these valves would cost approximately £8 each to install of companies did it themselves. Being conservative, we estimated the cost to be about £10 per valve. We multiplied this cost by the number of TRVs needed to produce the investment cost. Carbon reduction was determined by taking the kWh savings and multiplying it by the Carbon Trust conversion factors (see Appendix B) of 0.18523 or 0.24683 depending on if the building was heated by natural gas or oil.

4.1.6 Switching Heating Types

Switching from a boiler that uses oil to a boiler that uses natural gas was similar to the calculation done for boiler adjustment. The only difference is that we took the annual cost for oil and subtracted it from the annual cost for gas to calculate savings. The same thing was done for kWh.

$$Annual\ Savings = Annual\ Cost\ for\ Oil - Annual\ Cost\ for\ Gas$$

The carbon reduction was generated by:

$$CO2\ Reduction = (Annual\ kWh\ oil \times 0.24683) - (Annual\ kWh\ gas \times 0.18523)$$

Switching to biomass involved a series of much more complicated calculations. We used an excel sheet from the Carbon Trust (Carbon Trust Biomass Heating, 2009) that did these calculations for us. Biomass was only recommended once, and the calculations can be seen in Appendix H in the “Calculations” section.

With these calculations in mind, we totalled up the amount of monetary savings for all recommendations and divided it by the number of businesses to produce the average savings. The same process was done to produce the average investment and the average tonnes of carbon reduced.

However, Figures 11 and 12 also showed that the largest monetary savings didn’t necessarily result in the largest energy savings. For example, recommendations for Risbridger Ltd. resulted in the lower monetary savings than Armatool, yet resulted in a higher carbon reduction. Implementing our recommendations could yield a £3,270 annual savings for Armatool and a £3,233 annual savings for Risbridger Ltd., yet the annual carbon reduction for each was 14.73 and 19.82, respectively. This suggests that some recommendations are more beneficial for reducing carbon emissions, whereas other recommendations are more beneficial for saving money.

If implemented, we discovered that our recommendations would yield a combined carbon reduction of 437 tonnes. Figure 13 illustrates the percentages for each company from this total carbon reduction.

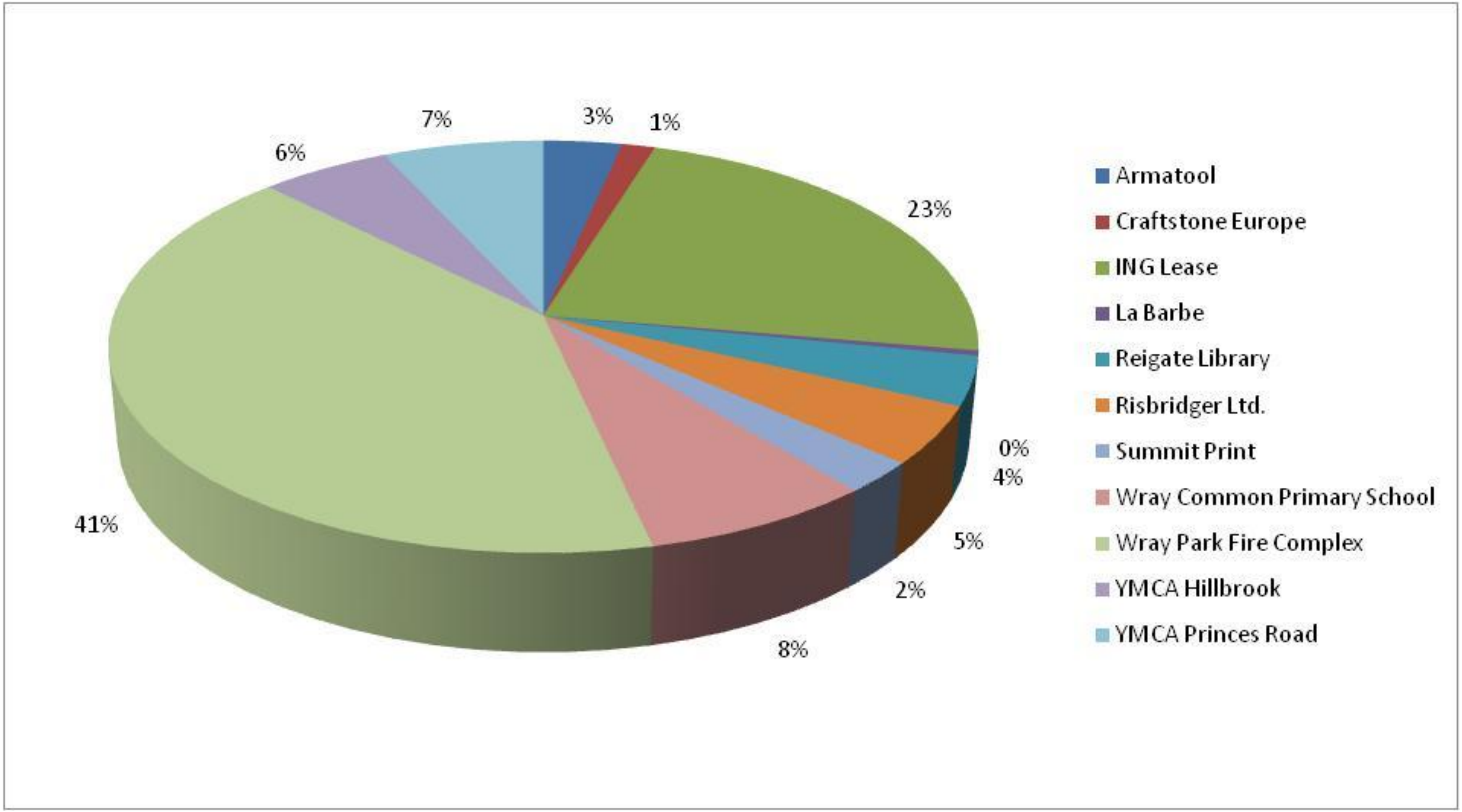


Figure 13 - Carbon Reduction Percentages Broken Down by Business

Our results provided statistical support for the Council to continue targeting both public buildings and small and medium enterprises in carbon reduction efforts. As shown in Figure 13, public buildings accounted for 53% of carbon savings, resulting in a 228.84 tonne reduction. Small and medium enterprises accounted for the other 47% of carbon savings, which totalled a decrease of 208.13 tonnes of carbon emissions. While our results showed that carbon savings from public buildings were higher than in small and medium enterprises, we concluded that targeting both sectors would provide significant amounts of carbon reduction. We discovered that public buildings were run by the Surrey County Council, hence suggesting that it is easier to setup energy surveys to reduce carbon emissions in these buildings than in privately owned small and medium enterprises. However, our results indicated that both sectors would bring the Council closer to meeting the goals set forth by the Sustainable Energy Strategy, as well as the Climate Change Act of 2008.

4.2 Top Three Energy Savers

While this initial analysis provided the statistical benefits of energy surveys and carbon reduction, we wanted to identify the most common energy consumption trends among small and medium enterprises. To do this, we found the three most common recommendations used throughout our reports found in Appendices F, H, J, L, N, P, R, T, V, X, and Z. In order, our results show that these are: (1) Changing Current Lighting to LED Lighting Solutions; (2) Increasing Energy Awareness; and (3) Adjusting Boiler and Hot Water Calorifier Operation Hours. Installing variable speed drives and thermostatic radiator valves were two recommendations that produced additional energy savings, but were not as frequent as the suggestions found in the top three.

Switching current lighting to LED lighting solutions was recommended for ten of the eleven energy surveys conducted. Additionally, Increasing Energy Awareness, or Behavioural Changes, was recommended eight times, with Adjusting Boiler and Hot Water Calorifier Operation Hours being recommended five times. Figures 14 and 15 represent the annual monetary savings and annual carbon reduction, respectively, for each of the top three recommendations. While permanently decommissioning three boilers was a valid recommendation for the Wray Park Fire Complex, we did not include this in the following calculations, since it was a unique recommendation and skewed the data.

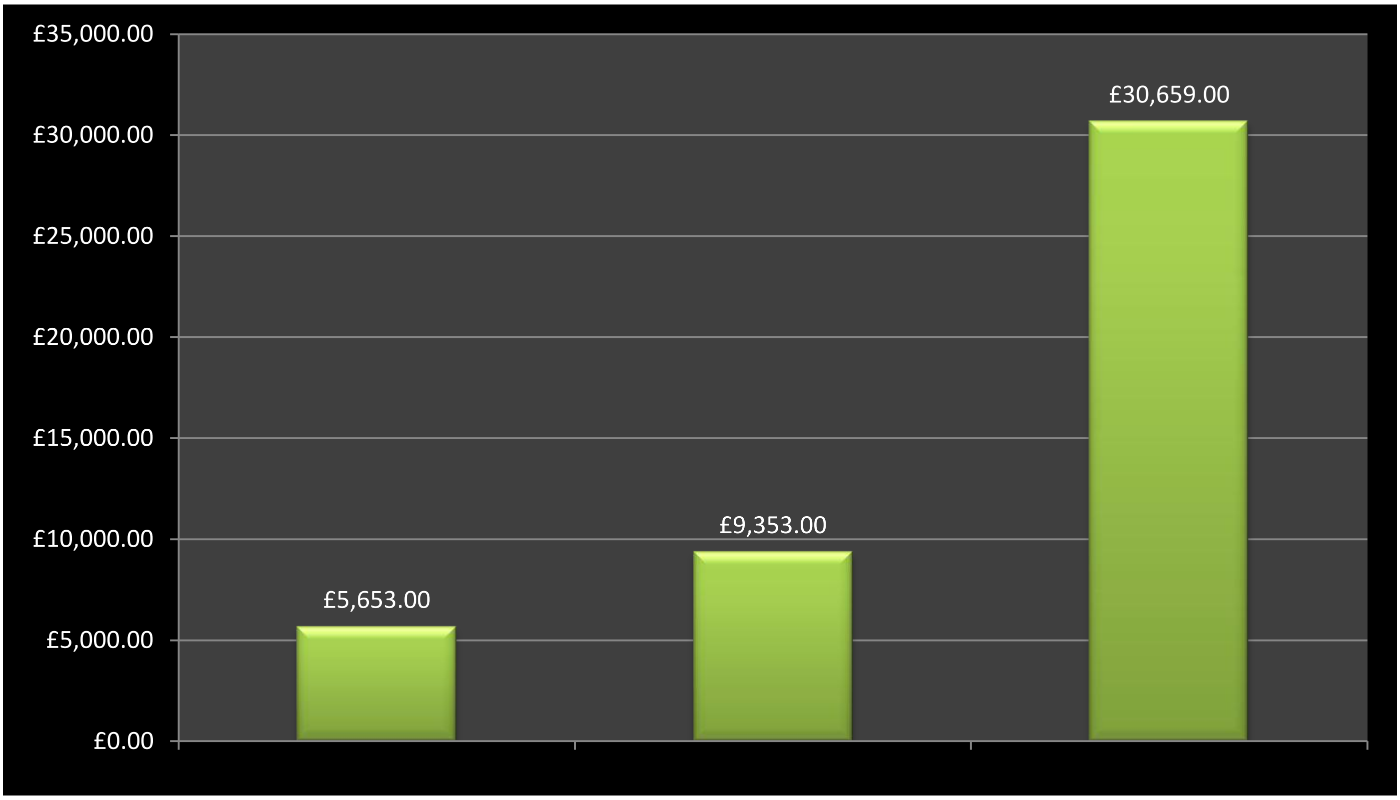


Figure 14 - Top Three Recommendations: Total Annual Monetary Savings

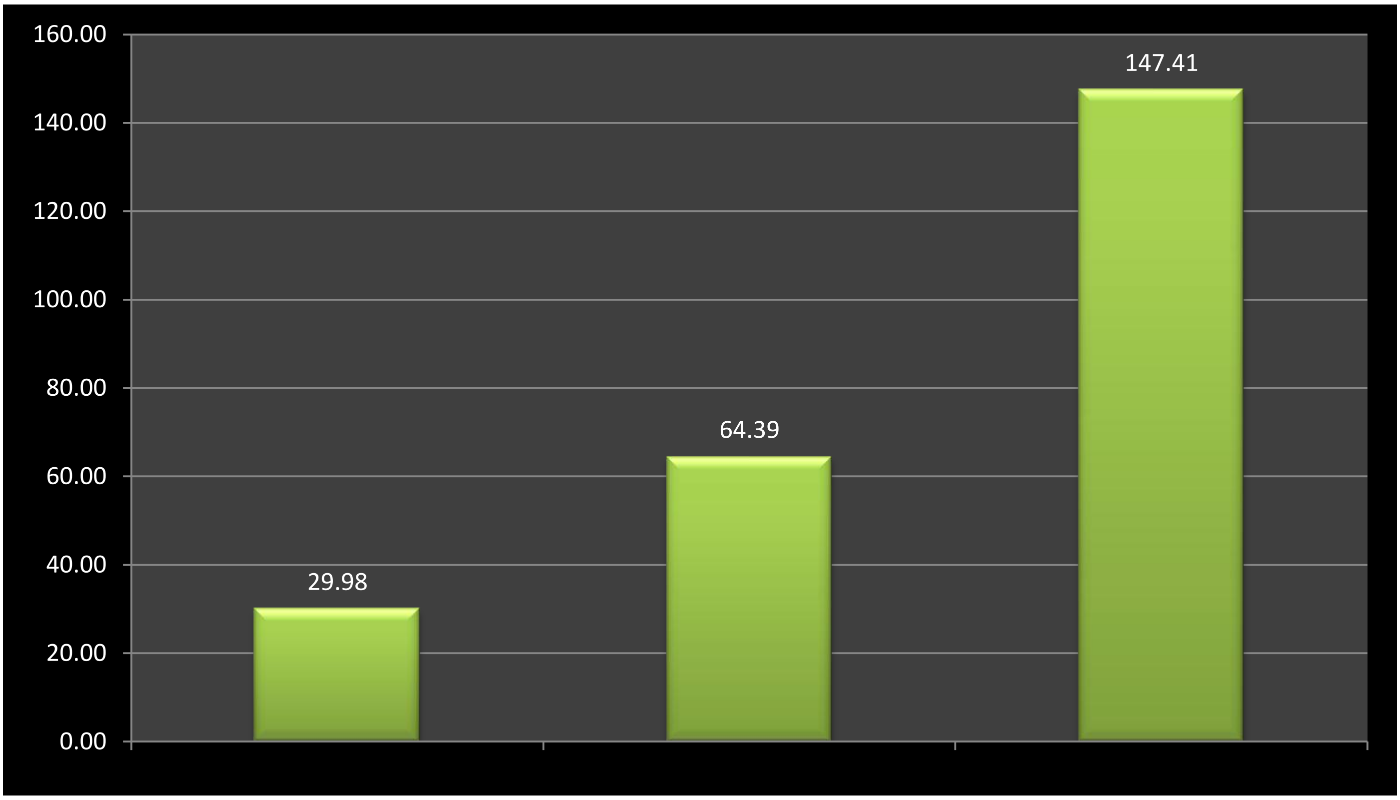
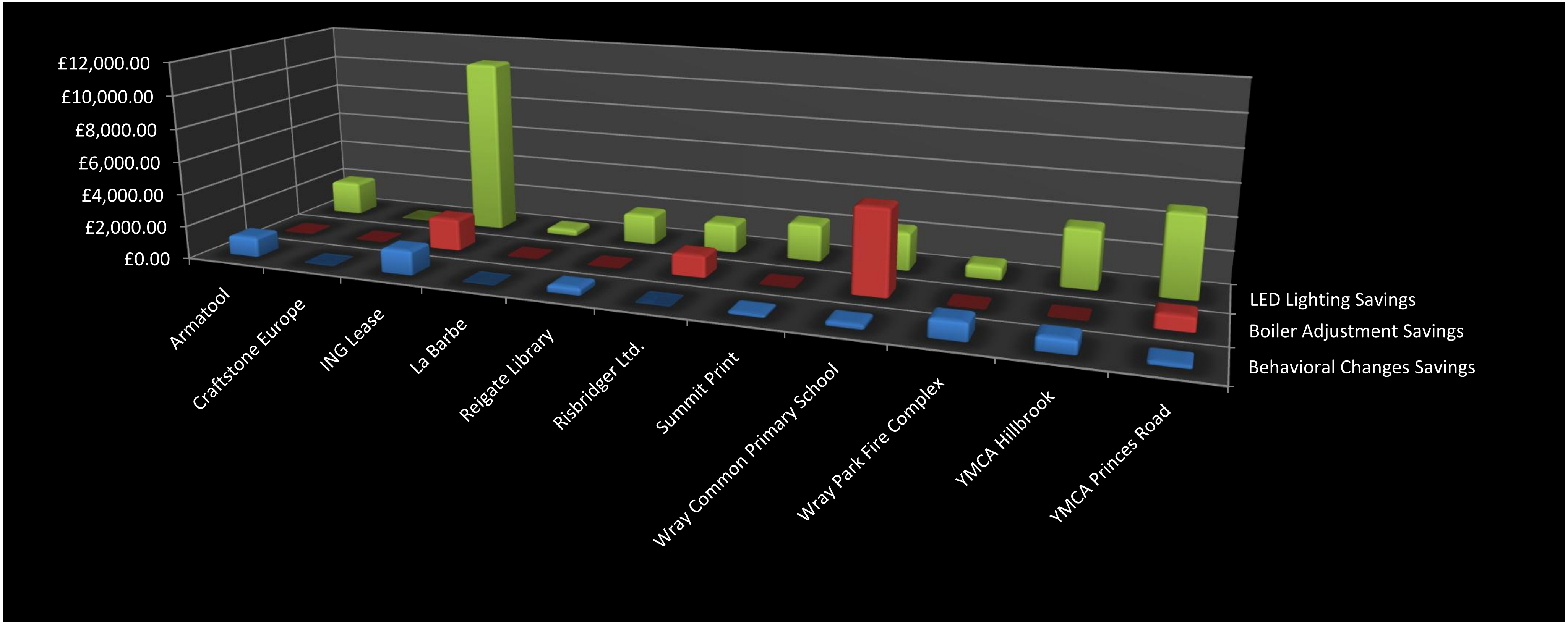


Figure 15 - Top Three Recommendations: Total Tonnes of Carbon Reduced

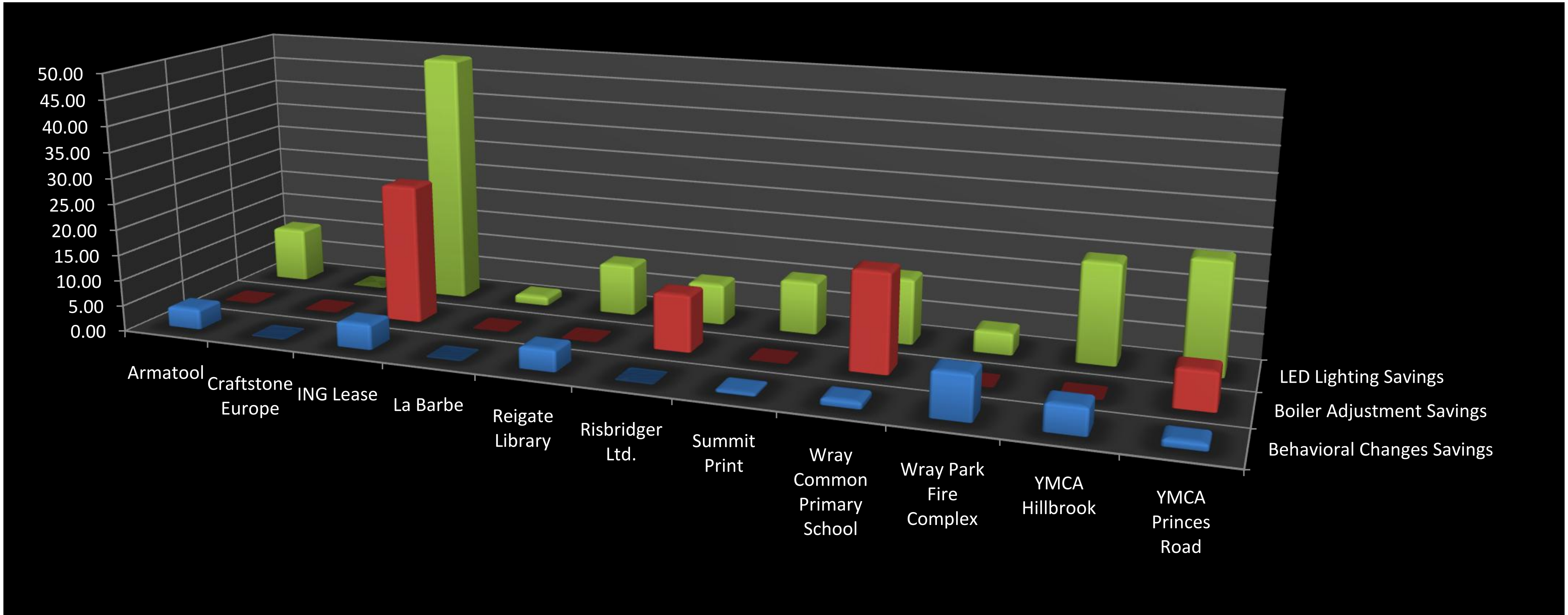
The decision to omit data from boiler adjustment for the Wray Park Fire Complex resulted in a decrease of 166.22 tonnes of carbon reduction, meaning that the other adjustment recommendations across five businesses only resulted in 64.39 tonnes of reduction. Additionally, this recommendation for the Wray Park Fire Complex also accounted for £19,474 in annual savings, leaving the remaining five businesses with monetary savings of £9,353 per year.

In order to further analyze energy consumption patterns, we broke down the data for the top three recommendations across all companies. This allowed us to see which recommendations benefited each individual company the most, both in monetary and energy savings. Figures 16, 17, and 18 compare monetary savings, carbon reduction in tonnes, and energy savings in kilowatt hours from the top three recommendations across all audited public buildings and small and medium enterprises.



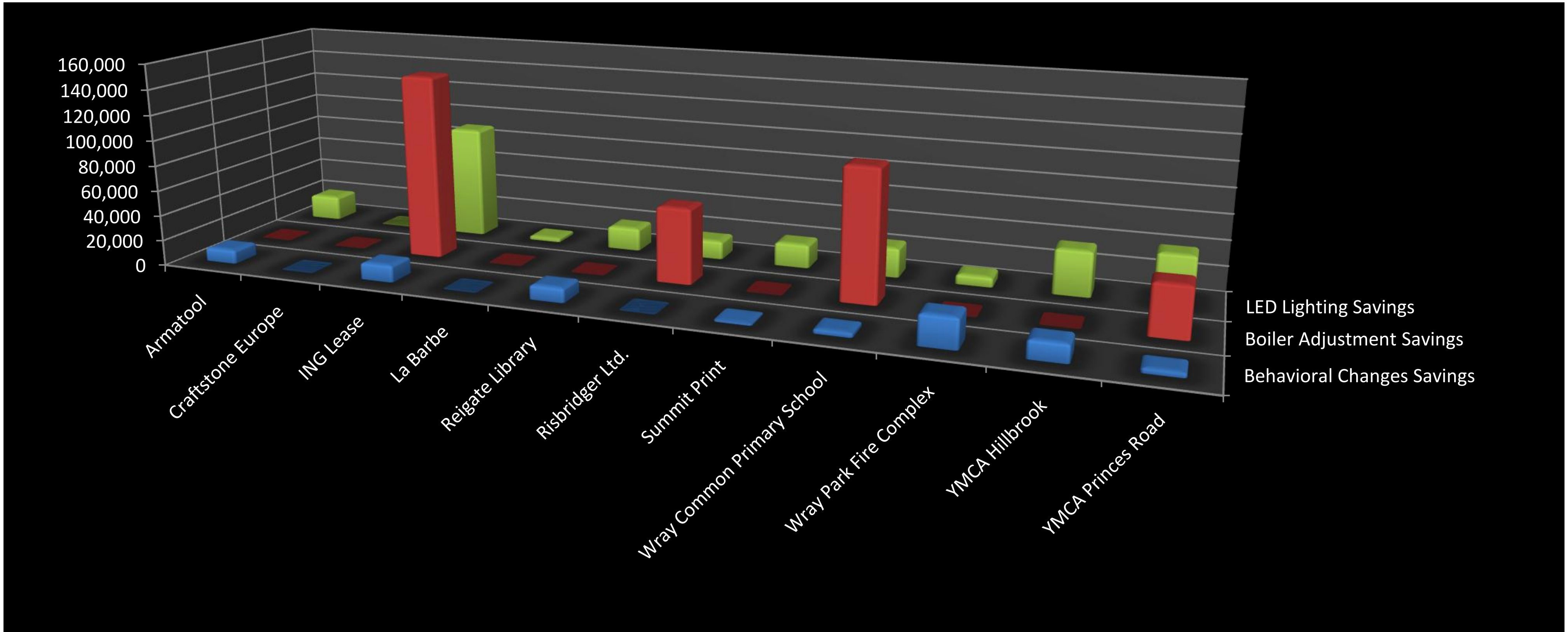
	Armatool	Craftstone Europe	ING Lease	La Barbe	Reigate Library	Risbridger Ltd.	Summit Print	Wray Common Primary School	Wray Park Fire Complex	YMCA Hillbrook	YMCA Princes Road
Behavioral Changes Savings	£1,203.00	£0.00	£1,481.00	£0.00	£450.00	£0.00	£156.00	£269.00	£1,079.00	£815.00	£200.00
Boiler Adjustment Savings	£0.00	£0.00	£1,953.00	£0.00	£0.00	£1,324.00	£0.00	£5,200.00	£0.00	£0.00	£876.00
LED Lighting Savings	£2,067.00	£0.00	£10,746.00	£386.00	£1,829.00	£1,750.00	£2,252.00	£2,329.00	£791.00	£3,551.00	£4,958.00

Figure 16 - Top Three Recommendations: Monetary Savings Broken Down by Business



	Armatool	Craftstone Europe	ING Lease	La Barbe	Reigate Library	Risbridger Ltd.	Summit Print	Wray Common Primary School	Wray Park Fire Complex	YMCA Hillbrook	YMCA Princes Road
Behavioral Changes Savings	4.00	0.00	4.92	0.00	4.20	0.00	0.58	1.31	8.50	5.11	1.37
Boiler Adjustment Savings	0.00	0.00	27.03	0.00	0.00	11.00	0.00	19.08	0.00	0.00	7.28
LED Lighting Savings	10.73	0.00	48.82	1.76	9.97	7.95	10.23	12.70	4.31	19.36	21.58

Figure 17 - Top Three Recommendations: Carbon Reduction (Tonnes) Broken Down by Business



	Armatool	Craftstone Europe	ING Lease	La Barbe	Reigate Library	Risbridger Ltd.	Summit Print	Wray Common Primary School	Wray Park Fire Complex	YMCA Hillbrook	YMCA Princes Road
Behavioral Changes Savings	10,950	0	13,472	0	11,490	0	1,581	3,593	23,268	13,980	3,758
Boiler Adjustment Savings	0	0	145,950	0	0	59,403	0	103,000	0	0	39,285
LED Lighting Savings	19,681	0	89,547	3,220	18,285	14,586	18,771	23,290	7,907	35,509	39,579

Figure 18 - Top Three Recommendations: Energy Savings (kWh) Broken Down by Business

The data from Figures 16, 17, and 18 suggested two things: (1) Higher kilowatt savings doesn't necessarily result in higher carbon reduction and higher monetary savings; and (2) Lighting and heating are the two largest opportunities for small and medium enterprises to reduce carbon emissions, further supporting our research from the Carbon Trust.

Throughout our energy surveys, we found that boilers used a significant amount of kilowatts to heat the building. Lighting, measured in watts rather than kilowatts, used a lot less energy unless there were a considerable number of lights. However, due to the cost of electricity and the cost of natural gas, we found that savings from switching to LED lights frequently resulted in higher monetary savings than adjusting heating. Additionally, the conversion factor (see Appendix BB) for calculating the amount of carbon emissions from kilowatt hour (kWh) consumption is much higher for electricity (.54522) than it is for natural gas (.18523). As a result, savings from lighting frequently yielded a higher amount of carbon reduction as well. Our results from YMCA Princes Road illustrate this point. Recommendations for boiler adjustment and LED lighting resulted in a 39,285 kWh and 39,579 kWh savings, respectfully, as seen in Figure 18. However, Figures 16 and 17 revealed that the monetary savings from switching to LED lighting were £4,082 greater than the monetary savings from adjusting the operating hours of the boiler system. Additionally, LED lights generated 21.58 tonnes of carbon reduction, which is much greater than the 7.28 tonnes reduced by boiler adjustment. These monetary savings and carbon reduction figures were drastically different despite nearly identical kWh savings.

Our data also suggested that lighting provided the largest opportunity for carbon reduction, with heating as the second largest prospect. Due to the large amount of savings in these areas, our results supported background research from the Carbon Trust stating that lighting and heating each accounted for 33% of carbon emissions in public and commerce buildings in 2002. The top three recommendations by frequency all deal with lighting and heating, with lighting supplying the largest carbon reduction numbers, as shown in Figure 17. As a result, focusing on lighting and heating will allow small and medium enterprises to effectively reduce their carbon emissions while saving money, especially with LED lighting. Behavioural changes and reducing boiler operation hours provide small and medium enterprises with a no cost solution to implement.

4.3 Energy Survey Feedback

In an effort to gauge whether companies benefitted from our energy surveys, we created feedback forms that we distributed to audited businesses at the conclusion of our personalized report presentations. Since the Wray Park Fire Complex, the Reigate Library, and the Wray Common Primary School were all managed by the Surrey County Council, we distributed a single feedback form for these three buildings. We also distributed one form for both YMCA buildings. Of the eight feedback forms emailed to these businesses, we received five back. These feedback forms can be viewed in Appendix AA. Our results suggested that audited companies benefitted from these energy surveys, while also providing a strong case for the continuation of a carbon reduction program targeting SMEs. Additionally, the feedback implied that our method of energy surveying was efficient for the short amount of time required.

The first thing we wanted to figure out was whether or not these energy surveys were worth the time for the clients. ING Lease, YMCA, Surrey County Council, Risbridger Ltd., and La Barbe all indicated that these audits were worthwhile in these feedback forms. Our feedback forms also showed that all of these businesses found our recommendations to be realistic, and that they would implement at least some of the carbon reducing solutions we recommended. These results suggested that the clients found our energy reports helpful for increasing energy efficiency and achieving monetary savings.

We also wanted to know if our method of energy surveying was efficient. ING Lease, Risbridger Ltd., and Surrey County Council indicated that our personalized reports were “Good Quality,” while La Barbe and the YMCA indicated that our personalized reports were “High Quality.” Additionally, all of these companies denoted that we were “Good” or “Excellent” in friendliness, helpfulness, competence, ease of contact, and response time, with the majority of these ratings being “Excellent.” The ratings suggested that we did these energy surveys efficiently and produced well above average reports for these businesses. To further this notion, Risbridger Ltd. wrote: “Everything seems to have been done efficiently and quickly.” Surrey County Council also wrote: “Quickly grasped concepts, allowing them to ask relevant questions and produce reports to a high standard.” These feedback forms revealed that our method of energy auditing produced great results in a short timeframe.

Lastly, our feedback forms helped us to determine whether or not the Council should continue targeting SMEs to achieve carbon reduction goals. Our results from these forms used in conjunction with the statistical benefits of carbon reduction opportunities in Figures 11, 12, and 13 provided strong evidence for the continuation of a carbon reduction program. Figure 11 indicated that businesses benefited from significant monetary savings, while Figure 12 suggested that the Council could achieve part of its carbon reduction goal through these energy surveys. Our feedback forms supplemented this statistical data. All of the companies that we received feedback from indicated that they would recommend an energy survey to another business. This suggested that other businesses could benefit from these surveys in the future, and that the Reigate and Banstead Borough Council should continue to target public buildings and SMEs.

4.4 Carbon Reduction: Local and National Implications

Our results indicated that identifying carbon reduction opportunities among small and medium enterprises can have a local impact in the borough of Reigate and Banstead. This local impact can aid in helping the United Kingdom achieve the carbon reduction goals set forth by the Climate Change Act of 2008.

4.4.1 Local Impact

Carbon reduction in public buildings and small and medium enterprises can have a significant impact both in monetary savings and in reducing emissions. The Reigate and Banstead Borough Council has indicated that "Reigate and Banstead is a relatively affluent borough with a buoyant local economy" (RBBC Economic Overview, 2011). Our time spent walking around in the borough confirmed this notion. With the exception of a few large companies like Toyota, Pfizer, and Canon, we noticed that most stores and shops were not large businesses, but rather locally owned and run SMEs. According to the Council's economic overview, Reigate and Banstead housed around 5,700 businesses at the time of our project, yielding around 61,000 jobs in total.

Our carbon reduction project only focused on 8 of these 5,700 businesses, along with an additional 4 public buildings. Four of these energy surveys took place in the Holmethorpe Industrial Estate, which housed over 70 businesses. Holmethorpe Industrial Estate was one of nine industrial estates in the Borough. The energy surveys conducted on all eleven businesses yielded recommendations resulting in 437 tonnes of carbon reduction and over £109,000 in monetary savings. These results indicated that there is a great opportunity to have an even larger carbon reduction impact through the nine industrial estates and 5,700 businesses found throughout the Borough. Additionally, results from our project allow the Council to present these carbon reduction findings to areas expecting to experience growth in the upcoming years. Companies may see the financial benefits of having exemplary energy awareness and using green technology, such as LED lighting.

To prove that our project can have a significant impact on the Borough, we examined accurately estimated carbon emissions data from 2005-2008 published by the Department of Energy and Climate Change. Table 4 provides an overview of the carbon emissions in the Borough in kilotonnes (kt).

Table 5 - Reigate and Banstead Carbon Emissions in Kilotonnes (Department of Energy and Climate Change, 2008)

Year	Industry and Commercial	Domestic	Road Transport	Total	% per capita reduction since 2005
2005	266	344	228	838	7.6%
2006	269	346	218	833	
2007	263	342	217	822	
2008	258	346	208	812	

The data from Table 4 shows that the industrial and commercial sector accounted for 258,000 tonnes of carbon emissions in 2008, which resulted in approximately 32% of the total for the Borough. Taking carbon emissions from the industrial and commercial sector and dividing it by 5,700 businesses gives the average carbon emission per business. In 2008, this average was 45.26 tonnes. Our results from Figure 12 indicated that the eight small and medium enterprises we surveyed could reduce carbon emissions by 208.13 tonnes, resulting in an average of 26.02 tonnes. While our recommendations only accounted for a .08% reduction of the total carbon emissions from the industry and commercial sector, the average reduction is quite significant. According to our data, all of our recommendations could account for a 57.49% reduction in carbon emissions in the industry and commercial sector. Even if all suggestions aren't implemented businesses reduce carbon emissions by an average of 10 tonnes, this would still be a 22.09% average reduction across all businesses. If every business in the Borough had a similar carbon reduction, this would result in 57,000 tonnes of carbon reduced. Since most of these businesses are SMEs, our results suggest that it makes sense for the Reigate and Banstead Borough Council to target SMEs to achieve part of their carbon reduction goals.

Our experience has allowed us to conclude that performing energy surveys was an efficient way of reducing carbon emissions for the Reigate and Banstead Borough Council. We found that businesses care more about the monetary savings, whereas the Council cares more about the total amount of carbon reduction. One successful method that we used to target SMEs was saying that they can save a significant amount of money from carbon reduction. We found that this was a successful way to pique the interest of businesses, and implementing carbon reduction solutions would benefit both the SMEs and the Council.

While effective, performing energy surveys for 5,700 businesses would take an extremely long time. We have decided that another effective way for promoting carbon reduction is through the use of headline figures and informational brochures. These headline figures (monetary savings, payback period, and carbon reduction) may provide an incentive for SMEs to look into carbon reduction. These eye catching numbers can be put on a posters and flyers, which can subsequently be included in newsletters and other means of media. In our experience, most people did not read the initial flyer put in the newsletter of the Holmethorpe Industrial Estate. However, companies may be more apt to read it if they see the amount of money they could save annually. Additionally, another option aside from energy surveys is an informational brochure with the top three carbon reducing solutions. This brochure would include information on what each of the top three recommendations entailed and how they reduce carbon emissions to save businesses money. We have created the content for both the poster and informational brochure for the Council to use.

4.4.2 National Impact

While the scope of our project was limited to the two towns of Reigate and Redhill, the impact of carbon reduction is beginning to spread to other areas throughout England. During the first few weeks of our project, we worked closely with officials from Surrey County Council, the government district that oversees the borough of Reigate and Banstead. They are making efforts to reduce carbon emissions by auditing public buildings throughout the entire district. Additionally, a similar project was conducted in Mole Valley. This project also worked to reduce carbon emissions in small and medium enterprises.

As the interest in energy and carbon reduction spreads, the United Kingdom will inch closer to achieving the goals set forth by the Climate Change Act of 2008. There is a major opportunity to reduce carbon emissions in the industry and commerce sector as well as in public buildings. We hope that our project will further reveal this opportunity not only to the

Reigate and Banstead Borough Council, but to other boroughs as well. Reducing carbon emissions and meeting these goals will reduce the amount of anthropogenic sources of carbon emissions, hopefully lessening the impacts associated with climate change.

5. Expanding and Modifying the Program

The purpose of this project was to identify carbon reduction opportunities among small and medium enterprises within the borough of Reigate and Banstead. We accomplished this goal by conducting a series of energy surveys used to find patterns in energy consumption and carbon emissions among smaller businesses. After completing these energy surveys, we created personalized reports with an action plan to reduce both carbon emissions and monetary expenditures on annual energy bills. Through our analysis of these personalized reports and patterns in energy consumption, we were able to recommend if the Reigate and Banstead Borough Council should continue outreach efforts to small and medium enterprises within the Borough.

Our results allowed us to draw some conclusions for the Reigate and Banstead Borough Council:

- Lighting and heating were the two most common sources of carbon emissions throughout our reports. Thus, they provide the largest opportunity for carbon reduction.
- Our method for conducting energy surveys produced high quality reports in an efficient manner.
- Businesses found that these energy surveys were worth their time.
- The Reigate and Banstead Borough Council should continue targeting SMEs and public buildings to reduce carbon emissions.

