CARBON REDUCTION IN THE MOLE VALLEY

An Interactive Qualifying Project submitted to the faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the degree of Bachelor of Science by:

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ABSTRACT

The per capita carbon footprint of Mole Valley is of the highest in southeast England. Working under the District Council, this project aided small businesses by performing energy consultations. Energy consultations result in proposed action plans describing how to reduce carbon emissions. The team found that Mole Valley might reduce their total carbon emissions by 1.3% through small businesses alone. The project offered the Council tools and information regarding social and physical observations to help with future carbon reduction efforts.

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NOMENCLATURE

AGM	Annual General Meeting
BEMS	Building Energy Management System
CFL	Compact Fluorescent Lamps
ECA	Enhanced Capital Allowance
ECM	Energy Conservation Measures
EuP	Energy using Product
GHG	Green House Gas
HVAC	Heating, Ventilating & Air Conditioning
LED	Light Emitting Diode
LTHW	Low Temperature Hot Water
MVDC	Mole Valley District Council
SETI	Search for Extra-Terrestrial Intelligence
SME	Small and Medium Enterprise
UNFCCC	United Nations Framework Convention on Climate Change
VAV	Variable Air Valve
WOMM	word of mouth marketing

EXECUTIVE SUMMARY

Global energy consumption is at an all-time high and if this rate of consumption continues, future generations will suffer shortages of fossil fuels. In addition to the problem of lack of resources, the consumption of fossil fuels leads to the emissions of carbon dioxide into the atmosphere. Carbon dioxide is the second most prevalent greenhouse gas (GHG) and believed to be a primary contributor to global climate change.

In order to reduce the emission of GHGs, the UK has established aggressive legislation to meet nationwide carbon emission reduction goals. The national government has proposed various policies and programs to limit emissions from different economic sectors. There are increasing efforts focusing on the business sector and in particular the energy efficiency of buildings. In the Mole Valley District businesses contribute to 219 kilotonnes of CO_2 as of 2008. The Carbon Trust currently offers free energy audits for businesses that spend over £50,000 a year on energy bills however this leaves behind small and medium enterprises (SME) who do not meet this criterion.

The group aimed to perform energy consultations on small and medium enterprises in the Mole Valley district in order to supplement the efforts of the Carbon Management Programme. To continue in the Council's efforts, the team will recruit SMEs in the Mole Valley district, conduct energy consultations for these SMEs and create an associtaed action plan with suggestions for each individual SME on how to reduce energy bills. In addition to serving SMEs, we also summarized our experiences from the whole consultation process and produced tools for Mole Valley District Council (MVDC) to utilize for future efforts in reducing carbon emissions.

The group had to first recruit a sample of SMEs to participate in the project. This was done with the aid of our sponsors who contacted the local newspaper with a press release about the project, which was a very useful initial recruitment strategy. The group next contacted the individual SMEs and set up consultation appointments. At each appointment two group members arrived at the SME and used the survey questionnaire to ask the building manager (or person with equivalent knowledge) about the business and its energy use. The two group members next walked through the building while completing an inventory checklist of all energy using products. In addition to this, the group members took photographs of the building. With this data, the group then created an action plan with suggestions on how the SME could reduce their energy bills. These

suggestions included initial cost, annual monetary savings, kWh savings, and CO_2 associated with a payback period for a complete cost-benefit analysis.

Through completing energy consultations and reports for eleven SMEs in Mole Valley the team, discovered interesting social and physical findings that can benefit the MVDC. They used these finding to help create tools for the Council to use after the completion of the project. The first discovery, involving recruiting SMEs, was that newspaper articles and direct connections to SMEs were the most effective recruitment techniques. To increase the participation of SMEs in the future, the team suggests the Council look into "word of mouth" marketing. The MVDC has other options for recruitment in addition to the ones previously mentioned. The third most effective recruitment strategy was passing out fliers at Council sustainability events, like the Annual General Meeting. The team suggests that the MVDC organize sustainabiltity events for the public so that everyone can learn about sustainable behavior.

During the energy consultations the team revealed a few findings that the MVDC could use if they chose to continue on doing energy consultations. When questioning an SME's owner or building manager, they are likely to expose many of the energy wasting qualities of the building. Only after the building manager or owner has ended his/her briefing, should the consultant reference the questionnaire. This is done to ensure that any information that the interviewee may have missed, is covered. The team also found that energy companies in the UK are only required to take meter readings once every two years. This results in estimated electricity charges based on the size of the building and averaged collected data of the business type. Due to these estimations, all SME owners should submit regular meter readings to their electric supplier in order to have accurate bills that reflect their energy usage.

After the consultations were performed, energy action plans, or consultation reports, had to be written. In writing these reports, the biggest consideration the group needed to make was balancing the return time of the report with the detail of calculations within the report. In order to accomplish this, calculators were made so that less time was spent on calculations and more detailed reports could be produced. However, the team sometimes could not derive a calculation to quantify savings. This was due to the large number of variables to account for, even though detailed research was performed. The action plans were mainly meant to provide suggestions on how the SME could reduce energy bills. Within these reports, most changes were simple and practical, although the team also made a few suggestions that were less likely to be implemented immediately. These were suggested for future reference, even though they had a low probability of being implemented. Technology is improving just as fast as energy costs are rising, therefore these suggestions may become more practical in the future.

The team created several tools that the MVDC can use to either increase energy awareness or to estimate energy savings. The first of these tools were a set of brochures. These brochures covered subjects such as, 'Top 5 Ways to Save', 'Energy Efficient Lighting Information', 'How to Find the Right Utility Company', and 'Enhanced Capital Allowance Awareness'. The second of these tools were a set of calculators that were used for creating action plans. These were streamlined and were made accessible for public use along with a questionnaire and inventory checklists so that an SME can assess their own building and calculate savings.

In general, from the whole consultation process, we established a few findings that the MVDC can take advantage of when making future carbon reduction efforts. The most important characteristic of a good energy consultant is to be flexible and quickly responsive to all aspects of the consultation approach. This means being a responsive consultant who can quickly identify an opportunity to attain another SME for consultation, by taking advantage of the most unexpected, unintuitive marketing opportunities and capitalizing upon them. As previously mentioned, direct contact, or word of mouth marketing, was one of the most effective recruitment measures, due to the group being flexible when recruitment opportunities subtly presented themselves.

Even with the best attempts at recruiting SMEs, some are still not interested. During our research, the team found that the biggest reason people don't take advantage of these efforts is a lack of knowledge. They may think it will be difficult or time consuming, and don't want to be inconvenienced. Energy conservation measures like those listed in the 'Top 5 Ways to Save' brochure are easily implemented, and of little time consumption. In order to gain the interest of the SMEs who need the most help, the public needs to be made aware of how easy it is to reduce their carbon footprint.

The overall totals for all the businesses in the Mole Valley District that the team consulted will help to reduce the Districts carbon emissions for businesses by 33.8 tonnes of CO_2. This includes four offices, two retail stores, two hospitalities, a school, a recreation center, and a large mixed estate. This may seem like an insignificant amount but if all the businesses in the area take an initiative to reduce their carbon emissions, there can be significant savings for the district. If all of the businesses in Mole Valley perform similar energy conservation measures to that of the eleven SMEs, then Mole Valley's total carbon emissions might be reduced by 1.3%.

Overall Totals

Money Savings (£)	5,655
CO_2 Savings (kg)	33,800
kWh Savings	68,220
Costs (£)	24,712
Payback Period (Years)	4.4

1.0 INTRODUCTION

Global energy consumption is at an all-time high and future generations will suffer shortages of fossil fuels, if this rate of consumption continues. In addition to the lack of available resources, the consumption of fossil fuels leads to the emission of carbon dioxide into the atmosphere. Carbon dioxide is the second most prevalent greenhouse gas (GHG) and believed to be a primary contributor to global climate change. In order to reduce the emission of GHGs, the United Kingdom (UK) has established aggressive legislation to meet nationwide carbon reduction goals. The national government has proposed various policies and programs to limit emissions from different economic sectors. There are increased efforts focusing on the business sector and the energy efficiency of buildings in particular.

Improving the energy efficiency of a building starts with a carbon survey. The Carbon Trust offers free carbon surveys to companies that spend more than £50,000 in annual energy bills. Unfortunately, this cut-off leaves behind a large amount of Small and Medium Enterprises (SMEs) who still need surveys. Although these SMEs have online resources to increase energy efficiency, they do not receive the surveys or action plans that large businesses do.

These surveys are beneficial for all types of businesses. Even the most basic surveys examine the different energy consuming systems of a building, including heating and lighting. These surveys also incorporate questions about the habits of the SME's employees. Information gathered from the survey is used to create an action plan, a report that suggests energy conservation measures (ECMs) rated by payback period, reduction goals, and funding opportunities.

To further contribute the carbon reduction effort focusing on SMEs, the goal of this project was to provide the Mole Valley District Council information and tools to aid them in future carbon reduction efforts. To achieve this, the team completed several project objectives. The first objective the team addressed was to recruit SMEs in the Mole Valley district who were interested in receiving energy consultations. The next task was to conduct energy consultations for these selected SMEs. Once the group had conducted the consultations, action plans needed to be create for and returned to each individual SME.

The team then used the experience they gained through these first three steps to create tools for Mole Valley District Council to utilize in their future efforts for reducing carbon emissions.