With these results in mind, we experienced a number of challenges and identified the limitations of our project throughout the process. These findings include:

Challenges faced during the project

- Difficulty recruiting small and medium enterprises
- Estimating data
- Difficulty persuading businesses to implement our recommendations

Future Limitations

- Lack of resources to continue conducting energy surveys
- Reducing anthropogenic sources of carbon emissions globally

These conclusions and challenges led to some recommendations for the Council to modify and expand the program to achieve carbon reduction goals. We recommended:

- Continuing to offer free energy surveys to interested businesses
  - Recruit students from local universities
  - Recruit volunteers within the Borough
- Conducting carbon reduction seminars for businesses
  - Teach businesses how to self assess energy usage
  - Provide businesses with information on carbon reducing solutions that result in monetary savings
- Using promotional materials to increase energy awareness
  - Flyers and posters with headline figures
  - Informational brochure on top three savers

These recommendations will help the Reigate and Banstead Borough Council to reduce the total amount of carbon emissions in the Borough, chiefly in the industry and commerce sector. This effort will contribute to the United Kingdom's goal of achieving an 80% carbon reduction from the emissions levels in 1990 by the year 2050. The United Kingdom aims to reduce the global impact of anthropogenic sources of carbon emissions, and the Reigate and Banstead Borough Council can target SMEs to help this cause.

5.1 Summary of Conclusions

We were able to draw a number of conclusions from our results. Through our analysis of energy consumption trends, we were able to conclude that lighting and heating provide the largest opportunity for carbon reduction in small and medium enterprises. From feedback, we determined that our method for conducting energy surveys was efficient, allowing us to produce high quality reports in a short amount of time. Additionally, businesses found that these energy surveys benefitted their companies, and that our recommendations were feasible. As a result, the Reigate and Banstead Borough Council should continue targeting SME and public buildings to achieve local and national carbon reduction goals. While the efforts of Reigate and Banstead cannot lessen the impacts of anthropogenic carbon emissions alone, promoting energy awareness throughout the Borough and eventually throughout England has a significant influence.

5.1.1 Lighting and Heating

Through an analysis of all personalized reports created for public buildings and SMEs, we were able to generate overall figures for the report. Most notably were the totals for monetary savings and carbon reduction, which were **£109,000** and **437 tonnes**, respectfully. Those numbers represent the amount of money saved and the environmental impact if all recommendations were implemented.

However, we went a step further and identified our most frequent recommendations across all of these businesses. From this, we produced our top three energy savers for small and medium enterprises.

1. **Switch Current Lighting to LED Lighting Solutions**
    a. *£30,659 Annual Savings*
    b. *£130,679 Investment*
    c. *4.26 Year Payback Period*
    d. *147.41 Tonnes of Carbon Reduced*
2. **Improve Energy Awareness**
    a. *£5,653 Annual Savings*
    b. *No Investment*
    c. *Immediate Payback*
    d. *29.98 Tonnes of Carbon Reduced*
3. **Adjust Boiler and Hot Water Calorifier Operation Hours**
    a. *£9,353 Annual Savings*
    b. *No Investment*
    c. *Immediate Payback*
    d. *64.39 Tonnes of Carbon Reduced*

LED lighting solutions were recommended to ten of the eleven audited public buildings and SMEs, with energy awareness and boiler adjustment being recommended eight and five times, respectively. The boiler adjustment calculation did not include data from the Wray Park Fire Complex due to the fact that it was an outlier. Decommissioning three boilers is not a typical recommendation.

From the most frequent recommendations, we concluded that the **largest opportunity for small and medium enterprises to reduce carbon emissions is through lighting and heating**. The top recommendation entails changes to lighting, the second most common recommendation involves strictly changes to heating, and our third solution combines changes to both lighting and heating. As a result, examining energy consumption caused by lighting and heating reveals the most common areas for potential improvement.

5.1.2 Efficient Energy Surveys

We have concluded that **our method of energy surveying was extremely efficient for the amount of time required.** While data for behavioural changes was estimated, we used numbers taken from Carbon Trust case studies to give more accurate approximations. Additionally, estimated metering data provided by the companies was used to cross-check our own calculations. Our feedback forms handed out after the reports provided enough data to conclude that our method of energy surveying worked.

Of the five feedback forms that we received back, all companies indicated that **these audits were worthwhile.** Additionally, these feedback forms suggested that all businesses found our **recommendations to be realistic and feasible.** A portion of the companies indicated that they would implement all of these carbon reducing solutions, whereas another portion indicated they would **implement at least some of these carbon reducing solutions.**

Additionally, all feedback forms denoted that we produced **"Good Quality"** or **"High Quality"** personalized reports. We received **"Good"** or **"Excellent" ratings** in friendliness, helpfulness, competence, ease of contact, and response time, with the majority of these ratings being "Excellent". Additionally, we received comments saying: "Everything seems to have been done efficiently and quickly," as well as "Quickly grasped concepts, allowing them to ask relevant questions and produce reports to a high standard." These comments, combined with the businesses' evaluation of our reports as high quality and our surveys as worthwhile, led us to conclude that our methods were an efficient way for conducting energy surveys.

5.1.3 Continuing to Target Small and Medium Enterprises

The last conclusion we were able to draw from our results was that the Reigate and Banstead Borough should continue to target SMEs to reduce carbon emissions. The feedback forms along with statistical evidence supported this claim.

On our feedback forms, we created a question that asked whether or not businesses would recommend having an energy survey done to other companies. All of the audited businesses that we received feedback from indicated that they would recommend these energy surveys.

Additionally, our statistical results enabled us to see the benefits from targeting SMEs. Eight small and medium enterprises could reduce a grand total of 208.13 tonnes of carbon emissions, or an average of 26.02 tonnes. Data from the Department of Energy and Climate

Change revealed that the industry and commerce sector accounted for 258 kilotonnes of carbon emission in the year 2008 in Reigate and Banstead. Since there are approximately 5,700 businesses, this amounted to an average of 45.26 tonnes across all companies. Even if an average of 10 tonnes were reduced across all audited companies during our project, 10 tonnes of reduction across all 5,700 businesses would result in 57,000 tonnes of carbon reduction. Since most of these companies are SMEs, there is clear statistical evidence supporting the strategic targeting of SMEs by the Reigate and Banstead Borough Council.

5.2 Project Challenges and Limitations

In order to evaluate opportunities for carbon reduction in small and medium enterprises, we conducted a number of energy surveys to find general energy consumption trends. During these energy surveys, we came across challenges identifying an appropriate sample of SMEs to audit, as well as difficulty analyzing gathered data. We experienced further challenges during our personalized presentations regarding potential recommendations to improve energy efficiency. We found that there was some difficulty in getting companies to implement these solutions.

In addition to these challenges, we were also able to identify the limitations of our project. Our experiences revealed that members of the Reigate and Banstead Borough Council have been conducting similar energy surveys themselves, mostly for public schools and libraries along with residential housing. Moving forward, the Borough may not have the resources to continue conducting energy surveys targeting small and medium enterprises. In terms of the larger scope of the project, one borough in a single nation cannot make a significant impact. Globally reducing anthropogenic sources of carbon emissions will require the efforts of other boroughs in the United Kingdom, as well as efforts from other countries.

5.2.1 Difficulty Recruiting Small and Medium Enterprises

One of the largest challenges that we encountered during our project was recruiting SMEs to participate in a free energy survey. Raymond Dill of the Reigate and Banstead Borough Council created a flyer advertising these free energy surveys that was published in the newsletter of the Holmethorpe Industrial Estate. We made a series of phone calls asking companies to participate. However, while calling our generated list of companies, we noticed that the majority of them either did not see or did not read this flyer. As a result, these companies were not aware that they could receive a free energy audit and save money on annual utility bills. This posed a bit of a problem for us, since we were under the impression that these companies knew of this energy surveying program. It resulted in us essentially cold calling these companies and explaining the benefits of monetary savings through carbon reduction.

However, the lack of awareness of this program was not the only difficulty we encountered. We found that some SMEs already thought that they were energy efficient and unable to benefit from an energy survey, whereas others simply weren't interested in receiving a free energy survey. As a result, the Borough may not be able to reach out to a large number of SMEs in the future. Future carbon reduction projects using a similar methodology may face resistance from getting companies to partake in energy surveys as well.

5.2.2 Estimated Data

In order to report our findings and recommendations to companies, we created personalized audit reports ranking energy efficiency solutions by priority. Many of these recommendations used qualitative data, such as shutting off unused lighting and equipment, removing objects obstructing the circulation of heat from radiators, and closing windows while the building was being heated.

We attempted to associate a number with these behavioural changes to illustrate potential savings. This was done by calculating the annual energy expenditures in electricity and heating, and estimating how much the company could save from making these changes. While we used percentages found in case studies from the Carbon Trust, there may be inaccuracy in these calculations. However, in an effort to be conservative in our estimates, we decided to use lower percentages than ones found in case studies. Due to this inaccuracy, we found that qualitative recommendations were difficult to quantify.

In addition to these savings estimates, we also discovered that data gathered from energy bills contained estimates as well. Unstructured interviews with experienced energy managers and building managers revealed that the United Kingdom has a different style of metering than in the United States. Meter readings are taken every month in the United States, with electric and gas companies billing buildings for their exact energy usage. This is a bit different than in the United Kingdom, where meter readings can sometimes be taken irregularly and utility bills can contain estimated energy usage rather than exact numbers. This posed a problem. Some of our data calculations for recommendations, primarily behavioural changes and boiler adjustment, utilized this data. If the company was being overcharged for electricity or gas, our calculated savings for these recommendations may be inaccurate.

However, while some of our calculations did use this data, it was largely used to cross-check our own calculations. For example, we calculated how much the utility bill for heating should be through our spreadsheets, and then checked if this data was consistent with the energy bills provided. Due to these different factors, we made sure to show companies how each calculation was done in the "Calculations" section of our personalized reports.

5.2.3 Implementing Recommendations

Persuading companies to implement our recommendations was perhaps the largest challenge that we faced during this project. We can show companies areas where they can benefit from monetary savings and carbon reduction, but we cannot make them apply these changes.

In our experience, one of the largest reasons for not implementing solutions was lack of funding. While we made an effort to generate no cost and cost solutions for these businesses, the cost solutions did require some initial capital. Despite low payback periods and clear monetary savings, smaller companies may not be able to afford this cost. During the course of the project, the Carbon Trust discontinued their zero-interest loans for improving energy efficiency, making outside sources of funding harder to find.

We found that there were additional challenges associated with no cost recommendations. Despite the lack of an initial investment, behavioural changes can be very difficult to implement. Simply put, it may be difficult to get someone to change their habits, regardless of the obvious benefits associated with the change. For example, someone who leaves their computer on overnight may find it annoying to power up their computer in the morning. While this seems like a miniscule change, we found that there may be some resistance to changing these habits.

5.2.4 Lack of Resources and Global Carbon Emissions

Looking toward the future, we determined that there is a lack of resources to continue conducting these energy surveys for small and medium enterprises. There are approximately 5,700 SMEs in the borough of Reigate and Banstead, and the eleven audits that we conducted took approximately five weeks to complete. Due to the amount of time required, we concluded that there is a significant limitation on the number of energy surveys able to be conducted for SMEs. In order to reach out to a large number of businesses, the Borough is going to need additional personnel or outside help.

The last limitation that we identified involved the overall scope of our carbon reduction project. While the project provided clear statistical benefits for carbon reduction, the borough of Reigate and Banstead is just one borough in an entire country. Additionally, England is just one country in the entire world. We realize that anthropogenic sources of carbon emissions aren't going to significantly decline solely as a result of this project. It will take the effort of the entire nation, as well as countries around the globe to mitigate the effects of carbon emissions.

5.3 Recommendations

From these conclusions and challenges, we were able to recommend a few different ways to modify and expand the Council's carbon reduction program. These recommendations include:

- **The continuation of free energy surveys for interested businesses**
- **Carbon reduction seminars for businesses**
- **The use of promotional materials to increase energy awareness**

The expansion of the program with these modifications will allow the Reigate and Banstead Borough Council to move closer toward achieving their overall carbon reduction goals.

5.3.1 Continuation of Free Energy Audits

Our first recommendation for the Reigate and Banstead Borough Council is the continuation of free energy surveys for small and medium enterprises. From the feedback we gathered, businesses were very satisfied with the audit and our overall recommendations. By continuing a free energy audit program, businesses will begin to realize that they can save money through carbon reduction efforts. Providing energy surveys for a large number of companies will provide significant amounts of carbon reduction, even if businesses only implement some recommendations.

We have some suggestions on how to go about implementing a free energy audit program in the future. The first of these suggestions is to work with local universities. Creating a program that will allow students to either volunteer or receive course credit will provide the Council with additional personnel to conduct these surveys. These students would recruit businesses, conduct free energy surveys, and ultimately produce personalized reports with recommendations. The training required to conduct a basic walkthrough audit is very minimal, and is easily achievable by someone with or without a technical background. These students could even use a similar methodology to the one used in this report, as it has proven to be efficient and successful. This would benefit the community twofold. Firstly, local businesses would get the visible benefit of receiving energy audits and the savings associated with the audit itself. Secondly, this program would help increase the community awareness by teaching students about energy savings and carbon reduction.

Another way to continue the free energy audit program is to set up a volunteer organization from within the community itself. This would operate similar to a program associated with a university, except that the people volunteering within it would be independent of an outside organization.

5.2.2 Business Outreach Seminars

Our next recommendation for the Council is to set up a program designed to reach out to local businesses. This program would encompass a basic training session on how to identify energy consumption trends. Identifying these trends would allow the business to save money through reducing energy use and reducing carbon emissions. Conducting a walkthrough survey does not require a lot of technical training, but requires calculation tools and easily identifiable places to reduce energy consumption. During these seminars, the Council could point out the top areas of energy loss, as well as provide businesses with the calculation tools necessary to tabulate savings. This would include information from the research done on the top energy savers from this project, as well as the calculation tools that we used to generate our reports. By offering seminars and materials to businesses, the Borough would be able to reduce the amount of free energy surveys done by themselves, as these companies would know how to self-assess and improve their energy consumption.

These seminars could be run as frequently as needed, since they would provide a basic training on the how to conduct energy surveys and identify the main areas of energy loss. By conducting these seminars, the Borough would move closer to meeting the goals set forth by the Sustainable Energy Strategy regarding community engagement in increasing energy awareness.

5.2.3 Promoting Energy Awareness

Our final recommendation for the Reigate and Banstead Borough Council is to use the numbers gathered from our project analysis to promote energy awareness throughout the Borough. These numbers can be displayed on promotional materials such as flyers and informational brochures. In our experience, displaying significant monetary savings will pique the interest of SMEs to reduce their carbon emissions. Ideally, these posters would be displayed in any buildings owned by the Council, in local town centres, and other public areas with high traffic. This passive marketing will help improve and encourage energy awareness within the Borough. Additionally, these flyers and posters would be distributed to local business to raise awareness of what carbon reduction can do monetarily. Informational brochure could also be used to provide businesses with the top areas for monetary savings and energy reduction.

This recommendation is perhaps the easiest to implement. By simply presenting the numbers associated with energy savings, the Borough will have a direct impact on increasing the energy awareness within the community, as well as small and medium enterprises. We have already created the content for these promotional materials for the Council.

5.4 Concluding Remarks

In closing, our project has successfully identified carbon reduction opportunities among small and medium enterprises within Reigate and Banstead. Our methods for identifying and analyzing these energy consumption trends were successful, as businesses found these energy surveys worthwhile and efficient. Additionally, businesses indicated that they would implement some of our recommendations, hence reducing their carbon emissions. We concluded that continuing outreach to small and medium enterprises is an effective way to achieve carbon reduction goals set forth by the Reigate and Banstead Borough Council, as well as England itself. To do this, we provided a few recommendations to modify and expand the current carbon reduction program. These recommendations included the continuation of free energy surveys through local students and volunteers, conducting carbon reduction seminars for businesses to learn how to self-assess energy usage, and finally, the use of promotional flyers, posters, and brochures to increase energy awareness. Even though our project was limited to the borough of Reigate and Banstead, the results and impact of this project can eventually spread throughout England. Reducing carbon emissions in small and medium enterprises throughout the nation can eventually lessen the impact anthropogenic sources of carbon emissions are having on our planet.

References

ABB. (2010). *Saving energy with variable speed drives.*, 2011, from http://www.abb.co.uk/cawp/seitp202/c253ae5e6abf5817c1256feb0053baf7.aspx

BBC. (2008). *Fitting thermostatic radiator valves (TRVs).*, 2011, from http://www.bbc.co.uk/bloom/actions/radiatorvalves.shtml

Berlo, D. M., Hunt, J. L., Martori, A. L., & Skelly, J. (2008). *Wind generation on nantucket.* No. E-project 121608-091223).

Berners-Lee, M., Howard, D. C., Moss, J., Kaivanto, K., & Scott, W. A. (2011). Greenhouse gas footprinting for small businesses — the use of input–output data. *Science of the Total Environment, 409*(5), 883-891. doi:DOI: 10.1016/j.scitotenv.2010.11.023

Bradford, J., & Fraser, E. D. G. (2008). Local authorities, climate change and small and medium enterprises: Identifying effective policy instruments to reduce energy use and carbon emissions. *Corporate Social Responsibility & Environmental Management, 15*(3), 156-172. doi:10.1002/csr.151

Carbon Trust. (2009). *CTG012 biomass heating: A practical guide for potential users* Carbon Trust. Retrieved from http://www.carbontrust.co.uk/Publications/pages/publicationdetail.aspx?id=CTG012

Carbon Trust. (2010). *CTV034 'better business guide to energy saving'* Carbon Trust. Retrieved from http://www.carbontrust.co.uk/Publications/pages/publicationdetail.aspx?id=CTV034&respos=0&q=better+business+guide&o=Rank&od=asc&pn=0&ps=10

Carbon Trust. (2007). *CTV021 'Lighting technology overview'* Carbon Trust. Retrieved from http://www.carbontrust.co.uk/Publications/pages/publicationdetail.aspx?id=CTV021

Carbon Trust. (2006). *CTV003 'Heating, ventilation and air conditioning technology overview'* Carbon Trust. Retrieved from http://www.carbontrust.co.uk/Publications/pages/publicationdetail.aspx?id=CTV003

Compact fluorescent lamps. (2010). Retrieved February 1, 2011, from http://www.energysavers.gov/your_home/lighting_daylighting/index.cfm/mytopic=12050

DiCesare, A., DiLullo, N., & Krasko, K. L. (2008). *Investigation of carbon reduction from overnight lighting in non-domestic building stock.* No. E-project-042308-123147).

Edward Vine, Nick Hall, Kenneth M. Keating, Martin Kushler and Ralph Prahl. Emerging issues in the evaluation of energy-efficiency programs: The US experience.

Ek, C., Lattanzio, R. K., Leggett, J. A., & Parker, L. (2009). *An overview of greenhouse gas (GHG) control policies in various countries* .

Energy Star. (2006). *Innovation. performance. savings.* United States Department of Energy.

Garskof, J. (2008). *Knock $4000 off your utility bill.* Retrieved February 1, 2011, from http://money.cnn.com/galleries/2008/pf/0809/gallery.utility_bill.moneymag/index.html

General Electric. (2010). *Compact fluorescent light bulbs (CFL) FAQs.*, 2011, from http://www.gelighting.com/na/home_lighting/ask_us/faq_compact.htm

Hall-Stinson, A. S., Gowell, C. M., & Collins, T. F. (2010). *Worcester art museum -- green technology evaluation*. Worcester, MA: Worcester Polytechnic Institute.

Hijioka, Y., Masui, T., Takahashi, K., Matsuoka, Y., & Harasawa, H. (2006). Development of a support tool for greenhouse gas emissions control policy to help mitigate the impact of global warming. *Environmental Economics & Policy Studies, 7*(3), 331-345. doi:10.1007/s10018-006-0109-3.

Home Heating Systems and Solutions. (2010). *Two pipe system- hydronic central heating.*, 2011, from http://www.home-heating-systems-and-solutions.com/two-pipe-system.html

Kiehl, J. T., & Trenberth, K. E. (1997). Earth's annual global mean energy budget. *Bulletin of the American Meteorological Society, 78*(2), 197-208. doi:10.1175/1520-0477(1997)078<0197:EAGMEB>2.0.CO;2

Kolega, V. (2005). Energy auditing in public buildings-data processing and a proposal for energy efficiency measures. *Journal of Energy, 54*(3), 215-25.

Krarti, M. (2000). *Energy audit of building systems : An engineering approach*. Boca Raton, FL: CRC Press. Retrieved from http://www.loc.gov/catdir/enhancements/fy0633/00050751-d.html

Kydd, A. H. (2010). Learning together, growing apart: Global warming, energy policy and international trust. *Energy Policy, 38*(6), 2675-2680. doi:DOI: 10.1016/j.enpol.2009.05.056

Bernstein, Bosch, & Canziani, Chen, Christ, Davidson, Hare, Huq, Karoly, Kattsov, Kundzewicz, Liu, Lohmann, Manning, Matsuno, Menne, Metz, Mirza, Nicholls, Nurse, Pachauri, Palutikof, Parry, Qin, Ravindranath, Reisinger, Ren, Riahi, Rosenzweig, Rusticucci, Schneider, Sokona, Solomon, Stott, Stouffer, Sugiyama, Swart, Tirpak, Vogel, Yoh. (2007). *IPCC climate change 2007: Synthesis report.*IPCC.

Lights and light fixtures. (2007). Retrieved February 1, 2011, from http://www.oregon.gov/ENERGY/CONS/RES/light/lights.shtml

Lloyd. (2009). *Energy saving using variable speed drives.,* The Motor Control Warehouse. Retrieved from http://www.motorcontrolwarehouse.co.uk/images/MCW%20HINTS%20Energy%20Saving%20Using_Variable%20Speed%20Drives.pdf

Mauna Loa observatory: Trends in atmospheric carbon dioxide. Retrieved 02/09, 2011, from http://www.esrl.noaa.gov/gmd/ccgg/trends/

NaturalGas. (2010). *Natural gas and the environment.*, 2011, from http://www.naturalgas.org/environment/naturalgas.asp

NetLED. (2011). *Products.*, 2011, from http://netledlighting.com/products.htm

Oreskes, N. (2004). The scientific consensus on climate change. *Science, 306*(5702), 1686-1686. doi:10.1126/science.1103618

Participation in climate change agreements: Kyoto protocol (2009).

Philips. (2011). *What are LEDs?*, 2011, from http://www.lighting.philips.co.uk/lightcommunity/trends/led/what_are_leds.wpd

Reigate and Banstead Borough Council. (2011). *Economic overview.*, 2011, from http://www.reigate-banstead.gov.uk/council_and_democracy/our_borough/the_local_economy/economic_overview/

Rensselaer Polytechnic Institute. (2002). T5 fluorescent systems. *Lighting Research Center, 6*(1), 2011. Retrieved from http://www.lrc.rpi.edu/programs/nlpip/lightingAnswers/lat5/abstract.asp

Richardson, C., Pawlowski, E. P., & Jahnke, C. A. (2006). *Mapping and evaluating carbon dioxide reduction in merton*. Worcester, MA: Worcester Polytechnic Institute.

Sustainable Energy Strategy. (2009). Reigate and Banstead Borough Council. Retrieved April 5, 2011, from http://www.reigate-banstead.gov.uk/Images/Sustainable%20Energy%20Strategy%20FINAL%20uly09_tcm9-37068.pdf

Robert, M. A., Luk, C. Y., Guzman, J. T., & DeMello, J. E. (2006). *Carbon reduction tools for municipal buildings*. Worcester, MA: Worcester Polytechnic Institute.

Rowland, F. S. (2005). *Global warming and climate change*

Thumann, A., & Mehta, P. D.*Handbook of energy engineering (6th edition)* Fairmont Press, Inc. Retrieved from http://www.knovel.com/web/portal/browse/display?_EXT_KNOVEL_DISPLAY_bookid=2409

UNFCCC kyoto protocol

United Kingdom Federation of Small Businesses. (2010). *'Small Business Statistics'* United Kingdom Federation of Small Businesses. Retrieved from http://www.fsb.org.uk/stats

United Kingdom Department of Energy & Climate Change. (2009). *'2009 final UK greenhouse gas emissions: data tables'* United Kingdom Department of Energy & Climate Change. Retrieved from http://www.decc.gov.uk/en/content/cms/statistics/climate_change/gg_emissions/uk_emissions/2009_final/2009_final.aspx

Kyoto Protocol Status of Ratification, (14 January 2009).

White, G., Gardner, N., & Swift, J. (2008). Carbon reduction: Obligation and opportunity at regional and local levels. *Local Economy, 23*(3), 235-241. doi:10.1080/02690940802197416

Appendix A—Carbon Trust Office Based Checklist

Walk around checklist CTL048

Business Activities (office based) walk around checklist

Use this walk around checklist to help identify key low or no cost energy saving opportunities within your organisation. Conducting regular housekeeping walk arounds will help form the basis of an action plan to reduce your energy use and carbon footprint.

This checklist should be read in conjunction with the Business Activities Sector Overview (CTV007), downloadable from the website, which provides further detail on most of the topics outlined below.

Heating, ventilation and air conditioning (HVAC)	Complete	Actions/comments
Check that radiators and other heating surfaces are unobstructed.		
Are windows and doors closed where possible when heating or air conditioning is operating?		
Check thermostat settings. The recommended temperature for an office is 19°C. A 1°C drop in average space temperature can cut fuel consumption by about 8%.		
Check thermostatic radiator valve (TRV) settings on radiators. Comfortable temperatures of 19°C are usually maintained when TRVs are set to '3'. If the valve is kept at '5' or 'max', there is no control over the amount of heat emitted from the radiator.		
Undertake regular checks on air conditioning control settings. Air conditioning should not be switched on until temperatures reach 24°C.		
Ensure HVAC time switches are adjusted to match occupancy patterns. Most systems use 7-day time controllers, so varying occupancy patterns can be catered for. Moreover, sufficient heat is often held in the building fabric and radiators to enable heating to be switched off a couple of hours before staff go home.		
Ensure hot water is switched off and time and temperature controls are adjusted over holiday periods. There is no need for water to remain at temperature during this time.		
Check boiler operation during summer walk arounds. In large offices, there are often several boilers for space heating and many of these can be switched off during the summer to save energy.		
Does the office have frost thermostats? These should be tamper-proof and checked regularly. Typically, internal thermostats are set to 4°C and external to 1°C.		

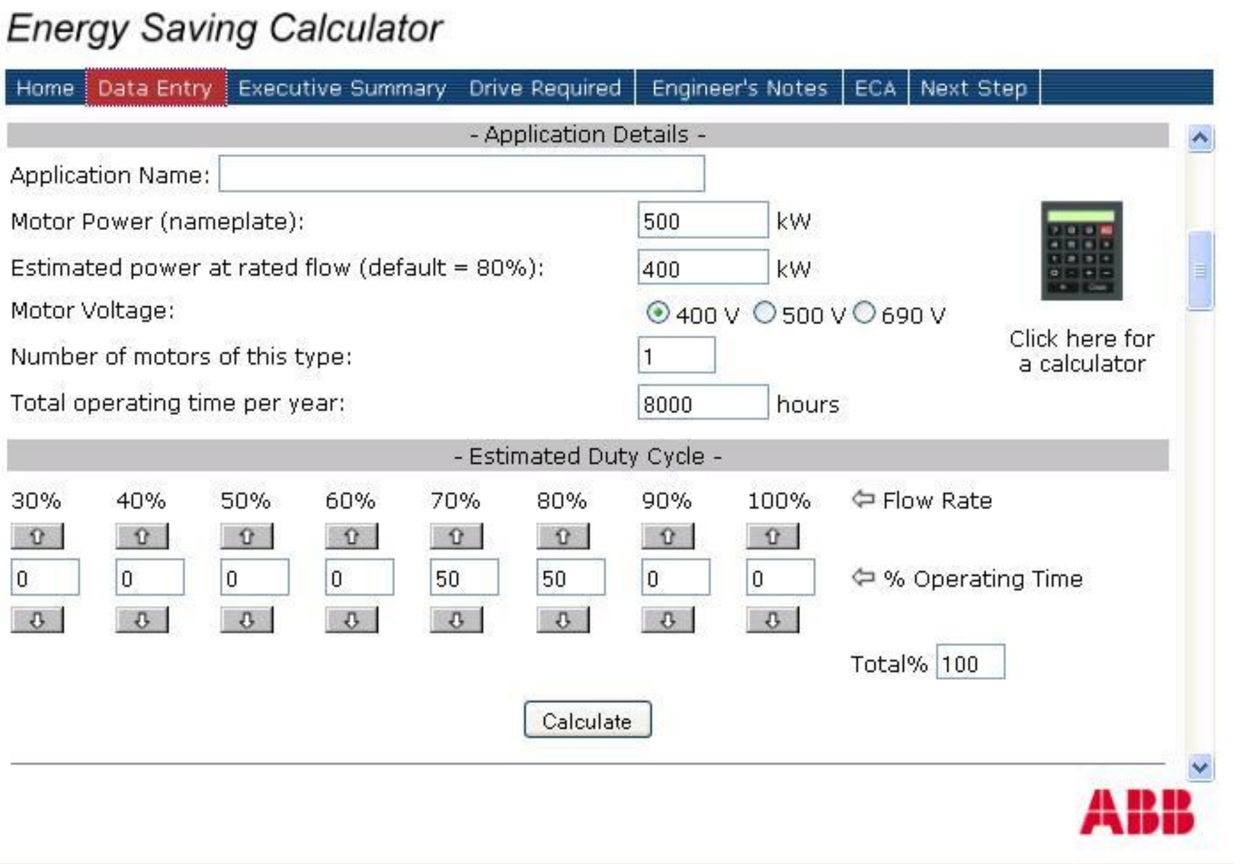
Heating, ventilation and air conditioning (HVAC)	Complete	Actions/comments
Are boilers operating efficiently? Check for warning lights, signs of leakage from pipework, valves and flanges, as well as smells of gas and oil. Look for damage and burn marks to boilers and hot surfaces. Is there undue noise from burners or pumps?		
Check extract fans are switched off after hours. Often, fan operation is linked with light operation and will continue to operate if lights are left switched on. Fans in themselves are expensive to run, and if fans continue to remove heat from the building overnight, this will also increase the amount of heat required to bring the building up to a comfortable temperature the next morning.		
Check filters in ventilation systems. Blocked filters reduce air flow and increase electricity consumption.		
Lighting	**Complete**	**Actions/comments**
Check that lighting in unoccupied areas is switched off and all non-essential lighting is switched off outside of business hours. • Are light switches clearly labelled? • Ensure external lighting is switched off during the day.		
Ensure blinds are open when there is sufficient daylight available. Large items of furniture such as filing cabinets should be moved so as not to obscure daylight.		
Do you still use traditional tungsten light bulbs? If so replace them with energy efficient, compact fluorescent lamps (CFLs) to reduce operating and maintenance costs.		
Review light levels in the office. Often, corridors are over-lit, especially if there have been changes to internal layout. Where appropriate, remove one fluorescent tube from multiple tube fittings in corridors and non-critical areas.		
Are lights switched off in toilets and store cupboards? If not, consider posters and stickers to remind staff to turn lights off, or possibly automatic lighting controls.		
Are windows, skylights, luminaires and sensors being kept clean? Establish a basic lighting maintenance and cleaning schedule to reduce costs as well as improving in-store appearance.		

Business Activities (office based) walk around checklist

Office equipment	Complete	Actions/comments
Check hours of operation of all equipment (such as photocopiers and vending machines) and ensure all unnecessary equipment is switched off overnight and at weekends.		
Building fabric	**Complete**	**Actions/comments**
Check whether parts of the building fabric are old or damaged. Cold air and water may infiltrate which can cause damage and lead to increased heating costs.		
Check for draughts and damage to windows, window frames and doors. Repair any damage and install or maintain draught seals.		

For further advice on how to improve existing systems across the above areas, please visit
www.carbontrust.co.uk/energy/startsaving/technology.htm

Appendix B—ABB Variable Speed Drive Energy Savings Calculator



Appendix C—Energy Survey Topics and Questions

Topic of Interest	What to Look for…
Heating, Ventilation, and Air Conditioning (HVAC)	• Are the radiators and other heating devices unobstructed? • Are fans, filters, air ducts, and other components clean? • Are the thermostat settings correctly set? • What is the power usage of the boiler system? • What are the operating hours of the boiler system? • When was the last time the heating system had maintenance? • Are there any windows open, causing the heating system to overwork? • Is the building being properly heated during different seasons?
Lighting	• Are light sensors used in areas of high traffic? • Are lights turned off when ambient lights are adequate enough to light an area? • What type of lighting does the building use? • How many light bulbs of each type are there? • Are some areas being over-lighted? • Are lights turned off outside of operation hours? • Is regular maintenance performed on windows to keep them clean and allow for more light to enter the building?
Building Envelope	• Are there areas of the building that lack insulation? • Are there areas of the building that have open-air leaks? • Which parts of the building are old and damaged? • Are there any cracks in the windows, window frames, or doors causing heat loss?
Building Usage	• What are the operating hours of the building? Are there any hours when the building is used past its normal operating hours? • What is the building primarily used for?

Appendix D—Call Prompt for Auditing Phone Calls

Good morning Mr./Mrs. __________,

My name is __________ and I'm calling on behalf of Raymond Dill from the Reigate & Banstead Borough Council. We understand you have expressed interest in receiving a free energy survey from the Council. We were wondering if you would like to schedule the survey at this time.

(if yes, schedule the audit)

(if no) Is there a later date you wish us to call in order to schedule the survey?

(if yes, note date for return call)

(if no) Ok thank you very much for your time. If you do wish to set up a time for an energy survey, please contact Raymond Dill at the Reigate & Banstead Borough council to arrange a date.

Good morning Mr./Mrs. __________,

My name is __________ calling on behalf of the Reigate & Banstead Borough Council. We have recently distributed a flyer regarding free energy surveys from the Council. We were wondering if you have any interest in this.

(if yes, schedule the audit)

(if no) Is there a later date you wish us to call in order to schedule the survey?

(if yes, note date for return call)

(if no) Ok thank you very much for your time. If you do wish to set up a time for an energy survey, please contact Raymond Dill at the Reigate & Banstead Borough council to arrange a date.

(if they ask what it entails) Results from an energy survey may save you a substantial amount of money off of your annual utility bills. Two individuals working on behalf of the council would conduct this energy survey. These two individuals would examine lighting, building envelope, heating, and the behavioral habits of the staff during a walkthrough of the building. A walkthrough will typically last anywhere from 15 minutes to an hour. After finishing the walkthrough of the building, we will then produce a report with our energy saving recommendations for your business. Do you have any interest in this?

Appendix E—Wray Park Fire Complex Checklist

Wray Park Fire Complex

Basic Information	
Date of Energy Audit:	March 22, 2011
Department/Building/Area covered:	All
Persons conducting audit:	Nicholas Mondor, Nicholas Solarz, Joe Lombardo, Kevin McCarthy
Normal occupancy hours of building:	Monday-Friday 6:00 A.M. – 7:00 P.M.

Lighting	
Are any tungsten lights present? Can they be replaced with compact fluorescents (energy saving bulbs)? Look particularly in store rooms, uplighters, desk lamps etc.	No.
If there are several light switches, can they be labelled to make it more obvious which switches relate to which fixtures?	Light switches were easily visible, but not labelled.
Can lights be switched off to make use of daylight? (e.g. lights parallel to windows or in corridors)	Yes. Lights were on under skylights.
Can light sensors be installed in spaces that are intermittently occupied (e.g. store rooms, toilets, kitchen areas, copying rooms, corridors, etc)	Yes, mainly in the kitchen and in other areas of varying traffic.
Are any external lights on during daylight hours?	Yes. The light outside the kitchen was on.
Can main lighting ever be switched off to make use of ambient light and desk lamps?	Yes.

Do any light fittings need cleaning?	No. Light fittings were clean.
Do windows and skylights need cleaning to allow in more natural light?	No. Windows and skylights were clean.
Number of T-5 lights	Exact count not known. Estimated to be 40 light fixtures, 2 lights per fixture.
Number of T-8 lights	Exact count not known. Estimated to be 25 light fixtures, 2 6ft. lights per fixture.
Number of T-12 lights	3 single tube fixtures.
Number of Halogen lights	9 in lobby area.
Number of CFLs	None

Heating	
What is the actual temperature in the space?	Unknown. Uncomfortably warm in hallway and office areas.
Does the temperature vary much during the day?	No.
Do occupants complain it is too hot or too cold?	Yes. Very hot in summer.
If there are Thermostatic Radiator Valves (TRVs), are they set correctly? Do they actually work or are they broken?	Yes.
Are radiators effective and giving consistent heat? They may need bleeding of air or maintenance to remove dust and sediment.	Yes, but some were blocked.
If the room tends to overheat, is there any bare pipework that could be insulated?	No; pipework was adequately insulated
Are radiators blocked, restricting air circulation?	Yes. Furniture blocking a radiator in the kitchen.
Are external doors and windows closed when heating is on?	No. Some windows were open to try to cool down certain areas.

Are windows in good condition? Are any window panes cracked or broken?	Yes.
If there is a roof space, is it insulated?	Yes.
Are blinds closed at the end of the day during winter to cut down on heat loss?	N/A
Is heating on in unused spaces, such as cupboards, corridors?	No unnecessary heating was noticed during the walkthrough.
How many kW do the boilers use?	3x 200 kW boilers in the Dingle
How long is each boiler on per day?	7 hours+

Cooling and Ventilation

If there is air conditioning with local controls, make sure it is only on when necessary. Is it obvious how to control it? What temperature is it set to?	N/A
Is air conditioning running at the same time as heating?	N/A
Are all external doors and windows closed when air conditioning is on?	N/A
Is natural ventilation (e.g. windows and doors open with no air conditioning on) being used?	N/A
Is air conditioning on in unused spaces, such as cupboards, corridors?	N/A

Electrical Equipment

Are computers, printers, photocopiers and other equipment switched off at the end of the day?	Yes.
Can computers and other electrical equipment be programmed to 'power down' or 'energy save' mode?	No. Computers are off when they are not being used.
Can a 7 day timer be put on some equipment (e.g.	No.

photocopiers, water coolers, cold drinks machines) to regulate when systems are powered down?	
Can any equipment be switched on later and switched off earlier?	No.
Can kettles be removed if there is a wall mounted boiler?	N/A
Are fridges places next to heat sources?	N/A
Is the office fridge/freezer defrosted regularly?	N/A
Is the fridge thermostat working and set to the right temperature (2-4 °C)?	N/A
Is equipment clearly labelled so that staff know how to activate energy saving features or switch it off?	No.