In order to meet these objectvies, the team recruited and visited eleven SMEs, performed walk-thourgh energy audits in their facilities and researched various solutions to reduce their energy consumptions. Based on the audit process and research result of various energy conservation measures, this study resulted in four informational brochures, three energy saving calculators, one energy useage questionnaire and two energy assessment checklists. The four brochures cover the following topics: 'Top 5 Ways to Save', 'How to Find the Right Utility Company', 'Energy Efficient Lighting Information', and 'Enhanced Capitol Allowance Awareness'. The energy saving calculator is a Microsoft Excel spreadsheet that can be used to calculate the payback period of energy efficient lighting solutions. The three energy assessment checklists include a questionnaire with energy saving tips, a room-based energy consumption checklist, and a boiler and building fabric checklist.

This project will have a direct impact on the eleven participating SMEs. In addition, a summary of the team's experience will provide insight into the difficulties faced in the effort to reduce carbon emissions. Finally, the brochures, calculators, and checklists will provide the Mole Valley District Council with tools to educate local businesses on how to achieve more energy efficient practices.

This project had a direct effect on the reduction of carbon emissions in the Mole Valley District by producing feasible energy conservation solutions for the eleven visited SMEs. The tools the group developed and left for the Council will indirectly contritbute to Council's carbon emissions reduction in the future.

2.0 BACKGROUND

In order to perform energy consultations on small and medium enterprises in the Mole Valley District, knowledge of how and why carbon surveys are performed was needed. This knowledge was also used to provide the Council with information and tools to aid them in future carbon reduction efforts. This information was comprised of the following: the United Kingdom's policies relating to carbon emissions and energy use, what an energy consultation consists of, the funding opportunities available to small and medium enterprises, and what the Mole Valley District Council has already contributed to the effort.

2.1 Reasons for Carbon Surveys

According to the U.S. Energy Information Administration, the global marketed energy consumption, defined as energy sources that are commercially traded, rose from 355 quadrillion British thermal units (BTUs) in 1990 to 495 quadrillion BTUs in 2007 and will rise steadily to 739 quadrillion BTUs by 2035, as can be seen in (International Energy Outlook 2010, 2010). In 2007, the United Kingdom consumed 9.44 quadrillion BTUs of primary energy, energy that exists naturally, which is the 11th highest in the world (United Kingdom, 2009). The enormous amount of energy that is being consumed leads to more sources of primary energy, such as fossil fuels, that are burned and used up. At such high rates of consumption, these non-renewable energies will not last. This excessive consumption of fossil fuels also leads to other issues.

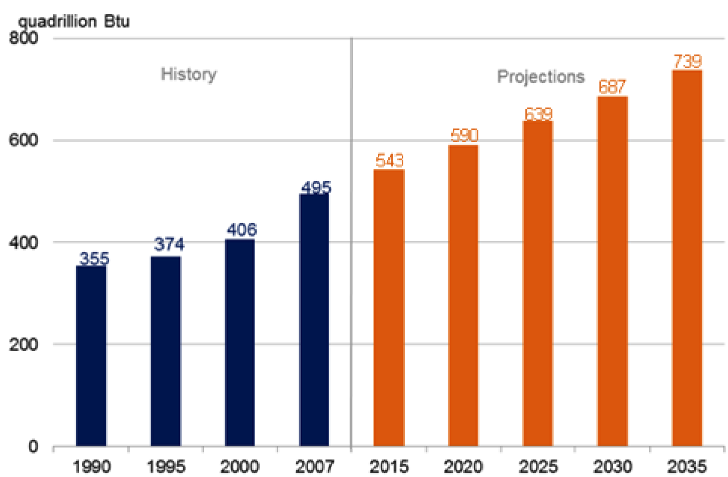

Figure 1: World marketed energy consumption, 1990-2035.

Most types of chemical reactions that involve primary energy consumption, including those using fossil fuels, end with carbon dioxide entering the atmosphere. Calculated annually, the amount of emitted carbon dioxide reaches hundreds of billions of metric tons each year. In 2007, the carbon dioxide emissions totaled 29.7 billion metric tons (Figure 2) worldwide and, in 2009, it rose to 30.5 billion metric tons (International Energy Outlook 2010, 2010). Carbon dioxide emissions will reach 42.4 billion metric tons by 2035 (Figure 2) (International Energy Outlook 2010, 2010). In 2009, the United Kingdom became the 10th highest carbon dioxide emitter in the world, but has since lowered its emissions (International Energy Statistics, 2009).

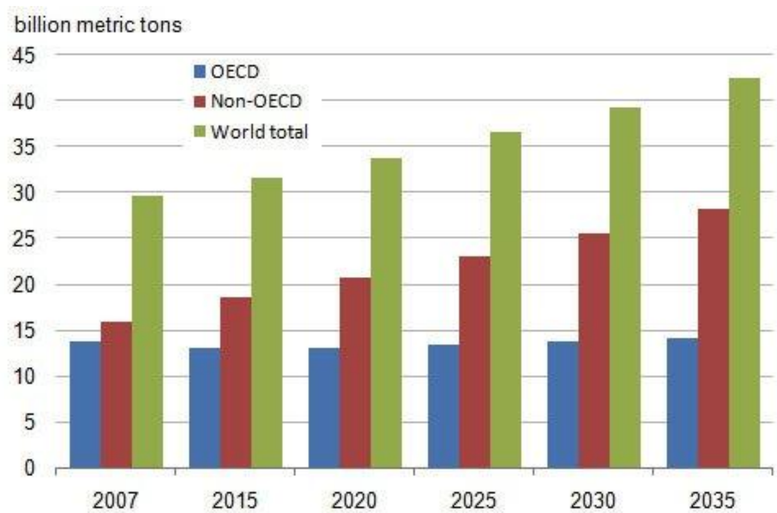

Figure 2: World energy-related carbon dioxide emissions

Carbon dioxide is one of the many GHGs that exist in the atmosphere. GHGs are necessary in order to keep the world at a habitable temperature; however, complications arise when excess amounts of GHGs enter the atmosphere. The effect of these emissions is that the average temperature in the world increases. This rise in average temperature can have negative effects involving health, the ecosystem, sea level rise, water resources, energy production and use, depletion of Polar Regions, and extreme events (Climate Change - Health and Environmental Effects, 2010). These problems are some of the reasons why global warming is such a well-known concern. Carbon dioxide is generally the GHG of most concern because carbon dioxide is the most abundant of the GHGs, at 390.46 parts per million as of December 2010 (Trends in Atmospheric Carbon Dioxide, 2011). This number has been on a rise and is at a historic high. A major influence to this is the high-energy usage rates and the consumption of fossil fuels, which when burned release carbon dioxide into the air. For this reason, policies for climate change generally focus on cutting the amount of carbon dioxide a country, state, or building releases into the atmosphere.

2.2 Policies

In recent years, there has been a coordinated international effort to mitigate the severity of future climate change by reducing the emissions of GHGs, in general, and carbon dioxide, in particular. This effort was set forth on 21 March 1994 with the creation of The United Nations Framework Convention on Climate Change, or UNFCCC. A recent policy that the UNFCCC has made to reduce carbon emissions is the creation of the Kyoto Protocol on 16 February 2005. The Kyoto Protocol is "an international and legally binding agreement to reduce greenhouse gas emissions worldwide". The Kyoto Protocol sets targets for carbon dioxide emissions that signatory countries will meet through national measures. It also establishes three other mechanisms to curb emissions, including emissions trading, clean development mechanism, and joint implementation (UNFCCC, 2011). The Kyoto Protocol provides a systematic way for a country to track its progress, and report their results, which aids these countries in their efforts to achieve their targets. These targets are for 2008-2012 and are based on data gathered in 1990. Target carbon dioxide emissions vary from country to country and may have a reduction or limitation that they are required to meet. This means that some countries have targets that require them to reduce their carbon emissions while others cannot increase their carbon emissions beyond a certain point. For example, Canada has a 5% reduction while Iceland has a 10% limitation that they are required to meet (Kyoto Protocol Reference Manual, 2008). These target reductions and limitations cause countries to be more attentive of their energy consumption.

Among the Kyoto signatories, the UK has adopted a particularly aggressive set of national targets and policies. Among these policies is an unachieved goal, which required the UK to reduce carbon dioxide emissions by 20% by the year 2010 (based on emissions levels in 1990) (Webster, 2010). The country has established several more policies to encourage the reduction of carbon emissions. The Climate Change Act 2008 sets legally binding targets, including a 34% reduction of greenhouse gas emissions by 2020 and 80%

reductions by the year 2050 (based on emission levels in 1990). The Committee on Climate Change is an organization created by the Climate Change Act to "advise the UK Government on setting and meeting carbon budgets and on preparing for the impacts of climate change" (Legislation, 2010). The Energy Act 2008 updates previous energy legislation, and covers issues such as carbon capture and storage, lowering carbon emissions from electrical sources, and the installation of smart meters. The Energy Act 2010 requires the UK to produce reports on progress that the country is making in the reduction of carbon from electricity as well as the use of the Carbon Capture and Storage method (Legislation, 2010). The Finance Act 2000 established the Climate Change Levy in the UK (Finance Act 2000, 2001). This is a tax on energy use for those included in the business and public sectors in order to encourage more energy efficiency from these areas (Climate Change Levy & Agreements, 2010. The Climate Change Agreements, which were also established by the Finance Act 2000, allow a break from this tax for energy intensive companies, only if the company meets certain efficiency goals. (Climate Change Levy & Agreements, 2010)

The Carbon Trust is a non-profit organization, designed by the national government, to aid local and regional government agencies in their efforts to comply with these regulations. Figure 3 shows that the business sector is the largest contributor to carbon emissions in the UK and is the focus of many of the Carbon Trust's efforts. The Trust has so far helped companies in the UK save 29.5 million tons of carbon, by providing free energy and carbon surveys to all companies with energy spending of at least £50,000 per year. These surveys provide the company in question with a cost effective action plan to lower their carbon emissions. While this has been a successful approach to reducing the country's emissions, it can leave the many Small and Medium Enterprises (SME's), who do not meet this criterion, behind. The Carbon Trust does supply methods for SME's to self-evaluate their buildings or provide suggestions for reducing their carbon emissions. This requires SMEs to take the initiative and does not provide appropriate emission reduction techniques (The Carbon Trust, 2010). These techniques include conducting carbon surveys, which are necessary to determine the patterns of energy use and waste within a company.