Water Use

Is there any evidence of water leaks? (e.g. wet pathways on a dry day)	None noticeable.
Are taps left running? Are there any dripping taps? Do taps need maintenance?	No taps noticeably dripping.
Are hot water heater timers set correctly?	Yes.
How long does the hot water calorifier take to heat up?	1 hour
How long is the hot water calorifier on for per day?	7 hours+

Awareness and Building Usage

Are there posters/guidance displayed to remind people of good practice?	No posters noticed.
When is the building primarily used and what is it used for?	Home to the Reigate fire brigade. Used to house and train fire fighters.

Appendix F—Wray Park Fire Complex Report

1. Introduction

The purpose of this energy survey was to discover potential areas of energy reduction and cost savings within the Wray Park Fire Service Complex. This audit was conducted using a basic walkthrough methodology, with supplementary data on past gas and electric usage. The Wray Park Fire Service Complex is home to the Reigate Fire Brigade and serves as a training facility for fire brigade members. Since the complex is so large, there are many areas for potential savings. The complex contains a wide variety of buildings including offices, workshops, and housing. The ages of the buildings also span a large time period.

2. Summary of Findings

Through our walkthrough audit of the fire complex, we discovered numerous areas of potential energy reduction.

2.1 Headquarters Building

Starting with the Complex Headquarters, we noticed the use of halogen lights in the lobby area. This area also seemed to be over lit, since there were multiple fixtures in a small area by the doorway shown in Figure 19 below.

Figure 19 - Wray Park Fire Complex Halogen Lights in Lobby

We noticed that the hallway was uncomfortably warm as well.

Looking into the office areas we noticed a few key things. Firstly, the lighting in many of the offices consisted of a mix of daytime skylights and T-5 light fixtures. From our observation, the T-5 light fixtures were all on, even with an adequate amount of ambient light filtering in from the skylights. Next we noticed that the office areas were being overheated. As a result, some employees opened windows to cool down the room and alleviate this overheating. After speaking with employees, we also discovered that these offices get hot during the summer due to direct sunlight radiating through the windows.

In the kitchen area we noticed similar situations with the electric lights being used in conjunction with the skylights. We also observed wall-mounted radiators being obstructed by furniture. This essentially makes the radiators unable to adequately disperse heat, causing the radiators to overwork to heat the area. This causes a reduction in efficiency.

Within the boiler room, we noted two large hot water calorifiers. We were made aware that these once served a restaurant within the complex that is no longer in service. We also noted the building is only used during standard business hours, with one room staying open longer. We learned that the building used to house 60 fire trainees, but now only houses 20. We also noted that there was no outside air temperature compensation system within the boiler system.

2.2 "Dingle" Building & Annex

The first thing that was pointed out to us was the building occupancy. During the day, this building only contains two business offices during standard business hours, while the rest of the building remains unoccupied. Within the building, we discovered a mix of light fixtures in use, with older T-12 fixtures being used throughout the building with the occupied offices being lit by the newer T-8 fixtures.

In the boiler room, we learned that the building had a single-pipe radiator system, meaning that the hot water input and return all flow through the same pipe. This leads to a difference in temperature between the consecutive radiators in a system. As a result, the first radiator in the system is hot and the water temperature decays in each subsequent radiator. This is a common method of radiator heating in older buildings such as the Dingle. We also noted that the building seemed to have a draft in some of the unused rooms, suggesting poor insulation throughout the building.

Within the annex workshop, we discovered the use of unit heaters. Unit heaters work by heating the air within an area. Since the workshop was fairly large, unit heaters are an inefficient way to heat this area. Additionally, we noted a few doors and windows were open to outside air.

2.3 St. David's (Schoolhouse)

The first thing we noticed upon entering the building was that it was under-occupied. The building was heated by a single-pipe system connected to two boilers. One of the boilers was approximately 35-40 years old and inefficient, as shown in Figure 20.

Figure 20 - Wray Park Fire Complex St. David's Gas Boiler

Additionally, the lighting fixtures in the building were the older T-12 style fixtures. We were unable to determine lighting habits and patterns due to the low occupancy in the building.

3. Potential Savings

There are many areas for potential savings and energy reduction. These areas are detailed in two different sections: (1) No Cost Solutions and (2) Cost Solutions

3.1 No Cost Solutions

No cost solutions consist of behavioral changes that will allow for monetary savings and energy reduction. These solutions are outlined by building, area, problem, solution, and savings in Table 6 below:

Table 6 - Wray Fire Complex No Cost Solutions

Building	Area	Problem	Solution	Savings
Headquarters	Office Rooms and Kitchen	Skylights provide a decent amount of light, yet lights were on.	Ask staff to turn off lights below skylights during the day when natural light is sufficient	~£95 per year (Based on two 18w tubes with 4w ballast loss in each fixture being run during full daylight hours 10-3 at 10p/kWh)
Headquarters	Kitchen	Furniture blocking radiators, causing a reduction in efficiency	Rearrange furniture so that all radiators are clear from obstruction	This will increase the efficiency of the heating system within the building, resulting in savings
Headquarters	Offices	Windows are being open due to certain areas being too warm	Close windows and lower the operating temperature of the building to adjust for discomfort	By closing the windows, the temperature will reach its desired level, which will let the boilers reduce their output to sustain the temperature
Headquarters	Boiler Room	More hot water is being heated than necessary. The hot water system no longer serves a restaurant as it did in the past. Additionally, the system only serves 20 residents as	Look into shutting down one of the two hot water calorifiers.	By decommissioning one of the calorifiers, you would reduce your energy use for hot water heating by £2,474 per year (Based on a 500 litre hot water calorifier

		opposed to the 60 residents that it did in the past.		with a stored water temperature of 65 degrees running 7 hours per day with a 1 hour heat up time 365 days per year at 2.23p/litre from British Gas)
Dingle	Building	Low occupancy in building, while the whole building is being heated.	Review occupancy of the building. Potentially increase the number of occupants or move current occupants out of the building. If this is not an option, consider zoning the building and not heating unused areas.	If occupants move from the building, boilers in the Dingle will be able to be shut off. We estimate this to save £17,000 per year (Based on three 200 kW boilers being run 7 hours per day, 5 days a week for 39 weeks at 80% efficiency with British Gas supplying natural gas at 2.23p/kWh)

3.2 Low Cost Solutions

Low cost solutions are solutions that have a low initial cost with a small payback period. These solutions will result in yearly savings after the payback period has been completed. Table 7 below outlines the solution, cost, savings per year, and payback period.

Table 7 - Wray Park Fire Complex Low Cost Solutions

Solution	Investment Cost	Savings Per Year	Payback Period
Replace T-5, T-8, T-12, and Halogen lighting with LED lighting	£4,797	£791 per year	6.1 years (calculations shown in Calculations section)

4. Recommendations

We have arranged our recommendations by priority, as seen in the tables below:

Priority no. 1	Improve Energy Awareness		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£1,079	*23,268*	*None*	*Immediate*
Detail	The energy survey revealed that there are potential opportunities to increase energy efficiency and save money via improved housekeeping. As noted in the Summary of Findings, lights were being left on despite ambient light filtering into the building through skylights. Asking staff to turn off these lights when they are not needed will reduce the monthly electric bill, resulting in a moderately high amount of annual savings. The same can be said about turning off computers and other equipment when it is not being used. Additionally, radiators were being blocked by furniture and rooms were being overheated. Closing windows and properly circulating heat around the offices and kitchen area will reduce the cost of heating. We estimate these simple changes to reduce the total energy consumption by 1% annually. In order to accomplish this goal, small notes, posters, and stickers reminding staff to shut windows, turn off lights, and turn off equipment are necessary. These notes will help remind staff about energy efficiency. Talking to the staff about energy awareness will also help in reducing cost.		

Priority no. 2	Replace Current Lighting with LED Lighting Solutions		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£791	*7,907*	*£4,797*	*6.1 Years*
Detail	The energy survey revealed that there are potential opportunities to replace current lighting with LED lighting solutions. LED Lighting provides similar lumens at much higher efficiency than current light fixtures. An 8 Watt T-5 LED tube outputs almost identical lumens per watt as an 18 Watt T-5 fluorescent tube. Additionally, the life of LED tubes is approximately 50,000 hours, which is over 30,000 hours longer than a typical T-5 tube. This calculation takes into account all current lights being replaced by LED lights. Another option would be to only replace current T-8, T-12, and halogen lights with LED lighting solutions. This will reduce the cost savings per year to £566, saving 5,660 kWh/year with an initial cost of £2,791. This gives a quicker payback period (4.9 years) and may be a better option than replacing all lights. Replacing current lighting with LED solutions will have an initial cost, but will save a lot on energy bills after the payback period is completed.		

Priority no. 3	Review Boiler Systems and Occupancy of Dingle		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£19,474	*897,369*	*Minimal*	*Immediate*
Detail	The energy survey revealed that the Dingle is an area that is currently underused, yet requires a large amount of energy and money to run. Three boilers in the basement of the Dingle heat the entire building. However, only two offices are used. Moving these offices to a different space would allow for the boilers to be shut down, as the Annex is heated by unit heaters. This will drastically reduce kWh on the gas bill for the Dingle, resulting in a high amount of savings. Additionally, the energy survey also revealed that the two hot water calorifiers in Headquarters used to service a restaurant, as well as an additional 40 residents. Since the restaurant has been decommissioned and there are approximately 20 residents living in the complex, we recommend shutting down one of these hot water calorifiers entirely.		

5. Conclusion

By completing an energy survey of the Wray Park Fire Complex, we found numerous areas of potential improvement, ranging from simple behavioral changes to upgrading lighting equipment throughout the complex. From these areas of potential savings, we formulated three main priority solutions. The first of these is to raise the energy awareness of employees. Simple things such as turning off unnecessary lighting, reducing the building temperature, and clearing obstructions from radiators can provide noticeable savings without any initial investment. Secondly, we recommend that all lighting throughout the complex be upgraded to newer, high-efficiency light emitting diode (LED) lighting. This will provide a high yearly savings and a reasonable payback period of around two years. Finally, from our observations, we recommend the closing of the Dingle office building. This building is underused for the amount of energy being spent on it. By moving the occupants out of the building and into another that has a higher occupancy, you can save all of the money spent on heating the Dingle. The implementation of this solution will provide the highest savings per year, but the logistics of moving the current occupants and disabling the building may prove difficult. Nevertheless, it is a solution that should be thoroughly looked into, as the resulting savings would be substantial.

6. Calculations

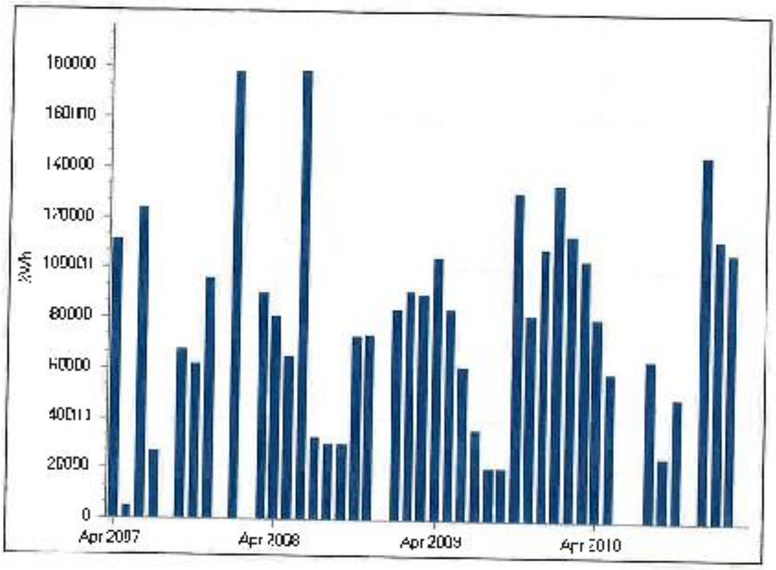
6.1 Priority no. 1 Calculations

Energy Awareness and Behavioral Changes

Expect to save 1% in annual consumption with energy awareness and behavioral changes. Savings is based on data from gas and electric metering below:

Reigate Wray Park (Surrey Fire & Rescue Service)

Invoice Data

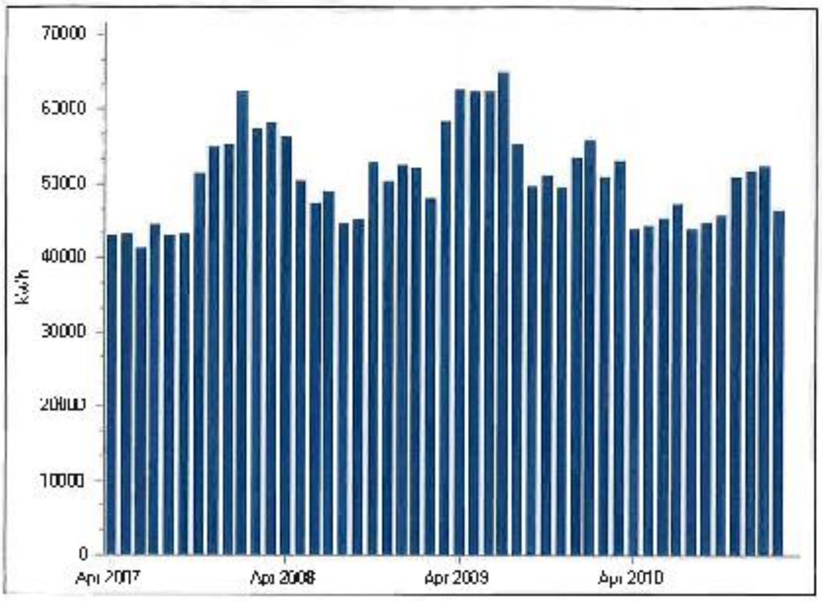


Gas
41306
Dingle & Annex

Month	2007 - 08 kWh	2008 - 09 kWh	2009 - 10 kWh	2010 - 11 kWh
Apr	110,889	90,814	104,703	80,377
May	4,888	64,626	84,056	58,716
Jun	123,888	178,675	60,947	0
Jul	26,897	32,909	36,053	0
Aug	0	28,924	20,557	64,316
Sep	67,533	30,064	20,599	25,377
Oct	61,615	72,981	130,900	48,820
Nov	95,696	73,813	81,634	0
Dec	0	0	108,605	146,069
Jan	177,831	83,800	134,061	112,813
Feb	0	90,922	113,940	107,174
Mar	89,744	89,678	104,057	
Total	755,568	827,808	1,000,111	843,862

Reigate Wray Park (Surrey Fire & Rescue Service)

Invoice Data

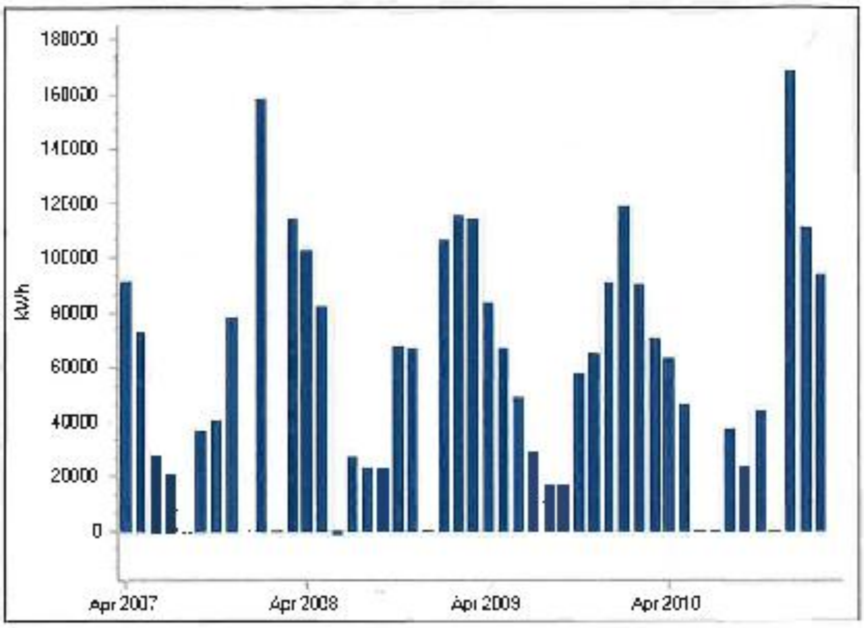


Electricity
1900005425969
St David's Control Dingle & Annex Fire s

Month	2007 - 08 kWh	2008 - 09 kWh	2009 - 10 kWh	2010 - 11 kWh
Apr	43.082	56,329	62,653	44,042
May	43.235	50,363	62,417	44,340
Jun	41.302	47,335	62,481	45,408
Jul	44,548	48,927	65,048	47,450
Aug	43,078	44,690	55,245	43,081
Sep	43,229	45,170	49,825	44,731
Oct	51,409	52,977	51,061	45,702
Nov	54.849	50,430	49,561	50,854
Dec	55,332	52,556	53,494	51.674
Jan	62,455	52,100	55,925	52.605
Feb	57,303	47.084	50,988	46.605
Mar	58,169	58.306	53,082	
Total	597,801	607.055	671,779	517,550

Reigate Wray Park (Surrey Fire & Rescue Service)

Invoice Data



Gas

41104

Wray Park HQ

Month	2007 - 08 kWh	2008 - 09 kWh	2009 - 10 kWh	2010 - 11 kWh
Apr	91,149	102,505	83,357	63,083
May	72,433	82,189	66,946	46,075
Jun	27,341	1,380	48,530	0
Jul	20,386	26,090	26,660	0
Aug	0	22,748	16,396	37,108
Sep	36,403	22,398	16,417	22,620
Oct	40,524	67,272	57,277	43,851
Nov	78,047	65,981	64,536	0
Dec	0	0	90,276	168,301
Jan	158,316	106,674	118,698	110,981
Feb	0	115,603	89,736	94,103
Mar	114,121	114,063	70,400	
Total	838,719	725,943	751,322	586,125

6.2 Priority no. 2 Calculations

LED Lighting Solutions

Based on calculations from http://www.netledlighting.co.uk/t5_tubes.htm

See attached Excel Spreadsheet and charts below:

Client	Surrey County Council
Site	Wray Park Fire Complex
Area	Entire Complex

Annual Operating Hours	2,340
Electricity Cost (p/kWh)	10.000
CCL payable?	No
Include VAT in calculation?	Exclude VAT

	Applicable rates	Used in calculation
Electricity CCL rate (p/kWh)		0
Product VAT rate	15%	0%
Electricity VAT rate	5%	0%

Existing									**Action**	**Replacement**									**Savings**		**Product Cost**	**Installation**
Site/Location	Product Code	Height (m)	Lamps PF	Watts	Ballast Losses	Quantity	OP Hrs Factor	kWh Usage		Product Code	Product Description	Watts	Ballast Losses	Unit Price	Installation	Quantity	OP Hrs Factor	kWh Usage	kWh	Electricity £		
Headquarters	T-5 Doubles (900mm)	3	2	18	4	40	1	4,118	Upgrade	LED	NetLED 900mm	10	0	£ 21.32	£3.75	80	1	1,872	2,246	£ 224.64	£ 1,705.60	£ 300.00
Dingle & Annex	T-8 Doubles (1200mm)	3	2	36	8	25	1	5,148	Upgrade	LED	NetLED 1200mm	15	0	£ 41.32	£3.75	50	1	1,755	3,393	£ 339.30	£ 2,066.00	£ 187.50
Dingle	T-12 Doubles (1800mm)	3	2	70	10	3	1	1,123	Upgrade	LED	NetLED 1800mm	32	0	£ 83.97	£3.75	3	1	225	899	£ 89.86	£ 251.91	£ 11.25
Headquarters	Par 30 Halogen	3	1	75	0	9	1	1,580	Upgrade	LED	Net10/Par30	10	0	£ 26.74	£3.75	9	1	211	1,369	£ 136.89	£ 240.66	£ 33.75
								-														
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								11,969										4,062	7,907	791	4,264	533

Client	Surrey County Council
Site	Wray Park Fire Complex
Date	03/22/2011

Area	Current kWh/pa	New kWh/pa	Savings kWh/pa	Savings CO2 tonnes/pa	Savings £/pa	Investment	Payback	Salix Persistence Factor	Cost per Tonne CO2
Wray Fire Complex	11969	4062	7907	4.3	£791	£4,797	6.1	10	111.3
Total	**11969**	**4062**	**7907**	4.3	**£791**	**£4,797**	**6.1**		

6.3 Priority no. 3 Calculations

Occupancy and Boiler Solutions

See attached Excel Spreadsheets and charts below:

DINGLE ANNUAL ENERGY CONSUMPTIONS AND RUNNING COSTS

Annual energy input (kJ)	=	boiler input or total heat loss x hours/day x days/year x 3600 x seasonal efficiency / thermal efficiency x part load efficiency	
Annual fuel consumption	=	Annual energy input (MJ) / gross calorific value of fuel (MJ/kg or MJ/m3)	

GCV for heating oil is 45.5 MJ/kg
GCV for anthracite is 32.0 MJ/kg
GCV for LPG is 25.5 MJ/litre
GCV for natural gas is 38.2 MJ/m3

Annual running costs (p)	annual fuel consumption (kg or litres or m3) x cost in p/kg or p/litre or p/m3
Annual running cost (£)	fuel cost (p) / 100

Seasonal efficiency use 60% (0.6)
Thermal efficiency use 80 - 95% (0.8 - 0.95) based on boiler efficiency
Part load efficiency use 80% (0.8)
1MJ = 1/3.6 or 0.278kWh

HEATING DETAILS:

Boiler input or total heat loss (kW)	200
Hours per day	7
Days per week	5
Week per year	39
Boiler thermal efficiency	0.8
Cost of NATURAL GAS per unit (p/kWh)	2.23
Cost of HEATING OIL per unit (p/litre)	52.5

TEMPLATE No. 1 (for NATURAL GAS only)

Calculated Annual Energy Input (HEATING)	921,375,000	kJ
Calculated Annual Energy Input (HWS)		kJ
Total Annual Energy Input	921,375,000	kJ
Annual Energy Consumption	256,142	kWh
Total Annual Energy Consumption (3 Boilers)	768,427	kWh
Annual Fuel Consumption (quantity)	24,120	m3
Calculated Annual Running Cost (£)	£5,712	
Total Annual Running Cost (3 Boilers)	£17,136	

DINGLE ANNUAL ENERGY CONSUMPTIONS AND RUNNING COSTS

Annual energy input (kJ) = boiler input or total heat loss x hours/day x days/year x 3600 x seasonal efficiency / thermal efficiency x part load efficiency

Annual fuel consumption = Annual energy input (MJ) / gross calorific value of fuel (MJ/kg or MJ/m3)

GCV for heating oil is 45.5 MJ/kg
GCV for anthracite is 32.0 MJ/kg
GCV for LPG is 25.5 MJ/litre
GCV for natural gas is 38.2 MJ/m3

Annual running costs (p) annual fuel consumption (kg or litres or m3) x cost in p/kg or p/litre or p/m3)

Annual running cost (£) fuel cost (p) / 100

Seasonal efficiency use 60% (0.6)
Thermal efficiency use 80 - 95% (0.8 - 0.95) based on boiler efficiency
Part load efficiency use 80% (0.8)
1MJ = 1/3.6 or 0.278kWh

HEATING/HOT WATER DETAILS:

Cylinder capacity (litres)	500
Required stored water temperature	65
Required heat up time (hours)	1
Hours per day	7
Days per year	365
Cost of NATURAL GAS per unit (p/kWh)	2.23
Cost of HEATING OIL per unit (p/litre)	52.5
Annual Stored Heat Loss (kWh)	19418
Daily Energy Requirement (MJ)	895.55
Daily Energy Requirement (kWh)	248.76
Annual Energy Requirement (kWh)	90799

TEMPLATE No. 1 (for NATURAL GAS only)

Calculated Annual Energy Input (HEATING)		kJ
Calculated Annual Energy Input (HWS)	399071164	kJ
Total Annual Energy Input	399071164	kJ
Annual Energy Consumption	110942	kWh
Annual Fuel Consumption (quantity)	10447	m3
Calculated Annual Running Cost (£)	£2,474	

Appendix G—Wray Common Primary School Checklist

Wray Common Primary School Checklist

Basic Information

Date of Energy Audit:	22/03/2011
Department/Building/Area covered:	Wray Common Primary School
Persons conducting audit:	Joe Lombardo, Kevin McCarthy
Normal occupancy hours of building:	60 hours per week, 39 weeks per year

Lighting

Are any tungsten lights present? Can they be replaced with compact fluorescents (energy saving bulbs)? Look particularly in store rooms, uplighters, desk lamps etc.	Yes, yes
If there are several light switches, can they be labeled to make it more obvious which switches relate to which fixtures?	No
Can lights be switched off to make use of daylight? (e.g. lights parallel to windows or in corridors)	Yes
Can light sensors be installed in spaces that are intermittently occupied (e.g. store rooms, toilets, kitchen areas, copying rooms, corridors, etc)	They can be, but it would not be very effective
Are any external lights on during daylight hours?	No
Can main lighting ever be switched off to make use of ambient light and desk lamps?	Yes

Do any light fittings need cleaning?	No
Do windows and skylights need cleaning to allow in more natural light?	No
Number of T-5 lights	125
Number of T-8 lights	588
Number of T-12 lights	187
Number of Halogen lights	0
Number of CFLs	6

Heating

What is the actual temperature in the space?	Comfortable
Does the temperature vary much during the day?	No
Do occupants complain it is too hot or too cold?	Sometimes windows are opened to combat the heat
If there are Thermostatic Radiator Valves (TRVs), are they set correctly? Do they actually work or are they broken?	They are set correctly
Are radiators effective and giving consistent heat? They may need bleeding of air or maintenance to remove dust and sediment.	Unsure
If the room tends to overheat, is there any bare pipework that could be insulated?	No
Are radiators blocked, restricting air circulation?	In some places
Are external doors and windows closed when heating is on?	Mostly, but there was one window open
Are windows in good condition? Are any window panes cracked or broken?	They are in good condition

If there is a roof space, is it insulated?	Yes
Are blinds closed at the end of the day during winter to cut down on heat loss?	Yes
Is heating on in unused spaces, such as cupboards, corridors?	No, but air conditioning is
How many kW do the boilers use?	2 boilers, 250 kW
How long is each boiler on per day?	7 hours

Cooling and Ventilation

If there is air conditioning with local controls, make sure it is only on when necessary. Is it obvious how to control it? What temperature is it set to?	Yes
Is air conditioning running at the same time as heating?	No
Are all external doors and windows closed when air conditioning is on?	Yes
Is natural ventilation (e.g. windows and doors open with no air conditioning on) being used?	Yes
Is air conditioning on in unused spaces, such as cupboards, corridors?	Yes

Electrical Equipment

Are computers, printers, photocopiers and other equipment switched off at the end of the day?	Some are switched off, some are left on
Can computers and other electrical equipment be programmed to 'power down' or 'energy save' mode?	Yes
Can a 7 day timer be put on some equipment (e.g. photocopiers, water coolers, cold drinks machines) to regulate when systems are powered down?	No

Can any equipment be switched on later and switched off earlier?	No
Can kettles be removed if there is a wall mounted boiler?	Yes
Are fridges places next to heat sources?	No
Is the office fridge/freezer defrosted regularly?	Yes
Is the fridge thermostat working and set to the right temperature (2-4 °C)?	Yes
Is equipment clearly labelled so that staff know how to activate energy saving features or switch it off?	No

Water Use

Is there any evidence of water leaks? (e.g. wet pathways on a dry day)	No
Are taps left running? Are there any dripping taps? Do taps need maintenance?	No
Are hot water heater timers set correctly?	Yes
How long does the hot water calorifier take to heat up?	N/A
How long is the hot water calorifier on for per day?	11 hours

Awareness and Building Usage

Are there posters/guidance displayed to remind people of good practice?	Some
When is the building primarily used and what is it used for?	Primarily used during the day, throughout the year, as a school for children

Appendix H—Wray Common Primary School Report

1. Introduction

The purpose of this energy survey was to discover potential areas of energy reduction and cost savings within the Wray Common Primary School. This audit was conducted using a basic walkthrough methodology, with supplementary data on past gas and electric usage. The main buildings were built in the 1970s, and originally a temporary construct that has been adopted to be a full-time permanent school. It has undergone serious renovation, such as replacing all windows with new double-panes, and the roof was redone with better insulation. Otherwise, there are likely many improvements to be made for reduced energy consumption.

2. Summary of Findings

Throughout the walkthrough of the school complex, we noticed many potential areas to improve that could result in a reduction of energy use.

2.1 Main Building

Beginning in the main building's boiler room, we were informed that the boilers are inefficient, and were last inspected in 1997. They work with a single-pipe system, and still use oil fuel. The boilers are run all day on an automatic setting, and the control system does not have hot air compensation to automatically adjust internal temperature based on outdoor temperature.

In the cafeteria kitchen, we first noted that it is over lit. There is an array of light fixtures, including T5 and T8 fluorescents and compact fluorescent. The kitchen receives substantial sunlight through windows and skylights, yet all of the ceiling lights, of which there are many, were all on. Further, the kitchen was unoccupied by anyone.

Moving through the school's main entrance and administration area, we noticed that in the large office area, one of the radiators was significantly obstructed. Blocking the radiators limits or completely prevents air from flowing around the fixture, and as a result, all of the energy is still going into the radiator, but no heat is given to the room, making it a complete waste of energy. In the head teacher's office, all of the lights were on, despite the vast amount of natural sunlight coming in through the windows. This room also had two radiators, both of which were set very high, and supplemented with a small space heater.

Proceeding next to the Large Hall, we noticed a large number of radiators all on a single-pipe line. By the nature of single-pipe technology, the last radiators in line will not receive as much heat as the first radiators. This hall also is not used much throughout the day, but is heated fully for the entire day.

In the classrooms identified by the letter N and a number, lighting was a very notable drawback. Each of these rooms, combined with their hallways, have twelve lighting fixtures with two T12 fluorescent bulbs each, as well has very significant skylights and windows. A few of these classrooms did not utilize the natural daylight which the rooms were so clearly intended to take advantage of, with the shades drawn, skylights covered, and the lights all on. A small percentage of the rooms had blocked the radiators partially, and some completely. We also noticed that one of the rooms both had the radiators on high, and the windows open to combat the radiators and cool the room.

From these classrooms we continued to the Small Hall. Our observations for the Small Hall are similar to those of the Large Hall.

In the staff area, we noticed in the hallways a number of T12 lights. In the staff lounge, we found that there were two radiators, both blocked by sofas. There were also four computers on, not always being used. We learned from employees that computers are often left on when not in use, including overnight and over the weekends. The flat, an area seemingly seldom used, rooms on the lower level were being heated, while the upper level was powering an air conditioner. This upper room also had five computers and a copy machine on with no one operating them.

The S-classrooms area, the toilets all had incandescent lights on. Three of the classrooms had windows and skylights blocked, and the lights all on, which are T8 fluorescents. Additionally, these classrooms were all empty at the time of this survey. Many of the rooms had a computer fully powered on, unattended, and sometimes an accompanying projector. One room, S5, had 17 computers on without anyone using them.

2.2 Technology Building

There is one boiler in the technology building. It too uses oil fuel, is on an auto setting, and lacks compensation technology.

The room M2 has an array of T12 fluorescent lights, and three computers. It is another room that does not take advantage of the “free” light available. The shades were all drawn, and all of the lights were on in an empty classroom. Room M1 had a blocked radiator and a space heater.

3. Potential Savings

There are many areas for potential savings and energy reduction. These areas are detailed in two different sections: (1) No Cost Solutions and (2) Cost Solutions

3.1 No Cost Solutions

No cost solutions consist of behavioral changes that will allow for monetary savings and energy reduction. These solutions are outlined by area, problem, solution, and savings in Table 8 below:

Table 8 - Wray Common Primary School No Cost Solutions

Area	Problem	Solution	Savings
Various rooms throughout the school	Skylights and windows provide a great amount of light, yet lights were on.	Ask staff to turn off lights during the day when natural light is sufficient and put up flyers to remind staff	Reducing the usage hours of the lights will directly reduce the amount paid for electricity. Using lights 50% of current usage can save about £1600 annually
Classroom N3, staffroom, room M1	Some radiators are blocked by furniture	Rearrange furniture as to clear space in front of radiators; or, turn radiators off permanently	Uncovering the radiators will greatly increase effectiveness, requiring lower heat settings, and can save 1% on heating bills.
Flat	Area seems underused,	Adjust temperature	Turning off the computers and

	but computers are on, and room is air conditioned	settings in the area, turn off computers	limiting the use of the air conditioner will reduce electric use and save money

3.2 Low Cost Solutions

Low cost solutions are solutions that have a low initial cost with a small payback period. These solutions will result in yearly savings after the payback period has been completed. Table 9 below outlines the solution, cost, savings per year, and payback period:

Table 9 - Wray Common Primary School Low Cost Solutions

Problem	Solution	Investment Cost	Savings Per Year	Payback Period
Usage of Fluorescent and Incandescent Lighting	Replace T-5, T-8, T-12, and incandescent lighting with LED lighting	£28,100	£2,329 per year 23,290 kWh per year	12.1 years (calculations shown in the Calculations section)

3.3 High Cost Solutions

Solutions in this category are much more aggressive actions, but can be well worth the large investment. Once the payback period is reached, savings will begin to accumulate. Table 9 below outlines the problem, solution, cost, savings and payback.

Table 10 - Wray Common Primary School High Cost Solutions

Problem	Solution	Investment Cost	Savings Per Year	Payback Period
Very old and inefficient boiler/boiler which is fuelled by oil	Replace current boiler with a renewable-resource wood chip burning boiler	~£175,000	~£37,000 per year Unsure kWh per year	~4 years (calculations shown in the Calculations section)

4. Recommendations

We have arranged our recommendations by priority. The tables below illustrate solutions that should be considered moving forward.

Priority no. 1	Install a Wood-chip Burning Boiler		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
~ £37,000	*Unknown*	*~£175,000*	*~4 years*
Detail	The energy survey revealed that there is potential to save great a great amount of energy and money through replacement of the boilers. Using oil as a fuel source is much more expensive than other options. This wood-chip fuel system we suggest is not only cheaper in cost of supply, but is also a renewable energy source, and thus can provide eligibility for		

	government incentives. It is possible to receive a sum of money to invest in buying and installing the new boiler unit. With metering, a quarterly incentive of a certain amount can be received based on metering data. Note: Calculations are rough estimates since actual cost has many other variables to take into account (grants, fuel storage and delivery, etc). These factors could adjust investment cost and savings in negative or positive ways.

Priority no. 2	**Adjust Boiler Operating Hours**		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
~£5200	*~103,000*	*None*	*Immediate*
Detail	The energy survey revealed that there are potential opportunities to increase energy efficiency and save money by adjusting boiler and hot water calorifier operating hours. Though we were unable to see the timer settings on the boiler system, adjusting the hours of operation by 1 hour can result in an annual savings of about 9% of the cost of heating. This amounts to an annual savings of about £5200 with oil fuel or about £2300 with natural gas fuel. If the boiler is shut off two hours early, then about 18% can be saved annually, about £10,000 with oil and about £5000 for natural gas. This trend continues as the boiler is run for a shorter amount of time, and it has been determined through previous works that many buildings can often shut off their boilers before the normal end of the day, and the building will still be of equally comfortable temperature. This simple action has been found to save substantial amounts of money, as the previous example calculations prove. The same is true about the energy savings. One possible option for accomplishing this savings is to shut the boilers off an hour before people leave the building. The building will retain a fairly constant, comfortable temperature since the building has new windows and is well insulated in most areas. As a result, this will also reduce the amount of energy used daily from the boiler system.		

Priority no. 3	**Improve Energy Awareness**		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£269	*3,953.41*	*Minimal*	*Immediate*
Detail	The energy survey revealed that there are potential opportunities to increase energy efficiency and save money via improved housekeeping. As noted in the Summary of Findings, some lights were being left on despite ambient light radiating down from skylights. Asking staff to turn off these lights when they are not needed will reduce the electric bill per month, resulting in a moderately high amount of annual savings. The same can be said about turning off computers and other equipment when it is not being used. Additionally, a few radiators were		

	being blocked by furniture and a number of rooms were being overheated. Closing windows and properly circulating heat will reduce the cost of heating. We estimate these simple changes to reduce the total energy consumption by 1% annually. In order to accomplish this goal, small notes, posters, and stickers reminding staff to turn off lights and equipment as well as shutting windows are necessary. These notes will help remind staff about energy efficiency. Talking to the staff about energy awareness will also help in reducing cost.

Priority no. 4	**Replace current lighting with LED lighting solutions**		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£2,329	*23,290*	*£28,100*	*12.1 years*
Detail	The energy survey revealed that there are potential opportunities to replace current lighting with LED lighting solutions. LED Lighting provides similar lumens at much higher efficiency than current light fixtures. They last 50,000 hours, which is greater than twice the lifetime of a typical T-5 tube. Replacing current lighting with LED solutions very significantly cuts down energy usage, but because we determined that lights are currently turned off for much of the day, the payback period is extremely long. However, an advantage of the LED lights is that very frequent powering on and off does not affect the life of the bulb, unlike with fluorescent bulbs, which are very negatively affected by this.		

5. Conclusion

By completing an energy survey of the Wray Common Primary School, we found numerous areas of potential improvement, ranging from simple behavioral changes to upgrading the boilers for the main building. From these areas of potential savings, we formulated three main priority solutions. A top priority is replacing the boilers. This is a critical improvement for two reasons: the current boiler uses oil, which is extremely expensive; the second reason being that the current boiler is not very efficient. The second priority suggestion is to adjust the operating hours of the boiler. It has been found that even when the boiler is shut down early, the building still remains sufficiently heated for the remainder of the day, and can lead to tremendous savings of money, energy, and carbon. The third of these will be to raise the energy awareness of employees. Simple things such as turning off unnecessary lighting and reducing the building temperature can provide noticeable savings without any initial investment. Another critical habitual solution is to for employees to set their computers to enter standby mode rather than running a screensaver. Standby mode uses significantly less energy than a screensaver. As an optional fourth idea, we recommend that it be considered to replace all lighting throughout the building to newer, high-efficiency light emitting diode (LED) lighting. The payback period is very long, but the LED lights save a huge amount of energy usage and carbon emission.

6. Calculations

6.1 1st Priority Calculations

The first priority was replacing the outdated current boiler, which is powered with oil fuel, with a new boiler which utilizes wood pellets for fuel. In order to calculate the associated savings, we used excel spreadsheets which contain formulas to interpret data and statistics to find usage and savings. It can be seen in the figure below how much more it costs to use oil rather than natural gas. The cost of natural gas is comparable to that of wood pellets, so the numbers given can provide us some idea of the difference.