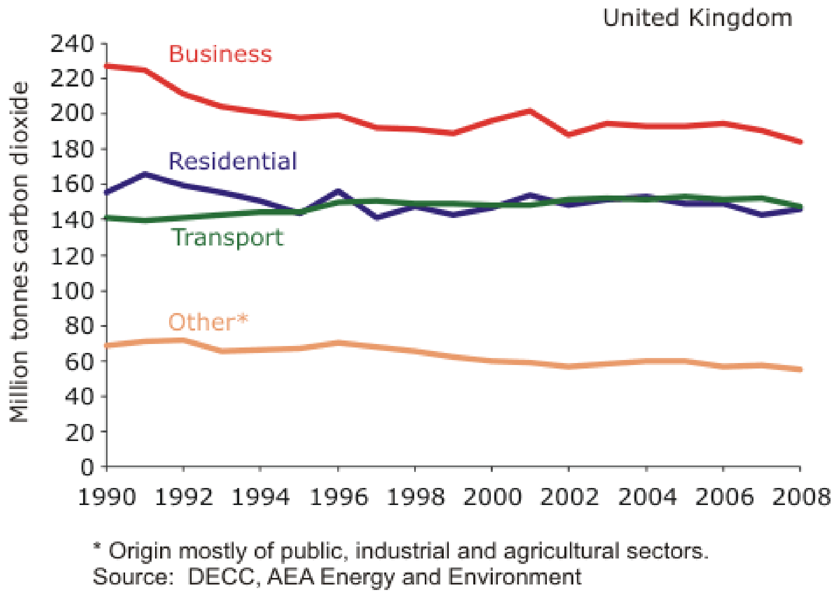

Figure 3: Carbon Dioxide Emission by Sector

2.3 Energy Consultations

Energy consultations are important tools for reaching the goals established in national and local climate change policies. However, the concept of energy consultations is very general and implementations can vary in complexity and thoroughness. Thumann and Younger (2008) distinguish between three different levels of energy consultations, the "walk-through audit", the "standard audit", and "computer simulation". The "walk-through audit" consists of visual inspections on the target facility. Usually the consulting professionals will take a close look at the quantities and patterns of past energy usage data. Walk-through audits are very low cost but provide important information on saving potentials and identify low-cost saving opportunities. The results of a walk-through audit are an important source for preliminary information to aid higher-level consultations. The second level of energy consultations, the "standard audit," involves a detailed analysis of energy consuming equipment, the energy delivering systems and operational characteristics of the company. In many cases, the consultant will go on-site and conduct cost analysis calculations. The most detailed consultations, "computer simulation," fully address all types of energy issues. This type of consultation involves a more comprehensive evaluation of energy use patterns by utilizing computer simulations to include equipment, weather and other variables to predict annual energy consumption. Once the simulation is properly tuned, the consultant will be able to imitate changes to seek saving opportunities. This is the most complicated and expensive type of consultation, but it is also the most effective. (Thumann & Younger, 2008)

Energy consultations differ across country lines just as they differ in complexity. For example, what is referred to as an energy audit in the US, is defined as a carbon survey in the UK. By comparing a survey performed by Carbon Trust and a sample audit from Thumann's book, the audits done in the US focus more on promoting the use of technology, while the UK surveys emphasize energy awareness, and consider behavioural changes just as important as other measures. The surveyors in the UK realize that improving energy saving awareness has significant effect with minimal cost. The action plans seen in the UK typically identify energy saving policy and education as the first or second priority. (Thorn, 2009)

Despite their differences, energy consultations in the US and UK share many similarities. In the book *Energy Audit of Building systems* by Moncef Krarti, the most common Energy Conservation Measures (ECMs) include inspections on building envelope, electrical systems, heating ventilation and air conditioning (HVAC) systems, energy management controls, compressed air systems, indoor water management and new technologies for each of the above. Krarti emphasizes that consultants should pay attention to actual characteristics of the building envelope by collecting necessary information and making comments about necessary repairs or replacements during the consultation.

Figure 4 shows a breakdown of these system's carbon emissions. Heating and lighting are the major contributors to carbon emissions and therefore will be the focus of our consultations.

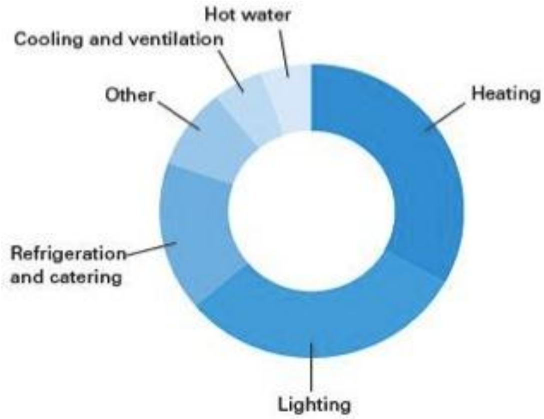

Figure 4: Carbon emissions by energy use

2.3.1 Building Envelope

The envelope of a building is "[t]he assembly of exterior partitions of a building which enclose conditioned spaces, through which thermal energy may be transferred to or from the exterior, unconditioned spaces, or the ground." Nebraska Energy Office) Along with the addition of thermal insulation, replacement of old windows to reduce air leakage is a typical measure to improve thermal performance. (Krarti, 2000)

Gaps and/or holes in a building's walls, windows, doors or skylights are one of the primary reasons for excess energy use. Even if there are no holes in any of the windows, old single pane windows with poor insulation cause uncomfortable drafts in the winter and loss of cold air in the summer.

An ECM for these types of efficiency faults is installing new windows, with double-glazing or a low emissivity, low e, coating (EWC, 2011), a surface that radiates low levels of radiant energy or heat. These kinds of windows increase building envelope because, as Krarti mentions, it stops the outside air from infiltrating the envelope. If the building is undergoing refurbishment, adding extra insulation to the building's walls will also increase building envelope and reduce heating and cooling bills. Effecting changes like these can add up to energy savings of 30% (Carbon Trust, 2011).

2.3.2 Electrical System

The electrical system of a building calls for the most attention from the person performing the energy consultation. Each utility bill has different energy ratios, but "[e]lectricity is much more expensive than gas or oil and the CO_2 emission factor for electricity (averaged across the EU) is also much higher." (ECI, 2006) A carbon survey performed by the Carbon Trust in October 2009 of the Dorking Sports Center showed that the utility bill included a £104,258 electricity cost, 81% of the utility bill. (Thorn, 2009) Using data from Mother Earth News, a kWh of natural gas emits approximately 180 g of CO_2 whereas a kWh of electricity emits 540 g of CO_2 into the atmosphere. Inspection of a building's electrical system includes lighting, office equipment, motors (such as vent fans), etc. The ECMs for electrical systems are both feasible and effective. (Landman, 2011)

Electrical systems are the most expensive part of any utility bill and emit the most carbon into the atmosphere. The most common sources of excessive electrical consumption are old and/or outdated energy-using products (EuPs), such as light bulbs, computers, refrigerators, etc. These consume an excessive amount of power when compared to the latest technology available. "The products currently affected by product policy or for which policy measures are being considered constitute more than 50% of all UK (non-transport) energy use." (DEFRA, 2009) The first type of solution we consider is replacing old EuPs with newer, more efficient ones. "Savings from EuPs are relatively quick and easy to deliver and the policies that surround these EuPs are amongst the most cost-effective available" (DEFRA, 2009).

2.3.2.1 Lighting

Reducing the emissions of carbon into the atmosphere can be as simple as changing a light bulb. There are many light bulbs currently used in office buildings with counterparts that are more efficient, see Figure 12 in Appendix B for a list (Carbon Trust, 2010). For example, "replacing a 100-watt [incandescent] light bulb with a 20-watt [Compact Fluorescent Lamp] costing £6 should save over £40 in electricity bills and replacement light bulbs over its life, as well as offering environmental benefits" (Murphy, 2007). CFLs used to be undesirable about four years ago, however since then CFLs have casually entered society. One of the product's shortcomings is that when dimmed, there is a major reduction in lifetime of the bulb. In addition, CFLs contain mercury and if are dropped on the floor and broken, cause small amounts of mercury to be airborne. (Murphy, 2007).