		Woodchip	Wood pellet	Heating Oil	Notes
Appraisal					
Single biomass installation					
Boiler CAPEX		£179,182	£179,182	£24,809	
Grant on biomass boiler		£44,796	£44,796	£0	
Net boiler CAPEX		£134,387	£134,387	£24,809	Denotes the capital cost premium over and above an equivalent sized fossil fuel alternative.
OPEX					
Boiler O & M		£2,064	£1,524	£302	Service costs and attendance
Fuel OPEX		£21,559	£25,446	£60,680	
Revenue Support					
Carbon abatement revenue		£0	£0		
Economic Appraisal					
Total annual energy expenditure	£/annum	41,882	45,229	64,353	Includes capital cost, operational expenditure and fuel costs
Unit heating cost	p/kWh	5.36	5.79	12	Delivered energy from the biomass boiler (excl additional cost of energy provided by any stand-by boiler but includes any reduction due to revenue support)
Using Woodchips					
Capital premium over benchmark fossil fuel cost				£134,387	
Operational savings against benchmark fuel	£/annum			£37,360	Accounts for operational expenditure only (fuel and maintenance)
Simple payback	years			4	Simple payback = the total biomass investment / the annual operational cost savings
Net Present Value of biomass option	10 year term			140,584	Based upon the capital investment in biomass plant
Internal Rate of Return of biomass option				24.76%	
Defined interest rate				6.00%	
Using Woodpellets					
Capital premium over benchmark fossil fuel cost				£134,387	
Operational savings against benchmark fuel	£/annum			34012	Accounts for operational expenditure only (fuel and maintenance)
Simple payback	years			4	Simple payback = the total biomass investment / the annual operational cost savings
Net Present Value of biomass option	10 year term			115946	Based upon the capital investment in biomass plant
Internal Rate of Return of biomass option				0	
Defined interest rate				6.00%	
Biomass Boiler					
Boiler Rating	kW	350	350		
Delivered Energy	kWh	781,830	781,830		
Boiler Efficiency		85%	85%		
Required energy displaced by biomass		245%	245%		
Fuel					
Woodchip Moisture Content		30%	8%		
Annual Fuel Tonnage Required	tonnes	269	196		
Fuel Storage Area	14 days (m3)	2,462	634		
(based on operating at MRO over that time)	7 days (m3)	616	159		
	3 days (m3)	113	29		
Emissions					
Emission	Kg	0	0	428,605	
CO2 savings over fossil fuel benchmark	T	429	429		
Cost of CO2 Saving	£/tonne	-52.43	-44.62		A negative number indicates a cost saving associated with the CO2 reduction

HEATING DETAILS:		
Boiler input or total heat loss (kW)	400	
Hours per day	11	
Days per week	5.5	
Week per year	44	
Boiler thermal efficiency	0.7	
Cost of NATURAL GAS per unit (p/kWh)	2.23	
Cost of HEATING OIL per unit (p/litre)	52.5	
TEMPLATE No. 1 (for NATURAL GAS only)		
Calculated Annual Energy Input (HEATING)	4107085714	kJ
Calculated Annual Energy Input (HWS)		kJ
Total Annual Energy Input	4107085714	kJ
Annual Energy Consumption	1141770	kWh
Annual Fuel Consumption (quantity)	107515	m3
Calculated Annual Running Cost (£)	£25,461	
Theromostat Adjustment Savings	£2,546.15	

HOT WATER DETAILS:		
Cylinder capacity (litres)	500	
Required stored water temperature	65	
Required heat up time (hours)	1	
Hours per day	11	
Days per year	273	
Annual Stored Heat Loss (kWh)	22823	
Daily Energy Requirement (MJ)	127.94	
Daily Energy Requirement (kWh)	35.54	
Annual Energy Requirement (kWh)	9702	
TEMPLATE No. 2 (for HEATING OIL only)		
Calculated Annual Energy Input	4107085714	kJ
Calculated Annual Energy Input (HWS)	119378238	kJ
Total Annual Energy Input	4226463953	kJ
Annual Energy Consumption	1174957	kWh
Annual Fuel Consumption (quantity)	92889	kg
Converted to litres	111245	litres
Calculated Annual Running Cost (£)	£58,403	

6.2 2nd Priority Calculations

The second priority was to adjust the operation hours of the boiler. To do this, we used the same excel sheet as the one found in section 6.1 and adjusted the hours down from 11 to 10.

6.3 3rd Priority Calculations

The third priority suggestion is increasing energy awareness. Expect to save 1% in annual consumption with energy awareness and behavioral changes. Savings is based on data from gas, oil and electric metering provided to us by the school.

6.4 4th Priority Calculations

LED Lighting Solutions

Based on calculations from http://www.netledlighting.co.uk/t5_tubes.htm

See attached Excel Spreadsheet and charts below:

Client	Wray Common Primary School
Site	Wray Common Primary School
Area	Entrance Area

Annual Operating Hours	1,000
Electricity Cost (p/kWh)	10.000
CCL payable?	No
Include VAT in calculation?	Exclude VAT

	Applicable rates	Used in calculation
Electricity CCL rate (p/kWh)		0
Product VAT rate	15%	0%
Electricity VAT rate	5%	0%

Existing									**Action**
Site/Location	Product Code	Height (m)	Lamps PF	Watts	Ballast Losses	Quantity	OP Hrs Factor	kWh Usage	
Entrance	T-5 Doubles (600mm)	3	4	14	4	8	1	576	Upgrade
	Par 30 Halogen	3	1	75	0	6	1	450	Upgrade
Nurse Ofiice	T-5 Doubles (600mm)	3	1	18	8	4	1	104	Upgrade
Closet	Par 30 Halogen	3	1	75	0	2	1	150	Upgrade
Offices	T-8 Doubles (900mm)	3	1	18	8	12	1	312	Upgrade
								1,592	

Site/Location	**Replacement**									**Savings**		**Product Cost**	**Installation**
	Product Code	Product Description	Watts	Ballast Losses	Unit Price	Installation	Quantity	OP Hrs Factor	kWh Usage	kWh	Electricity £		
Entrance	LED	NetLED 600mm	7	0	£ 15.33	£3.75	32	1	224	352	£ 35.20	£ 490.56	£ 120.00
	LED	30 NetLED	12	0	£ 26.74	£3.75	6	1	72	378	£ 37.80	£ 160.44	£ 22.50
Nurse Ofiice	LED	NetLED 600mm	7	0	£ 15.33	£3.75	4	1	28	76	£ 7.60	£ 61.32	£ 15.00
Closet	LED	30NetLED	12	0	£ 26.74	£3.75	2	1	24	126	£ 12.60	£ 53.48	£ 7.50
Offices	LED	NetLED 900mm	11	0	£ 34.65	£3.75	12	1	132	180	£ 18.00	£ 415.80	£ 45.00
									480	1,112	111	1,182	210

Payback Report									
Client	Wrat Common Primary School								
Site	Wray Common Primary School Reception and Administration								
Date	3/22/2011								
Area	Current kWh/pa	New kWh/pa	Savings kWh/pa	Savings CO2 tonnes/pa	Savings £/pa	Investment	Payback	Salix Persistence Factor	Cost per Tonne CO2
Administration	1592	480	1112	0.6	£111	£1,392	12.5	10	233.0
Total	**1592**	**480**	**1112**	0.6	**£111**	**£1,392**	**12.5**		

Client	Wray Common Primary School
Site	Wray Common Primary School
Area	Large Hall, Library

Annual Operating Hours	1,000
Electricity Cost (p/kWh)	10.000
CCL payable?	No
Include VAT in calculation?	Exclude VAT

	Applicable rates	Used in calculation
Electricity CCL rate (p/kWh)		0
Product VAT rate	15%	0%
Electricity VAT rate	5%	0%

Existing									**Action**
Site/Location	Product Code	Height (m)	Lamps PF	Watts	Ballast Losses	Quantity	OP Hrs Factor	kWh Usage	
Large Hall	T-8 Doubles (1200mm)	5	2	18	8	10	1	520	Upgrade
Library	T-5 Single (600mm)	3	1	14	4	1	1	18	Upgrade
	T-5 Double (600mm)	3	2	14	4	6	1	216	Upgrade
								-	
								754	

Site/Location	**Replacement**									**Savings**		**Product Cost**	**Installation**
	Product Code	Product Description	Watts	Ballast Losses	Unit Price	Installation	Quantity	OP Hrs Factor	kWh Usage	kWh	Electricity £		
Large Hall	LED	NetLED T-8 (900mm)	11	0	£ 41.32	£3.75	20	1	220	300	£ 30.00	£ 826.40	£ 75.00
Library	LED	NetLED T-5 (600mm)	7	0	£ 15.33	£3.75	1	1	7	11	£ 1.10	£ 3.75	£ 1.00
	LED	NetLED T-5 (600mm)	7	0	£ 15.33	£3.75	12	1	84	132	£ 13.20	£ 45.00	£ 12.00
									-	-	£ -	£ -	£ -
									311	443	44	875	88

Payback Report									
Client	Wray Common Primary School								
Site	Wray Common Primary School Library and Large Hall								
Date	3/22/2011								
Area	Current kWh/pa	New kWh/pa	Savings kWh/pa	Savings CO2 tonnes/pa	Savings £/pa	Investment	Payback	Salix Persistence Factor	Cost per Tonne CO2
Library and Large Hall	754	311	443	0.2	£44	£963	21.7	10	404.9
Total	**754**	**311**	**443**	0.2	**£44**	**£963**	**21.7**		

Client	Wray Common Primary School
Site	Wray Common Primary School
Area	Small Hall

Annual Operating Hours	1,000
Electricity Cost (p/kWh)	10.000
CCL payable?	No
Include VAT in calculation?	Exclude VAT

	Applicable rates	Used in calculation
Electricity CCL rate (p/kWh)		0
Product VAT rate	15%	0%
Electricity VAT rate	5%	0%

Existing									**Action**	**Replacement**									**Savings**		**Product Cost**	**Installation**
Site/Location	Product Code	Height (m)	Lamps PF	Watts	Ballast Losses	Quantity	OP Hrs Factor	kWh Usage		Product Code	Product Description	Watts	Ballast Losses	Unit Price	Installation	Quantity	OP Hrs Factor	kWh Usage	kWh	Electricity £		
Small Hall	T-12 Double (1200mm)	4	2	35	10	12	1	1,080	Upgrade	LED	NetLED T-10 (1200mm)	15	0	£ 47.74	£3.75	12	1	180	900	£ 90.00	£ 572.88	£ 45.00
								-										-	-	£ -	£ -	£ -
								1,080										180	900	90	573	45

Payback Report									
Client	Wray Common Primary School								
Site	Wray Common Primary School Small Hall								
Date	3/22/2011								
Area	Current kWh/pa	New kWh/pa	Savings kWh/pa	Savings CO2 tonnes/pa	Savings £/pa	Investment	Payback	Salix Persistence Factor	Cost per Tonne CO2
Small Hall	1080	180	900	0.5	£90	£618	6.9	10	127.8
Total	**1080**	**180**	**900**	0.5	**£90**	**£618**	**6.9**		

Client Wray Common Primary School
Site Wray Common Primary School
Area N Rooms

Annual Operating Hours	1,180
Electricity Cost (p/kWh)	10.000
CCL payable?	No
Include VAT in calculation?	Exclude VAT

	Applicable rates	Used in calculation
Electricity CCL rate (p/kWh)		0
Product VAT rate	15%	0%
Electricity VAT rate	5%	0%

Existing									**Action**	**Replacement**									**Savings**		**Product Cost**	**Installation**
Site/Location	Product Code	Height (m)	Lamps PF	Watts	Ballast Losses	Quantity	OP Hrs Factor	kWh Usage		Product Code	Product Description	Watts	Ballast Losses	Unit Price	Installation	Quantity	OP Hrs Factor	kWh Usage	kWh	Electricity £		
N Classrooms	T-12 Doubles (1800mm)	3	2	35	10	96	1	10,195	Upgrade	LED	NetLED T-10 (1200mm)	15	0	£ 41.32	£3.75	96	1	1,699	8,496	£ 849.60	£ 3,966.72	£ 360.00
	T-5 Single (600mm)	3	1	14	4	3	1	64	Upgrade	LED	NetLED T-5 (600mm)	7	0	£ 15.33	£3.75	3	1	25	39	£ 3.89	£ 45.99	£ 11.25
								-										-	-	£ -	£ -	£ -
								10,259										1,724	8,535	853	4,013	371

Payback Report									
Client	Wray Common Primary School								
Site	Wray Common Primary School 'N' classrooms								
Date	3/22/2011								
Area	Current kWh/pa	New kWh/pa	Savings kWh/pa	Savings CO2 tonnes/pa	Savings £/pa	Investment	Payback	Salix Persistence Factor	Cost per Tonne CO2
'N' classrooms	10259	1724	8535	4.6	£853	£4,384	5.1	10	95.7
Total	**10259**	**1724**	**8535**	4.6	**£853**	**£4,384**	**5.1**		

Client	Wray Common Primary School
Site	Wray Common Primary School
Area	Kitchen Area

Annual Operating Hours	1,755
Electricity Cost (p/kWh)	10.000
CCL payable?	No
Include VAT in calculation?	Exclude VAT

	Applicable rates	Used in calculation
Electricity CCL rate (p/kWh)		0
Product VAT rate	15%	0%
Electricity VAT rate	5%	0%

Existing									**Action**	**Replacement**										**Savings**		**Product Cost**	**Installation**
Site/Location	Product Code	Height (m)	Lamps PF	Watts	Ballast Losses	Quantity	OP Hrs Factor	kWh Usage		Product Code	Product Description	Watts	Ballast Losses	Unit Price	Installation	Quantity	OP Hrs Factor	kWh Usage		kWh	Electricity £		
Kitchen	T-5 Doubles (600mm)	3	4	14	4	16	1	2,022	Upgrade	LED	NetLED T-5 (600mm)	7	0	£ 15.33	£3.75	64	1	786		1,236	£ 123.55	£ 981.12	£ 240.00
	T-8 Doubles (900mm)	3	1	18	8	8	1	365	Upgrade	LED	NetLED T-8 (900mm)	11	0	£ 34.65	£3.75	8	1	154		211	£ 21.06	£ 277.20	£ 30.00
Side Rooms	T-5 Doubles (600mm)	3	1	18	8	2	1	91	Upgrade	LED	NetLED T-5 (600mm)	7	0	£ 15.33	£3.75	2	1	25		67	£ 6.67	£ 30.66	£ 7.50
	Par 30 Halogen	3	1	75	0	3	1	395	Upgrade	LED	NetLED Par 30	12	0	£ 26.74	£3.75	3	1	63		332	£ 33.17	£ 80.22	£ 11.25
	T-8 Doubles (900mm)	3	1	18	8	6	1	274	Upgrade	LED	NetLED T-8 (900mm)	11	0	£ 34.65	£3.75	6	1	116		158	£ 15.80	£ 207.90	£ 22.50
								-										-		-	£ -	£ -	£ -
								3,147										1,144		2,002	200	1,577	311

Payback Report									
Client	Wrat Common Primary School								
Site	Wray Common Primary School Kitchen								
Date	3/22/2011								
Area	Current kWh/pa	New kWh/pa	Savings kWh/pa	Savings CO2 tonnes/pa	Savings £/pa	Investment	Payback	Salix Persistence Factor	Cost per Tonne CO2
Kitchen	3147	1144	2002	1.1	£200	£1,888	9.4	10	175.6
Total	**3147**	**1144**	**2002**	1.1	**£200**	**£1,888**	**9.4**		

Client	Wray Common Primary School
Site	Wray Common Primary School
Area	Technology Area

Annual Operating Hours	1,180
Electricity Cost (p/kWh)	10.000
CCL payable?	No
Include VAT in calculation?	Exclude VAT

	Applicable rates	Used in calculation
Electricity CCL rate (p/kWh)		0
Product VAT rate	15%	0%
Electricity VAT rate	5%	0%

Existing									**Action**
Site/Location	Product Code	Height (m)	Lamps PF	Watts	Ballast Losses	Quantity	OP Hrs Factor	kWh Usage	
Entrance	Incandescent	3	1	60	4	18	1	1,359	Upgrade
Kitchen	T-8 Doubles (900mm)	3	1	18	8	6	1	184	Upgrade
M1	T-8 Doubles (900mm)	3	1	18	8	10	1	307	Upgrade
M2	T-12 Doubles (1200mm)	3	1	18	8	9	1	276	Upgrade
								-	
								2,126	

Site/Location	**Replacement**									**Savings**		**Product Cost**	**Installation**
	Product Code	Product Description	Watts	Ballast Losses	Unit Price	Installation	Quantity	OP Hrs Factor	kWh Usage	kWh	Electricity £		
Entrance	LED	NetLED E27/4-CW	4	0	£ 19.25	£3.75	18	1	85	1,274	£ 127.44	£ 346.50	£ 67.50
Kitchen	LED	NetLED T-8 (900mm)	11	0	£ 34.65	£3.75	6	1	78	106	£ 10.62	£ 207.90	£ 22.50
M1	LED	NetLED T-8 (900mm)	11	0	£ 34.65	£3.75	10	1	130	177	£ 17.70	£ 346.50	£ 37.50
M2	LED	NetLED T-10 (1200mm)	15	0	£ 41.32	£3.75	9	1	159	117	£ 11.68	£ 371.88	£ 33.75
									-	-	£ -	£ -	£ -
									452	1,674	167	1,273	161

Payback Report									
Client	Wrat Common Primary School								
Site	Wray Common Primary School Technology area								
Date	3/22/2011								
Area	Current kWh/pa	New kWh/pa	Savings kWh/pa	Savings CO2 tonnes/pa	Savings £/pa	Investment	Payback	Salix Persistence Factor	Cost per Tonne CO2
Technology Building	2126	452	1674	0.9	£167	£1,434	8.6	10	159.5
Total	**2126**	**452**	**1674**	0.9	**£167**	**£1,434**	**8.6**		

Client	Wray Common Primary School
Site	Wray Common Primary School
Area	S Rooms Area

Annual Operating Hours	1,180
Electricity Cost (p/kWh)	10.000
CCL payable?	No
Include VAT in calculation?	Exclude VAT

	Applicable rates	Used in calculation
Electricity CCL rate (p/kWh)		0
Product VAT rate	15%	0%
Electricity VAT rate	5%	0%

Existing									**Action**
Site/Location	Product Code	Height (m)	Lamps PF	Watts	Ballast Losses	Quantity	OP Hrs Factor	kWh Usage	
Entrance	T-8 Doubles (900mm)	3	4	18	4	12	1	1,246	Upgrade
	Incandescent	3	1	60	4	6	1	453	Upgrade
Workbay 2	T-8 Doubles (900mm)	3	4	18	8	9	1	1,104	Upgrade
S1-S4	T-8 Doubles (900mm)	3	4	18	8	51	1	6,259	Upgrade
S5-S9	T-8 Doubles (900mm)	3	4	18	8	37	1	4,541	Upgrade
	T-8 Doubles (900mm)	3	2	18	8	6	1	368	Upgrade
	Incandescent	3	1	60	4	5	1	378	Upgrade
	T-12 Doubles (1200mm)	3	1	35	10	1	1	53	Upgrade
Hallway	T-12 Doubles (1200mm)	3	1	35	10	3	1	159	Upgrade
								-	
								14,561	

Replacement										**Savings**		**Product Cost**	**Installation**
Site/Location	Product Code	Product Description	Watts	Ballast Losses	Unit Price	Installation	Quantity	OP Hrs Factor	kWh Usage	kWh	Electricity £		
Entrance	LED	NetLED T-8 (900mm)	11	0	£ 34.65	£3.75	48	1	623	623	£ 62.30	£ 1,663.20	£ 180.00
	LED	NetLED E27/4-CW	4	0	£ 10.66	£3.75	6	1	28	425	£ 42.48	£ 63.96	£ 22.50
Workbay 2	LED	NetLED T-8 (900mm)	11	0	£ 34.65	£3.75	36	1	467	637	£ 63.72	£ 1,247.40	£ 135.00
S1-S4	LED	NetLED T-8 (900mm)	11	0	£ 34.65	£3.75	204	1	2,648	3,611	£ 361.08	£ 7,068.60	£ 765.00
S5-S9	LED	NetLED T-8 (900mm)	11	0	£ 34.65	£3.75	148	1	1,921	2,620	£ 261.96	£ 5,128.20	£ 555.00
	LED	NetLED T-8 (900mm)	11	0	£ 34.65	£3.75	12	1	156	212	£ 21.24	£ 415.80	£ 45.00
	LED	NetLED E27/4-CW	4	0	£ 10.66	£3.75	5	1	24	354	£ 35.40	£ 53.30	£ 18.75
	LED	NetLED T-12 (1200mm)	15	0	£ 41.32	£3.75	1	1	18	35	£ 3.54	£ 41.32	£ 3.75
Hallway	LED	NetLED T-12 (1200mm)	15	0	£ 41.32	£ 3.75	3	1	53	106	£ 10.62	£ 11.25	£ 3.00
									-	-	£ -	£ -	£ -
									5,938	8,623	862	15,693	1,728

Payback Report									
Client	Wrat Common Primary School								
Site	Wray Common Primary School 'S' Classrooms and Hallway								
Date	3/22/2011								
Area	Current kWh/pa	New kWh/pa	Savings kWh/pa	Savings CO2 tonnes/pa	Savings £/pa	Investment	Payback	Salix Persistence Factor	Cost per Tonne CO2
'S' Classrooms	14561	5938	8623	4.6	£862	£17,421	20.2	10	376.2
Total	**14561**	**5938**	**8623**	4.6	**£862**	**£17,421**	**20.2**		
	Total investment		**total kWh savings**		**total savings £/pa**		**total payback**		
	£28,100		23290.255		£2,329		12.1		

Appendix I—Reigate Library Checklist

Reigate Library Checklist

Basic Information

Date of Energy Audit:	March 24, 2011
Department/Building/Area covered:	Entire Building
Persons conducting audit:	Nicholas Mondor, Nicholas Solarz, Ian Sharpe
Normal occupancy hours of building:	**Library** 9:30-1:00 Monday 9:30-7:00 Tuesday Closed Wednesday 9:30-5:00 Thursday-Saturday Closed Sunday **Registrar** 9:00-1:00, 2:00-4:30 Monday, Tuesday, Thursday, Friday 10:30-1:00, 1:00-4:30 Wednesday

Lighting

Are any tungsten lights present? Can they be replaced with compact fluorescents (energy saving bulbs)? Look particularly in store rooms, uplighters, desk lamps etc.	1 Halogen Light in Stairway
If there are several light switches, can they be labelled to make it more obvious which switches relate to which fixtures?	Switches can be labelled for second floor lighting
Can lights be switched off to make use of daylight? (e.g. lights parallel to windows or in corridors)	Yes. There are lots of windows throughout the building, as well as skylights on the 2nd floor. Ambient light could be used.
Can light sensors be installed in spaces that are intermittently occupied (e.g. store rooms, toilets, kitchen areas, copying rooms, corridors, etc)	No. Lights were off in the kitchen area, even though some of the staff were there drinking tea/coffee. High energy awareness among staff.

Are any external lights on during daylight hours?	No
Can main lighting ever be switched off to make use of ambient light and desk lamps?	Main lights can sometimes be shut off to make use of ambient light, but not desk lamps
Do any light fittings need cleaning?	Yes. Some light fittings were dirty.
Do windows and skylights need cleaning to allow in more natural light?	Yes. Windows were clear, but some of the skylights were not
Number of T-5 lights	None
Number of T-8 lights	27 8ft fixtures on first floor 14 8ft fixtures, 4 4ft fixtures, 1 6ft fixtures on second floor 7 6ft fixtures
Number of T-12 lights	10 8ft fixtures on first floor 4 8ft fixtures, 1 6ft fixtures on second floor
Number of Halogen lights	1 in stairway
Number of CFLs	None

Heating

What is the actual temperature in the space?	Comfortable—around 68° F
Does the temperature vary much during the day?	During the winter, yes.
Do occupants complain it is too hot or too cold?	Warm in the summer. Varying heat during winter
If there are Thermostatic Radiator Valves (TRVs), are they set correctly? Do they actually work or are they broken?	Radiators don't have TRVs so they choose which ones to turn on
Are radiators effective and giving consistent heat? They may need bleeding of air or maintenance to remove dust and sediment.	No due to no TRV controls
If the room tends to overheat, is there any bare pipework that could be insulated?	Pipework is all insulated
Are radiators blocked, restricting air circulation?	Only on the storage room

Are external doors and windows closed when heating is on?	Yes. Windows were all shut and only the front door was open for people to walk into the library.
Are windows in good condition? Are any window panes cracked or broken?	No. Window panes in great condition.
If there is a roof space, is it insulated?	N/A
Are blinds closed at the end of the day during winter to cut down on heat loss?	Yes.
Is heating on in unused spaces, such as cupboards, corridors?	No.
How many kW do the boilers use?	50 kW
How long is each boiler on per day?	Building manager didn't know how long it was on each day

Cooling and Ventilation

If there is air conditioning with local controls, make sure it is only on when necessary. Is it obvious how to control it? What temperature is it set to?	We did not notice any air conditioning controls.
Is air conditioning running at the same time as heating?	N/A
Are all external doors and windows closed when air conditioning is on?	N/A
Is natural ventilation (e.g. windows and doors open with no air conditioning on) being used?	N/A
Is air conditioning on in unused spaces, such as cupboards, corridors?	No. Heating is on in used spaces.

Electrical Equipment

Are computers, printers, photocopiers and other equipment switched off at the end of the day?	Yes. Computers and monitors are turned off prior to closing the building.

Can computers and other electrical equipment be programmed to 'power down' or 'energy save' mode?	No. They already are.
Can a 7 day timer be put on some equipment (e.g. photocopiers, water coolers, cold drinks machines) to regulate when systems are powered down?	No.
Can any equipment be switched on later and switched off earlier?	No. Equipment is turned on as needed and turned off after use.
Can kettles be removed if there is a wall mounted boiler?	No.
Are fridges places next to heat sources?	No.
Is the office fridge/freezer defrosted regularly?	N/A
Is the fridge thermostat working and set to the right temperature (2-4 °C)?	N/A
Is equipment clearly labelled so that staff know how to activate energy saving features or switch it off?	No. However, most energy saving features are already enabled

Water Use

Is there any evidence of water leaks? (e.g. wet pathways on a dry day)	No noticeable water leakage.
Are taps left running? Are there any dripping taps? Do taps need maintenance?	No taps were left running or dripping
Are hot water heater timers set correctly?	Yes.
How long does the hot water calorifier take to heat up?	Small hot water tank with expansion vessels. Brand new and very energy efficient
How long is the hot water calorifier on for per day?	N/A

Awareness and Building Usage

Are there posters/guidance displayed to remind people of good practice?	No.
When is the building primarily used and what is it used for?	See Basic Information for operation hours The building is used for public reading and to also register marriages, births, and deaths in the borough of Reigate

Appendix J—Reigate Library Report

1. Introduction

The purpose of this energy survey was to discover potential areas of energy reduction and cost savings within the Reigate Public Library. This audit was conducted using a basic walkthrough methodology. The Reigate Public Library is a small, two-story brick building. The building is open for about 38 hours per week during normal workday hours. It is closed on Sundays and partly closed on Wednesdays, as only the small Registrars Office in the rear of the building is open 10:30 to 4:30 on Wednesdays.

2. Summary of Findings

Through our walkthrough audit of the library, we discovered a few potential areas for energy reduction. Upon entering the building, we noticed the use of overhead fluorescent light fixtures throughout the building. This overhead lighting consisted of a mix of T-12 and T-8 lighting, with the T-12 tubes being replaced by T-8 tubes as they failed. There were 37 8 ft fixtures on the first floor and 18 8 ft fixtures on the second floor. Additionally, there were four 4 ft fixtures and nine 6 ft fixtures on the second floor. Numerous windows and skylights provided an ample amount of ambient light throughout the building.

The boiler for the heating system was a natural gas boiler running at 89% efficiency and an estimated 50 kilowatt power draw. Though we were unable to determine the operating hours of the boiler system, we did discover that the building can be quite warm during the winter due to the lack of thermostatic valves on the radiators. This lack of thermostatic radiator valves causes the need for the manual regulation of radiators. The building manager must determine which radiators are on and which radiators are off at different points during the day. As a result, determining where and when to disperse heat throughout the building becomes a difficult task for the building manager. The presence of thermostatic radiator valves would allow for a more controlled heating system. Hot water is provided by two small, localized hot water heaters located near a kitchen sink and a restroom. Lastly, all computers and office equipment are turned off during the night to conserve energy.

3. Potential Savings

There are many areas for potential savings and energy reduction. These areas are detailed in two different sections: (1) No Cost Solutions and (2) Cost Solutions

3.1 No Cost Solutions

No cost solutions consist of behavioral changes that will allow for monetary savings and energy reduction. These solutions are outlined by building, area, problem, solution, and savings in Table 11 below (calculations are shown in the Calculations section):

Table 11 - Reigate Library No Cost Solutions

Building	Area	Problem	Solution	Savings
Library	Second Floor	Skylights provide a decent amount of light, yet all lights were on.	Ask staff to turn off lights below skylights during the day when natural light is sufficient	Utilizing ambient light from windows and skylights throughout the building will save an estimated 10% on annual lighting costs (approximately £228)
Library	Building	It was noted that the building was sometimes warm during the winter	Adjust the building temperature down to a more comfortable level (see low cost solutions for installing TRVs as well)	Adjusting the thermostat down 1 degree can potentially save 10% off of your heating bill (estimated £200)

3.2 Low Cost Solutions

Low cost solutions are solutions that have a low initial cost with a small payback period. These solutions will result in yearly savings after the payback period has been completed. Table 12 below outlines the solution, cost, savings per year, and payback period.

Table 12 - Reigate Library Low Cost Solutions

Solution	Investment Cost	Savings Per Year	Payback Period
Install Thermostatic Valves on radiators in order to increase control of the heating system.	£8 per valve + £150 installation cost Estimated 10 valves * £8 = £80 + £150 installation cost £230	£308.06 per year (estimated by approximating the total heating bill with a 15% savings, per information from BBC on Thermostatic Valves)	.75 years
Install LED lighting throughout the building in order to increase efficiency	£6,411	£1,463 per year	4.4 years

4. Recommendations

We have arranged our recommendations by priority as seen in the tables below:

Priority no. 1	Improve Energy Awareness		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£450	*11490*	*None*	*Immediate*
Detail	The energy survey revealed that there are potential opportunities to increase energy efficiency and save money via improved housekeeping. Due to the high amount of windows and skylights in the building, the library should take advantage of ambient light on bright days. We noticed that lights were on even though ambient light was sufficient enough to light the entire room. This could potentially save 10% on the total lighting costs per year. It was also noted that the building temperature was sometimes warm during winter. Adjusting the temperature down to a more comfortable level will result in energy savings. A consistent 1°C adjustment will result in 8-10% savings per year.		

Priority no. 2	Install Thermostatic Radiator Valves		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£308.06	*13,814*	*£230*	*.75 years*
Detail	The energy survey revealed that there are potential opportunities to save on heating by installing Thermostatic Radiator Valves (TRVs). During the energy survey, we discovered that radiators were manually turned on and off depending on the temperature of the building. Installing TRVs will provide basic zoning controls based on the radiator. This will allow for more control over temperature regulation, resulting in a greater heating efficiency and more savings per year.		

Priority no. 3	Replace Current Lighting with LED Lighting Solutions		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£1,829	*18,285*	*£6,411*	*3.5 Years*
Detail	The energy survey revealed that there are potential opportunities to replace current lighting with LED lighting solutions. LED Lighting provides similar lumens at much higher efficiency than current light fixtures. They last 50,000 hours, which is over 30,000 hours longer than a typical T-5 tube. Additionally, only one tube per fixture is needed due to the ample amount of ambient light filtering in through windows. Currently there are two T-8s or T-12s per fixture, but replacing these with one LED fixture would reduce cost and still		

	function well enough to light the area. Replacing current lighting with LED solutions will have an initial cost, but will save a lot on energy bills after the payback period is completed.

5. Conclusion

By completing an energy survey of the Reigate Library, we found a number of areas for potential improvement, ranging from simple housekeeping to upgrading lighting equipment throughout the building. From these areas of potential savings, we formulated three main priority solutions. The first priority is to raise energy awareness. Due to the amount of windows and skylights in the building, the library staff can determine if the amount of ambient light filtering in is adequate enough to light the building. Turning off lights when they are unnecessary can save up to 10% on the lighting bill. Additionally, adjusting the temperature down 1°C to a more comfortable level will result in 8-10% savings on heating. Secondly, we recommend that Thermostatic Radiator Valves (TRVs) be installed on all radiators. We noticed that there was inconsistent heating throughout the building due to radiators manually being turned on and off. Installing TRVs will allow for more control over temperature in the building, resulting in an estimated 15% savings on heating with a low initial cost. Lastly, we recommend that current lighting be replaced with light emitting diode (LED) lighting solutions. These LEDs have a high initial cost, but will save the library approximately £2,000 per year in lighting costs. However, this was our 3rd recommendation since we know that current T-12s are being replaced with higher efficiency T-8s as they burn out.

6. Calculations

6.1 Priority no. 1 Calculations

Energy Awareness and Behavioral Changes

See attached Excel Spreadsheet (Calculated Annual Running Cost of Heating and Current £/pa of Lighting)

6.2 Priority no. 2 Calculations

Thermostatic Radiator Valves

ANNUAL ENERGY CONSUMPTIONS AND RUNNING COSTS

Annual energy input (kJ) = boiler input or total heat loss x hours/day x days/year x 3600 x seasonal efficiency / thermal efficiency x part load efficiency

Annual fuel consumption = Annual energy input (MJ) / gross calorific value of fuel (MJ/kg or MJ/m3)

GCV for heating oil is 45.5 MJ/kg
GCV for anthracite is 32.0 MJ/kg
GCV for LPG is 25.5 MJ/litre
GCV for natural gas is 38.2 MJ/m3

Annual running costs (p) annual fuel consumption (kg or litres or m3) x cost in p/kg or p/litre or p/m3)

Annual running cost (£) fuel cost (p) / 100

Seasonal efficiency use 60% (0.6)
Thermal efficiency use 80 - 95% (0.8 - 0.95) based on boiler efficiency
Part load efficiency use 80% (0.8)
1MJ = 1/3.6 or 0.278kWh

HEATING DETAILS:

Boiler input or total heat loss (kW)	50
Hours per day	7
Days per week	6
Week per year	52
Boiler thermal efficiency	0.89
Cost of NATURAL GAS per unit (p/kWh)	2.23
Cost of HEATING OIL per unit (p/litre)	52.5

TEMPLATE No. 1 (for NATURAL GAS only)

Calculated Annual Energy Input (HEATING)	331280899	kJ
Calculated Annual Energy Input (HWS)		kJ
Total Annual Energy Input	331280899	kJ
Annual Energy Consumption	92096	kWh
Annual Fuel Consumption (quantity)	8672	m3
Calculated Annual Running Cost (£)	£2,054	
Theromostat Adjustment Savings	£205.37	
Thermostatic Valve Savings	£308.06	

6.3 Priority no. 3 Calculations

LED Lighting Solutions

Based on calculations from http://www.netledlighting.co.uk/t5_tubes.htm

Client	Reigate Library
Site	Reigate Library
Area	Library Building

Annual Operating Hours	2,080
Electricity Cost (p/kWh)	10.000
CCL payable?	No
Include VAT in calculation?	Exclude VAT

	Applicable rate:	Used in calculation
Electricity CCL rate (p/kWh)		0
Product VAT rate	15%	0%
Electricity VAT rate	5%	0%

Existing									**Action**	**Replacement**									**Savings**		**Product Cost**	**Installation**
Site/Location	Product Code	Height (m)	Lamps PF	Watts	Ballast Losses	Quantity	OP Hrs Factor	kWh Usage		Product Code	Product Description	Watts	Ballast Losses	Unit Price	Installation	Quantity	OP Hrs Factor	kWh Usage	kWh	Electricity £		
Library	T-8 Doubles (2400mm)	3	2	80	8	55	1	20,134	Upgrade	LED	NetLED T-10 2400mm	35	0	£ 99.96	£3.75	55	1	4,004	16,130	£ 1,613.04	£ 5,497.80	£ 206.25
Library	T-8 Doubles (1200mm)	3	2	36	8	4	1	732	Upgrade	LED	NetLED T-8 1200mm	15	0	£ 41.32	£3.75	4	1	125	607	£ 60.74	£ 165.28	£ 15.00
Library	T-8 Doubles (1800mm)	3	2	70	8	6	1	1,947	Upgrade	LED	NetLED T-8 1800mm	32	0	£ 83.97	£3.75	6	1	399	1,548	£ 154.75	£ 503.82	£ 22.50
								-										-	-	£ -	£ -	£ -
								-														
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								22,813										4,528	18,285	1,829	6,167	244

Payback Report									
Client	Reigate Library								
Site	Reigate Library								
Date	03/24/2011								
Area	Current kWh/pa	Current £/pa	New kWh/pa	Savings kWh/pa	Savings CO2 tonnes/pa	Savings £/pa	Investment	Payback	Salix Persistence Factor	Cost per Tonne CO2
Reigate Library	22813	£2,281	4528	18285	10.0	£1,829	£6,411	3.5	10	64.3
Total	**22813**	**£2,281**	**4528**	**18285**	10.0	**£1,829**	**£6,411**	**3.5**		
Turning Lights Off Savings	**£228.13**									

Appendix K—La Barbe Checklist

La Barbe Restaurant Checklist

Basic Information	
Date of Energy Audit:	March 28, 2011
Department/Building/Area covered:	Full building
Persons conducting audit:	Nicholas Mondor and Nicholas Solarz
Normal occupancy hours of building:	9:30 A.M. – 11:00 P.M. Everyday

Lighting	
Are any tungsten lights present? Can they be replaced with compact fluorescents (energy saving bulbs)? Look particularly in store rooms, uplighters, desk lamps etc.	24 halogen lights present in main sitting areas that can be replaced with CFLs or LEDs
If there are several light switches, can they be labelled to make it more obvious which switches relate to which fixtures?	No
Can lights be switched off to make use of daylight? (e.g. lights parallel to windows or in corridors)	Not enough ambient light to switch off lights
Can light sensors be installed in spaces that are intermittently occupied (e.g. store rooms, toilets, kitchen areas, copying rooms, corridors, etc)	No. The kitchen is always in use while open and the sitting areas need constant lighting for customers.
Are any external lights on during daylight hours?	External lights were off
Can main lighting ever be switched off to make use of ambient light and desk lamps?	No.

Do any light fittings need cleaning?	No. Light fittings were clean.
Do windows and skylights need cleaning to allow in more natural light?	No skylights and the windows were very clean already.
Number of T-5 lights	None
Number of T-8 lights	2 fixtures, 2 1800mm tubes per fixture in kitchen area
Number of T-12 lights	None
Number of Halogen lights	14 halogen in side sitting area 10 halogen in main sitting area
Number of CFLs	1 in kitchen

Heating

What is the actual temperature in the space?	24° Celsius
Does the temperature vary much during the day?	No. However, cold air from the main entrance does cause temperatures to fluctuate during the winter.
Do occupants complain it is too hot or too cold?	No. Temperature is relatively consistent
If there are Thermostatic Radiator Valves (TRVs), are they set correctly? Do they actually work or are they broken?	2 Daikin VRV Ceiling Suspended Systems in side sitting area, set to 24° Celsius. 2 Daikin VRV Ceiling Suspended Connector Systems in main sitting area.
Are radiators effective and giving consistent heat? They may need bleeding of air or maintenance to remove dust and sediment.	Daikin systems give off consistent heat and provide the ability to heat and cool the building efficiently.
If the room tends to overheat, is there any bare pipework that could be insulated?	No bare pipework
Are radiators blocked, restricting air circulation?	No. Radiators are open and blow 360° so that the room is evenly heated.
Are external doors and windows closed when heating is on?	The main entrance was open for customers to enter.

Are windows in good condition? Are any window panes cracked or broken?	Windows were in great condition.
If there is a roof space, is it insulated?	N/A
Are blinds closed at the end of the day during winter to cut down on heat loss?	No blinds to close and cut down on heat loss.
Is heating on in unused spaces, such as cupboards, corridors?	No.
How many kW do the boilers use?	~40 kW (estimated by size and age of the boiler)
How long is each boiler on per day?	9:30 A.M.-11:00 P.M.

Cooling and Ventilation

If there is air conditioning with local controls, make sure it is only on when necessary. Is it obvious how to control it? What temperature is it set to?	Yes. The air conditioning has a set temperature.
Is air conditioning running at the same time as heating?	No. However, air conditioning and heating can be run by the same system.
Are all external doors and windows closed when air conditioning is on?	Only the main door is open so that customers may enter the restaurant.
Is natural ventilation (e.g. windows and doors open with no air conditioning on) being used?	N/A
Is air conditioning on in unused spaces, such as cupboards, corridors?	No.

Electrical Equipment

Are computers, printers, photocopiers and other equipment switched off at the end of the day?	No computers other than the register. All equipment is turned off at the end of the day.
Can computers and other electrical equipment be programmed to 'power down' or 'energy save' mode?	No.
Can a 7 day timer be put on some equipment (e.g.	No.

photocopiers, water coolers, cold drinks machines) to regulate when systems are powered down?	
Can any equipment be switched on later and switched off earlier?	The hot water boiler is run when the employees arrive until when they close for the night. This is necessary for cooking and serving customers. The heat system automatically regulates itself and can be turned down at night when employees leave.
Can kettles be removed if there is a wall mounted boiler?	The restaurant uses a wall mounted hot water boiler
Are fridges places next to heat sources?	No
Is the office fridge/freezer defrosted regularly?	N/A
Is the fridge thermostat working and set to the right temperature (2-4 °C)?	3° Celsius
Is equipment clearly labelled so that staff know how to activate energy saving features or switch it off?	N/A

Water Use

Is there any evidence of water leaks? (e.g. wet pathways on a dry day)	No evidence of water leaks.
Are taps left running? Are there any dripping taps? Do taps need maintenance?	Taps were not left running and there were no noticeably dripping taps during the audit.
Are hot water heater timers set correctly?	Yes.
How long does the hot water calorifier take to heat up?	N/A
How long is the hot water calorifier on for per day?	See boiler information

Awareness and Building Usage

Are there posters/guidance displayed to remind people of good practice?	N/A
When is the building primarily used and what is it used for?	See operation hours in “Basic Information”

Appendix L—La Barbe Report

1. Introduction

The purpose of this energy survey was to discover potential areas of energy reduction and cost savings within the La Barbe restaurant. The audit was conducted using a basic walkthrough methodology. The restaurant is on the ground floor of a three-story building, with two flats occupying the remaining two floors. The scope of our audit was limited strictly to the restaurant itself and not the upper floors of the building. The restaurant has occupancy hours from 9:30 A.M. to 11 P.M. Monday through Saturday, with the restaurant closing mid-afternoon on Sundays. This results in an estimated 90 hours of occupancy per week.

2. Summary of Findings

During our walkthrough energy survey of La Barbe Restaurant, we learned that the restaurant was already very energy efficient. Upon entering the restaurant, we noticed that there was an air curtain by the main door. This air curtain helps to prevent cold air from entering and circulating around the building during colder months. While the restaurant stays at a comfortable and consistent temperature during the fall, spring, and summer, the restaurant owner said that the entrance and part of the main sitting area becomes a bit drafty during the winter months. In addition to the air curtain, there are two large commercial Daikin air conditioning units. These Daikin air conditioning units are part of a Variable Refrigerant Volume (VRV) system and are mounted into the ceiling. They are shown in Figure 21 below:

Figure 21 - La Barbe Daikin Air Conditioning Unit

The air conditioning units also have a heating pump built into the system. Built in heat pumps can circulate heat extracted from the outside air around the building, as well as circulate heat extracted from inside the building to the outside air. These Daikin VRV systems are very energy efficient and allow for the ability to heat and cool the building through the same ceiling mounted units. Additionally, there were large windows in the front of the restaurant and 10 halogen lights scattered throughout the main sitting area. These large windows provided adequate ambient lighting for the tables at the front of the restaurant, while the halogen lights provided lighting for the tables further back.

In addition to the lights in main sitting area, there were also 14 halogen lights scattered around the side sitting area. These halogen lights were the same size as the halogen lights in the main sitting area and can be seen in Figure 22 below:

Figure 22 - La Barbe Halogen Lighting

Again, the large windows at the front of the restaurant provided adequate ambient light for the tables at the front of the side sitting area, while the halogen lights provided lighting for the tables further back. Another two Daikin VRV air conditioning units were mounted to the ceiling in the side sitting room as well. These Daikin air conditioning units were set to 24° Celsius.

Lastly, the kitchen contained a wall mounted boiler used to heat water. While the wattage wasn't listed, we estimate it to use around 40 Watts judging by the size and the age (7-10 years old) of the boiler. This hot water boiler can be seen in Figure 23 below:

Figure 23 - La Barbe Hot Water Boiler

The refrigeration unit had its own separate room and was not located next to any heat sources. The thermostat on the refrigerator was set to 3° Celsius. There were two fixtures with two, 1800mm T-8 tubes per fixture lighting the kitchen. Additionally, there was a CFL lighting the area by the back door in the kitchen.

3. Potential Savings

Since the building is very energy efficient and the staff has high energy awareness already, we have only formulated one low cost recommendation for consideration. This is outlined in Table 13 below, with the calculations located in the Calculations section:

Table 13 - La Barbe Restaurant Low Cost Solutions

Solution	Investment Cost	Savings Per Year	Payback Period
Install LED lighting throughout the restaurant in order to increase lighting efficiency	£815	£386 per year	2.1 years

4. Recommendations

We have arranged our recommendations by priority. The tables below illustrate solutions that should be considered moving forward.

Priority no. 1	Replace Current Lighting with LED Lighting Solutions		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£386	*3,220*	*£815*	*2.1 Years*
Detail	The energy survey revealed that there are potential opportunities to replace current lighting with LED lighting solutions. LED Lighting provides similar lumens at much higher efficiency than current light fixtures. They last 50,000 hours, which is over 30,000 hours longer than a typical T-5 tube and over 5 times longer than a conventional halogen lamp. The restaurant can benefit from replacing the halogen lamps and T-8 tubes with LED lighting solutions. Replacing current lighting with LED solutions will have an initial cost, but will save on energy bills after the payback period is completed.		

5. Conclusion

By completing an energy survey of the La Barbe restaurant, we learned that the building was very energy efficient and didn't have much room for improvement. The main area for potential savings involves lighting the restaurant. There were halogen lamps throughout the sitting areas, as well as T-8 tubes lighting parts of the kitchen. Switching to LED lighting solutions will allow the restaurant to have the same level of lighting at a much higher efficiency. This will save approximately £386 per year with a low investment cost and relatively quick payback period.

6. Calculations

6.1 Priority no. 1 Calculations

Lighting costs for halogen lamps and T-8 tubes taken from the latest price guide from NetLED Lighting.

Client	La Barbe
Site	La Barbe
Area	Restaurant

Annual Operating Hours	4,680
Electricity Cost (p/kWh)	10.000
CCL payable?	No
Include VAT in calculation?	Include VAT

	Applicable rate	Used in calculation
Electricity CCL rate (p/kWh)		0
Product VAT rate	20%	20%
Electricity VAT rate	20%	20%

Existing									Action	Replacement									Savings		Product Cost	Installation
Site/Location	Product Code	Height (m)	Lamps PF	Watts	Ballast Losses	Quantity	OP Hrs Factor	kWh Usage		Product Code	Product Description	Watts	Ballast Losses	Unit Price	Installation	Quantity	OP Hrs Factor	kWh Usage	kWh	Electricity £		
Main Seating Areas	Halogen Lamps	3	1	25	0	24	1	2,808	Upgrade	LED	NetLED Lamp (50x55,5mm)	4	0	£ 10.66	£3.75	24	1	449	2,359	£ 283.05	£ 307.01	£ 90.00
Kitchen Areas	T-8 Doubles (1800mm)	3	2	70	8	2	1	1,460	Upgrade	LED	NetLED T-8 (1800mm)	32	0	£ 83.97	£3.75	4	1	599	861	£ 103.33	£ 403.06	£ 15.00
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								-														
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								4,268										1,048	3,220	386	710	105

Payback Report										
Client	La Barbe									
Site	La Barbe									
Date	03/28/2011									
Area	Current kWh/pa	Current £/pa	New kWh/pa	Savings kWh/pa	Savings CO2 tonnes/pa	Savings £/pa	Investment	Payback	Salix Persistence Factor	Cost per Tonne CO2
La Barbe	4268	£469	1048	3220	1.8	£386	£815	2.1	10	46.4
Total	**4268**	**£469**	**1048**	**3220**	1.8	**£386**	**£815**	**2.1**		

Appendix M—Summit Print Checklist

Summit Print Checklist

Basic Information	
Date of Energy Audit:	28 March 2011
Department/Building/Area covered:	Summit Print, Ltd
Persons conducting audit:	Joe Lombardo and Kevin McCarthy
Normal occupancy hours of building:	Office: 7.00 A.M.-6:00 P.M. Monday-Saturday Factory: 6.00 A.M.-10:00 P.M. Every Day

Lighting	
Are any tungsten lights present? Can they be replaced with compact fluorescents (energy saving bulbs)? Look particularly in store rooms, uplighters, desk lamps etc.	No.
If there are several light switches, can they be labelled to make it more obvious which switches relate to which fixtures?	No.
Can lights be switched off to make use of daylight? (e.g. lights parallel to windows or in corridors)	Yes.
Can light sensors be installed in spaces that are intermittently occupied (e.g. store rooms, toilets, kitchen areas, copying rooms, corridors, etc)	No.
Are any external lights on during daylight hours?	No.
Can main lighting ever be switched off to make use of ambient light and desk lamps?	No.

Do any light fittings need cleaning?	No.
Do windows and skylights need cleaning to allow in more natural light?	No.
Number of T-5 lights	None.
Number of T-8 lights	50 total.
Number of T-12 lights	23 total.
Number of Halogen lights	None.
Number of CFLs	7 total.

Heating

What is the actual temperature in the space?	Office: 25°C Factory: 21°C
Does the temperature vary much during the day?	No.
Do occupants complain it is too hot or too cold?	No.
If there are Thermostatic Radiator Valves (TRVs), are they set correctly? Do they actually work or are they broken?	Radiators have TRVs that are set correctly.
Are radiators effective and giving consistent heat? They may need bleeding of air or maintenance to remove dust and sediment.	Yes. Radiators give off consistent heat.
If the room tends to overheat, is there any bare pipework that could be insulated?	No.
Are radiators blocked, restricting air circulation?	No.
Are external doors and windows closed when heating is on?	Yes, except for 1 window.
Are windows in good condition? Are any window panes	All double-pane in excellent condition.

cracked or broken?	
If there is a roof space, is it insulated?	Yes.
Are blinds closed at the end of the day during winter to cut down on heat loss?	N/A
Is heating on in unused spaces, such as cupboards, corridors?	No.
How many kW do the boilers use?	N/A
How long is each boiler on per day?	N/A

Cooling and Ventilation

If there is air conditioning with local controls, make sure it is only on when necessary. Is it obvious how to control it? What temperature is it set to?	No air conditioning in the building.
Is air conditioning running at the same time as heating?	N/A
Are all external doors and windows closed when air conditioning is on?	N/A
Is natural ventilation (e.g. windows and doors open with no air conditioning on) being used?	N/A
Is air conditioning on in unused spaces, such as cupboards, corridors?	N/A

Electrical Equipment

Are computers, printers, photocopiers and other equipment switched off at the end of the day?	Computers are turned off. Printing equipment must be left on at all times to function.
Can computers and other electrical equipment be programmed to 'power down' or 'energy save' mode?	Yes.
Can a 7 day timer be put on some equipment (e.g. photocopiers, water coolers, cold drinks machines) to	No.

regulate when systems are powered down?	
Can any equipment be switched on later and switched off earlier?	No.
Can kettles be removed if there is a wall mounted boiler?	N/A
Are fridges places next to heat sources?	No.
Is the office fridge/freezer defrosted regularly?	Yes.
Is the fridge thermostat working and set to the right temperature (2-4 °C)?	N/A
Is equipment clearly labelled so that staff know how to activate energy saving features or switch it off?	No.

Water Use

Is there any evidence of water leaks? (e.g. wet pathways on a dry day)	No.
Are taps left running? Are there any dripping taps? Do taps need maintenance?	No.
Are hot water heater timers set correctly?	Yes.
How long does the hot water calorifier take to heat up?	N/A
How long is the hot water calorifier on for per day?	N/A

Awareness and Building Usage

Are there posters/guidance displayed to remind people of good practice?	Some posters are displayed to remind people of good energy practices.
When is the building primarily used and what is it used for?	Office: office work, daytime Factory: printing jobs, constantly

Appendix N—Summit Print Report

1. Introduction

The purpose of this energy survey was to discover potential areas of energy reduction and cost savings within the confines of Summit Print, Ltd. The audit was conducted using a basic walkthrough methodology. The company owns a three-story building, occupying the top floor for its own office space along with the printing factory on the ground floor. The remainder of the building is rented out as additional office space. The scope of our audit was limited to the office area and factory area of Summit Print, as well as two of the four rented out offices. The offices are occupied from 7:00 A.M. to 6:00 P.M. Monday through Saturday. The printing factory runs from 6:00 A.M. to 10:00 P.M. every day of the week all year, with the exception of three days every quarter for maintenance. The rented offices operate from 7:00 A.M. to 5:00 P.M. Monday through Friday. This report separately analyzes the Summit Print office, the Summit Print factory, and the rented offices because of the discrepancy of occupation hours. This yields an estimated 66 hours of occupancy per week for the Summit Print offices, 112 hours per week for the factory, and 50 hours per week for the rented offices.

2. Summary of Findings

During our walkthrough of Summit Print Ltd, we noticed many areas for potential savings, mostly dealing with lighting and staff habits.

2.1 Reception/Office Area

We first noticed that all the lights were on despite adequate ambient light filtering in from skylights. Additionally, all lighting in this area was either T-8 or T-12 fluorescent bulbs. The area felt overheated, with a temperature of 25^{o} C circulating through 7 single pipe radiators. Windows were open in the reception/office area due to the uncomfortably warm temperature. Lastly, we noticed that many idle computers were left on with a screensaver as opposed to being put into standby mode.

2.2 Factory Area

In the factory area, we noticed that there were over thirty T-8 and T-12 light fixtures in use. Even though this area needs sufficient lighting, it may be able to adequately function with less light fixtures on. The factory area was also uncomfortably warm. However, this temperature must be maintained to ensure consistent and optimum quality of paper and print specifications used by the company. We also learned that employees leave the machines on while taking breaks or while they are using a different machine. These machines can be turned off or put into standby mode when they are not in use. Lastly, the factory area contains new boilers the company installed last year. These boilers are very efficient and use exhaust recycling technology.

2.3 Supplementary Areas

This area consists of supplementary offices sublet to other companies, as well as some of the less used storage and conference rooms. Most of the lights in this area were turned off when they were not in use. We noticed that most rooms use CFLs along with T-8s and T-12s.

2.4 Other Notes

We observed that the building had double pane windows, and that insulation had recently been added to all sections of the roof and exterior walls. In an effort to raise energy awareness, there were some stickers advertising to shut off lights that were not in use. We also learned that some employees would go around and shut off lights and machines when they were not needed. However, the majority of employees do not do this.

3. Potential Savings

There are many areas for potential savings and energy reduction. These areas are detailed in two different sections: (1) No Cost Solutions and (2) Cost Solutions

3.1 No Cost Solutions

No cost solutions consist of behavioral changes that will allow for monetary savings and energy reduction. These solutions are outlined by area, problem, solution, and savings in Table 14 below:

Table 14 - Summit Print Ltd No Cost Solutions

Area	Problem	Solution	Savings
Reception/Offices Area	Skylights provide a decent amount of light, yet lights were on.	Ask staff to turn off lights during the day when natural light is sufficient and put up flyers to remind staff	By using lights 33% less, savings of £126 per year. By using lights 50% less, savings of £189 per year
Reception/Offices Area	Unused computers using screensavers instead of standby mode	Ask staff to adjust setting of computers to enter standby mode instead of screen savers	Standby usage can lower the energy consumption of the computers by about 90% per year
Reception/Offices Area	Area seemed to be overheated/windows open while heat on	Adjust temperature settings in the area	Heating costs will go down due to lower heat loss.
Factory Area	Employees leave machines on while not in use	Ask staff to turn off machines when not in immediate use and put up flyers to remind staff	Electrical costs will go down since machines use large amounts of electricity

3.2 Low Cost Solutions

Low cost solutions are solutions that have a low initial cost with a small payback period. These solutions will result in yearly savings after the payback period has been completed. Table 15 below outlines the solution, cost, savings per year, and payback period:

Table 15 - Summit Print Ltd Low Cost Solutions

Problem	Solution	Investment Cost	Savings Per Year	Payback Period
Usage of Fluorescent Lighting in Reception and Supplementary Areas	Replace T-8 and T-12 lighting with LED lighting	£4,230	£932 per year	4.5 years (calculations shown in Calculations section)
Usage of Fluorescent Lighting in Factory Area	Replace T-8 and T-12 lighting with LED lighting	£3,782	£1,320 per year	2.9 years (calculations shown in Calculations section)

4. Recommendations

We have arranged our recommendations by priority. The tables below illustrate solutions that should be considered moving forward.

Priority no. 1	Improve Energy Awareness		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£126	*£1581*	*None*	*Immediate*
Detail	The energy survey revealed that there are potential opportunities to increase energy efficiency and save money via improved housekeeping. As noted in the *Summary of Findings*, lights were being left on despite ambient light radiating into the building from skylights. Asking staff to turn off these lights when they are not needed will reduce the monthly electric bill, resulting in annual savings on lighting. The same can be said about turning off computers and other equipment when it is not being used. Additionally, the office area was being overheated. Closing windows and lowering heat temperature settings around the office area will reduce the cost of heating. This cost savings is an estimation based on reducing light use by 33%. A light usage reduction of 50% and 75% would result in a £189 and £284, respectively. Since this estimation is for lights only, savings are even greater when reduced heat and computer usage is considered. In order to accomplish this goal, small notes, posters, and stickers reminding staff to turn off lights and equipment and shut windows are necessary. These notes will help remind staff about energy efficiency. Talking to the staff about energy awareness will also help in reducing cost.		

Priority no. 2	In Reception and Supplementary Areas: Replace Current Lighting with LED Lighting		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£932	*7,767*	*£4,230*	*4.5 Years*
Detail	The energy survey revealed that there are potential opportunities to replace current lighting with LED lighting solutions. LED Lighting provides similar lumens at much higher efficiency than current light fixtures. They last 50,000 hours, which is greater than twice the lifetime of a typical T-5 tube. Replacing current lighting with LED solutions will have an initial cost, but will save a lot on energy bills after the payback period is completed. An additional note—LED lighting is much more easily powered by solar panels than other types of lighting. Because LED lights require less wattage than fluorescent and incandescent lights, solar panels can power a greater number of LEDs.		

Priority no. 3	In Factory Area: Replace Current Lighting with LED Lighting		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£1,320	*11,004*	*£3,782*	*2.9 years*
Detail	The same can be said here as in Priority 2. The reason for this distinction, however, is the great discrepancy in operation hours between the office and factory areas. The initial cost is higher than for the office area, but the payback period is shorter because the lights are more used.		

5. Conclusion

By completing an energy survey of Summit Print, Ltd., we found a few areas for potential savings, ranging from simple behavioral changes to upgrading lighting equipment throughout the building. From these areas of potential savings, we formulated three main priority solutions. The first of these is to raise the energy awareness of employees. Simple things such as turning off unnecessary lighting and reducing the building temperature can provide noticeable savings without any initial investment. Another habitual solution is to have employees set their computers to standby mode rather than running a screensaver. Standby mode uses significantly less energy than a screensaver. Secondly and thirdly, we recommend that all lighting throughout the building, both the reception offices and the factory, be upgraded to newer, high-efficiency light emitting diode (LED) lighting. This will provide a moderately high yearly savings and a reasonable payback period of around four years.

6. Calculations

6.1 1st Priority Calculations

The first priority was increasing energy awareness. In order to calculate the associated savings, we based our estimations by approximating that by increasing awareness, lighting usage may be reduced by 33%, 50% or 75%. To do this, operating hours of the lights were reduced by these percentages, and the reduced hours were then used with the price of electricity to determine potential savings.

6.2 2nd Priority Calculations

LED Lighting Solutions in the Reception Office area

Based on calculations from http://www.netledlighting.co.uk/t5_tubes.htm. See attached Excel Spreadsheet and charts below:

Client	Summit Print LTD
Site	Summit Print
Area	Reception and Supplementary Areas

Annual Operating Hours	3,432
Electricity Cost (p/kWh)	10.000
CCL payable?	No
Include VAT in calculation?	Include VAT

	Applicable rate	Used in calculation
Electricity CCL rate (p/kWh)		0
Product VAT rate	20%	20%
Electricity VAT rate	20%	20%

Existing									**Action**	**Replacement**									**Savings**		**Product Cost**	**Installation**
Site/Location	Product Code	Height (m)	Lamps PF	Watts	Ballast Losses	Quantity	OP Hrs Factor	kWh Usage		Product Code	Product Description	Watts	Ballast Losses	Unit Price	Installation	Quantity	OP Hrs Factor	kWh Usage	kWh	Electricity £		
Reception Office Area	T-12 Doubles (2400mm)	3	2	100	10	1	1	755	Upgrade	LED	NetLED T-10 (2400mm)	35	0	£ 99.96	£3.75	2	1	240	515	£ 61.78	£ 239.90	£ 7.50
	T-8 Doubles (1800mm)	3	2	70	8	8	1	4,283	Upgrade	LED	Net LED T-8 (1800mm)	32	0	£ 83.97	£3.75	16	1	1,757	2,526	£ 303.11	£ 1,612.22	£ 60.00
	T-8 Singles (1800mm)	3	1	70	8	1	1	268	Upgrade	LED	Net LED T-8 (1800mm)	32	0	£ 83.97	£3.75	1	1	110	158	£ 18.94	£ 100.76	£ 3.75
Other Offices/Rooms/Stairs	T-12 Doubles (2400mm)	3	2	100	10	2	1	1,510	Upgrade	LED	NetLED T-10 (2400mm)	35	0	£ 99.96	£3.75	2	1	240	1,270	£ 152.38	£ 239.90	£ 7.50
	T-8 Doubles (1800mm)	3	2	70	8	1	1	535	Upgrade	LED	NetLED T-8 (1800mm)	32	0	£ 83.97	£3.75	2	1	220	316	£ 37.89	£ 201.53	£ 7.50
	T-8 Singles (1800mm)	3	1	70	8	11	1	2,945	Upgrade	LED	NetLED T-8 (1800mm)	32	0	£ 83.97	£3.75	11	1	1,208	1,737	£ 208.39	£ 1,108.40	£ 41.25
	T-12 Singles (2400mm)	3	1	100	10	4	1	1,510	Upgrade	LED	NetLED T-10 (2400mm)	35	0	£ 99.96	£3.75	4	1	480	1,030	£ 123.55	£ 479.81	£ 15.00
	T-12 Singles (1800mm)	3	1	85	10	1	1	326	Upgrade	LED	NetLED T-10 (1800mm)	32	0	£ 83.97	£3.75	1	1	110	216	£ 25.95	£ 100.76	£ 3.75
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								12,132										4,366	7,767	932	4,083	146

Payback Report										
Client	Summit Print Ltd									
Site	Summit Print Reception and Supplementary Areas									
Date	03/28/2011									
Area	Current kWh/pa	Current £/pa	New kWh/pa	Savings kWh/pa	Savings CO2 tonnes/pa	Savings £/pa	Investment	Payback	Salix Persistence Factor	Cost per Tonne CO2
Reception/Offices Area	12132	£1,335	4366	7767	4.2	£932	£4,230	4.5	10	99.9
Total	**12132**	**£1,335**	**4366**	**7767**	4.2	**£932**	**£4,230**	**4.5**		

6.3 3rd Priority Calculations

LED Lighting Solutions in the Factory area

Based on calculations from http://www.netledlighting.co.uk/t5_tubes.htm. See attached Excel Spreadsheet and charts below:

Client	Summit Print LTD
Site	Summit Print
Area	Warehouse

Annual Operating Hours	5,600
Electricity Cost (p/kWh)	10.000
CCL payable?	No
Include VAT in calculation?	Include VAT

	Applicable rate	Used in calculation
Electricity CCL rate (p/kWh)		0
Product VAT rate	20%	20%
Electricity VAT rate	20%	20%

Existing									**Action**	**Replacement**									**Savings**		**Product Cost**	**Installation**
Site/Location	Product Code	Height (m)	Lamps PF	Watts	Ballast Losses	Quantity	OP Hrs Factor	kWh Usage		Product Code	Product Description	Watts	Ballast Losses	Unit Price	Installation	Quantity	OP Hrs Factor	kWh Usage	kWh	Electricity £		
Warehouse	T-12 Doubles (2400mm)	3	2	100	10	1	1	1,232	Upgrade	LED	NetLED T-10 (2400mm)	35	0	£ 99.96	£3.75	1	1	196	1,036	£ 124.32	£ 119.95	£ 3.75
	T-8 Doubles (1800mm)	5	2	70	8	11	1	9,610	Upgrade	LED	NetLED T-8 (1800mm)	32	0	£ 83.97	£3.75	22	1	3,942	5,667	£ 680.06	£ 2,216.81	£ 82.50
	T-8 Singles (1800mm)	3	1	70	8	3	1	1,310	Upgrade	LED	NetLED T-8 (1800mm)	32	0	£ 83.97	£3.75	3	1	538	773	£ 92.74	£ 302.29	£ 11.25
	T-12 Singles (1800mm)	3	1	85	10	10	1	5,320	Upgrade	LED	NetLED T-10 (1800mm)	32	0	£ 83.97	£3.75	10	1	1,792	3,528	£ 423.36	£ 1,007.64	£ 37.50
								-														
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								17,472										6,468	11,004	1,320	3,647	135

Payback Report										
Client	Summit Print Ltd									
Site	Summit Print Factory Area									
Date	3/28/2011									
Area	Current kWh/pa	Current £/pa	New kWh/pa	Savings kWh/pa	Savings CO2 tonnes/pa	Savings £/pa	Investment	Payback	Salix Persistence Factor	Cost per Tonne CO2
Factory Area	17472	£1,922	6468	11004	6.0	£1,320	£3,782	2.9	10	63.0
Total	**17472**	**£1,922**	**6468**	**11004**	6.0	**£1,320**	**£3,782**	**2.9**		

Appendix O—Risbridger Ltd Checklist

Risbridger Ltd. Checklist

Basic Information

Date of Energy Audit:	March 29, 2011
Department/Building/Area covered:	All
Persons conducting audit:	Nicholas Mondor and Nicholas Solarz
Normal occupancy hours of building:	Monday-Friday 9 hours per day

Lighting

Are any tungsten lights present? Can they be replaced with compact fluorescents (energy saving bulbs)? Look particularly in store rooms, uplighters, desk lamps etc.	No tungsten lights that were actually on.
If there are several light switches, can they be labelled to make it more obvious which switches relate to which fixtures?	Light switches were clearly labelled
Can lights be switched off to make use of daylight? (e.g. lights parallel to windows or in corridors)	The vast majority of lights were switched off when ambient light was adequate enough to light the room. The only area that didn't make full use of ambient light was a couple of the offices on the 2nd floor.
Can light sensors be installed in spaces that are intermittently occupied (e.g. store rooms, toilets, kitchen areas, copying rooms, corridors, etc)	Yes, but there is no use for them. Lights are already turned off when the area is not being used.
Are any external lights on during daylight hours?	No.
Can main lighting ever be switched off to make use of ambient light and desk lamps?	Yes. Lights are already switched off to make use of ambient light.

Do any light fittings need cleaning?	No. Light fittings were clean.
Do windows and skylights need cleaning to allow in more natural light?	No. Windows and skylights were clean.
Number of T-5 lights	65 fixtures, 2 6ft tubes per fixture in workshop 29 fixtures, 4 6ft tubes per fixture total in offices 10 fixtures, 2 6ft tubes per fixture by entrance and storage areas.
Number of T-8 lights	Some in workshop (being replaced by T-5s)
Number of T-12 lights	3 fixtures, 1 8ft tube per fixture in hallways
Number of Halogen lights	None.
Number of CFLs	None

Heating

What is the actual temperature in the space?	19 degrees Celsius
Does the temperature vary much during the day?	No
Do occupants complain it is too hot or too cold?	Nothing was brought to our attention
If there are Thermostatic Radiator Valves (TRVs), are they set correctly? Do they actually work or are they broken?	TRVs installed; set to 3 or lower (<21 degrees Celsius)
Are radiators effective and giving consistent heat? They may need bleeding of air or maintenance to remove dust and sediment.	No noticeable radiator maintenance required
If the room tends to overheat, is there any bare pipework that could be insulated?	No; pipework was adequately insulated
Are radiators blocked, restricting air circulation?	One instance in the kitchen area where dish towels were placed on the radiator to dry
Are external doors and windows closed when heating is on?	Yes; new double-glazed windows installed throughout building. Outside doors were all closed during walkthrough

Are windows in good condition? Are any window panes cracked or broken?	Windows are all brand new, double-glazed windows. No drafts noticed from the seals.
If there is a roof space, is it insulated?	N/A
Are blinds closed at the end of the day during winter to cut down on heat loss?	N/A
Is heating on in unused spaces, such as cupboards, corridors?	No unnecessary heating was noticed during the walkthrough
How many kW do the boilers use?	5x 50kW + insulated pipes. Heats hot water as well 7 overhead radiator units in workshop 2 1150 W pumps Radiators to heat offices 2 150W pumps
How long is each boiler on per day?	Boilers are automatic

Cooling and Ventilation

If there is air conditioning with local controls, make sure it is only on when necessary. Is it obvious how to control it? What temperature is it set to?	Office area cooled by overhead Daikin AC units. Did not see a control panel for the AC during our walkthrough
Is air conditioning running at the same time as heating?	There was no mixed heating and cooling during the time of the walkthrough
Are all external doors and windows closed when air conditioning is on?	N/A
Is natural ventilation (e.g. windows and doors open with no air conditioning on) being used?	N/A
Is air conditioning on in unused spaces, such as cupboards, corridors?	N/A

Electrical Equipment

Are computers, printers, photocopiers and other equipment switched off at the end of the day?	Most factory equipment was shut down during the night
Can computers and other electrical equipment be	No. Computers are off when they are not being used.

programmed to 'power down' or 'energy save' mode?	
Can a 7 day timer be put on some equipment (e.g. photocopiers, water coolers, cold drinks machines) to regulate when systems are powered down?	N/A
Can any equipment be switched on later and switched off earlier?	No.
Can kettles be removed if there is a wall mounted boiler?	N/A
Are fridges places next to heat sources?	None noticed
Is the office fridge/freezer defrosted regularly?	N/A
Is the fridge thermostat working and set to the right temperature (2-4 °C)?	N/A
Is equipment clearly labelled so that staff know how to activate energy saving features or switch it off?	Light switches are already clearly labelled

Water Use

Is there any evidence of water leaks? (e.g. wet pathways on a dry day)	None noticeable. The company had one fixed recently in the main boiler room.
Are taps left running? Are there any dripping taps? Do taps need maintenance?	No taps noticeably dripping.
Are hot water heater timers set correctly?	Yes.
How long does the hot water calorifier take to heat up?	145 litres hot water calorifier Megaflo Model CL145 http://www.heatraesadia.com/docs/Megaflo_systemfit_-_Issue_5_-_36005882.pdf 24 minutes to heat up from 15°C to 60°C with a 17 minute recovery time 18.7 kW
How long is the hot water calorifier on for per day?	On during office hours

Awareness and Building Usage

Are there posters/guidance displayed to remind people of good practice?	No posters noticed, however, lighting habits suggest some training in this area.
When is the building primarily used and what is it used for?	Building used during normal business hours for manufacturing.

Appendix P—Risbridger Ltd Report

1. Introduction

The purpose of this energy survey was to discover potential areas of energy reduction and cost savings within the Risbridger factory building. This audit was conducted using a basic walkthrough methodology. The Risbridger factory building is used for about nine hours a day during the standard business week, resulting in an estimated 45 hours of occupancy per week. The building composition is a mix of offices and workshop floors, all located in a brick building. The building has a large amount of specialized equipment used for production.

2. Summary of Findings

Upon entering Risbridger, we noticed that the hallway lights were turned off and there was an adequate amount of ambient light filtering in through the windows. As we entered the first work area, we saw that this trend continued. The work area was located on the outer edge of the building and had many large windows. As a result, natural light sufficiently lighted the room. It was pointed out to us that a large amount of windows in the building were recently replaced with newer double glazed windows. These windows create a greater insulation barrier, which reduces the heat loss in the building. All of the small work areas were very similar—each made use of natural sunlight and had these new double glazed windows. These areas were heated and cooled by overhead heating and air conditioning units.

Moving on to the main floor, we noted that the good lighting habits continued. The main floor was lit by 65 six-foot T-8 tubes, but only around half of them were turned on during our energy survey. This can be seen in Figure 24 below:

Figure 24 - Risbridger Ltd. Workshop Lighting

Again, the area was well lit due to the amount of ambient light coming in from the skylights above. The workshop area was heated by seven ceiling mounted radiator units, each with a fan attached to them to pull air through. These radiator units can be seen in Figure 25 below:

Figure 25 - Risbridger Ltd. Radiation Unit

All of the doors and windows in this area were kept closed and the temperature was at a comfortable level.

After viewing the workshop area, we moved onto the main boiler room. The boiler system consisted of five 50 kW natural gas boilers, with the water being pumped by three 1.15 kW pumps. These pumps can be seen in Figure 26 below:

Figure 26 - Risbridger Ltd. Grundfos Pumps

We were told that the boiler system was about seven years old. The piping for the boiler was all adequately insulated. We were made aware that the heating system was a compensated system, meaning that the outside air temperature is taken into account when heating the building. This means that as the outside air temperature rises, the boiler system does less work to heat the building, therefore reducing the amount of energy used. Additionally, a smaller boiler room contained a 145 litre hot water calorifier and two small 150W Grundfos pumps. There was also a Broag Remeha W60-m ECO boiler used to heat the offices on the second floor.

Moving to the office area, we noticed the use of wall-mounted radiators with thermostatic radiator valves. The offices were lit by T-8 fixtures, with four tubes per fixture. Again, the lighting habits were exceptional, with lights turned on only in occupied offices. These offices were cooled by overhead AC units (the same as seen in the smaller workshops). In a nearby kitchen area, there was one instance of an obstructed radiator where dish towels were placed over the radiator to dry.

3. Potential Savings

There are many areas for potential savings and energy reduction. These areas are detailed in two different sections: (1) No Cost Solutions and (2) Cost Solutions

3.1 No Cost Solutions

No cost solutions consist of behavioral changes that will allow for monetary savings and energy reduction. These solutions are outlined by building, area, problem, solution, and savings in Table 16 below (calculations are shown in the Calculations section):

Table 16 - Risbridger Ltd. No Cost Solutions

Building	Area	Problem	Solution	Savings
Main Building	Small Boiler Room	Could not find timer settings on the hot water tank. Assuming that the hot water calorifier is running during hours of operation (9 hours per day).	Consider adjusting the startup and shutdown hours of the calorifier to reduce the running time.	Turning the hot water calorifier off 1 hour earlier or turning it on 1 hour later will result in a £162 per year savings (calculated in Appendix A using a 145 litre tank 9 hours a day, 260 days a year with water temperature of 65°C)
Main Building	Large Boiler Room	Boilers were on timers, but we could not find the timer settings for when the boiler turned on and off daily. Assuming that the boilers run during hours of operation (9 hours per day).	Consider adjusting the startup and shutdown hours of the boilers to reduce the running time.	Turning the boilers off 1 hour or turning it on 1 hour later will result in a £1,162 per year savings (calculated in Appendix A using 50kW boilers running 8-9 hours per day, 5 days a week, 50 weeks a

				year at 90% efficiency). Does not include Broag Remeha W60-m ECO boilers

3.2 Low Cost Solutions

Low cost solutions are solutions that have a low initial cost with a small payback period. These solutions will result in yearly savings after the payback period has been completed. Table 17 below outlines the solution, cost, savings per year, and payback period.

Table 17 - Risbridger Ltd. Low Cost Solutions

Solution	Investment Cost	Savings Per Year	Payback Period
Install Variable Speed Drives (VSDs) on boiler pumps	£404 (£202 per drive unit)	£159 per year	2.55 years

4. Recommendations

We have arranged our recommendations by priority. The tables below illustrate solutions that should be considered moving forward.