The next step up in technology, or down in energy consumption from the CFL, is the light emitting diode or LED. When replacing LEDs with conventional halogen and incandescent bulbs, the energy savings are always more than 80%, a slight increase over CFL bulb. Unlike a CFL however, dimming a LED can increase its lifetime and LED bulbs contain no mercury. From solely a sustainability point of view, LEDs are the best choice, however the technology is too primitive, and costs are very high. Other shortcomings of the LED bulbs are that they cannot compete against fluorescent fittings due to their unappealing light color, inequivalent brightness and the narrow angle at which the light is cast. (Landman, 2011)

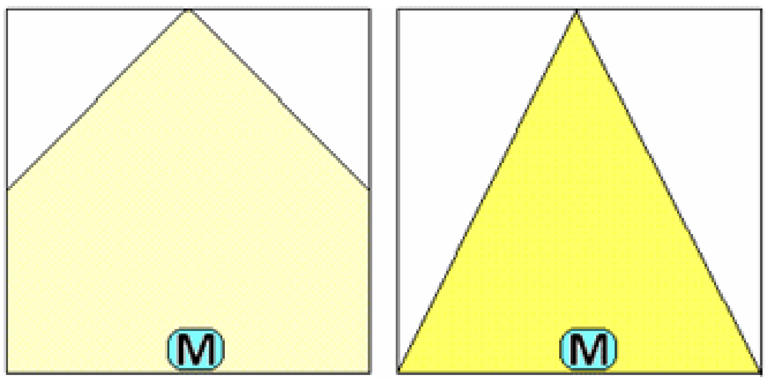

Figure 5: Wide lighting angle versus narrow

2.3.2.2 Computers

Computers are another example of an EuP in which a more energy efficient model exists. "On average, 20% of the total energy bill in commercial offices is accounted for by office equipment, [and] about half of this use stems from PCs and monitors" (Carbon Trust, 2010). "An ENERGY STAR qualified computer meeting the new ENERGY STAR specification will use between 30% and 65% less energy than [an old, non-Energy Star computer,] depending on how it is used," however this is only if the energy management software is enabled (Energy Star, 2000). In order for a computer to meet the Energy Star standard it's "equipment [must] automatically enter a low power mode after a preset amount of time" (Carbon Trust, 2010).

Thin client is software that functions as an access device on a network. This software allows a machine to connect to a server where the bulk of the processing takes place. Thin client devices have no hard drive, allowing for more secure storage of data and applications on the server. These devices have no fans or other moving parts, which help them, have a much longer lifespan than standard computers and use significantly less power. [Talk about energy savings of IGELs from Robert Steele's report to Graeme]. However, thin client devices, since they must work through a server, are usually much slower than a desktop computer or PC. Installing the thin client software can be a strain on the IT department of a company, as it requires additional training and/or the assistance of a trained professional. In addition, thin clients need servers to operate; this must also be considered when comparing energy efficiency of a desktop to a thin client. (Hewlett-Packard Development Company, L.P., 2011)

Purchasing a new desktop or using a thin client system is one way to improve energy efficiency, however along with this purchase, a change in behaviour also reduces energy consumption. A study by the University of Oxford found that "[a] desktop computer and monitor will consume about 920 kWh of electricity if left on all year, but only 198 kWh if powered down overnight, weekends and holidays. This currently equates to an annual saving of £86 and 387 kg CO_2-eq. per computer" (University of Oxford, 2007). The primary reason people do not do this is the inconvenience of having to wait for the computer to turn on the next morning.

2.3.3 Heat Ventilation and Air Conditioning (HVAC)

Along with building envelope and electrical systems, the HVAC system is another place where energy savings can occur. For commercial buildings, Krarti states that if the current system is using constant volume fans for air conditioning, a more efficient alternative would be to use a variable air volume (VAV) (Krarti, 2000). The HVAC system is directly proportional to the building it heats and cools. Changing the characteristics of the HVAC system can be technologically complicated and expensive when compared to electrical systems.

HVAC systems often include a Low Temperature Hot Water (LTHW) boiler. Many ECMs for this system include maintenance from a trained professional. However, even measures that require little to no training can make a considerable difference. For example, "insufficient insulation of LTHW can result in up to 10% loss of energy" (Carbon Trust, 2006). Simple ECMs for this problem include insulating pipe work, boilers and valves. Although businesses may be wary of insulating valves because of limited access, valve insulators currently available in stores allow use of the valves, due to quick release fastenings.

"If a boiler is more than 15 years old or showing signs of inefficiency, it may need replacing with a new, more efficient boiler. For example: replacing a conventional boiler with a condensing model can save 10-20% of annual energy costs." (Carbon Trust, 2011) However, in terms of cost effectiveness, it is better to replace a boiler when replacement parts are hard to find or if the boiler is in need of major refurbishment. A trained professional should conduct any other type of ECM, including annual maintenance mostly consisting of cleaning, in order to maintain efficiency and therefore preserve low energy bills (Carbon Trust, 2006).

2.3.4 Building Energy Management System (BEMS)

Using a BEMS is a cost-effective ECM that utilizes computer technology and imposes automated control on a wide range of energy systems. Most large commercial buildings have such systems installed; however it is important to ensure that this system is maintained. Tune-up measures include calibration and scheduled improvements. (Krarti, 2000)

All buildings should have meters so the utility company can track energy consumption, however these meters can be difficult to interpret. The solution to these enigmatic meters is an advanced meter. An advanced meter is any type of meter that supplies more information than a monthly billing statement from the electric company. This is advantageous for companies to examine their carbon planning and to determine its effectiveness. Another type of meter is a smart meter, an advanced meter with two-way communication. The communication is between the company who installs the meter and the person who is using the meter for their building. This includes energy information, streamed to the user's computer every fifteen minutes and presented in an easy to read plot. This added capability gives users of smart meters the opportunity to change energy consumption habits and observe the results of these changes. All businesses are required to install smart meters by the year 2020. (Carbon Trust, 2010)

All buildings need to have at least a heating system in order to be considered habitable, and most often accompanying heating systems are cooling systems. With a heating system comes the need for a thermostat to control the temperature inside the building. Old thermostats can be unreliable, depending on their age and are often inaccurate. Electronic thermostats can help a heating system become more efficient because they allow the user to program a schedule. “A Building Energy Management System can deliver energy efficiency improvements of 10-20%, compared with an independent control. Buildings with changing usage and occupation patterns will greatly benefit from having a Building Energy Management System installed.” (Carbon Trust, 2011)

2.3.5 Behaviour

Though behavioural changes have little to no monetary cost, they are among the more difficult solutions. Studies “…characteris[e] people as self-interested, uninformed and unrepresentative of the community they are part of.” (Barnett, 2010) Public resistance to changing behaviour ameliorates by providing suitable incentives. Condly, Clark and Stolovich found that “the overall average effect of all incentive programs in all work settings and on all work tasks was a 22% gain in performance” (Condly, 2003). Regardless of the setting (government, school, business), how incentives were earned, or whether the study was conducted in a lab or in the field, the results remained the same. In long-term programs, the test subjects fostered better results than in short term programs. This is because test subjects took ownership of the program and therefore became much more involved. In addition, when monetary awards were offered, the test subjects worked much more efficiently than if other rewards of equal economic value were offered.

The limited attention given to behavioural change in the UK's climate change policies focuses on voluntary reduction of energy use by individuals, encouraged through provision of information and economic incentives and subsidies. “To date, however, this approach seems to have had little or no impact on individual behaviour.” (Lorenzoni, Nicholson-Cole, & Whitmarsh, 2007) Though most people are resistive to change, technologies that avoid changing lifestyles are becoming more common.

Most technologies presented above, especially BEMS, have been created to automatically control electric and heating systems so that humans do not have to. A programmable thermostat allows the users of a building to never worry about lowering heat at night when they leave work. The thermostat is on a programmed schedule, so it knows when to shut off and will never forget. There are some managers that take advantage of "placebo thermostats" that are not connected to the heating system, but still display a temperature and in some cases, even pretends to work (Kelly & Levy, 1993). This is a response to "thermostat wars" that may happen in a building, and to complaints of employees being too hot or too cold. This is done in hopes that a "placebo effect" will take place and employees will simply think they are warming up or cooling down.

Another example of BEMS, which is programmed to automatically save power, is the sleep or "power saver" mode software on computers that use half of the energy that a fully running computer uses. This goes further if employees turn off computers at night and on weekends; however starting a computer each morning can is an inconvenience for most users. There are three situations that force a computer to be left on, if it is a server, if it is on a network and is backed up/upgraded each night by the network administrator, or if it is running a program such as SETI@home, Search for Extraterrestrial Intelligence (SETI), which desires a continuous data stream (howstuffworks.com, 2011). In the case of administrator use, a linked power button or timer could be used, to turn all computers on and off at the same time so that they are never left on continuously and always available.

Two more technological BEMS are motion sensors and light sensors, which if used together can provide for dramatic savings. The use of a motion sensor allows lights to be turned on and off automatically without ever touching a light switch. This is especially effective in areas where use is inconsistent such as restrooms and storage rooms. Lighting sensors detect how much light is in a room and turn off lights when there is sufficient natural lighting. This is most effective when lights are zoned parallel to windows; see Figure 6 (Carbon Trust, 2010).

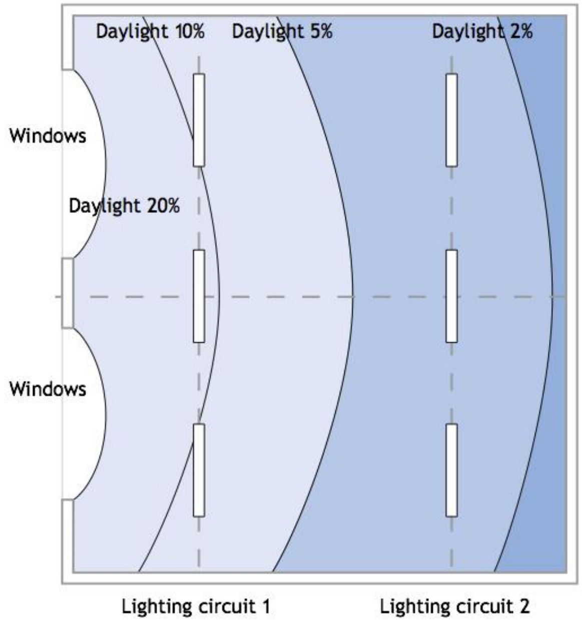

Figure 6: Switching in Parallel

Technology is a great way to trump inflexible employee behaviour, however there are still behavioural patterns that waste energy and have no technological solution. As an example, carpooling to work or using public transportation help lower carbon emissions. If each person that drives to work alone carpooled in a sedan, roughly a quarter of cars would be left on the road. "Ultimately, there is a need for UK policies and governance structures to initiate a systemic shift to a low consumption paradigm in order to move people out of their comfort zone of carbon-intensive living." (Lorenzoni, Nicholson-Cole, & Whitmarsh, 2007)

2.4 Funding Opportunities

Some of the ECMs mentioned are very expensive and would require external funding, if they were installed. This would especially be the case for SMEs because a carbon efficiency renovation may not be something they have created a budget for, so help from an external source would be required. We found two major ways for SMEs to get funding for their ECMs. The first being the Carbon trust's zero interest loans and the second being Enhanced Capital Allowance (ECA).