Priority no. 1	**Adjust Boiler and Hot Water Calorifier Operating Hours**		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£1,324	*59,403*	*None*	*Immediate*
Detail	The energy survey revealed that there are potential opportunities to increase energy efficiency and save money by adjusting boiler and hot water calorifier operating hours. Though we were unable to see the timer settings on the boiler system, adjusting the hours of operation by 1 hour can result in a *£1,162* savings. One possible option for accomplishing this savings is to shut the boilers off an hour before people leave the building. The building will retain a fairly constant, comfortable temperature since the building has new double glazed windows and is well insulated. As a result, this will also reduce the amount of energy used daily from the boiler system. The same concept can be used for the hot water calorifier. Though we were unable to see the timer settings on the hot water tank, adjusting the hours of operation by 1 hour can result in a *£162* savings. Since this hot water tank only services the offices, it's possible to turn the tank off an hour earlier each day to reduced daily energy use. The water will retain a relatively high temperature even when the tank is off, allowing for employees in the offices to still have hot water.		

Priority no. 2	**Install Variable Speed Drives (VSDs) on Grundfos Pumps**		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£159	*1,587*	*£404*	*2.55 years*
Detail	The energy survey revealed that there are potential opportunities to save using Variable Speed Drives (information taken from http://www.armitage-comms.co.uk/energy/esc/ and ABB.co.uk). Variable Speed Drives are typically recommended for larger pumps and motors. However, even though the Grundfos 1.15 kW pumps are small pumps, installing Variable Speed Drives can result in energy savings. Running these pumps between 70-80% of normal levels can result in a *£159* savings per year. Since the initial investment cost and payback period is reasonable, we're recommending this as a cheap solution that will save a little bit on the company's energy bill each year.		

Priority no. 3	**Replace Current Lighting with LED Lighting Solutions**		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£1,750	*14,586*	*£16,735*	*9.6 Years*
Detail	This isn't really a recommended solution right now, but rather something to look into for the future. LED lighting is more efficient and has a longer life than fluorescent tubes. Replacing current lighting with LED lighting solutions as they burn out may be a good idea. This calculation was done assuming that all lighting throughout the building was replaced with LED lighting, hence why the cost is so high. Additionally, due to the great habits of turning off unused lights and making use of natural daylight, we calculated that the lights are only on for 1,170 hours per year (9 hours per day, 5 days per week, 52 weeks per year, 50% of lighting on). If all the lights were on for 2,340 hours (9 hours per day, 5 days per week, 52 weeks per year), then this solution would certainly be worth the investment cost. We're providing LED lighting solutions as an option for when fluorescent tubes burn out, but not necessarily recommending it due to the great habits of the employees.		

5. Conclusion

By completing an energy survey of Risbridger, we found a few different areas for potential energy savings. Firstly, adjusting the hours of operation for the hot water calorifier and the boiler systems will save money on heating bills. Since the building is well insulated, the boiler system can be turned off an hour earlier with minimal heat loss. Additionally, the hot water tank can also be turned off an hour earlier and still maintain a high temperature. Our second recommendation is to install Variable Speed Drives on the larger Grundfos pumps. Installing VSDs will allow for more control over the kilowatts used by the pumps. Reducing the power to 70-80% of the current power will allow for similar output at a higher efficiency. Our last recommendation is to install LED lighting.

However, since the company has great lighting habits, we don’t recommend that all current lighting is replaced by LED lighting solutions. Overall, we were impressed by the habits of the employees and the overall energy efficiency of the building.

6. Calculations

6.1 Priority no. 1 Calculations

Adjust Boiler and Hot Water Calorifier Operation Hours

The calculations below show the usage of 5 boilers for 9 hours per day versus the usage of 5 boilers for 8 hours per day.

RISBRIDGER ANNUAL ENERGY CONSUMPTIONS AND RUNNING COSTS

Annual energy input (kJ) = boiler input or total heat loss x hours/day x days/year x 3600 x seasonal efficiency / thermal efficiency x part load efficiency

Annual fuel consumption = Annual energy input (MJ) / gross calorific value of fuel (MJ/kg or MJ/m3)

GCV for heating oil is 45.5 MJ/kg
GCV for anthracite is 32.0 MJ/kg
GCV for LPG is 25.5 MJ/litre
GCV for natural gas is 38.2 MJ/m3

Annual running costs (p) = annual fuel consumption (kg or litres or m3) x cost in p/kg or p/litre or p/m3)

Annual running cost (£) = fuel cost (p) / 100

Seasonal efficiency use 60% (0.6)
Thermal efficiency use 80 - 95% (0.8 - 0.95) based on boiler efficiency
Part load efficiency use 80% (0.8)
1MJ = 1/3.6 or 0.278kWh

HEATING DETAILS:

Boiler input or total heat loss (kW)	50		50	
Hours per day	9		8	
Days per week	5		5	
Week per year	50		50	
Boiler thermal efficiency	0.9		0.9	
Cost of NATURAL GAS per unit (p/kWh)	2.23		2.23	
Cost of HEATING OIL per unit (p/litre)	52.5		52.5	

TEMPLATE No. 1 (for NATURAL GAS only)

Calculated Annual Energy Input (HEATING)	337,500,000	kJ	300,000,000	kJ
Calculated Annual Energy Input (HWS)		kJ		kJ
Total Annual Energy Input	337,500,000	kJ	300,000,000	kJ
Annual Energy Consumption	93,825	kWh	83,400	kWh
Total Annual Energy Consumption (5 Boilers)	469,125	kWh	417,000	kWh
Annual Fuel Consumption (quantity)	8,835	m3	7,853	m3
Calculated Annual Running Cost (£)	£2,092		£1,860	
Total Annual Running Cost (5 Boilers)	£10,461		£9,299	

The same calculation is done for the usage of the hot water calorifier 9 hours per day versus 8 hours per day.

RISBRIDGER ANNUAL ENERGY CONSUMPTIONS AND RUNNING COSTS

Annual energy input (kJ) = boiler input or total heat loss x hours/day x days/year x 3600 x seasonal efficiency / thermal efficiency x part load efficiency

Annual fuel consumption = Annual energy input (MJ) / gross calorific value of fuel (MJ/kg or MJ/m3)

GCV for heating oil is 45.5 MJ/kg
GCV for anthracite is 32.0 MJ/kg
GCV for LPG is 25.5 MJ/litre
GCV for natural gas is 38.2 MJ/m3

Annual running costs (p) annual fuel consumption (kg or litres or m3) x cost in p/kg or p/litre or p/m3)

Annual running cost (£) fuel cost (p) / 100

Seasonal efficiency use 60% (0.6)
Thermal efficiency use 80 - 95% (0.8 - 0.95) based on boiler efficiency
Part load efficiency use 80% (0.8)
1MJ = 1/3.6 or 0.278kWh

HEATING/HOT WATER DETAILS:

Cylinder capacity (litres)	145		145	
Required stored water temperature	65		65	
Required heat up time (hours)	0.4		0.4	
Hours per day	9		8	
Days per year	260		260	
Cost of NATURAL GAS per unit (p/kWh)	2.23		2.23	
Cost of HEATING OIL per unit (p/litre)	52.5		52.5	
Annual Stored Heat Loss (kWh)	5157.36		4584.32	
Daily Energy Requirement (MJ)	834.78		742.03	
Daily Energy Requirement (kWh)	231.88		206.12	
Annual Energy Requirement (kWh)	60290		53591	
TEMPLATE No. 1 (for NATURAL GAS only)				
Calculated Annual Energy Input (HEATING)		kJ		kJ
Calculated Annual Energy Input (HWS)	237899709	kJ	211720808	kJ
Total Annual Energy Input	237899709	kJ	211720808	kJ
Annual Energy Consumption	66136	kWh	58858	kWh
Annual Fuel Consumption (quantity)	6228	m3	5542	m3
Calculated Annual Running Cost (£)	£1,475		£1,313	

6.2 Priority no. 2 Calculations

Install Variable Speed Drives

Information for the calculation can be found below:

Page 1 of 1

Call 07000 DRIVES for more information

Executive Summary — *Print this page*

Company Name: **Risbridger Ltd.**
Contact Name: **Reigate & Banstead Borough Council**

Date of Report: **31 / 3 / 2011**
Cost of Electricity: **10 p/kWh**

Application No. 1

Application Name: **Risbridger Ltd.**
Motor Power: **1.15 kW**
Number of motors of this type: **2**

	Energy consumed	CO_2 Emissions	Annual Energy Cost
Fixed speed:	3,980 kWh	2 tonnes	£398
Variable speed:	2,393 kWh	1 tonnes	£239
Annual saving:	1,587 kWh	1 tonnes	**£159**

Drive: **ACS 350-03E-04A1-4** Installed Cost: **£405**

Payback Time: **2.55 years**

Total Year-on-year savings, based on annual saving

Year 1	Year 2	Year 5	Year 10	Year 20
-	-	**£390**	**£1,185**	**£2,775**

http://www.armitage-comms.co.uk/energy/esc/executive_summary.htm 31/03/2011

Drive Required

Print this page

These figures are estimated drive and installation figures, please contact your local ABB Drives Alliance partner for exact costs. Call 0700 2 266722 NOW for exact costs.

Application No.1 : Risbridger Ltd.

Type designation: **ACS 350-03E-04A1-4**

Nett price:	**£184**
Estimated Installation Cost:	**£18**
Total outlay:	**£202**

Rated motor power P_N: 1.5 kW

Output Current $3{\sim}I_2$: 3.6 A

Phase/Voltage: 1-phase 200-240V, 3-phase 200-240V, 3-phase 380-480V
Built-in I/O: 2 Analogue Inputs, 1 Analogue Output, 5 Digital Inputs, 1 Relay Output, 1 Digital Output
Communication Facilities: PROFIBUS DP, DeviceNet, CANopen, Modbus

6.3 Priority no. 3 Calculations

Replace Current Lighting with LED Lighting Solutions

Client	Risbridger Ltd.
Site	Risbridger Ltd.
Area	Full Building

Annual Operating Hours	1,170
Electricity Cost (p/kWh)	10.000
CCL payable?	No
Include VAT in calculation?	Include VAT

	Applicable rate	Used in calculation
Electricity CCL rate (p/kWh)		0
Product VAT rate	20%	20%
Electricity VAT rate	20%	20%

Existing									**Action**
Site/Location	Product Code	Height (m)	Lamps PF	Watts	Ballast Losses	Quantity	OP Hrs Factor	kWh Usage	
Workshop	T-8 Doubles (1800mm)	3	2	70	8	65	1	11,864	Upgrade
Offices	T-8 Quads (1800mm)	3	4	70	8	29	1	10,586	Upgrade
Entrance and Storage Areas	T-8 Doubles (1800mm)	3	2	70	8	10	1	1,825	Upgrade
Hallway	T-12 Singles (2400mm)	3	1	100	12	3	1	393	Upgrade
								-	
								-	
								-	
								-	
								-	
								-	
								24,668	

Site/Location	**Replacement**										**Savings**		**Product Cost**	**Installati**
	Product Code	Product Description	Watts	Ballast Losses	Unit Price	Installation	Quantity	OP Hrs Factor	kWh Usage		kWh	Electricity £		
Workshop	LED	NetLED T-8 (1800mm)	32	0	£ 10.66	£3.75	130	1	4,867		6,997	£ 839.59	£ 1,662.96	£ 487.
Offices	LED	NetLED T-8 (1800mm)	32	0	£ 83.97	£3.75	116	1	4,343		6,243	£ 749.17	£ 11,688.62	£ 435.
Entrance and Storage Areas	LED	NetLED T-8 (1800mm)	32	0	£ 83.97	£3.75	20	1	749		1,076	£ 129.17	£ 2,015.28	£ 75.
Hallway	LED	NetLED T-10 (2400mm)	35	0	£ 99.96	£3.75	3	1	123		270	£ 32.43	£ 359.86	£ 11.
									-		-	£ -	£ -	£ -
									-		-	£ -	£ -	£ -
									-		-	£ -	£ -	£ -
									-		-	£ -	£ -	£ -
									-		-	£ -	£ -	£ -
									10,082		14,586	1,750	15,727	1,0

Payback Report									
Client	Risbridger Ltd.								
Site	Risbridger Ltd.								
Date	4/1/2011								
Area	Current kWh/pa	Current £/pa	New kWh/pa	Savings kWh/pa	Savings CO2 tonnes/pa	Savings £/pa	Investment	Payback	Salix Persistence Factor
Risbridger Ltd.	24668	£2,714	10082	14586	8.0	£1,750	£16,735	9.6	10
Total	**24668**	**£2,714**	**10082**	**14586**	8.0	**£1,750**	**£16,735**	**9.6**	

Appendix Q—Armatool Checklist

Armatool Distributors, Ltd. Checklist

Basic Information	
Date of Energy Audit:	31/03/2011
Department/Building/Area covered:	Office and Warehouse
Persons conducting audit:	Joe Lombardo and Kevin McCarthy
Normal occupancy hours of building:	Monday-Friday 8.30-5.00

Lighting	
Are any tungsten lights present? Can they be replaced with compact fluorescents (energy saving bulbs)? Look particularly in store rooms, uplighters, desk lamps etc.	Yes. There were 3 tungsten lights present.
If there are several light switches, can they be labelled to make it more obvious which switches relate to which fixtures?	No
Can lights be switched off to make use of daylight? (e.g. lights parallel to windows or in corridors)	Yes, in the offices.
Can light sensors be installed in spaces that are intermittently occupied (e.g. store rooms, toilets, kitchen areas, copying rooms, corridors, etc)	Yes
Are any external lights on during daylight hours?	No
Can main lighting ever be switched off to make use of ambient light and desk lamps?	No

Do any light fittings need cleaning?	No
Do windows and skylights need cleaning to allow in more natural light?	Yes, the skylights
Number of T-5 lights	None
Number of T-8 lights	18 W, 2 ft, 8 fixtures, 4 bulbs (reception) 18 W, 2 ft, 32 fixtures, 4 bulbs (offices) 70 W, 6 ft, 35 fixtures, 1 bulb (warehouse lower level)
Number of T-12 lights	100 W, 8 ft, 20 fixtures, 2 bulbs (warehouse upper level)
Number of Halogen lights	None
Number of CFLs	2D, 4 fixtures (office hallway)

Heating

What is the actual temperature in the space?	Indeterminate
Does the temperature vary much during the day?	Yes
Do occupants complain it is too hot or too cold?	No
If there are Thermostatic Radiator Valves (TRVs), are they set correctly? Do they actually work or are they broken?	N/A
Are radiators effective and giving consistent heat? They may need bleeding of air or maintenance to remove dust and sediment.	They all work effectively
If the room tends to overheat, is there any bare pipework that could be insulated?	No bare pipes
Are radiators blocked, restricting air circulation?	No
Are external doors and windows closed when heating is on?	Yes
Are windows in good condition? Are any window panes cracked or broken?	Windows are good condition, but single-pane

If there is a roof space, is it insulated?	No insulation
Are blinds closed at the end of the day during winter to cut down on heat loss?	Unsure
Is heating on in unused spaces, such as cupboards, corridors?	No
How many kW do the boilers use?	Warehouse gas heaters: 33-36 kW Office heaters: large 3.4-4.3, small 0.65-0.73
How long is each boiler on per day?	Heaters: Set to climate control program

Cooling and Ventilation

If there is air conditioning with local controls, make sure it is only on when necessary. Is it obvious how to control it? What temperature is it set to?	Yes, it is only on when essential
Is air conditioning running at the same time as heating?	No
Are all external doors and windows closed when air conditioning is on?	Yes
Is natural ventilation (e.g. windows and doors open with no air conditioning on) being used?	No
Is air conditioning on in unused spaces, such as cupboards, corridors?	No

Electrical Equipment

Are computers, printers, photocopiers and other equipment switched off at the end of the day?	Some
Can computers and other electrical equipment be programmed to 'power down' or 'energy save' mode?	Yes
Can a 7 day timer be put on some equipment (e.g. photocopiers, water coolers, cold drinks machines) to regulate when systems are powered down?	No

Can any equipment be switched on later and switched off earlier?	Yes
Can kettles be removed if there is a wall mounted boiler?	No
Are fridges places next to heat sources?	No
Is the office fridge/freezer defrosted regularly?	Not required
Is the fridge thermostat working and set to the right temperature (2-4 °C)?	Yes
Is equipment clearly labelled so that staff know how to activate energy saving features or switch it off?	No

Water Use

Is there any evidence of water leaks? (e.g. wet pathways on a dry day)	No
Are taps left running? Are there any dripping taps? Do taps need maintenance?	No
Are hot water heater timers set correctly?	Yes
How long does the hot water calorifier take to heat up?	No hot water calorifier
How long is the hot water calorifier on for per day?	n/a

Awareness and Building Usage

Are there posters/guidance displayed to remind people of good practice?	No
When is the building primarily used and what is it used for?	Used during typical work day during workweek. Some offices and a warehouse for storage of product.

Appendix R—Armatool Report

1. Introduction

The purpose of this energy survey was to discover potential areas of energy reduction and cost savings in the Armatool Distributors, Ltd. building. This audit was conducted using a basic walkthrough methodology. The Armatool building is used for about eight and a half hours a day , for about 51 weeks in the year, during the standard business week, resulting in an estimated 42.5 hours of occupancy per week. The building composition is a mix of offices and warehouse space in a poorly insulated building. There are likely many potential improvements to be made to the facility.

2. Summary of Findings

During our walkthrough of Armatool Distributors Ltd, we noticed many ways in which the company could improve energy efficiency.

2.1 Office Areas

Starting in the reception area, we first noticed there seemed to be an abundance of lights. Through they were turned off at the time, there were 8 fixtures each with 4 T-8 bulbs, far more than necessary to light the room, especially with a window with open shades. We then entered the hallway, which had more efficient compact fluorescent tubes in the lights.

Moving on into the first office, we noticed it was also over lit, using 6 fixtures each with 4 T-8 bulbs. We also noted that the office made use of skylights, which, despite their dirtiness, provide a good amount of natural light into the room. The office also used an electric air condition/heater ranging from 3.4 kilowatts to 4.05 kilowatts dependent on settings.

The second office had the same number of lights as the first, which was, again, more than necessary. The skylights were also somewhat dirty in this office as well. When we entered the office it was empty, and the lights were all off, a good habitual sign. However, there was a computer fully running, which didn't appear to be in any immediate use. The air conditioner/heater for this office ranged from 0.65 kilowatts to 0.73 kilowatts.

We then moved to the third office, which also had 6 fixtures with 4 T-8 bulbs as well as skylights all in use. We noticed that although only one person was working in this office, there was a second computer fully running. The air conditioner/heater for this office was the same as the first, ranging from 3.4 kilowatts to 4.05 kilowatts.

We noticed that the fourth office was somewhat larger than the previous, and had 8 fixtures each with 4 T-8 bulbs, much more than necessary considering it also had skylights and windows with open shades. It also had one of the larger air conditioner/heaters ranging from 3.4 kilowatts to 4.05 kilowatts.

In the final office, we noticed it also had 6 fixtures each with 4 T-8 bulbs, and like the other offices it too was over lit despite the fact that it did not have skylights. We also saw that it used one of the smaller air condition/heaters ranging from 0.65 kilowatts to 0.69 kilowatts.

2.2 Warehouse

From the offices we proceeded into the warehouse, starting on the upper level. We first noticed that at the time, there was no one present on the upper level and it seemed to be an area of low traffic. We also noticed it had more lights than necessary, using 20 fixtures each with 2 T-12 bulbs. We even noted that in some cases the lights were being almost entirely obstructed by the high shelves of boxes, rendering them useless. Shown in Figure 27 below.

Figure 27 - Armatool Lighting

This area also had skylights. However they were quite dirty and could be cleaned to provide more adequate lighting. These skylights are shown in Figure 28 below.

Figure 28 - Armatool Dirty Skylights

We then went to the lower part of the warehouse, where we noticed many of the same issues. First, the majority of employees seemed to be in only one area for an extended amount of time, yet the entire warehouse was being lit. We saw there were 33 fixtures each using 1 T-8 bulb in the lower area of the warehouse. Again, we noticed that there were some lights that were blocked by equipment in this area. We were told that the warehouse was heated by two separate gas heaters. The first ranged from 33 to 36 kilowatts, but we were unable to obtain information about the second.

We also observed that the bathroom areas possessed incandescent bulbs, but they appeared to be minimally utilized. In the break room there was a single fixture with 2 T-8 bulbs, but it also did not appear to receive much use.

2.3 Other Notes

After talking with the owner of the company, we found out that only a small portion of the building's walls have any insulation, and that the roof does not have any. We also found out that all the windows are single pane.

3. Potential Savings

There are many areas for potential savings and energy reduction. These areas are detailed in two different sections: (1) No Cost Solutions and (2) Cost Solutions

3.1 No Cost Solutions

No cost solutions consist of behavioral changes that will allow for monetary savings and energy reduction. These solutions are outlined by area, problem, solution, and savings in Table 18 below:

Table 18 - Armatool No Cost Solutions

Area	Problem	Solution	Savings
Offices/Warehouse	Areas are over lit	Reduce the number of lights used in the areas to supply a sufficient amount of light	By reducing the number of lights used by 25% savings of £653 per year can be achieved
Office Areas	Unused computers using screensavers instead of standby mode	Ask staff to adjust setting of computers to enter standby mode instead of screen savers	Standby usage can lower the energy consumption of the computers by about 90% per year
Offices/Warehouse Areas	Skylights very dirty, hence not supplying optimal natural light	Clean skylights	Cleaner skylights will allow more natural light in, thus lowering need for more light fixtures
Warehouse Area	Areas of low traffic are lit at all times	Ask staff to turn off lights when not immediately using an area	By reducing the use of lights in warehouse by 33% saving of £550 per year can be achieved

3.2 Low Cost Solutions

Low cost solutions are solutions that have a low initial cost with a small payback period. These solutions will result in yearly savings after the payback period has been completed. Table 19 below outlines the solution, cost, savings per year, and payback period:

Table 19 - Armatool Low Cost Solutions

Problem	Solution	Investment Cost	Savings Per Year	Payback Period
Usage of Fluorescent Lighting in Reception/Offices Area	Replace T-8 lighting with LED lighting	£2,753	£795 per year	3.5 years (calculations shown in the Calculations section)
Usage of Fluorescent Lighting in Factory Area	Replace T-8 and T-12 lighting with LED lighting	£4,830	£1,272 per year	3.4 years (calculations shown in the Calculations section)

4. Recommendations

We have arranged our recommendations by priority. The table below illustrates solutions that should be considered moving forward.

Priority no. 1	**Improved Energy Awareness**		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£1,203	*10,950*	*None*	*Immediate*
Detail	As noted in the *Summary of Findings*, lights were being left on despite ambient light radiating down from skylights. Asking staff to turn off these lights when they are not needed will reduce the electric bill per month, resulting in a moderately high amount of annual savings. The same can be said about turning off computers and other equipment when it is not being used. Also cleaning the skylights will allow for more natural light to enter, hence reducing the need for lighting fixtures. This cost savings is an estimation based on reducing light use by 33% in the warehouse area, and reducing number of lights throughout the building by 25%. Additional savings would also come from reducing the need to replace bulbs. In order to accomplish this goal, small notes, posters, and stickers reminding staff to turn off lights and equipment may be necessary. These notes will help remind staff about energy efficiency. Talking to the staff about energy awareness will also help in reducing cost.		

Priority no. 2	Replace Current Lighting with LED Lighting		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£2,067	*19,681*	*£7,133*	*3.5 years*
Detail	The energy survey revealed that there are potential opportunities to replace current lighting with LED lighting solutions. LED Lighting provides similar lumens at much higher efficiency than current light fixtures. They last 50,000 hours, which is greater than twice the lifetime of a typical T-5 tube. Additionally, only one LED tube per fixture is needed as opposed to the two T-5s, T-8s, and T-12s in every fixture, reducing cost when replacement is needed. Replacing current lighting with LED solutions will have an initial cost, but will save a lot on energy bills after the payback period is completed.		

5. Conclusion

By completing an energy survey of Armatool Distributors, Ltd., we found numerous areas of potential improvement, ranging from simple behavioral changes to upgrading lighting equipment throughout the building. From these areas of potential savings, we formulated two main priority solutions. The first of these will be to raise the energy awareness of employees. Simple things such as turning off unnecessary lighting and reducing the building temperature can provide noticeable savings without any initial investment. Another habitual solution is for employees to set their computers to enter standby mode rather than running a screensaver. Standby mode uses significantly less energy than a screensaver. Furthermore, if the skylights are cleaned, they will allow much more light into the building, requiring less electric lighting. We also advise that some lighting fixtures be moved or removed, as we found some areas over lit. Additionally, in the upper warehouse, some light fixtures were directly above the shelves, resulting in the products blocking the light output. Our second recommendation was that all lighting throughout the building, both in the offices and the warehouse, be upgraded to newer, high-efficiency light emitting diode (LED) lighting. This will provide a moderately high yearly savings and a reasonable payback period of just over 3 years, and they will become quite profitable after that time.

6. Calculations

6.1 1st Priority Calculations

Calculations for the savings associated with energy awareness are calculated by adjusting the annual operation hours and number of lights for certain areas in the Excel worksheets shown below.

6.2 2nd Priority Calculations

<u>LED Lighting Solutions in the Reception Office area</u>

Based on calculations from http://www.netledlighting.co.uk/t5_tubes.htm

See attached charts below:

Client	Armatool Distributors Ltd
Site	Armatool
Area	Reception/Offices

Annual Operating Hours	2,150
Electricity Cost (p/kWh)	10.000
CCL payable?	No
Include VAT in calculation?	Include VAT

	Applicable rates	Used in calculation
Electricity CCL rate (p/kWh)		0
Product VAT rate	15%	15%
Electricity VAT rate	5%	5%

Existing									**Action**	**Replacement**									**Savings**		**Product Cost**	**Installation**
Site/Location	Product Code	Height (m)	Lamps PF	Watts	Ballast Losses	Quantity	OP Hrs Factor	kWh Usage		Product Code	Product Description	Watts	Ballast Losses	Unit Price	Installation	Quantity	OP Hrs Factor	kWh Usage	kWh	Electricity £		
Reception Office Area	T-8 Fixtures (600mm)	3	4	18	8	40	1	8,944	Upgrade	LED	NetLED T-8 600mm	8	0	£ 26.66	£3.75	80	1	1,376	7,568	£ 794.64	£ 2,452.72	£ 300.00
								-										-	-	£ -	£ -	£ -
								8,944										1,376	7,568	795	2,453	300

Client	Armatool Distributors Ltd
Site	Armatool
Area	Warehouse

Annual Operating Hours	2,150
Electricity Cost (p/kWh)	10.000
CCL payable?	No
Include VAT in calculation?	Include VAT

	Applicable rate	Used in calculation
Electricity CCL rate (p/kWh)		0
Product VAT rate	15%	15%
Electricity VAT rate	5%	5%

Existing									**Action**	**Replacement**									**Savings**		**Product Cost**	**Installation**
Site/Location	Product Code	Height (m)	Lamps PF	Watts	Ballast Losses	Quantity	OP Hrs Factor	kWh Usage		Product Code	Product Description	Watts	Ballast Losses	Unit Price	Installation	Quantity	OP Hrs Factor	kWh Usage	kWh	Electricity £		
Warehouse Upper	T-12 Fixtures (2400mm	3	2	100	10	20	1	9,460	Upgrade	LED	NetLED T-10 2400m	35	0	£ 99.96	£3.75	20	1	1,505	7,955	£ 835.28	£ 2,299.08	£ 75.00
Warehouse Lower	T-8 Fixtures (1800mm)	3	1	70	8	33	1	5,534	Upgrade	LED	NetLED T-8 1800mn	32	0	£ 83.97	£3.75	20	1	1,376	4,158	£ 436.60	£ 1,931.31	£ 75.00
								-										-	-	£ -	£ -	£ -
								14,994										2,881	12,113	1,272	4,230	150

Payback Report										
Client	Armatool Distributors Ltd									
Site	Armatool Reception/Ofiices									
Date	31/03/2011									
Area	Current kWh/pa	Current £/pa	New kWh/pa	Savings kWh/pa	Savings CO2 tonnes/pa	Savings £/pa	Investment	Payback	Salix Persistence Factor	Cost per Tonne CO2
Armatool Offices	8944	£984	1376	7568	4.1	£795	£2,753	3.5	10	67.7
Armatool Warehouse	14994	£1,649	2881	12113	6.5	£1,272	£4,380	3.4	10	67.3
Total	**23938**	**£2,633**	**4257**	**19681**	10.6	**£2,067**	**£7,133**	**3.5**		**135.1**

Appendix S—ING Lease Checklist

ING Lease Checklist

Basic Information	
Date of Energy Audit:	April 4, 2011
Department/Building/Area covered:	Floors 2-5
Persons conducting audit:	Nicholas Mondor, Nicholas Solarz, Joe Lombardo, Kevin McCarthy
Normal occupancy hours of building:	Monday-Friday 8:00 A.M.-6:00 P.M. (open from 6:00 A.M.-8:00 P.M.) Open all year (except holidays)

Lighting	
Are any tungsten lights present? Can they be replaced with compact fluorescents (energy saving bulbs)? Look particularly in store rooms, uplighters, desk lamps etc.	Only some halogen lights present.
If there are several light switches, can they be labelled to make it more obvious which switches relate to which fixtures?	No.
Can lights be switched off to make use of daylight? (e.g. lights parallel to windows or in corridors)	Yes. Building had large windows in office areas on all floors. These windows also had blinds.
Can light sensors be installed in spaces that are intermittently occupied (e.g. store rooms, toilets, kitchen areas, copying rooms, corridors, etc)	Sensor lighting in bathrooms.
Are any external lights on during daylight hours?	No.
Can main lighting ever be switched off to make use of ambient light and desk lamps?	Yes. Blinds can be opened to make use of ambient light filtering through large windows.

Do any light fittings need cleaning?	No.
Do windows and skylights need cleaning to allow in more natural light?	No. Skylights and windows were clean.
Number of T-5 lights	14W, 2ft 4 fixtures, 4 per fixture (2nd floor reception) 14W, 2ft 28 fixtures, 4 per fixture (2nd floor meeting rooms) 14W, 2ft 79 fixtures, 4 per fixture (2nd floor offices) 14W, 2ft 115 fixtures, 4 per fixture (3rd floor offices) 14W, 2ft 4 fixtures, 4 per fixture (2nd floor and 3rd floor kitchens) 14W, 2ft 140 fixtures, 4 per fixture (4th floor offices, kitchens, and meeting rooms) 14W, 2ft 131 fixtures, 4 per fixture (5th floor offices, kitchens, and meeting rooms)
Number of T-8 lights	6ft 26 fixtures, 2 tubes per (car park)
Number of T-12 lights	None
Number of Halogen lights	55 (2nd floor reception and hallway areas)
Number of CFLs	5 (stairwells) 8 (2nd floor reception) 16 (2nd floor meeting rooms) 4 (2nd and 3rd floor kitchens) 10 (3rd floor halls and bathrooms) 75 (4th floor) 55 (5th floor offices and meeting rooms). 36W Bulbs

Heating

What is the actual temperature in the space?	A little warm (22 degree C)
Does the temperature vary much during the day?	No.
Do occupants complain it is too hot or too cold?	No.
If there are Thermostatic Radiator Valves (TRVs), are they set correctly? Do they actually work or are they broken?	TRV set to 4 in hallway by stairs
Are radiators effective and giving consistent heat? They	Yes. Consistent heat is given through air ducts.

may need bleeding of air or maintenance to remove dust and sediment.	
If the room tends to overheat, is there any bare pipework that could be insulated?	Piping is all insulated.
Are radiators blocked, restricting air circulation?	No.
Are external doors and windows closed when heating is on?	Yes.
Are windows in good condition? Are any window panes cracked or broken?	Window panes are in good condition.
If there is a roof space, is it insulated?	Yes.
Are blinds closed at the end of the day during winter to cut down on heat loss?	Yes.
Is heating on in unused spaces, such as cupboards, corridors?	No.
How many kW do the boilers use?	4x 7.5 kW Grundfos Wahlstedt pumps 2x 1.5 kW Grundfos backup pumps 2x 3 kW ABB M2000 pumps 5x 140 kW Hamworthy Warmwell boilers
How long is each boiler on per day?	Pumps are on 12 hours per day. Only 3 boilers are used at a time, but they are on for 12 hours a day.

Cooling and Ventilation

If there is air conditioning with local controls, make sure it is only on when necessary. Is it obvious how to control it? What temperature is it set to?	Air conditioning wasn't on.
Is air conditioning running at the same time as heating?	No.
Are all external doors and windows closed when air conditioning is on?	N/A
Is natural ventilation (e.g. windows and doors open with no air conditioning on) being used?	N/A

Is air conditioning on in unused spaces, such as cupboards, corridors?	No.

Electrical Equipment

Are computers, printers, photocopiers and other equipment switched off at the end of the day?	Yes. Employees turn off computers, printers, and photocopiers when they are not in use.
Can computers and other electrical equipment be programmed to 'power down' or 'energy save' mode?	Yes.
Can a 7 day timer be put on some equipment (e.g. photocopiers, water coolers, cold drinks machines) to regulate when systems are powered down?	Yes, but it's not useful considering the equipment habits of the employees.
Can any equipment be switched on later and switched off earlier?	No.
Can kettles be removed if there is a wall mounted boiler?	No.
Are fridges places next to heat sources?	No.
Is the office fridge/freezer defrosted regularly?	N/A
Is the fridge thermostat working and set to the right temperature (2-4 °C)?	N/A
Is equipment clearly labelled so that staff know how to activate energy saving features or switch it off?	N/A

Water Use

Is there any evidence of water leaks? (e.g. wet pathways on a dry day)	No noticeable water leaks.
Are taps left running? Are there any dripping taps? Do taps need maintenance?	No taps were left running.
Are hot water heater timers set correctly?	Yes.

How long does the hot water calorifier take to heat up?	N/A
How long is the hot water calorifier on for per day?	N/A

Awareness and Building Usage

Are there posters/guidance displayed to remind people of good practice?	None noticeable.
When is the building primarily used and what is it used for?	Approximately 350 people on the 2nd-5th floor of the office building. Landlord managed (plant, heating, cooling, equipment room, etc). Refer to normal occupancy hours for when the building is primarily used.

Appendix T—ING Lease Report

1. Introduction

The purpose of this energy survey was to discover potential areas of energy reduction and cost savings within the ING Lease office building. ING Lease occupies the second through fifth floor of a large office building. The offices on the ground floor are vacant. The remainder of the building consists of a parking garage attached to the second floor, as well as another company occupying offices on the first floor. The building is run and maintained by a landlord. The occupancy hours for the ING floors are from 6 A.M. to 8 P.M., with business operating hours from 8 A.M. to 6 P.M. The building is open five days a week, year round, with the exception of holidays.

2. Summary of Findings

Upon entering ING Lease, the first thing we noticed was the use of halogen bulbs to light the reception area. These bulbs, while small, use up a considerable amount of energy. As we continued through the main workspace floors, we noticed that the lighting primarily consisted of small 2 ft. T-5 fixtures with four tubes per fixture, along with supplementary compact fluorescent lights near the entryways to each floor. We found 111 T-5 fixtures on the second floor, 117 on the third floor, 140 on the fourth floor and 131 on the fifth floor, with an approximate total of 500 fixtures within ING Lease’s office space. Additionally, we counted around 173 CFLs and 55 halogen lights throughout the office building.

Next we took a look at the car park. The first thing we noticed was that all of the lights were off during the time of our visit. We were later told that the car park lights were controlled by ambient light sensors, as well as timers. There were 26 6 ft. T-8 fixtures within the car park.

We then looked at the air conditioning and boiler units. In the chiller room on the roof, we discovered two dual-head pumps, with each head running at 7.5 kW. In the boiler room, we noted two dual-head pumps for the heating system, each running at 3 kW. These were supplemented by two additional dual-head pumps running at 1.5 kW. None of these pumping systems were connected to variable speed drives (VSDs).

The heating system itself consisted of five 140 kW boilers set to 85 degrees Celsius. These were controlled by a BMS system, with a max of three boilers running at any given time. The average building temperature ranged from 19-24 degrees depending on the outside temperature. During our energy survey, it was at a consistent 22 degrees Celsius.

There was no centralized hot water calorifier. Instead, the building had small, localized hot water heaters located near the bathrooms and kitchen areas on each floor.

3. Potential Savings

There are many areas for potential savings and energy reduction. These areas are detailed in two different sections: (1) No Cost Solutions and (2) Cost Solutions

3.1 No Cost Solutions

No cost solutions consist of behavioral changes that will allow for monetary savings and energy reduction. These solutions are outlined by building, area, problem, solution, and savings in Table 20 below (calculations are shown in the Calculations section):

Table 20 – ING Lease No Cost Solutions

Building	Area	Problem	Solution	Savings
Main Building	Office Workspace	Blinds were covering windows, blocking ambient light from entering the space.	Open up blinds and turn off inside lights to take advantage of the outside light during the daytime.	By using the outside light and turning off inside lights, there is a potential to save 10% off of lighting costs, which we estimate to be £1,481 per year.
Main Building	Large Boiler Room	Boilers were on timers, but we could not find the timer settings for when the boiler turned on and off daily. Assuming that the boilers run during hours of operation (12hours per day).	Consider adjusting the startup and shutdown hours of the boilers to reduce the running time.	Turning the boilers off 1 hour or turning it on 1 hour later will result in a £1,953 per year savings (calculated in Appendix A using 140kW boilers running 11 hours per day, 5 days a week, 50 weeks a year at 90% efficiency).

3.2 Cost Solutions

Cost solutions are solutions that have an initial investment with a small payback period. These solutions will result in yearly savings after the payback period has been completed. Table 21 outlines the solution, cost, savings per year, and payback period.

Table 21 – ING Lease Cost Solutions

Solution	Investment Cost	Savings Per Year	Payback Period
Install Variable Speed Drives (VSDs) on boiler pumps	£4,611	£3,538 per year	1.3 years
Replace current lighting with LED lighting	£30,666	£10,746 per year	2.9 years

4. Recommendations

We have arranged our recommendations by priority. The tables below illustrates solutions that should be considered moving forward.

Priority no. 1	**Adjust Boiler Operating Hours and Take Advantage of Ambient Lighting**		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£3,434	*159,421*	*None*	*Immediate*
Detail	The energy survey revealed that there are potential opportunities to increase energy efficiency and save money by adjusting boiler and operating hours and allowing natural light to come through the windows. Though we were unable to see the timer settings on the boiler system, adjusting the hours of operation by 1 hour can result in £1,953 savings per year. One possible option for accomplishing this savings is to shut the boilers off an hour before people leave the building. The building will retain a fairly constant, comfortable temperature since the building has new double glazed windows and is well insulated. As a result, this will also reduce the amount of energy used daily from the boiler system. Another thing we noticed during the walkthrough was the abundant amount of windows throughout the building. The majority of these windows were covered by blinds, preventing ambient light from filtering into the main office spaces. Opening blinds will allow for more natural light. As a result, some of the internal lights can be turned off and adequate lighting will be maintained. We estimate the resulting savings to be approximately 10% of the total lighting costs for the building, or about £1,481 per year.		

Priority no. 2	**Install Variable Speed Drives on Grundfos Pumps**		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£3,538	*35,385*	*£4,611*	*1.3 years*
Detail	In a normal HVAC system, the pumps are used to circulate hot and cold water throughout the building. These pumps normally operate near their maximum load (95-100%). The flow is then dampened to its required rate by a mechanical valve after the water has left the pump. Variable speed drives achieve savings by lowering the power input to the pump rather than restricting the flow of the pump. Variable speed drives allow for the pumps to run at a higher efficiency, resulting in less kilowatt hours used. This solution provides a decent amount of savings per year, with a reasonable investment and an extremely fast payback period.		

Priority no. 3	Replace Current Lighting with LED Lighting Solutions		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£10,746	*89,547*	*£30,666*	*2.9 years*
Detail	LED Lighting provides similar lumens at much higher efficiency than current light fixtures. They last 50,000 hours, which is over 30,000 hours longer than a typical T-5 tube and over 5 times longer than a conventional halogen lamp. ING Lease can benefit from replacing the halogen lamps, CFLs, and T-5 tubes throughout the building with LED lighting solutions. While this solution provides the highest savings per year, we consider it to be less of a priority due to the high investment cost. However, should the investment capital be available, this solution has a high return with a payback period just under three years.		

5. Conclusion

Through our walk-through of ING Lease, we found numerous areas for potential energy savings. The first few of these can be grouped into no-cost, behavioral solutions. This includes simple things like adjusting the start up and shutdown times of the boilers and taking advantage of natural light. The next solution to look into is the installation of variable speed drives. These provide noticeable savings by reducing the amount of power required to pump the HVAC system. These have a relatively small investment and quick payback period. Finally, the highest amount of annual savings is through upgrading the current office lighting to more efficient LED lighting. LED lights offer similar lumen values with a dramatically reduced power consumption and extended lifetime. The one drawback to this solution is the high initial investment cost. Fortunately, LED lighting compensates for this high initial cost with a large yearly savings and fast payback period. Overall, the building was very energy efficient, yet there are still areas for improvement.

6. Calculations

6.1 Priority no. 1 Calculations

ING LEASE ANNUAL ENERGY CONSUMPTIONS AND RUNNING COSTS

Annual energy input (kJ) = boiler input or total heat loss x hours/day x days/year x 3600 x seasonal efficiency / thermal efficiency x part load efficiency

Annual fuel consumption = Annual energy input (MJ) / gross calorific value of fuel (MJ/kg or MJ/m3)

GCV for heating oil is 45.5 MJ/kg
GCV for anthracite is 32.0 MJ/kg
GCV for LPG is 25.5 MJ/litre
GCV for natural gas is 38.2 MJ/m3

Annual running costs (p) annual fuel consumption (kg or litres or m3) x cost in p/kg or p/litre or p/m3)

Annual running cost (£) fuel cost (p) / 100

Seasonal efficiency use 60% (0.6)
Thermal efficiency use 80 - 95% (0.8 - 0.95) based on boiler efficiency
Part load efficiency use 80% (0.8)
1MJ = 1/3.6 or 0.278kWh

HEATING DETAILS:	Current Operation	Reduced Hours
Boiler input or total heat loss (kW)	140	140
Hours per day	12	11
Days per week	5	5
Week per year	50	50
Boiler thermal efficiency	0.9	0.9
Cost of NATURAL GAS per unit (p/kWh)	2.23	2.23
Cost of HEATING OIL per unit (p/litre)	52.5	52.5

TEMPLATE No. 1 (for NATURAL GAS only)

	Current Operation		Reduced Hours	
Calculated Annual Energy Input (HEATING)	1,260,000,000	kJ	1,155,000,000	kJ
Total Annual Energy Input	1,260,000,000	kJ	1,155,000,000	kJ
Annual Energy Consumption	350,280	kWh	321,090	kWh
Total Annual Energy Consumption (5 Boilers)	1,751,400	kWh	1,605,450	kWh
Annual Fuel Consumption (quantity)	32,984	m3	30,236	m3
Calculated Annual Running Cost (£)	£7,811		£7,160	
Total Annual Running Cost (3 Boilers)	£23,434		£21,481	
Total Annual Running Cost (5 Boilers)	£39,056		£35,802	
Estimated savings by reducing operationg hours			£1,953	
			145,950	kWh

6.2 Priority no. 2 Calculations

Call 07000 DRIVES for more information

Executive Summary

Print this page

Company Name: **ING Lease**
Contact Name: **Reigate & Banstead Borough Council**

Date of Report: **4 / 4 / 111**
Cost of Electricity: **10 p/kWh**

Application No. 1

Application Name: **Grundfos Chiller Pumps**
Motor Power: **7.5 kW**
Number of motors of this type: **4**

	Energy consumed	CO_2 Emissions	Annual Energy Cost
Fixed speed:	66,556 kWh	37 tonnes	£6,655
Variable speed:	40,017 kWh	22 tonnes	£4,001
Annual saving:	26,539 kWh	15 tonnes	**£2,654**

Drive: **ACS 550-01-015A-4** Installed Cost: **£3,066**

Payback Time: **1.16 years**

Total Year-on-year savings, based on annual saving

Year 1	Year 2	Year 5	Year 10	Year 20
-	**£2,242**	**£10,204**	**£23,474**	**£50,014**

Call 07000 DRIVES for more information

Executive Summary

Print this page

Company Name: **ING Lease**
Contact Name: **Reigate & Banstead Borough Council**

Date of Report: **4 / 4 / 111**
Cost of Electricity: **10 p/kWh**

Application No. 1	Application Name:	**Grundfos Backup Pumps**
	Motor Power:	**1.5 kW**
	Number of motors of this type:	**2**

	Energy consumed	CO_2 Emissions	Annual Energy Cost
Fixed speed:	6,655 kWh	3 tonnes	£665
Variable speed:	4,001 kWh	2 tonnes	£400
Annual saving:	2,654 kWh	1 tonnes	**£265**

Drive: **ACS 350-03E-04A1-4** Installed Cost: **£405** Payback Time: **1.53 years**

Total Year-on-year savings, based on annual saving

Year 1	Year 2	Year 5	Year 10	Year 20
-	**£125**	**£920**	**£2,245**	**£4,895**

Call 07000 DRIVES for more information

Executive Summary *Print this page*

Company Name: **ING Lease**
Contact Name: **Reigate & Banstead Borough Council**

Date of Report: **4 / 4 / 111**
Cost of Electricity: **10 p/kWh**

Application No. 1

Application Name: **ABB Main Boiler Pumps**
Motor Power: **3.5 kW**
Number of motors of this type: **2**

	Energy consumed	CO_2 Emissions	Annual Energy Cost
Fixed speed:	15,529 kWh	8 tonnes	£1,552
Variable speed:	9,337 kWh	5 tonnes	£933
Annual saving:	6,192 kWh	3 tonnes	**£619**

Drive: **ACS 550-01-08A8-4** Installed Cost: **£1,140**

Payback Time: **1.84 years**

Total Year-on-year savings, based on annual saving

Year 1	Year 2	Year 5	Year 10	Year 20
-	**£98**	**£1,955**	**£5,050**	**£11,240**

6.3 Priority no. 3 Calculations

Client	INGLease
Site	INGLease
Area	2nd-5th Floor

Annual Operating Hours	3,000
Electricity Cost (p/kWh)	10.000
CCL payable?	No
Include VAT in calculation?	Include VAT

	Applicable rate:	Used in calculation
Electricity CCL rate (p/kWh)		0
Product VAT rate	15%	15%
Electricity VAT rate	20%	20%

Existing									**Action**
Site/Location	Product Code	Height (m)	Lamps PF	Watts	Ballast Losses	Quantity	OP Hrs Factor	kWh Usage	
2nd Floor	T-5 Quads (600mm)	3	4	14	4	111	1	23,976	Upgrade
3rd Floor	T-5 Quads (600mm)	3	4	14	4	117	1	25,272	Upgrade
4th Floor	T-5 Quads (600mm)	3	4	14	4	140	1	30,240	Upgrade
5th Floor	T-5 Quads (600mm)	3	4	14	4	131	1	28,296	Upgrade
2nd Floor	Halogen (50x55.5mm)	3	1	50	0	55	1	8,250	Upgrade
Offices, Meeting Rooms, Kitchens, and Bathrooms	CFL (Bayonet Cap or Screw Cap)	3	1	36	0	173	1	18,684	Upgrade
								-	
								-	
								-	
								-	
								-	
								134,718	

Site/Location	**Replacement**									**Savings**		**Product Cost**	**Installation**
	Product Code	Product Description	Watts	Ballast Losses	Unit Price	Installation	Quantity	OP Hrs Factor	kWh Usage	kWh	Electricity £		
2nd Floor	LED	NetLED T-5 (600mm)	7	0	£ 8.23	£3.75	444	1	9,324	14,652	£ 1,758.24	£ 4,202.24	£ 1,665.00
3rd Floor	LED	NetLED T-5 (600mm)	7	0	£ 8.23	£3.75	468	1	9,828	15,444	£ 1,853.28	£ 4,429.39	£ 1,755.00
4th Floor	LED	NetLED T-5 (600mm)	7	0	£ 8.23	£3.75	560	1	11,760	18,480	£ 2,217.60	£ 5,300.12	£ 2,100.00
5th Floor	LED	NetLED T-5 (600mm)	7	0	£ 8.23	£3.75	524	1	11,004	17,292	£ 2,075.04	£ 4,959.40	£ 1,965.00
2nd Floor	LED	Net GU10/4-CW (50x55.5mm)	4	0	£ 10.66	£3.75	55	1	660	7,590	£ 910.80	£ 674.25	£ 206.25
Offices, Meeting Rooms, Kitchens, and Bathrooms	LED	SimplyLED B22 (Bayonet Cap)	5	0	£ 14.99	£3.75	173	1	2,595	16,089	£ 1,930.68	£ 2,982.26	£ 648.75
									-	-	£ -	£ -	£ -
									-	-	£ -	£ -	£ -
									-	-	£ -	£ -	£ -
									-	-	£ -	£ -	£ -
									-	-	£ -	£ -	£ -
									45,171	89,547	10,746	22,548	8,340

Payback Report								
Client	INGLease							
Site	INGLease							
Date	4/4/2011							
Area	Current kWh/pa	Current £/pa	New kWh/pa	Savings kWh/pa	Savings CO2 tonnes/pa	Savings £/pa	Investment	Payback
ING Lease	134718	£14,819	45171	89547	48.1	£10,746	£30,888	2.9
Total	**134718**	**£14,819**	**45171**	**89547**	48.1	**£10,746**	**£30,888**	**2.9**
Ambient Light Savings	**£1,481.90**							
	13,472	**kWh**						

Appendix U—YMCA Princes Road Checklist

YMCA Princes Road Checklist

Basic Information

Date of Energy Audit:	05/04/2011
Department/Building/Area covered:	Princes Road Facility
Persons conducting audit:	Joe Lombardo and Kevin McCarthy
Normal occupancy hours of building:	Monday-Thursday: 9.00am-10.00pm Friday: 9.00am-9.00pm Saturday: 10.00am-6.00pm Sunday: 10.00am-4.00pm

Lighting

Are any tungsten lights present? Can they be replaced with compact fluorescents (energy saving bulbs)? Look particularly in store rooms, uplighters, desk lamps etc.	No
If there are several light switches, can they be labelled to make it more obvious which switches relate to which fixtures?	No
Can lights be switched off to make use of daylight? (e.g. lights parallel to windows or in corridors)	No
Can light sensors be installed in spaces that are intermittently occupied (e.g. store rooms, toilets, kitchen areas, copying rooms, corridors, etc)	Yes
Are any external lights on during daylight hours?	No

Can main lighting ever be switched off to make use of ambient light and desk lamps?	No
Do any light fittings need cleaning?	No
Do windows and skylights need cleaning to allow in more natural light?	No
Number of T-5 lights	None
Number of T-8 lights	345
Number of T-12 lights	None
Number of Halogen lights	6
Number of CFLs	11

Heating

What is the actual temperature in the space?	Comfortable, but not known
Does the temperature vary much during the day?	No
Do occupants complain it is too hot or too cold?	No
If there are Thermostatic Radiator Valves (TRVs), are they set correctly? Do they actually work or are they broken?	Most are set correctly, none broken
Are radiators effective and giving consistent heat? They may need bleeding of air or maintenance to remove dust and sediment.	Yes
If the room tends to overheat, is there any bare pipework that could be insulated?	Pipes are insulated
Are radiators blocked, restricting air circulation?	Yes

Are external doors and windows closed when heating is on?	Yes
Are windows in good condition? Are any window panes cracked or broken?	Yes
If there is a roof space, is it insulated?	Yes
Are blinds closed at the end of the day during winter to cut down on heat loss?	Unknown
Is heating on in unused spaces, such as cupboards, corridors?	No
How many kW do the boilers use?	100.7
How long is each boiler on per day?	About 11 hours

Cooling and Ventilation

If there is air conditioning with local controls, make sure it is only on when necessary. Is it obvious how to control it? What temperature is it set to?	Air conditioning is only in the fitness room
Is air conditioning running at the same time as heating?	No
Are all external doors and windows closed when air conditioning is on?	No
Is natural ventilation (e.g. windows and doors open with no air conditioning on) being used?	No
Is air conditioning on in unused spaces, such as cupboards, corridors?	No

Electrical Equipment

Are computers, printers, photocopiers and other equipment switched off at the end of the day?	Some are; all are in theory
Can computers and other electrical equipment be programmed to 'power down' or 'energy save' mode?	Yes
Can a 7 day timer be put on some equipment (e.g. photocopiers, water coolers, cold drinks machines) to regulate when systems are powered down?	No
Can any equipment be switched on later and switched off earlier?	Yes
Can kettles be removed if there is a wall mounted boiler?	No
Are fridges places next to heat sources?	No
Is the office fridge/freezer defrosted regularly?	Not required
Is the fridge thermostat working and set to the right temperature (2-4 °C)?	Yes
Is equipment clearly labelled so that staff know how to activate energy saving features or switch it off?	No

Water Use

Is there any evidence of water leaks? (e.g. wet pathways on a dry day)	No
Are taps left running? Are there any dripping taps? Do taps need maintenance?	No
Are hot water heater timers set correctly?	yes
How long does the hot water calorifier take to heat up?	N/A

How long is the hot water calorifier on for per day?	During operation hours

Awareness and Building Usage	
Are there posters/guidance displayed to remind people of good practice?	No
When is the building primarily used and what is it used for?	Building is used at all times of the day. There are some offices, and a large amount of common recreational space

Appendix V—YMCA Princes Road Report

1. Introduction

The purpose of this energy survey was to discover potential areas of energy reduction and cost savings in the YMCA Princes Road building. This audit was conducted using a basic walkthrough methodology. The building is an athletic facility composed of athletic and recreational rooms, spa rooms, and a number of offices. Operating hours of the building are from 9:00 A.M. to 10:00 P.M. Monday through Thursday, 9:00 A.M. to 9:00 P.M. on Friday, 10:00 A.M. to 6:00 P.M. on Saturday, and 10:00 A.M. to 4:00 P.M. on Sunday. It is open all year, only closing on bank holidays. This results in an estimated 78 hours of occupancy per week.

2. Summary of Findings

During our walkthrough of the YMCA on Princes Road, we noticed a few different ways in which the building could improve energy efficiency.

2.1 Reception/ Office Area

We first noticed that the small reception area was illuminated by 9 light fixtures, each containing 3 T-8 tubes. The shades in the room were closed, preventing supplementary natural light from entering through windows. As a result, some of the low traffic areas of the reception area were being lit as high traffic areas. Additionally, we also noticed that 1 of the 3 radiators in the area was being blocked, causing the radiator to overwork to heat the room.

We noticed more effective and efficient lighting in the two offices in the reception area. There were only two, single tube fixtures in these offices. However, during our energy survey, one of the offices was not being used, yet the lights and other appliances were left on. Each office had a single radiator, and one of the offices had a window open while the radiator was still running. This caused heat to escape from the room and forced the boiler to continuously work to bring the room to a constant temperature.

2.2 Redland Room

After walking through the reception area, we then moved to the Redland Room. We first noticed that the room appeared to be over lit. The small area had 8 fixtures, each containing 4 T-8 tubes. It did not appear that this was a high traffic area, as it was only being used by two people at the time of our visit. We also noticed that all the shades had been drawn in the area to avoid sunlight and glare. The room had three radiators in it, none of which were on at the time.

2.3 Sports Hall Area

We then moved into the T.D.K. Sports Hall. Despite the vast size of the room, only 6 powerful halogen lamps were lighting the area. Since the lamps were too high up to examine, we were unable to get any useful information on their energy usage. The hall also had 4 large electric heaters hanging from the roof; however, they were not being used while we were there. We noticed that this area was a high traffic area accommodating a range of activities, so we guessed most of the heat was natural.

The T.D.K Sports Hall area also had male and female locker rooms. Since we were unable to enter the ladies locker room, we were told ahead of time that both of the locker rooms were nearly identical. The changing room had 6 fixtures, each containing 2 T-8 tubes, along with an additional 3 compact fluorescent lamps. The lights in the area seemed to always be on, whether people were present or not. We noticed that the area only had one radiator in use, as well as exposed heating pipes serving as a heat source.

2.4 Fitness Area

After the changing room, we entered the hallway and proceeded toward the fitness area. In the hallway, we noticed that there were 4 fixtures, each containing a single T-8 tube. The fitness area itself was lit by 45 fixtures, each containing 4 T-8 tubes. The area also had mirrors along the walls, which helped to disperse light more effectively. The area had two radiators, neither of which was on. However, the area was quite warm from all the residual body heat of people working out. We also saw a number of air conditioning units, but these were not in use during our visit. Within the fitness area was a section called the treatment area, which had a shower, sauna, and treatment room. We noticed that all of the lights in the treatment area were turned off. There were no radiators in this area either, as heat from the sauna caused the rooms to be quite warm.

2.5 Upstairs Office Area

We then began to survey the upstairs areas, starting with the offices. We saw that the stairs were lit by 2 fixtures, each containing a single T-8 tube. These appeared to be on continuously throughout the day. The hallway area leading to the offices used 2 compact fluorescent lamps. The first office we entered had 2 fixtures, each containing 2 larger T-8 tubes. The second office was also lit by 2 fixtures, but each fixture only contained a single T-8 tube. The final office only used one T-8 tube for lighting. We found that all of the rooms only had one radiator in them, and they were kept between low and medium temperature settings. A window was open in one of the offices, resulting in heat loss.

2.6 Smith's Charity Room and Brewer Room

Since there was a meeting going on in the Brewer room during on walkthrough, we were unable to visit the area. However, we were told ahead of time that the Smiths and Brewer Rooms were identical. As a result, we based our findings for the Brewer Room off of the findings for the Smiths Room. We noticed that the Smiths Room was illuminated by 10 light fixtures, each containing 2 T-8 tubes. The shades in the room were also closed. The two radiators heating the room were set to a medium temperature setting, and the area seemed to be comfortably warm.

2.7 Coffee Bar Area

The entrance leading up to the Coffee Bar was a small hallway with a couple of bathrooms. This area was lit by 4 compact fluorescent lamps being used in conjunction with 3 light fixtures, each using 2 T-8 tubes. We then moved into the Coffee Bar itself. The first thing we noticed was that about half the lights were off in this area. We later discovered that the Coffee Bar had two separate sets of lights, with each set having its own light switch. The room had 13 fixtures total, with each fixture using 2 T-8 tubes. The area seemed adequately lit with only half of the light fixtures turned on. We also saw that the room had 4 radiators, 3 of which were being blocked by furniture in the room. The Children's Services Office located near the Coffee Bar used a single light fixture containing 2 T-8 tubes.

2.8 Sanctuary and Kitchen

We then entered the sanctuary and found that it was being lit by 4 fixtures, each with 2 T-8 tubes. The shades were also closed in this room. The area was heated by 2 radiators set to a low temperature setting. This room appeared to be a low traffic area, yet all of the lights were turned on. In addition to the sanctuary, the kitchen used 5 light fixtures, each containing a single tube. We also saw what appeared to be an electric heater in the kitchen. Similar to the sanctuary, all of the lights were on in the seemingly scarcely used kitchen area.

2,9 Boiler Room

The building used a 370 litre tank with an 80 kilowatt power draw for their source of hot water. The boiler system consisted of an Ideal Concord CX 275, which used 100.7 kilowatts of energy to heat the whole building. We noticed that the boiler seemed to be left on past occupancy hours, and that the pumps appeared to have a variable temperature control setting for manual adjustment.

3. Potential Savings

There are many areas for potential savings and energy reduction. These areas are detailed in two different sections: (1) No Cost Solutions and (2) Cost Solutions.

3.1 No Cost Savings

No cost solutions consist of behavioral changes that will allow for monetary savings and energy reduction. These solutions are outlined by building, area, problem, solution, and savings in Table 22 below:

Table 22 - YMCA Princes Road No Cost Solutions

Area	Problem	Solution	Savings
Various Locations	Space heaters throughout the building are sometimes being used.	Ask staff to remove space heaters.	Eliminating space heaters can save around 1% on energy bills.
Fitness Room	The room is over lit.	Remove one bulb per fixture.	This simple act will use 25% less energy, saving £837.

Boiler Room	Boilers are on at all times during occupancy hours.	Consider adjusting the start-up and shutdown hours of the boilers to reduce the running time.	Turning the boilers off 1 hour earlier or turning it on 1 hour later will result in an annual savings of £876 (calculated in Appendix A using 140kW boilers running 11 hours per day, 5 days a week, 50 weeks a year at 90% efficiency).
Coffee Bar	3 radiators are blocked by furniture.	Move/remove obstructing furniture.	Heating costs will go down, and less heat will be wasted.

3,2 Low Cost Savings

Low cost solutions are solutions that have a low initial cost with a small payback period. These solutions will result in yearly savings after the payback period has been completed. Table 23 below outlines the solution, cost, savings per year, and payback period:

Table 23 - YMCA Princes Road Low Cost Solutions

Problem	Solution	Investment Cost	Savings Per Year	Payback Period
Usage of Fluorescent and Incandescent Lighting	Replace T-5, T-8, T-12, and incandescent lighting with LED lighting	£14,653	£4,958 per year	3.0 years (calculations shown in Calculations section)

4. Recommendations

Recommendations are arranged by priority. Table 3 below illustrates solutions that should be considered moving forward.

Priority no. 1	**Reduce Boiler Usage**		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£876	*39,285*	*None*	*Immediate*
Detail	The energy survey revealed that there are potential opportunities to increase energy efficiency and save money by adjusting boiler operating hours. The boiler system was being run during all hours of occupancy in the building. Adjusting the hours of operation by 1 hour can result in £876 savings per year. One possible option for accomplishing this savings is to shut the boilers off an hour before people leave the building. The building will retain a fairly constant, comfortable temperature since the building is well insulated. As a result, this will also reduce the amount of energy used daily from the boiler system.		

Priority no. 2	Improved Energy Awareness		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£200	*3,758*	*£1,423*	*3.6 Years*
Detail	The energy survey revealed potential savings through increasing energy awareness. This savings is estimated as 1% of the current annual energy bill. Savings may amount to more if greater measures are taken. As noted in the *Summary of Findings*, lights were being left on despite ambient light radiating in from skylights. Asking staff to turn off these lights when they are not needed will reduce the monthly electric bill, resulting in annual energy savings. Additionally, a few offices were being overheated. Closing windows open in conjunction with heating and lowering heat temperature settings around the office area will reduce the cost of heating. In order to accomplish this goal, small notes, posters, and stickers reminding staff to turn off lights and equipment as well as shutting windows are necessary. These notes will help remind staff about energy efficiency. Talking to the staff about energy awareness will also help in reducing cost.		

Priority no. 3	Replace Current Lighting with LED Lighting		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£4,958	*39,579*	*£14,653*	*3.0 years*
Detail	The energy survey revealed that there are potential opportunities to replace current lighting with LED lighting solutions. LED Lighting provides similar lumens at much higher efficiency than current light fixtures. They last 50,000 hours, which is greater than twice the lifetime of a typical T-5 tube. Replacing current lighting with LED solutions will have an initial cost, but will save a lot on energy bills after the payback period is completed.		

5. Conclusions

Through our walk-through of the Princes Road YMCA building, we found numerous areas for potential energy savings. A few of these can be grouped into no-cost, behavioural solutions. The first is to reduce the operation hours of the boilers. As explained, a building is capable of maintaining a desirable temperature if the boilers are shut down before the end of the day, and yield great savings, about 9% off heating for every hour the boiler is reduced. Second includes simple things like reducing the usage of lights in over lit areas and taking advantage of natural light, as well as reducing set building temperature. Reducing building temperature by one degree can save 8% on the cost of heating. Finally, the highest amount of annual savings is through upgrading the current lighting to more efficient LED lighting. LED lights offer similar lumen values with a dramatically reduced power consumption and extended lifetime. The one drawback to this solution is the high initial investment cost. Fortunately, LED lighting compensates for this high initial cost with a large yearly savings and fast payback period. Overall, the building was very energy efficient, yet there are still areas for improvement.

6. Calculations

6.1 Priority 1 Calculations

Decrease the operating time of the boiler. Calculations can be seen in the Excel Spreadsheet below.

GCV for heating oil is 45.5 MJ/kg				
GCV for anthracite is 32.0 MJ/kg				
GCV for LPG is 25.5 MJ/litre				
GCV for natural gas is 38.2 MJ/m3				
Annual running costs (p)	annual fuel consumption (kg or litres or m3) x cost in p/kg or p/litre or p/m3)			
Annual running cost (£)	fuel cost (p) / 100			
Seasonal efficiency use 60% (0.6)				
Thermal efficiency use 80 - 95% (0.8 - 0.95) based on boiler efficiency				
Part load efficiency use 80% (0.8)				
1MJ = 1/3.6 or 0.278kWh				
HEATING DETAILS:				
	Current Operation		Reduced Operation	
Boiler input or total heat loss (kW)	100.7		100.7	
Hours per day	11.14285714		10	
Days per week	7		7	
Week per year	52		52	
Boiler thermal efficiency	0.800397		0.800397	
Cost of NATURAL GAS per unit (p/kWh)	2.23		2.23	
Cost of HEATING OIL per unit (p/litre)	52.5		52.5	
TEMPLATE No. 1 (for NATURAL GAS only)				
Calculated Annual Energy Input (HEATING)	1377798567	kJ	1236485894	kJ
Total Annual Energy Input	1377798567	kJ	1236485894	kJ
Annual Energy Consumption	383028	kWh	343743	kWh
Annual Fuel Consumption (quantity)	36068	m3	32369	m3
Calculated Annual Running Cost (£)	£8,542		£7,665	
Estimated annual savings by reducing operationg hours			£876	
			39,285	kWh

6.2 Priority 2 Calculations

From energy bills provided, 1% of annual costs were taken to find savings

6.3 Priority 3 Calculations

Client	YMCA
Site	YMCA Princes Road
Area	1st Floor

Annual Operating Hours	4,056
Electricity Cost (p/kWh)	10.000
CCL payable?	No
Include VAT in calculation?	Exclude VAT

	Applicable rate	Used in calculation
Electricity CCL rate (p/kWh)		0
Product VAT rate	15%	0%
Electricity VAT rate	5%	0%

Existing: Site/Location	Product Code	Height (m)	Lamps PF	Watts	Ballast Losses	Quantity	OP Hrs Factor	kWh Usage	**Action**	Replacement: Product Code	Product Description	Watts	Ballast Losses	Unit Price	Installation	Quantity	OP Hrs Factor	kWh Usage	Savings: kWh	Electricity £	**Product Cost**	**Installation**
Reception Office Area	T-8 Fixtures (900mm)	3	3	36	8	9	1	4,819	Upgrade	LED	NetLED T-8 900mm	11	0	£ 34.65	£3.75	27	1	1,205	3,614	£ 361.39	£ 935.55	£ 101.25
	T-8 Fixtures (1200mm)	3	1	58	8	4	1	1,071	Upgrade	LED	NetLED T-8 1200mn	15	0	£ 41.32	£3.75	4	1	243	827	£ 82.74	£ 165.28	£ 15.00
Redland Room	T-8 Fixtures (600mm)	3	4	18	8	8	0.75	2,531	Upgrade	LED	NetLED T-8 600mm	8	0	£ 26.66	£3.75	32	0.75	779	1,752	£ 175.22	£ 853.12	£ 120.00
T.D.K. Sports Hall	Halogen Lamps	0	0	0	0	0	0	-				0	0	£ -	£0.00	0	0	-	-	£ -	£ -	£ -
Locker Rooms	T-8 Fixtures (1200mm)	3	2	58	8	6	1	3,212	Upgrade	LED	NetLED T-8 1200mn	15	0	£ 41.32	£3.75	12	1	730	2,482	£ 248.23	£ 495.84	£ 45.00
	T-8 Fixtures (1200mm)	3	1	58	8	6	1	1,606	Upgrade	LED	NetLED T-8 1200mn	15	0	£ 41.32	£3.75	6	1	365	1,241	£ 124.11	£ 247.92	£ 22.50
Fitness Gym Area	T-8 Fixtures (900mm)	3	4	36	8	39	1	27,840	Upgrade	LED	NetLED T-8 900mm	11	0	£ 34.65	£3.75	156	1	6,960	20,880	£ 2,088.03	£ 5,405.40	£ 585.00
	T-8 Fixtures (600mm)	3	4	18	8	6	1	2,531	Upgrade	LED	NetLED T-8 600mm	8	0	£ 26.66	£3.75	24	1	779	1,752	£ 175.22	£ 639.84	£ 90.00
	T-8 Fixtures (900mm)	3	3	36	8	1	1	535	Upgrade	LED	NetLED T-8 900mm	11	0	34.65	£ 3.75	3	1	134	402	£ 40.15	£ 103.95	£ 11.25
Hallway	T-8 Fixtures (1200mm)	3	1	58	8	4	1	1,071	Upgrade	LED	NetLED T-8 1200mn	15	0	41.32	£ 3.75	4	1	243	827	£ 82.74	£ 165.28	£ 15.00
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								45,216										11,438	33,778	3,378	9,012	1,005

Client	YMCA
Site	YMCA Princes Road
Area	2nd Floor

Annual Operating Hours	4,056
Electricity Cost (p/kWh)	10.000
CCL payable?	No
Include VAT in calculation?	Exclude VAT

	Applicable rate	Used in calculation
Electricity CCL rate (p/kWh)		0
Product VAT rate	15%	0%
Electricity VAT rate	5%	0%

Existing: Site/Location	Product Code	Height (m)	Lamps PF	Watts	Ballast Losses	Quantity	OP Hrs Factor	kWh Usage	**Action**	Replacement: Product Code	Product Description	Watts	Ballast Losses	Unit Price	Installation	Quantity	OP Hrs Factor	kWh Usage	Savings: kWh	Electricity £	**Product Cost**	**Installation**
Stairway	T-8 Fixtures (1200mm)	3	1	58	8	2	1	535	Upgrade	LED	NetLED T-8 1200mn	15	0	£ 41.32	£3.75	2	1	122	414	£ 41.37	£ 82.64	£ 7.50
Hallway	T-8 Fixtures (1200mm)	3	2	58	8	3	1	1,606	Upgrade	LED	NetLED T-8 1200mn	15	0	£ 41.32	£3.75	6	1	365	1,241	£ 124.11	£ 247.92	£ 22.50
Coffee Bar	T-8 Fixtures (1200mm)	3	2	58	8	13	0.75	5,220	Upgrade	LED	NetLED T-8 1200mn	15	0	£ 41.32	£3.75	26	0.75	1,186	4,034	£ 403.37	£ 1,074.32	£ 97.50
Sanctuary Room	T-8 Fixtures (1200mm)	3	2	58	8	4	0.5	1,071	Upgrade	LED	NetLED T-8 1200mn	15	0	£ 42.32	£3.75	8	0.5	243	827	£ 82.74	£ 338.56	£ 30.00
Brewer Room	T-8 Fixtures (1200mm)	3	2	58	8	10	0.75	4,015	Upgrade	LED	NetLED T-8 1200mn	15	0	£ 41.32	£3.75	20	0.75	913	3,103	£ 310.28	£ 826.40	£ 75.00
Kitchen	T-8 Fixtures (1200mm)	3	1	58	8	5	1	1,338	Upgrade	LED	NetLED T-8 1200mn	15	0	£ 41.32	£3.75	5	1	304	1,034	£ 103.43	£ 206.60	£ 18.75
Smiths Charity Room	T-8 Fixtures (1200mm)	3	2	58	8	10	0.75	4,015	Upgrade	LED	NetLED T-8 1200mn	15	0	£ 41.32	£3.75	20	0.75	913	3,103	£ 310.28	£ 826.40	£ 75.00
Offices	T-8 Fixtures (1200mm)	3	2	58	8	1	1	535	Upgrade	LED	NetLED T-8 1200mn	15	0	£ 41.32	£3.75	2	1	122	414	£ 41.37	£ 82.64	£ 7.50
	T-8 Fixtures (1200mm)	3	1	58	8	2	1	535	Upgrade	LED	NetLED T-8 1200mn	15	0	41.32	£ 3.75	2	1	122	414	£ 41.37	£ 82.64	£ 7.50
	T-8 Fixtures (1800mm)	3	2	70	12	2	1	1,330	Upgrade	LED	NetLED T-8 1800mn	32	0	83.97	£ 3.75	4	1	519	811	£ 81.12	£ 335.88	£ 15.00
	T-8 Fixtures (1800mm)	3	1	70	12	2	1	665	Upgrade	LED	NetLED T-8 1800mn	32	0	83.97	£ 3.75	2	1	260	406	£ 40.56	£ 167.94	£ 7.50
								-										-	-	£ -	£ -	£ -
								-										-	-	£ -	£ -	£ -
								20,868										5,068	15,800	1,580	4,272	364

Payback Report										
Client	YMCA									
Site	YMCA Princes Road									
Date	04/05/2011									
Area	Current kWh/pa	Current £/pa	New kWh/pa	Savings kWh/pa	Savings CO2 tonnes/pa	Savings £/pa	Investment	Payback	Salix Persistence Factor	Cost per Tonne CO2
YMCA 1st Floor	45216	£4,974	11438	33778	18.1	£3,378	£10,017	3.0	10	55.2
YMCA 2nd Floor	20868	£2,295	5068	15800	8.5	£1,580	£4,636	2.9	11	49.7
Total	**66084**	**£6,608**	**16506**	**49579**	26.6	**£4,958**	**£14,653**	**3.0**		**104.9**

Appendix W—YMCA Hillbrook Checklist

YMCA Hillbrook Checklist

Basic Information

Date of Energy Audit:	04/07/2011
Department/Building/Area covered:	Hillbrook Residence Building
Persons conducting audit:	Joe Lombardo, Kevin McCarthy
Normal occupancy hours of building:	Office: Monday-Friday 9.00am-5.00pm Support Office: Every Day 9.00am-5.00pm Residential Areas: Open at all times

Lighting

Are any tungsten lights present? Can they be replaced with compact fluorescents (energy saving bulbs)? Look particularly in store rooms, uplighters, desk lamps etc.	Yes
If there are several light switches, can they be labelled to make it more obvious which switches relate to which fixtures?	No
Can lights be switched off to make use of daylight? (e.g. lights parallel to windows or in corridors)	No
Can light sensors be installed in spaces that are intermittently occupied (e.g. store rooms, toilets, kitchen areas, copying rooms, corridors, etc)	No
Are any external lights on during daylight hours?	No

Can main lighting ever be switched off to make use of ambient light and desk lamps?	No
Do any light fittings need cleaning?	No
Do windows and skylights need cleaning to allow in more natural light?	No
Number of T-5 lights	None
Number of T-8 lights	109 total throughout the building
Number of T-12 lights	None
Number of Halogen lights	None
Number of CFLs	391 throughout the whole building

Heating

What is the actual temperature in the space?	Comfortable in some areas, hot in other areas
Does the temperature vary much during the day?	No
Do occupants complain it is too hot or too cold?	No
If there are Thermostatic Radiator Valves (TRVs), are they set correctly? Do they actually work or are they broken?	Set correctly, none broken
Are radiators effective and giving consistent heat? They may need bleeding of air or maintenance to remove dust and sediment.	Yes
If the room tends to overheat, is there any bare pipework that could be insulated?	Pipes are insulated
Are radiators blocked, restricting air circulation?	No

Are external doors and windows closed when heating is on?	1 window open in laundry room
Are windows in good condition? Are any window panes cracked or broken?	Yes
If there is a roof space, is it insulated?	Yes
Are blinds closed at the end of the day during winter to cut down on heat loss?	Some, behavior in residential rooms unknown
Is heating on in unused spaces, such as cupboards, corridors?	No
How many kW do the boilers use?	Central Heating:13.6 – 68.8 kW
How long is each boiler on per day?	Always on due to residences

Cooling and Ventilation

If there is air conditioning with local controls, make sure it is only on when necessary. Is it obvious how to control it? What temperature is it set to?	None
Is air conditioning running at the same time as heating?	N/A
Are all external doors and windows closed when air conditioning is on?	N/A
Is natural ventilation (e.g. windows and doors open with no air conditioning on) being used?	N/A
Is air conditioning on in unused spaces, such as cupboards, corridors?	N/A

Electrical Equipment

Are computers, printers, photocopiers and other equipment	Yes

switched off at the end of the day?	
Can computers and other electrical equipment be programmed to 'power down' or 'energy save' mode?	Yes
Can a 7 day timer be put on some equipment (e.g. photocopiers, water coolers, cold drinks machines) to regulate when systems are powered down?	No
Can any equipment be switched on later and switched off earlier?	Yes
Can kettles be removed if there is a wall mounted boiler?	No
Are fridges places next to heat sources?	No
Is the office fridge/freezer defrosted regularly?	Yes
Is the fridge thermostat working and set to the right temperature (2-4 °C)?	Yes
Is equipment clearly labelled so that staff know how to activate energy saving features or switch it off?	Yes

Water Use

Is there any evidence of water leaks? (e.g. wet pathways on a dry day)	No
Are taps left running? Are there any dripping taps? Do taps need maintenance?	Not in offices and staff areas; unknown in residential rooms
Are hot water heater timers set correctly?	Yes
How long does the hot water calorifier take to heat up?	N/A
How long is the hot water calorifier on for per day?	All the time

Awareness and Building Usage

Are there posters/guidance displayed to remind people of good practice?	No
When is the building primarily used and what is it used for?	Usage hours noted above. Used for offices and rooms for rent

Appendix X—YMCA Hillbrook Report

1. Introduction

The purpose of this energy survey was to discover potential areas of energy reduction and cost savings in the YMCA Hillbrook building. This audit was conducted using a basic walkthrough methodology. The Hillbrook building is composed of offices and residential rooms, in a very well insulated building. Operating hours of the offices are 9:00am to 5:00pm Monday through Friday, and there are support offices with operation hours of 9:00am to 5:00pm Monday through Sunday. The majority of the building is occupied at all times, as it is used for housing. It is open all weeks of the year, and is only closed on bank holidays, resulting in an estimated 40 hours of occupancy per week in the offices, and 56 hours per week for the support offices.