The Caron Trust offers zero interest loans for many different types of carbon reducing projects. The amount a SME can receive a loan for is dependent on the amount of carbon saved by installing the ECM. SMEs apply for these loans on the Carbon Trust website, where the amount and type of projects eligible are also shown. Some examples of the types of projects that qualify for a loan are shown in Table 1. (Carbon Trust, 2011)

Building Technologies	**Industrial Process Technologies**
Air conditioning	Compressed air fittings
Heating	Motors
Heating controls	Materials handling equipment
Building insulation	Power factor correction
Heat recovery	Process heating
Lighting	Process controls
Pipe insulation	Refrigeration
Solar thermal systems	Variable speed drives

Table 1: Potential Energy Saving Projects

ECA allows for companies who are investing in energy saving technologies to receive a tax relief on their profits for the year, based on the amount they spent on the energy saving technologies. This allows companies to have additional capital to be able to put energy saving equipment in that would normally be too expensive. There are many energy saving technologies out there for the many different areas of a business from lighting, to HVAC, to pipe insulation, to motors, etc. The technologies for these sectors can often provide great energy savings but can cost more than a business is willing to spend. ECA provides a company with additional capital so that they can benefit from the savings of the energy efficient technology, as well as reduce the amount of carbon they are emitting.

2.5 The Council's Contribution

The Mole Valley District Council (MVDC) has created a Carbon Management Programme, with the help of The Carbon Trust, which is working toward the UK's vision of living in a low carbon economy. The MVDC has also utilized the Carbon Trust's free surveying for large companies, to reduce emissions from these few higher contributors. Last year the Council took part in the 10:10 campaign, which aimed to reduce carbon emissions by 10% in the year 2010; the results of this challenge have not yet totaled (The Council's Contribution, 2011).

The Mole Valley District Council is making a great effort to reduce their carbon emissions, and the emissions of the companies falling in their district. The Mole Valley District Council's Carbon Management Programme aims to reduce the Council's carbon footprint. By doing this the Council will save money by reducing energy bills, prepare for new legislation and regulations relating to climate change and carbon emissions, and lead local businesses and communities by example in carbon management. Through this programme several carbon reduction projects have already been implemented and future projects will be carried out in a prioritized order, based on their carbon reduction potential. The Carbon Management Programme's target carbon reduction is 35% by April 2015 and 45% by April 2020, compared with the 2008/2009 baseline. To help meet this target, the Council has committed both finances and staff members to the programme and are expecting to receive savings form the efforts, in the long-term. Mole Valley District Council hopes to embed carbon management throughout their organization and it's decision-making.

While they have made much progress, and have taken advantage of the Carbon Trust resources, Mole Valley is mainly comprised of small and medium companies that cannot afford their own energy consultations and have no coverage from The Carbon Trust. In order to help the district meet future carbon reduction goals they will need to know which of these SMEs, who are not covered by the Carbon trust, are producing the most carbon as well as the best ways for the companies to reduce their emissions (The Council's Contribution, 2011).

Energy use is rising, resulting in higher carbon emissions. There are many policies, such as the Kyoto Protocol, in place directed at reducing the amount of energy consumed and carbon emitted. To meet the standards set by these policies, energy consultations have been conducted and action plans have been created to show where reductions can be made. In the UK, large enterprises receive free energy consultations and action plans, while SMEs are excluded. For areas such as the Mole Valley, which are primarily comprised of SMEs, a greater effort must be made in order to reduce their energy use and carbon emissions.

3.0 METHODOLOGY

Having signed the Kyoto Protocol, as well as creating many of their own national policies, the United Kingdom is striving toward a low carbon economy. The goal of this project was to perform energy consultations on small and medium enterprises in the Mole Valley District and provide the Council with information and tools to aid them in future carbon reduction efforts. The project had several objectives aimed at reaching this goal. The first of which, was to gain an understanding of the state of the art or best practices in energy consulting. We began with research into the background of energy consultations, which was further developed, while abroad, by reviewing additional materials, such as policy documents, carbon survey reports, and publications that are only available in the UK. We fully established our knowledge by conducting interviews with professionals in the field of energy consultations and evaluating case studies. After we assessed the latest practices in energy consulting, we identified the most common sources of excess energy use among the SMEs for whom we performed consultations.

We did this by developing survey protocols, identifying SMEs that will be surveyed, performing carbon surveys generated from the protocols, and analyzing the associated data. The data we derived helped to identify patterns of energy consumption and potential for carbon reduction. After the consultations of SMEs were completed, we developed overall strategies for achieving carbon reduction and specific plans for each SME. We based this planning on economic and technological feasibility of suggested ECMs. Then we produced an action plan for each SME that identifies priority actions and potential funding opportunities. We gave the resulting data, analysis, and conclusions to the MVDC, so that they can use the information to further reduce carbon emissions for more SMEs in the Mole Valley.

3.1 Characterizing the state-of-the-art practices in carbon surveying

Our first objective was to characterize the state-of-art/best practices in energy consulting. We first completed a primary examination of literature pertaining to energy consultations, in order to gain an understanding of the current terms used in the field and the general energy consulting process. The literature review was a primary step in learning how consultations are performed and how the associated data is analyzed. Reference manuals and books were sufficient for gaining general background information, but interviews allowed for insight into the nuances of a carbon survey. We interviewed staff from MVDC when we arrived in the UK in order to augment our knowledge of carbon surveys. When we arrived we sought out the people in the Council who had knowledge of building regulations, building management systems, energy saving technology, building maintenance, and carbon management programs. These individuals aided us by providing resources that they had as well as answering any questions that came up during energy consultations.

3.2 Energy Consumption Patterns among SMEs

Our second objective was to identify the energy consumption patterns among the selected SMEs. To achieve this objective, we had to develop consulting protocols, identify an appropriate sample of SMEs, conduct energy consultations, and analyze the data collected from the consultations. The analyzed data from the selected ECMs revealed the most common energy consumption patterns.

3.2.1 Developing Carbon Surveying Protocols

The literature review supplied us with specific information about common types of EuPs found in businesses, such as light bulbs and heating and air conditioning systems. Technology overviews provided by the Carbon Trust described their characteristics, such as maintenance, upgrades, and basic functionality of the technologies found in (Carbon Trust, 2010) The Carbon Trust also offers “walk around” checklists, or energy consultations on the walk through level, for SMEs to use on their own enterprises. These checklists are comprised of basic questions about the building and employee behaviour, and also common EuPs to look for when quickly performing a consultation on a business. This information allowed us to identify the most basic energy saving opportunities in enterprises and was the basis for developing our own questionnaire.

The survey checklists provided by the Carbon Trust served as a basis for the development of our own survey, seen in Appendix D. First we examined the different Carbon Trust checklists. One we had created our own checklist, it was tested when we performed a pilot consultation on a Fraternity House at WPI. Through this, we realized the questionnaire did not include enough detail. We compared the Carbon Trust checklists with a list of "look- for" items and a sample questionnaire from the appendix of Doty, 2004. This comparison unveiled some of the shortcomings of the Carbon Trust checklists.

After combining surveys from the Carbon Trust and the *Commercial Energy Auditing Reference Handbook*, we comprised a second draft of our questionnaire. When we arrived in the UK we performed pilot surveys on the Park House building and Day Centre, to further develop our protocols. During the Park House consultation we realized that the format of our checklist and questionnaire was inefficient. We reorganized these and tested the new format with the Day Centre consultation. In addition to these pilot consultations, we sought advice from the MVDC staff, and compared other consultations, which provided insight into the development of our complete set of protocols. The process of testing our consultations and tools, and making further improvements to them was continuous. With these efforts we were able to provide the MVDC with a set of easy to understand tools.

3.2.2 Engaging SMEs

Having developed a protocol for performing energy consultations, we then recruited a sample of ten SMEs in the Mole Valley District using several techniques to recruit SMEs. The first of which was creating an A5 sized flier and a letter with the help of our sponsors, Graeme Kane and Josh Lambe, to promote our project to the presidents of the Chamber of Commerce (CoC) of both Dorking[1] and Leatherhead[2], see Appendix A. This information was then delivered to the businesses in the district. The response rate of this initial effort determined that we needed to directly contact some SMEs.

In an additional effort to recruit more SMEs, we asked participating SMEs for recommendations of other businesses that would potentially participate in our project, though few useful suggestions were given.