2. Summary of Findings

During our walkthrough of YMCA Hillbrook House, we noticed many ways in which the company could improve energy efficiency.

2.1 Reception and Offices

Starting in the reception area, we first noticed there seemed to be an abundance of lights. A large proportion of the lights were off, only 12 had been left on and the shades had been opened to allow for natural light. We observed that there were 23 fixtures in the area each using 2 compact fluorescent lamps. In the reception office, there were 2 fixtures each using 2 T8 fluorescent tubes as well as a single fixture using only a single T-8 tube. We also learned that although the radiator in the area was off at the time, the night staff would often turn it on and leave it on for extended periods of time, even into the next day.

The first office area we saw was the Training Suite. We found here that there were 2 fixtures each using larger T-8 fluorescent tubes as well a single fixture using a single tube. There were also 4 compact fluorescent bulbs being used in the area. We did notice that the area had all 4 radiators off, and the window was open since it was a warm day. We even noted that the computers had all been put into standby mode as opposed to a screen saver.

We then went into the office areas on the 2nd floor. The first office we saw had 4 fixtures each with 2 fluorescent tubes, which were off, and 2 radiators which were also off. The office had opened the window and shades, allowing for natural light, and all the computers in the office were in standby mode. The second office was empty at the time, and was in good order for being so. The 2 light fixtures with 2 tubes each were both off and the shades were open. The single radiator in the office was off and the 2 computers were also off.

We were also impressed when this same atmosphere was present in the next office we visited, especially since it was not empty at the time. The office had both light fixtures off, and shades open. The radiator was off, although we did note that it was hidden in the current state of the office. The computer was in use, and therefore on. The next office was also empty, and kept the most of the same standards. The 2 fixtures each using a single larger fluorescent tube were off and the shades were open. The radiator in this area, however, was on a low setting. We did notice that the computer was fully off, implying that the area had not been occupied in some time.

We then proceeded to the 1st floor. We began by first looking at the laundry room. The room had 3 fixtures each using a single fluorescent tube which were off at the time. There was a single radiator on low, and an open window in the room. We thought the heating of this radiator made little sense, since it was a warm day and there is usually plenty of residual heat from running dryers. We then moved on into the activity room, which was unoccupied during our visit. The large room had 8 fixtures each using 2 fluorescent tubes as well as a single fixture using a single tube, all of which were off. The shades had also been opened in the area, so there was sufficient light even with the lights off. We also noticed both radiators in the area were off. We then went into the Next Step office. The room had 2 fixtures each using 2 of the larger fluorescent tubes but were off, and the shades were opened. We saw that of the 2 radiators in the area, one was on low while the other was off. However, we noticed that there was a space heater in the room, albeit not being used.

While proceeding from room to room, we noticed in the hallways and stairways the fixtures utilized 2D compact fluorescent bulbs for their lighting. We found out that these lights needed to be on at all times since it was a residential building, although only a fraction of the lights present were on during the day, and the lighting in the stairways was controlled by ambient light sensors.

We were unable to see every office area in the building, but we were told which offices were the same as the ones we missed, and so we based the ones we missed on the ones we saw for our future calculations.

2.2 Residence Rooms

We then were taken to an unoccupied resident room to take note on what was allotted to the residents. In the room we found that 4 compact fluorescent bulbs used in different fixtures as well as a single fluorescent tube fixture. Each room also had 2 radiators, and a few windows around the area. We learned that there were 36 rooms exactly like the one we had seen for residents.

Next we moved onto the rooms referred to as shared rooms, in which more than one person would reside. These areas consisted of two bedrooms and shared kitchen and bathroom. Here we noted a room that was in use at the current time. We only viewed one of the bedrooms, but they are both identical and thus the findings may be applied to the unseen room. We found that in the bedroom there were 2 compact fluorescent bulbs being used, and a single radiator turned on high. We also noted that there was an open window in the room, making the radiator ineffective. The shared bathroom used a single fixture that used 2 compact fluorescent bulbs. The kitchen had a single fixture using a single fluorescent tube, there was also a single radiator in the kitchen that was on a low setting. We were told that there were 6 of these shared room areas in the building and that this sort of behaviour (i.e. leaving heat on with open windows, leaving lights on, etc) was not uncommon of residents.

2.3 Boiler Room

We also observed the fixtures being used in the boiler room for heating and hot water. We saw that the building had 2 gas boilers each drawing 68.8 kilowatts and with a 110 liter capacity. The hot water had 2 tanks each requiring 44 kilowatts and with a 276 liter capacity. We also saw that both the boiler and hot water had been inspected within the last year.

2.4 Other Notes

After talking with the building manager, we learned that the building had good insulation all around and was fitted with all double pane windows. We also learned that since the building is residential, the hallways, stairs, and reception are in use 24 hours a day 365 days a year, with some areas requiring constant lighting.

3. Potential Savings

There are many areas for potential savings and energy reduction. These areas are detailed in two different sections: (1) No Cost Solutions and (2) Cost Solutions.

3.1 No Cost Solutions

No cost solutions consist of behavioral changes that will allow for monetary savings and energy reduction. These solutions are outlined by area, problem, solution, and savings in Table 24 below:

Table 24 - YMCA Hillbrook No Cost Solutions

Area	Problem	Solution	Savings
Reception	Area has abundance of lights, both being used and not being used	Reduce the number of lights being used in the areas to supply a sufficient amount of light	By only using a single CFL bulb in fixtures as opposed to 2, savings of £355 per year can be achieved
Resident Rooms	Residents will leave lights on even when they are not in room	Ask residents to be more energy aware, and possibly supply posters and other reminders	If residents shut of lights for an additional hour each day saving of £275 per year can be achieved
Resident Rooms	Residents will overheat rooms and/or leave heater on when they are not in room	Ask residents to only use heat as needed and turn heaters off or low when not in room	Assuming a 1% reduction in heating costs, savings of £184 per year can be achieved
Reception	Night staff will turn heat on high for shift and leave it on into the next day	Ask staff to lower heaters and make sure they turn them off when leaving	Heating costs will go down, and it will make temperature more comfortable for morning staff

3.2 Low Cost Solutions

Low cost solutions are solutions that have a low initial cost with a small payback period. These solutions will result in yearly savings after the payback period has been completed. Table 25 below outlines the solution, cost, savings per year, and payback period:

Table 25 - YMCA Hillbrook Low Cost Solutions

Problem	Solution	Investment Cost	Savings Per Year	Payback Period
Usage of Fluorescent Lighting in Resident Areas	Replace current residential lighting with LED lighting	£9,598	£3,463 per year	2.8 years (calculations shown in Calculations section)
Usage of Fluorescent Lighting in entire Complex	Replace all current lighting with LED lighting	£13,357	£3,551 per year	3.8 years (calculations shown in Calculations section)

4. Recommendations

Recommendations are arranged by priority. The tables below illustrates solutions that should be considered moving forward.

Priority no. 1	**Decrease Lighting Usage**		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£630	5,720	*None*	*Immediate*
Detail	The energy survey revealed that there are potential opportunities to increase energy efficiency and save money by reducing the usage of lights in the reception and resident rooms. These savings are calculated by estimation. As mentioned previously in the potential no cost solutions, if each of the CFL light fixtures are fitted with only one bulb rather than two, then £355 can be saved. The other savings is derived of an estimation that the residents waste light, and if they turn lights off for one hour of disuse per day, then £275 can be saved. It will prove to be far simpler to make the changes to reception lighting, as it will be difficult to gain any benefit from actions of residents.		

Priority no. 2	Improved Energy Awareness – adjust radiator settings		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£185	*8,260*	*None*	*immediate*
Detail	This savings is estimated as 1% of the current annual energy bill. Savings may amount to more if greater measures are taken. The energy survey revealed that there are potential opportunities to increase energy efficiency and save money by reducing the usage of heating in the reception and resident rooms. We were told that the reception office and some resident rooms were overheated because radiators are left on unnecessarily. It will be a much easier feat to ask the night staff to use heat more conservatively than the residents, but any effort will yield savings. In order to accomplish this goal, small notes, posters, and stickers reminding staff and residents to turn radiators down or off when possible as well as shutting windows when heat is on. These notes will help remind everyone about energy efficiency.		

Priority no. 3	Replace Current Lighting with LED Lighting		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£3,551	*35,509*	*£13,357*	*3.8 years*
Detail	The energy survey revealed that there are potential opportunities to replace current lighting with LED lighting solutions. LED Lighting provides similar lumens at much higher efficiency than current light fixtures. They last 50,000 hours, which is greater than twice the lifetime of a typical T-5 tube. Additionally, only one LED tube per fixture is needed as opposed to the two T-5s, T-8s, and T-12s in every fixture, reducing cost when replacement is needed. Replacing current lighting with LED solutions will have an initial cost, but will save a lot on energy bills after the payback period is completed. This recommendation is for the entire building, including residential rooms. It was made aware to us, however, that it may not be in the management's best interest to place new expensive lighting with residents. If it is decided that lighting will not be replaced in residential rooms, it is advised that lights also not be replaced in offices. Lighting can be effectively replaced in the reception area, however.		

5. Conclusions

Through our walk-through of the Hillbrook House YMCA building, we found numerous areas for potential energy savings. A few of these can be grouped into no-cost, behavioral solutions. The first is to decrease the usage of lighting where possible, which has been determined to be in reception and residents' rooms. This can amount to modest savings, though it will likely not be possible to reduce lighting use by residents. Our second recommendation suggests reducing the usage of heating in warm areas, which we learned to be the reception office and the resident rooms. Reducing building temperature by one degree can save 8% on the cost of heating. Finally, the highest amount of annual savings is through upgrading the current lighting to more efficient LED lighting. LED lights offer similar lumen values with a dramatically reduced power consumption and extended lifetime. The one drawback to this solution is the high initial investment cost. Fortunately, LED lighting compensates for this high initial cost with a large yearly savings and fast payback period. The complications unique to this solution and this building have been discussed. Overall, the building was very energy efficient, yet there are still areas for improvement.

6. Calculations

6.1 Priority no. 1 Calculations

Savings are taken as 1% of total electricity, which was determined from metering bills provided.

6.2 Priority 2 Calculations

Savings are taken as 1% of total gas usage, which was determined from metering bills provided.

6.3 Priority no. 3 Calculations

Client	YMCA
Site	YMCA Hillbrook House
Area	Reception/Offices

Annual Operating Hours	2,080
Electricity Cost (p/kWh)	10.000
CCL payable?	No
Include VAT in calculation?	Exclude VAT

	Applicable rate	Used in calculation
Electricity CCL rate (p/kWh)		0
Product VAT rate	15%	0%
Electricity VAT rate	5%	0%

Existing									**Action**	**Replacement**									**Savings**		**Product Cost**	**Installation**
Site/Location	Product Code	Height (m)	Lamps PF	Watts	Ballast Losses	Quantity	OP Hrs Factor	kWh Usage		Product Code	Product Description	Watts	Ballast Losses	Unit Price	Installation	Quantity	OP Hrs Factor	kWh Usage	kWh	Electricity £		
Training Suite	T-8 Fixtures (1800mm)	3	2	58	8	2	0.3	165	Upgrade	LED	NetLED T-8 1800mm	32	0	£ 83.97	£3.75	4	0.3	80	85	£ 8.49	£ 335.88	£ 15.00
	T-8 Fixtures (900mm)	3	1	30	8	1	0.2	16	Upgrade	LED	NetLED T-8 900mm	11	0	£ 34.65	£3.75	1	0.2	5	11	£ 1.12	£ 34.65	£ 3.75
	CFL Bulbs	3	1	32	0	4	0.1	27	Upgrade	LED	SimplyLED E27	5	0	£ 14.00	£3.75	4	0.1	4	22	£ 2.25	£ 56.00	£ 15.00
Aministration Offices	T-8 Fixtures (1200mm)	3	2	36	8	10	0.2	366	Upgrade	LED	NetLED T-8 1200mm	32	0	£ 41.32	£3.75	20	0.2	266	100	£ 9.98	£ 826.40	£ 75.00
Chief Executive Office	T-8 Fixtures (1200mm)	3	2	36	8	2	0.2	73	Upgrade	LED	NetLED T-8 1200mm	32	0	£ 41.32	£3.75	4	0.2	53	20	£ 2.00	£ 165.28	£ 15.00
Development Offices	T-8 Fixtures (1800mm)	3	2	58	8	4	0.2	220	Upgrade	LED	NetLED T-8 1800mm	32	0	£ 83.97	£3.75	3	0.2	40	180	£ 17.97	£ 251.91	£ 11.25
Laundry Room	T-8 Fixtures (1200mm)	3	1	36	8	3	0.1	27	Upgrade	LED	NetLED T-8 1200mm	32	0	£ 41.32	£3.75	3	0.1	20	7	£ 0.75	£ 123.96	£ 11.25
Activity Room	T-8 Fixtures (1200mm)	3	2	38	8	8	0.4	612	Upgrade	LED	NetLED T-8 1200mm	32	0	£ 41.32	£3.75	16	0.4	426	186	£ 18.64	£ 661.12	£ 60.00
	T-8 Fixtures (1200mm)	3	1	38	8	1	0.2	19	Upgrade	LED	NetLED T-8 1200mm	15	0	41.32	£ 3.75	1	0.2	6	13	£ 1.29	£ 41.32	£ 3.75
Next Step Offices	T-8 Fixtures (1800mm)	3	2	58	8	6	0.3	494	Upgrade	LED	NetLED T-8 1800mm	32	0	83.97	£ 3.75	12	0.3	240	255	£ 25.46	£ 1,007.64	£ 45.00
								2,019										1,140	879	88	3,504	255

Client	YMCA
Site	YMCA Hillbrook House
Area	Resident Areas

Annual Operating Hours	8,760
Electricity Cost (p/kWh)	10.000
CCL payable?	No
Include VAT in calculation?	Exclude VAT

	Applicable rate	Used in calculation
Electricity CCL rate (p/kWh)		0
Product VAT rate	15%	0%
Electricity VAT rate	5%	0%

Existing									**Action**	**Replacement**									**Savings**		**Product Cost**	**Installation**
Site/Location	Product Code	Height (m)	Lamps PF	Watts	Ballast Losses	Quantity	OP Hrs Factor	kWh Usage		Product Code	Product Description	Watts	Ballast Losses	Unit Price	Installation	Quantity	OP Hrs Factor	kWh Usage	kWh	Electricity £		
Single Resident Rooms	CFL Bulbs	3	1	32	0	144	0.2	8,073	Upgrade	LED	SimplyLED E27	5	0	£ 14.00	£3.75	144	0.2	1,261	6,812	£ 681.18	£ 2,016.00	£ 540.00
	T-8 Fixtures (900mm)	3	1	30	8	36	0.2	2,397	Upgrade	LED	NetLED T-8 900mm	11	0	£ 34.65	£3.75	36	0.2	694	1,703	£ 170.29	£ 1,247.40	£ 135.00
Shared Resident Rooms	CFL Bulbs	3	1	32	0	24	0.3	2,018	Upgrade	LED	SimplyLED E27	5	0	£ 14.00	£3.75	24	0.3	315	1,703	£ 170.29	£ 336.00	£ 90.00
	CFL Bulbs	3	2	32	0	6	0.4	1,346	Upgrade	LED	SimplyLED E27	5	0	£ 14.00	£3.75	12	0.4	210	1,135	£ 113.53	£ 168.00	£ 45.00
	T-8 Fixtures (900mm)	3	1	30	8	6	0.3	599	Upgrade	LED	NetLED T-8 900mm	11	0	£ 34.65	£3.75	6	0.3	173	426	£ 42.57	£ 207.90	£ 22.50
Reception Areas	CFL Bulbs	3	2	32	0	23	0.5	6,447	Upgrade	LED	SimplyLED E27	5	0	£ 14.00	£3.75	46	0.5	1,007	5,440	£ 544.00	£ 644.00	£ 172.50
	T-8 Fixtures (1200mm)	3	2	36	8	2	1	1,542	Upgrade	LED	NetLED T-8 1200mm	15	0	£ 41.32	£3.75	2	1	263	1,279	£ 127.90	£ 82.64	£ 7.50
	T-8 Fixtures (1200mm)	3	1	36	8	1	1	385	Upgrade	LED	NetLED T-8 1200mm	15	0	£ 41.32	£3.75	1	1	131	254	£ 25.40	£ 41.32	£ 3.75
Hallways	CFL 2D Bulbs	1.5	1	38	0	80	0.5	13,315	Upgrade	LED	NetLED 2D SQR	13	0	22.72	£ 3.75	80	0.5	4,555	8,760	£ 876.00	£ 1,817.60	£ 300.00
Stairways	CFL 2D Bulbs	1.5	1	38	0	65	0.5	10,819	Upgrade	LED	NetLED 2D SQR	13	0	22.72	£ 3.75	65	0.5	3,701	7,118	£ 711.75	£ 1,476.80	£ 243.75
								46,941										12,312	34,629	3,463	8,038	1,560

Payback Report										
Client	YMCA									
Site	YMCA Hillbrook House									
Date	07/04/2011									
Area	Current kWh/pa	Current £/pa	New kWh/pa	Savings kWh/pa	Savings CO2 tonnes/pa	Savings £/pa	Investment	Payback	Salix Persistence Factor	Cost per Tonne CO2
Hillbrook House Office Areas	2019	£222	1140	879	0.5	£88	£3,759	42.7	10	796.0
Hillbrook House Resident Areas	46941	£5,164	12312	34629	18.6	£3,463	£9,598	2.8	11	46.9
Total	**48961**	**£5,386**	**13452**	**35509**	19.1	**£3,551**	**£13,357**	**3.8**		

Craftstones Ltd. Checklist

Basic Information	
Date of Energy Audit:	April 12, 2011
Department/Building/Area covered:	Full building
Persons conducting audit:	Nicholas Mondor and Nicholas Solarz
Normal occupancy hours of building:	9:00 A.M.-5:00 P.M. Monday-Friday

Lighting	
Are any tungsten lights present? Can they be replaced with compact fluorescents (energy saving bulbs)? Look particularly in store rooms, uplighters, desk lamps etc.	No tungsten lights present aside from spot lighting in the upstairs area.
If there are several light switches, can they be labelled to make it more obvious which switches relate to which fixtures?	N/A
Can lights be switched off to make use of daylight? (e.g. lights parallel to windows or in corridors)	Most lights were turned off to make use of ambient light.
Can light sensors be installed in spaces that are intermittently occupied (e.g. store rooms, toilets, kitchen areas, copying rooms, corridors, etc)	Light sensors already installed in office spaces.
Are any external lights on during daylight hours?	No.
Can main lighting ever be switched off to make use of ambient light and desk lamps?	Main lighting is switched off to make use of ambient lighting from skylights and windows.

Do any light fittings need cleaning?	No.
Do windows and skylights need cleaning to allow in more natural light?	No. Windows allowed for sufficient ambient light.
Number of T-5 lights	None
Number of T-8 lights	2 fixtures, 4 2ft 18W tubes per fixture in office 1 fixture, 4 4ft 36W tubes per fixture in office Motion sensors in office 4x 6ft, 2 per fixture storage 1 6x 6ft singles storage 1 5x 6ft 2 per fixture storage 2 7x 6ft singles storage 2 2x 6ft singles hallway 8x 6ft triples upstairs
Number of T-12 lights	40 W 4 ft, 4 per x 2 in office 5x 6ft T-12, storage 1 5x 6ft singles, storage 2 75W 6x 6ft doubles, hallways/offices 12x 6ft doubles upstairs3
Number of Halogen lights	None
Number of CFLs	None

Heating

What is the actual temperature in the space?	Temperature varied throughout the building. Thermostat set to 20°C
Does the temperature vary much during the day?	Yes.
Do occupants complain it is too hot or too cold?	Storage areas are very cold, but no complaints from in the offices.
If there are Thermostatic Radiator Valves (TRVs), are they set correctly? Do they actually work or are they broken?	Only a few TRVs set to maximum.
Are radiators effective and giving consistent heat? They may need bleeding of air or maintenance to remove dust and sediment.	No, since some of the radiators are blocked.

If the room tends to overheat, is there any bare pipework that could be insulated?	N/A
Are radiators blocked, restricting air circulation?	Yes.
Are external doors and windows closed when heating is on?	Yes.
Are windows in good condition? Are any window panes cracked or broken?	Windows are old, single glazed style.
If there is a roof space, is it insulated?	Roof space is not insulated, causing a lot of heat loss.
Are blinds closed at the end of the day during winter to cut down on heat loss?	N/A
Is heating on in unused spaces, such as cupboards, corridors?	No.
How many kW do the boilers use?	Single 45 kW oil boiler Supplementary heaters in storage rooms
How long is each boiler on per day?	Around 9 hours.

Cooling and Ventilation

If there is air conditioning with local controls, make sure it is only on when necessary. Is it obvious how to control it? What temperature is it set to?	No air conditioning.
Is air conditioning running at the same time as heating?	N/A
Are all external doors and windows closed when air conditioning is on?	N/A
Is natural ventilation (e.g. windows and doors open with no air conditioning on) being used?	N/A
Is air conditioning on in unused spaces, such as cupboards, corridors?	N/A

Electrical Equipment

Are computers, printers, photocopiers and other equipment switched off at the end of the day?	Yes.
Can computers and other electrical equipment be programmed to 'power down' or 'energy save' mode?	No.
Can a 7 day timer be put on some equipment (e.g. photocopiers, water coolers, cold drinks machines) to regulate when systems are powered down?	No.
Can any equipment be switched on later and switched off earlier?	No.
Can kettles be removed if there is a wall mounted boiler?	No.
Are fridges places next to heat sources?	Fridge is in same room as boiler
Is the office fridge/freezer defrosted regularly?	N/A
Is the fridge thermostat working and set to the right temperature (2-4 °C)?	N/A
Is equipment clearly labelled so that staff know how to activate energy saving features or switch it off?	N/A

Water Use

Is there any evidence of water leaks? (e.g. wet pathways on a dry day)	No obvious leaks.
Are taps left running? Are there any dripping taps? Do taps need maintenance?	No.
Are hot water heater timers set correctly?	Yes.
How long does the hot water calorifier take to heat up?	N/A
How long is the hot water calorifier on for per day?	N/A

Awareness and Building Usage	
Are there posters/guidance displayed to remind people of good practice?	No.
When is the building primarily used and what is it used for?	Used during operation hours for the manufacturing of items with stones.

Appendix Z—Craftstones Europe Ltd. Report

1. Introduction

The purpose of this energy survey was to discover potential areas of energy reduction and cost savings within the Craftstones Europe building. This audit was conducted using a basic walkthrough methodology, supplemented by one year of electric and heating bills. The Craftstones Europe building is occupied from 9 A.M.-5 P.M. on weekdays and is closed on the weekends, resulting in an estimated 40 hours of occupancy per week. The building consists of an office-like front end of the building with a warehouse style storeroom located in the back end of the building. There is a second story above the front offices that is used as a showroom.

2. Summary of Findings

Upon entering the building, the first thing we noticed was that the majority of the lights were turned off. There were scattered lights on in some of the front offices and the main work area, but the amount of ambient light filtering in through windows was adequate enough to illuminate these areas. The lighting consisted of a mix of T-8 and T-12 fixtures. In most cases, burned out T-12 tubes were being replaced by higher efficiency T-8 tubes. In the storage area, we discovered that the good lighting habits continued—most lights in low traffic or unoccupied areas were turned off. The smaller office rooms located in the building were lit by a mix of 2 ft. and 4 ft. T-8 tubes, with 4 tubes in each light fixture.

After the initial look at the lighting, we then viewed the heating system. This system consisted of a 45 kW oil boiler supplemented by two forced air furnaces in the storage and warehouse rooms. We were told that the boiler turns on everyday one hour before occupancy and turns off at closing. The two supplementary furnaces were turned on as needed during the colder winter months. We also learned that the thermostat was normally set at a high temperature in order to provide adequate heat to these large rooms. While looking in these areas, we discovered that there was no insulation between the ceiling and the steel roof. These, along with the older windows present in the building, are the main contributors to the heat loss in the building.

We then looked upstairs at the showroom area. There were a number of overhead fixtures (both T-12 and T-8), but all of them were switched off at the time of our energy survey. Along the outer wall were radiators. However, these were almost completely blocked by the display shelves for the showroom. Upon further investigation, we discovered only one thermostatic radiator valve in the building. This was set to the highest allowable temperature.

3. Potential Savings

There are many areas for potential savings and energy reduction. These areas are detailed in two different sections: (1) No Cost Solutions and (2) Cost Solutions

3.1 No Cost Solutions

No cost solutions consist of behavioral changes that will allow for monetary savings and energy reduction. These solutions are outlined by building, area, problem, solution, and savings in Table 26 below (calculations are shown in the Calculations section):

Table 26 – Craftstone Europe Ltd. No Cost Solutions

Building	Area	Problem	Solution	Savings
Main Building	Showroom	Radiators are being blocked by display shelves	Rearrange shelves so that radiators are not blocked or covered.	Radiator efficiency increases when they are fully exposed. An increase in radiator efficiency increases the efficiency of the whole heating system.

3.2 Cost Solutions

Cost solutions are solutions that have an initial investment with a small payback period. These solutions will result in yearly savings after the payback period has been completed. Table 27 outlines the solution, cost, savings per year, and payback period.

Table 27 – Craftstone Europe Ltd. Cost Solutions

Solution	Investment Cost	Savings Per Year	Payback Period
Review and Invest in Building Envelope Improvements	Estimate Required	Estimate Required	Estimate Required
Replace Oil Boiler with Natural Gas	~£4000	£3,117 per year	1.3 years

4. Recommendations

We have arranged our recommendations by priority. The tables below illustrates solutions that should be considered moving forward.

Priority no. 1	Review and Invest in Building Envelope Improvements		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
Estimate Required	Estimate Required	Estimate Required	Estimate Required
Detail	One of the largest and most important issues discovered during the audit of Craftstone Europe was the lack of adequate insulation throughout the building. One of the best ways to increase energy efficiency is to have a properly insulated building. Insulation allows any heating and/or cooling systems to be scaled back and not overworked. Inversely, a poorly insulated building puts a larger demand on the heating and cooling systems in order to maintain a comfortable		

	temperature. During the audit, we were made aware that the thermostat had to be set abnormally high in order to keep the main building area at a reasonable temperature level. This is highly inefficient, as all of the energy used to heat the building is essentially being wasted since the building has poor heat retention. During our walkthrough, we discovered a few key areas of the building envelope that needed attention. The first of these is the roof above the main workshop and storage area. Right now there is no thermal barrier between the roof and these areas, allowing heat to essentially pour out of the top of the building. By insulating these areas, there will be a measurable reduction in annual heating costs. Similarly, the majority of the windows within the building are of the old, single-glazed variety. By replacing the windows with more modern, double-glazed windows, you will add to the thermal resistance of the building, therefore preventing energy loss. The reason there are no numbers associated with this recommendation is that there are too many variables to take into account before the work is actually done. Therefore we recommend contacting a contractor to give an estimate on the work required, as well as the potential savings. This is listed as priority 1, as all of the subsequent priorities will only supplement the improvements to building envelope. Similarly, if the building envelope is not improved, the remaining improvements will not be as effective.

Priority no. 2	**Replace Oil Boiler With Natural Gas Boiler and BMS System**		
Cost Savings £/year	**Energy Savings kWh/year**	**Cost £**	**Payback Period**
£3,117	*None*	*~£4,000*	*1.3 years*
<u>Detail</u>	One of the ways to achieve monetary savings is by switching from an oil-supplied boiler system to one supplied by natural gas. Natural gas is considerably cheaper when compared to heating oil. Changing to natural gas can save approximately 50% on your current heating expenditure. When implementing a new boiler system, one of the things worth the investment is a Building Management System, or BMS. BMS allows for more control over heating and cooling in a building, specifically with features such as outside air compensation, in-building heat zones, and optimised start-up and shutdown timings. The savings listed is based strictly on the gross savings of converting from oil to gas. Any savings from implementing a BMS system will add to this amount. The cost of installing a new boiler is based on research online and is on the high side of what you may expect to pay. Nevertheless, the payback period is extremely quick. (Please note that		

	these calculations are strictly for the boiler system and do not include the supplementary forced-air furnaces.)

5. Conclusion

Through our walkthrough of Craftstones Europe, we discovered areas for potential improvements in energy efficiency. Overall, we were very impressed with the habits of the employees within the building in regards to lighting. Lights that weren't needed were turned off, and if adequate daylight was available for work, the lights were kept off. Unfortunately, the energy savings resulting from the strong behaviour of employees is offset by the building itself. By investing in the building envelope and replacing the current boiler system, the energy efficiency of the building will greatly increase, resulting in considerable annual savings.

6. Calculations

6.1 Priority no. 2 Calculations

Annual fuel consumption	=	Annual energy input (MJ)	
		gross calorific value of fuel (MJ/kg or MJ/m3)	
GCV for heating oil is 45.5 MJ/kg			
GCV for anthracite is 32.0 MJ/kg			
GCV for LPG is 25.5 MJ/litre			
GCV for natural gas is 38.2 MJ/m3			
Annual running costs (p)		annual fuel consumption (kg or litres or m3) x cost in p/kg or p/litre or p/m3)	
Annual running cost (£)		fuel cost (p) / 100	
Seasonal efficiency use 60% (0.6)			
Thermal efficiency use 80 - 95% (0.8 - 0.95) based on boiler efficiency			
Part load efficiency use 80% (0.8)			
1MJ = 1/3.6 or 0.278kWh			

HEATING DETAILS:	
Boiler input or total heat loss (kW)	45
Hours per day	9
Days per week	5
Week per year	50
Boiler thermal efficiency	0.75
Cost of NATURAL GAS per unit (p/kWh)	2.728
Cost of HEATING OIL per unit (p/litre)	61.3

TEMPLATE No. 1 (for NATURAL GAS only)			TEMPLATE No. 2 (for HEATING OIL only)		
Calculated Annual Energy Input (HEATING)	364500000	kJ	Calculated Annual Energy Input	364500000	kJ
Calculated Annual Energy Input (HWS)	0	kJ	Calculated Annual Energy Input (HWS)	0	kJ
Total Annual Energy Input	364500000	kJ	Total Annual Energy Input	364500000	kJ
Annual Energy Consumption	101331	kWh	Annual Energy Consumption	101331	kWh
Annual Fuel Consumption (quantity)	9542	m3	Annual Fuel Consumption (quantity)	8011	kg
			Converted to litres	9594	litres
Calculated Annual Running Cost (£)	£2,764		Calculated Annual Running Cost (£)	£5,881	
Annual Gas Conversion Savings (£)	£3,117				

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Energy Survey: How Can We Improve?

Please take a moment to help us improve the quality of our energy surveys. Once completed, please email the feedback form to crirb@wpi.edu.

Name of Company: Reigate and Redhill YMCA

Date: 18/4/11

Product Quality and Feedback

How would you rate the overall quality of our report?

- ☒ High Quality
- ☐ Good Quality
- ☐ Fair Quality
- ☐ Poor Quality

Were our recommendations feasible and useful for your business?

- ☒ Yes
- ☐ No

Will you implement any of our recommendations?

- ☐ All
- ☒ Some
- ☐ None

Was this energy survey worth your time?

- ☒ Yes
- ☐ No

Please rate each of the following criteria for the site surveyors.

	Poor	Fair	Average	Good	Excellent
Friendliness	☐	☐	☐	☐	☒
Helpfulness	☐	☐	☐	☐	☒
Competence	☐	☐	☐	☐	☒
Response Time	☐	☐	☐	☐	☒
Ease of Contact	☐	☐	☐	☒	☐

Would you recommend an energy survey to other businesses?

- ☒ Yes
- ☐ Probably
- ☐ No

Additional Comments

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Energy Survey: How Can We Improve?

Please take a moment to help us improve the quality of our energy surveys. Once completed, please email the feedback form to crirb@wpi.edu.

Name of Company: Surrey County Council

Date: April 21, 2011

Product Quality and Feedback

How would you rate the overall quality of our report?

- ☐ High Quality
- ☒ Good Quality
- ☐ Fair Quality
- ☐ Poor Quality

Were our recommendations feasible and useful for your business?

- ☒ Yes
- ☐ No

Will you implement any of our recommendations?

- ☐ All
- ☒ Some
- ☐ None

Was this energy survey worth your time?

- ☒ Yes
- ☐ No

Please rate each of the following criteria for the site surveyors.

	Poor	Fair	Average	Good	Excellent
Friendliness	☐	☐	☐	☐	☒
Helpfulness	☐	☐	☐	☐	☒
Competence	☐	☐	☐	☒	☐
Response Time	☐	☐	☐	☒	☐
Ease of Contact	☐	☐	☐	☒	☐

Would you recommend an energy survey to other businesses?

- ☒ Yes
- ☐ Probably
- ☐ No

Additional Comments

Quickly grasped concepts, allowing them to ask relevant questions and ultimately produce reports to a high standard.

Thank you for your participation.

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Energy Survey: How Can We Improve?

Please take a moment to help us improve the quality of our energy surveys. Once completed, please email the feedback form to crirb@wpi.edu.

Name of Company: La barbe Restaurant

Date: 16th April 2011

Product Quality and Feedback

How would you rate the overall quality of our report?

- ☒ High Quality
- ☐ Good Quality
- ☐ Fair Quality
- ☐ Poor Quality

Were our recommendations feasible and useful for your business?

- ☒ Yes
- ☐ No

Will you implement any of our recommendations?

- ☒ All
- ☐ Some
- ☐ None

Was this energy survey worth your time?

- ☒ Yes
- ☐ No

Please rate each of the following criteria for the site surveyors.

	Poor	Fair	Average	Good	Excellent
Friendliness	☐	☐	☐	☐	☒
Helpfulness	☐	☐	☐	☐	☒
Competence	☐	☐	☐	☐	☒
Response Time	☐	☐	☐	☐	☒
Ease of Contact	☐	☐	☐	☐	☒

Would you recommend an energy survey to other businesses?

- ☒ Yes
- ☐ Probably
- ☐ No

Additional Comments

Thank you for your participation.

Energy Survey: How Can We Improve?

Please take a moment to help us improve the quality of our energy surveys. Once completed, please email the feedback form to crirb@wpi.edu.

Name of Company: Risbridger Ltd

Date: 29th March 2011

Product Quality and Feedback

How would you rate the overall quality of our report?

- ☐ High Quality
- ☒ Good Quality
- ☐ Fair Quality
- ☐ Poor Quality

Were our recommendations feasible and useful for your business?

- ☒ Yes
- ☐ No

Will you implement any of our recommendations?

- ☐ All
- ☒ Some
- ☐ None

Was this energy survey worth your time?

- ☒ Yes
- ☐ No

Please rate each of the following criteria for the site surveyors.

	Poor	Fair	Average	Good	Excellent
Friendliness	☐	☐	☐	☒	☐
Helpfulness	☐	☐	☐	☐	☒
Competence	☐	☐	☐	☐	☒
Response Time	☐	☐	☐	☐	☒
Ease of Contact	☐	☐	☐	☐	☒

Would you recommend an energy survey to other businesses?

- ☒ Yes
- ☐ Probably
- ☐ No

Additional Comments

Everything seems to have been done efficiently and quickly

Thank you for your participation.

Energy Survey: How Can We Improve?

Please take a moment to help us improve the quality of our energy surveys. Once completed, please email the feedback form to crirb@wpi.edu.

Name of Company: ING Lease (UK) Ltd.

Date: April 15, 2011

Product Quality and Feedback

How would you rate the overall quality of our report?

- ☐ High Quality
- ☒ Good Quality
- ☐ Fair Quality
- ☐ Poor Quality

Were our recommendations feasible and useful for your business?

- ☒ Yes
- ☐ No

Will you implement any of our recommendations?

- ☐ All
- ☒ Some
- ☐ None

Was this energy survey worth your time?

- ☒ Yes
- ☐ No

Please rate each of the following criteria for the site surveyors.

	Poor	Fair	Average	Good	Excellent
Friendliness	☐	☐	☐	☐	☒
Helpfulness	☐	☐	☐	☐	☒
Competence	☐	☐	☐	☒	☐
Response Time	☐	☐	☐	☐	☒
Ease of Contact	☐	☐	☐	☐	☒

Would you recommend an energy survey to other businesses?

- ☒ Yes
- ☐ Probably
- ☐ No

Additional Comments

Thank you for your participation.

Appendix BB—Carbon Trust Conversion Factors

Conversion to CO2e (gross CV basis)

Energy source*	Units	Kg CO2e per unit
Grid electricity	kWh	0.54522
Natural gas	kWh	0.18523
LPG	kWh	0.21445
	litres	1.492
Gas oil	kWh	0.27533
	litres	3.0212
Fuel oil	kWh	0.26592
	tonnes	3219.7
Burning oil	kWh	0.24683
	tonnes	3164.9
Diesel	kWh	0.25301
	litres	2.672
Petrol	kWh	0.24176
	litres	2.322
Industrial coal	kWh	0.32227
	tonnes	2336.5
Wood pellets	kWh	0.03895
	tonnes	183.93