SMEs considered for consultations had to fit certain criterion in order to be considered for the program. Firstly, we only considered SMEs that spent under £50k

[1] http://www.dorkingchamber.co.uk/
[2] http://www.leatherheadchamber.co.uk/

annually on energy bills because these are the businesses that would not receive free energy consultations from the Carbon Trust. SMEs that owned the building they were operating in were more favorable than enterprises that rent or lease, unless the lease was for a long period of time. If the SME owns the building, then they had more opportunities to save money on energy bills, because they are fully entitled to freely change any characteristics of it. If the building is rented or leased, the owner of the building may not agree to any changes because they will not benefit from them. For example, if we suggested the purchase of a new energy efficient heating system, the property owner may not have agreed because they were not paying the heating bills and wouldn't have seen any direct benefits. There was no restriction on the type of enterprise considered, because all types of enterprises can benefit from even the most basic ECMs, no matter how technologically complex their operation.

3.2.3 Conducting a Carbon Survey

After contact with a SME was established and we confirmed a date and time with the building manager, either two or four of the students from the group, depending on the size of the SME, visited the facilities to perform the energy consultation. While we were in the facilities, lighting meters and billing statements were used to analyze the SME's energy consumption. This method of consultation exceeded the expectations of a walk-through audit, but did not cover the extent of a standard audit.

The energy consultations were comprised of two things, questions to ask the building manager, or someone else with equivalent knowledge, and a checklist of items. Since this information was proprietary, we first needed to assure the owner of confidentiality. The information gained during the consultation was reported anonymously, unless we were given consent to do otherwise. To gain permission to use the business's name, we asked before the start of the consultation. The questionnaire and checklist used during the energy consultations is included in Appendix D for reference. The Questionnaire, Checklist, and following sections are divided into energy usage categories, which include General, HVAC, Lighting, and Building Envelope, and consist of both questions and items to look for.

3.2.3.1 General Building Information

A background of the SME's energy consumption and behavioural patterns was attained from questions in the General category of the questionnaire. At the start of consultation, we asked the building manager questions pertaining to the overall characteristics of the building and its usage. This preliminary knowledge was used to help decide where our efforts would be focused during the rest of the energy consultation. These questions revealed the basic energy needs of the business and its employees.

This section of the questionnaire also included questions that can have helped motivate carbon-reducing behaviour because of their nature because they would have brought the issue into the awareness of the building manager.

3.2.3.2 Building Envelope

The building envelope is defined as the parts of the building that separate inside and outside air. This section of the questionnaire included questions on the presence of uncomfortable hot or cold spots, as this was an indication that there was something wrong with the building envelope, as well as other similar questions. Along with a floor plan, the checklist assisted in locating the source of these hot or cold spots. The building envelope section of the checklist required that an inventory of the windows and doors, with their condition and quality, be taken. To conclude the building envelope section, we performed an inspection of the exterior walls of the building to check for large holes in the building's skin. Holes, such as old external vents, doors, or windows, which were not appropriately sealed, were often the cause of drafts in a building.

3.2.3.3 HVAC

The heating, ventilation and air conditioning system regulates the temperature of the inside of the building. The questionnaire, for this section, included questions about the heating system, its controls and their maintenance. These were asked when we were showed the building's boiler room, and they provided information that helped us to identify potential areas of wasted heat. With the checklist we listed heated pipes and valves that were not insulated, as well as leaks in the ventilation system, such as broken air shafts. Another aspect of the HVAC system, which we recorded in the checklist, was the number of radiators, their settings, and whether they were obstructed by items in the room.

3.2.3.4 Electrical System

Questions about the use of items such as lighting and other electricity consuming equipment are covered in the electrical system section of the questionnaire. The checklist for this section requires that we take note of the amount, type, and usage of the lights and other technology present in the building. This helped to see where upgrades could be made, how many would occur, and overall energy savings. Some things we looked for were items which could be upgraded to save energy, such as loudly idling equipment, personal electrical heaters, and outdated light bulbs.

3.2.4 Analysis of Survey Data

After the survey was completed, the gathered data was analyzed and a report was produced, though sometimes results could not be cleanly calculated. Light bulbs and new electrical technology were simple in terms of calculating savings. Adding double pane windows and sealing any leaks in doors and windowpanes was not a straightforward calculation, but there are rules of thumb that we used. Approximately a quarter of heat lost in an office building is through the windows as is shown in (The Carbon Trust, 2010).

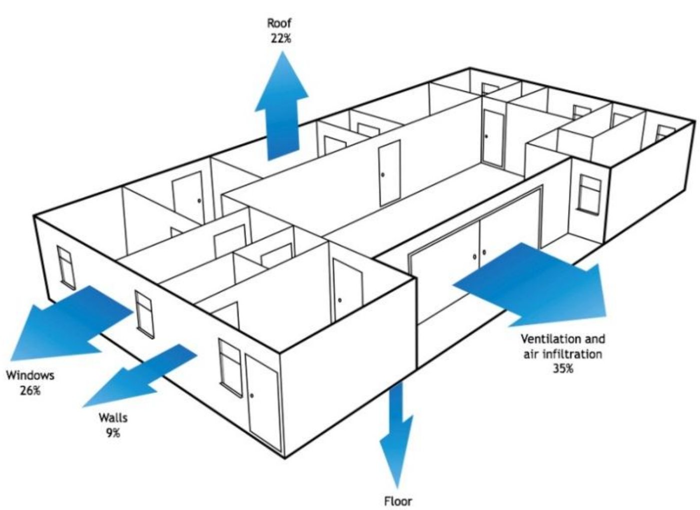

Figure 7: Heat loss in typical office building

For the exactly calculable results, we made excel spreadsheets to quickly calculate the savings. In the case of envelope or HVAC, the Carbon Trust has approximated savings for each suggested ECM. A few of these percentages have been mentioned in 2.3. These will be simply taken away from the original energy bills before any ECM has been made.

3.2.4.1 Lighting and Electrical Equipment

To see how long it takes to payback an ECM, we needed to know the wattage of the electrical piece, the estimated lifetime of the product, and the cost of electricity per kWh. In the case of light bulbs this was easy; light bulbs have a measured lifetime, so we had an estimated savings per light bulb.

$$Savings = (Bulb_{INC} - Bulb_{CFL}) + (watts_{INC} * lifetime_{INC} - watts_{CFL} * lifetime_{CFL}) * (\frac{price}{kWh}) * (1kW / 1000W)$$

An example of this compares a 60-watt incandescent costing one-pound with a 14 Watt CFL costing 5£. 10p per kWh was a common cost for electricity so it is inserted in the example below. However, since an incandescent lasts a sixth of the lifetime of a CFL, we will multiply the incandescent part of the equation by 6.

$$Savings = (6 * 1[£] - 5[£]) + (6 * 60[W] * 1000[hrs] - 14[W] * 6000[hrs]) * (0.1[\frac{£}{kWh}]) * (1[kW] / 1000[W])$$

$$Savings = 27.60£$$

The result of this equation is that the business will save £27.60 each time a CFL bulb is used instead of an incandescent.

The 60-watt bulb was the lower limit of what bulbs were used. The wattage and savings only increased as different bulbs were looked at, as seen in Section 2.3.2. For other kinds of electrical equipment, an estimation of use per week or use per day was used as an estimate for lifetime.

3.2.4.2 HVAC

Another type of calculation that we made was the heat loss from non-insulated hot water or steam pipes. Using a table found in *Commercial Energy Auditing Reference Handbook* by Steve Doty, included in the appendix, we calculated how much money would be saved if the ECM was performed. Using the excel spreadsheet that we made, given the temperature of the pipe and its diameter; savings can be estimated for 2.5cm and 5cm of insulation. If the pipe is to be 85°C and is 10cm in diameter, adding 5cm of insulation can save up to £80 per meter of piping, if the cost of natural gas is 3.9p per kWh.

Although the goal of our surveys was to provide cost effective solutions with a short payback period, sometimes sufficient and important savings could only be made with the purchase of expensive equipment. This was especially the case with the HVAC system. If the SME was heating/cooling their building with an old system, a new one should be purchased. However, our SMEs did not have the large sums of money needed to purchase such a system. Therefore, we needed to know about the funding opportunities available to SMEs.

3.3 Strategy and Plans for SMEs

Our third objective was to develop overall strategies for achieving carbon reduction and specific plans for each SME that we survey. The associated tasks required to achieve this objective are to identify the range of carbon reduction options available in the UK, economic and technological feasibility of these options, prepare an action plan that identifies priority actions and potential funding sources.

3.3.1 Identifying ECMs and Funding Opportunities

We examined case studies and reference manuals, which provided us with lists of options for reducing energy consumption in all types of buildings. Reference manuals list ECMs possible for each type of energy consumption and case studies suggest an ECM to address specific efficiency flaws found during the carbon survey. In examining the lists of ECMs and the case studies, we found that, generally, ECMs consist of purchasing a newer, more efficient technology, performing maintenance on equipment or making a personal change in energy consumption behaviour (Carbon Trust, 2011).

3.3.2 Assessing Economic and Technological Feasibility

When determining whether or not an ECM was a reasonable suggestion for a SME first we conducted a cost-benefit analysis along with an evaluation of the technological complexity of the ECM. These analyses were used to help prioritize the ECMs that were being suggested, and whether they should be suggested at all.

The cost-benefit analysis was the same as that from the analysis of each system in Section 3.2.3, except that the money saved from the ECM was compared to the initial investment. We derived an equation to calculate the payback period of an ECM by a simple analysis of units. The annual savings of an ECM was proportional to the reduction of carbon emissions, the more money saved on energy, the less carbon emitted into the atmosphere.

We considered economic feasibility alongside technological practicality. Technological complexity of an ECM implied that a professional technician was required to maintain and install the system. The cost of this professional's services was added onto the initial investment of the ECM. If an ECM required the attention of a trained professional, then it was likely that the ECM was too complicated for a SME owner or manager to maintain on their own. Even though the ECM may have been technologically complex, it could have still resulted in overall savings, with reasonable payback period.

Some ECMs were not considered because their payback period was very large and/or they required extensive knowledge to maintain. For example, Figure 8 shows that a thermal vapor recompression system (TVR) has a high cost and high payback period. The TVR is also technologically complicated due to the nature of its function, therefore it was considered as a low priority ECM (Antares Group Incorporated, 2011).

		Payback Period		
		Low	**Moderate**	**High**
Capital Investment	**Low**	2a - Insulate Hot Piping 3b - Use CB Boiler More 5a - Move Air Compressor 5d - Fermenter Drains 5f - Remove P#1 6a - Interval timers 6c - Lighting Upgrades 6d - Install Cogged V-Belts 6e - Energy Package AC 7b - Premium Motors	6f - Insulate Cold Piping	
	Mod.	1a - Boiler Economizer #2 1b - Boiler Economizer #1 5g - Energy Education 6b - Control NH3 pressure	5b - Closed loop cooling 5c - Reclaim final rinse H2O 5e - Cooling tower - P#7	2b - Insulate Tanks
	High		3a - O2 trim control	4a - TVR w/o ES 4b - TVR w/ ES

Figure 8: Sample ECM Summary Matrix

3.3.3 Preparing and Action Plan

An action plan provides an SME with suggested ECMs explaining how they can reduce their carbon footprint. We created a standardized action plan template with a section for site-specific examples. This was done so that each action plan could be created in an efficient manner while maintaining the individuality and specialization for each SME. The action plan contains tables showing specific ECMs, their annual monetary savings, kWh and carbon savings, initial investment, and payback period. We prioritized the suggestions differently for each SME based on their characteristics. For example, if an SME has low gross income, then low cost solutions with a four to five year payback will take priority over high investment solution with a short payback period. However, anything over six-year payback period, in any case, is usually one of the last suggestions due to its impracticality.

3.4 Future Efforts in Mole Valley

The most important objective of this project was the continuation of carbon reduction efforts after we left the UK. Creating user-friendly calculators, consultations and "skeleton" reports were of the upmost importance for any individual conducting carbon consultations. In addition to the provided tools, case studies of the SMEs will be used by the MVDC as a basis to put all of the given tools together. Not only will we provide tools for future consultations, we will also provide several informational brochures that explain different ways to save energy. The more information that is accessible to SMEs, the more the Council can provide assistance to those who wish to reduce their carbon footprint.

4.0 RESULTS & DISCUSSION

After completing energy consultations on small and medium enterprises in the Mole Valley District, we provided the Council with information and tools to aid them in future carbon reduction efforts. Through our experiences, we learned the best methods for recruiting SMEs, conducting consultations, and writing action plans. The team applied these findings to the physical consultation protocols and derived some of the social aspects to the protocols that must be taken into account when performing these consultations. The methodology includes producing an action plan for each SME that delivers a list of numbers including the total savings amounts if every ECM is performed. The group added these numbers together to produce a list of the totals for all of the SMEs who received a consultation. From the background research, observations and totals, we derived information and tools that were given to the Mole Valley District Council. These tools will provide the SMEs in Mole Valley with the necessary information to help further reduce carbon emissions.

4.1 Observations

The method we took in completing the project's energy consultations followed a three-step process. The first step was to recruit Small and Medium Enterprises in the Mole Valley District. The second was to conduct the consultations. The final step was writing and returning the action plans for the SMEs. As we completed each of these steps, we had many experiences, which improved our technique, quality and efficiency with which we were able to approach these consultations.

4.1.1 Recruiting Small and Medium Enterprises

The team used five different methods to try to recruit as many SMEs as possible. The most effective of these approaches was through connections with SMEs who had already had a consultation completed for them. Through these connections, the team gained four of the eleven total SMEs, who would not have otherwise known about the free consultations. The next most effective recruitment approach was through articles published in the local newspapers. These articles about the project and its energy saving efforts, seen in Appendix B, also caught the attention of four SMEs. The team created A5 fliers and had them handed out at the Annual General Meeting, AGM, which is a yearly meeting for all businesses in the district. This recruitment attempt earned the interest of two more SMEs. Another approach was to directly ask the businesses in the area if they wanted a consultation, though this attempt only earned one SME. The last, and least effective, recruitment technique was through posting fliers, the same A5 handed out at the AGM, in store windows along High Street in Dorking. This final method did not find us any interested SMEs. The chart below shows this break-up of the recruitment of the eleven SMEs.

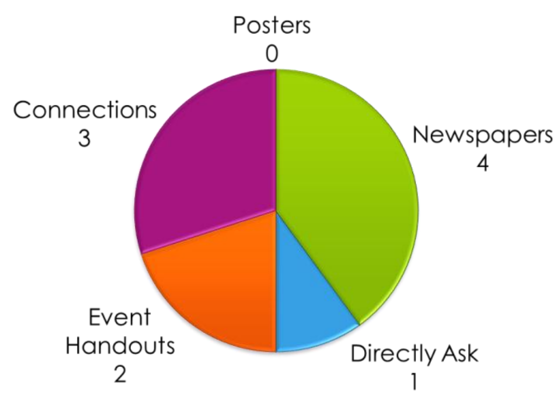

Figure 9: Chart of the breakdown of how many SMEs were attained through various methods of recruitment

The SMEs we recruited expressed interest in our project, however not all SMEs are prone to taking energy conservation measures. How do you recruit SMEs who are not interested in saving energy or reducing carbon emissions? Different approaches will work for different businesses, but the most effective solution is to start with SMEs that are already interested in energy savings, then they will spread word of the energy consultations and their effectiveness. Figure 9 shows that word of mouth marketing, WOMM, or marketing through connections is the best marketing technique, especially for those who are not interested, since they are more likely to listen to friends or colleagues than someone they have never met. The most recent recruitment, Petris Technology, sublets to Brodie Plant Goddard an SME who found us through newspaper. Had the group not been in contact with BPG, they would not have been able to provide a consultation to Petris Technology.

Once you have started conducting consultations, the awareness of and interest in them will grow. The most important part of SME recruitment is to allot a large amount of time to draw attention to the programme. It is difficult have a large amount of awareness with little advertising time. Each week throughout the time in the UK, the team recruited at least one SME. Even in the last week of performing energy consultations, two additional SMEs agreed to have consultations done. This shows that SME recruitment is slow and being patient is very important. To facilitate this process of recruitment, it is advantageous to target the appropriate population. We found that the only SMEs to respond to us and request a consultation were those who were already making efforts towards energy reduction and needed the least help.

Another way in which to recruit adverse SMEs is to be a good salesperson. There are many benefits to accepting an energy consultation; however, these SMEs may not know it. A good salesperson can explain the benefits of the product before a potential customer can say no. Ensure that the SME understands the benefits and that the consultation is free and takes up little time. Some SME owners were busy when directly asked and were often hesitant because they expected the consultation to take up much of their time. An example of this was the Venhill Motorcycle Company who expressed interest in the project, but never set up a date for consultation because of the potential time commitment.

4.1.2 Conducting Consultations

While conducting energy consultations we had many valuable experiences, each of which improved the protocols and skills with either conducting the consultations or dealing with the business owners or managers. The theoretical formulation of the questionnaire and checklist and actual conducting of the consultations are completely different. Theory is good when researching, however when actually applied, experience is the best teacher. With the first pilot consultation, the team discovered that the questionnaire and checklist, while containing all of the necessary information, was not easy to use or follow and needed reformatting. After this consultation, reworking the questionnaire and checklists into the condensed and organised formats, seen in Appendix D, was necessary.

When questioning an SME's owner or building manager they are likely to expose all the energy wasting items or qualities in the building. It is good to remember that the consultation is a conversation and not an interrogation or else helpful information may be missed. A notebook to take notes should supplement the questionnaire in order to keep the flow of conversation alive. Only after the building manager or owner has finished talking should the consultant reference the questionnaire, to ensure that any information that the interviewee may have missed is covered. The team first realized this during the Day Centre consultation when the building manager fully explained every energy efficiency problem in the building. Had we not had a notebook present, we would have missed important information that eased our consultation and allowed us to focus on the things that were more important.

Learning basic information about the business such as what they do, how many staff members they have, what their mission statement is, obtaining a floor plan, and possibly past energy bills. This information will help to plan out the best way to conduct the consultation. The group received preliminary information about Park House, the first consultation, from the MVDC before arriving, such as it was a 24-hour facility operating emergency services. During the questioning, the team formulated inquires specifically based around this characteristic. Had there not been questions relating to its 24-hour operation our calculations would have mistaken 8-hour employees for those that work 24-hour shifts. We also dismissed a few ECMs because they may have disturbed employee comfort, which is very important especially for 24-hour workers.

Most SMEs, specifically in the Dorking area, are located in historic buildings. Historic buildings are difficult to manage and tend to waste a lot of energy because they were built long before energy efficient technology and building regulations incorporated this technology. Although these buildings waste large amounts of energy, there are many regulations, regarding the changes allowed for the exterior of the building. When suggesting an ECM to a business that is in a historic building, owners are usually hesitant to do anything because they are unsure of the regulations. Most historic buildings restrict alterations to the front of the building where the public can see it. Though the legislation sounds confusing, the MVDC staff is very cooperative in offering free advice in what a business owner can do to a historic building. The planning committee in the MVDC Pippbrook building had said that if an e-mail were to be written with name of person, building address, brief description of renovation with pictures, then they would be very willing to give advice.

Throughout all of the consultations, we discovered that there were varying amounts of ECMs already implemented in every business. Some businesses were already doing everything we would have suggested them, while others were missing even the most basic energy saving behaviours, such as ensuring the employees turn out the lights when they leave a room. The energy consultation for Polesden Lacey Infant School was difficult because they were instilling the sustainable mindset into the children at the school. Most of the staff worked in their office with the lights off and if they weren't, the children were correcting their superiors' wasteful behavior. An example of the other extreme was a small store in Dorking, which refused consultation that was using T-12 fluorescent light bulbs, the most inefficient type of bulb.

If an SME was already taking sustainable action, it did not necessarily mean that the building manager has an interest in sustainability. The orders for sustainable management could be coming from a higher authority. A couple of the recruited SMEs came through the owners of the business; however, we contacted the building manager to set up the consultation appointment. If the building manager is adverse to sustainability, the consultation can be difficult. Either the person you are dealing with is not responsive to energy saving advice, they may think that it is a waste their time, or they rush the consultation process. If the building manager is not cooperative, persistence and timeliness is everything. This means continually trying to contact the business before the consultation to set it up and then ensuring that the consultation process is as efficient as possible.

One of the most interesting facts learned while conducting energy consultations was that energy companies in the United Kingdom are only required to take meter readings once every two years. This results in estimated electricity charges based on the size of the building, building energy usage history, and type of business (some types businesses use more energy than others, e.g. small retail, restaurant, gymnasium, etc…). With estimated energy usage, the business could be receiving exorbitant charges and not actual ones, reflecting their savings. To solve this it is necessary that all SME owners submit regular meter readings to their electric supplier, in order to have bills correlating to the correct amount of energy usage.

4.1.3 Creating Action Plans

The final step in the consultation approach was to create and return the action plans, or consultation reports. The most difficult challenge throughout writing action plans was balancing detail of research with return time of report. While it was important to ensure rigorous calculation for the upmost accuracy, it was also important to return reports in a quick manner. If returning reports took a long time, the conducting of more consultations would continue, while the reports still needing to be completed built up. During the report process, we quickly picked up a few self-taught tips when considering how to weigh such an important decision.

Writing the action plans revealed that it was much easier and efficient if we had generic energy savings calculators, such as the one for installing higher efficiency light bulbs seen in Appendix C. These generic calculators were useful for the calculations done in most of the action plans. Reusing calculators helped make time to research new technologies that appeared in every consultation. These were usually potential energy savers specific to the SME; however, they often also applied to another SME. For the Rug Centre's consultation report, we had to research night storage heaters and compare them to portable heaters used during store hours. Through the extra research, made available by the calculators, we helped the SME potentially save an extra £142. This observation also proves that no two SMEs are the same, however technology used in one business may be viable for another. For the Petris Technology consultation report, we suggested the use of night storage heaters and economy 7 electricity billing similar to that of the Rug Centre.

In addition to having calculators, it was necessary that we make educated guesses about the data that went into the calculators in order to be able to return the action plans in a timely manner. Estimated data included the number of hours a light is on for during a year or the length of time that the heating system is on during the winter. These approximated hours were somewhat accurate due to the inquiries made in the questionnaire relating to the hours of operation and when the heating system was in use. As much as the team aimed for exactness in these calculations, they could not account for some variables, resulting in uneducated approximations, such as how much a personal heater is used. In all of the consultation reports, we include disclaimers that recommend a consultant or salesperson give a free quote of how much an ECM would cost and how much energy it would save, as this is a common selling point. Our calculations are more of a second opinion for the SME to know that they are getting a good deal or that the salesperson is not fabricating savings.

Each ECM needs to be analyzed from different points of view, because the effectiveness of an ECM can differ between different SMEs. It is necessary to consider ECMs from the business and practicality side and not just the energy saving side. During the tour of the Pippbrook building with Andrew Carter, a MVDC employee, the team made suggestions for potential ECMs for the building, and every time he would counterpoint with an intuitive answer. This was training in itself to realize that there is not just an energy side to energy saving, practicality is very important. An example of intuitive thinking showed up in the Ashtead Squash and Tennis Club consultation where LED lighting was a potential ECM; however, this may cause patrons to see these courts as undesirable, which would potentially risk their membership and income.

Some ECMs may seem out of reach for an SME due to high price or long payback period, sometimes more than 15 years. Though suggestions like these may seem ludicrous, they should still be included in the report as a low priority or as something to consider in the future. These suggestions serve many purposes even though the SME may not implement them immediately. If the business does any major renovations these larger ECMs no longer seems so preposterous, since there is already another reason to tear down walls. Another reason for suggesting is that energy prices are raising at an exponential rate, in the future these ECMs could become more reasonable with a much shorter payback period. Another exponentially increasing area is green technology; it may happen that a suggested ECM currently has primitive technology and in a few years, the technology becomes cheaper and more effective. The last reason for suggesting a seemingly crazy ECM is to open the mind of the business owner, which could potentially create another energy saving idea.

For every consultation provided and action plan written, the team learned something, but also confirmed preconceived notions from our background research. Some people are resistant to changes, such as using a bulb with a bluer colour. Some concerns are whether it will affect the comfort of the customers or their employees. When performing a consultation for the Vineyard, a wine retail store, the owner had told us that he had designed the interior of the building to be similar to a romantic restaurant. If LEDs are to be used in this business and they cause a customer to not buy a £200 bottle of wine and they only save him £250 a year, our energy savings have been compromised. Concerns such as this needed consideration when prioritizing the ECMs in our action plans.

4.2 Totals

The group conducted consultations and wrote action plans for six different types of SMEs, these action plans can be read in detail in 0-Appendix V. The consultations were on four office buildings, two retail stores, two hospitalities, one school, one recreation centre, and one mixed estate. The office buildings typically get most of the energy savings from employee behaviour since they usually contain a large amount of people in few rooms. Retail stores must cater to the patrons and create a comfortable environment to shop and purchase items. As previously mentioned, if performing an ECM involves the risk of damaging that environment, such as the blue-white LED lighting, then they probably will not perform the suggested ECM due to the risk of losing business. There are differences within each category as well as between the different varieties.

4.2.1 Derivation of Tables

Energy savings are realized by monetary values, pounds, though they are calculated in BTUs or kWh. To reduce the amount of unit conversions and make numbers easy to understand, the group converted all existing data, such as heat savings, in BTU units to kWh units before completing calculations. Once the amount of kWh savings has been found, simple conversion rates are used to calculate annual monetary savings and CO_2 savings. Table 2 shows the conversion rates used for this project.

A kWh is equal to	3412 BTU
	10p or £0.10 (electricity)
	3p or £0.03 (gas)
	0.5422 kg CO_2 (electricity)
	0.18523 kg CO_2 (gas)

Table 2: kWh conversion rates used for SME consultation reports

The only conversion rate that is exact is the first one, the rest are estimations used by the Carbon Trust in their audit action plans for large enterprises. When possible, the company's current energy rate was used for in calculating numbers for the action plan, however when the rate of was not known 10p or 3p per kWh was used, depending on the energy source. The next set of numbers in the list depends on what energy provider is being used. Some energy bills include what source their electricity is created from, e.g. percent from hydroelectric, coal, natural gas, wind, etc…, so this number will fluctuate for different companies. Though a company will explain what sources are used to make their electricity, they will not show carbon emissions per kWh.

4.2.2 Savings by SME

4.2.2.1 Office Buildings

The four office buildings we performed consultations and created action plans for were the following. Park House is a twenty-four hour a day emergency elderly response centre. Found in Appendix K is the action plan for this building. Biwater is an international water treatment company. Found in Appendix M, is the action plan for this building. Brodie Plant Goddard is a green roof engineering company. Found in Appendix N, is the action plan for this building. Petris Technology is a software engineering company. Found in Appendix O, is the action plan for this building. The following table shows the totals from each of the reports added together.

Office Buildings	
Money Savings (£)	1,968
CO_2 Savings (kg)	12,322
kWh Savings	22,599
Costs (£)	6,494
Payback Period (Years)	3.3

Table 3: Total savings, spending, and payback period for the office buildings who received consultations

4.2.2.2 Retail Stores

The two retail stores we performed consultations for were the following. The Rug Centre is a retail store specializing in hand woven rugs. Found in Appendix P, is the action plan for this building. The Vineyard is an independent wine merchant. Found in Appendix Q, is the action plan for this building. The following table shows the totals for these two SMEs.

Retail Stores	
Money Savings (£)	1,573
CO_2 Savings (kg)	5,274
kWh Savings	9,672
Costs (£)	2,295
Payback Period (Years)	1.5

Table 4: Total savings, spending, and payback period for the retail stores who received consultations.

4.2.2.3 Hospitality

The two hospitality businesses we performed consultations for were the following. The Day Centre is a senior day centre in Leatherhead. Found in Appendix R, is the action plan for this building. The Falkland Arms is a pub in Dorking. Found in Appendix S, is the action plan for this building. The following table shows the totals for the two of them.

Hospitalities	
Money Savings (£)	995
CO_2 Savings (kg)	6,573
kWh Savings	12,047
Costs (£)	3,943
Payback Period (Years)	4.0

Table 5: Total savings, spending, and payback period for the hospitality businesses who received consultations

4.2.2.4 School

The school we performed a consultation for was The Polesden Lacey Infant School, a small infant school who teaches their students to take environmentally friendly actions. The action plan for this building can be found in Appendix T. The following table shows the totals for this school building.

School	
Money Savings (£)	100
CO_2 Savings (kg)	430
kWh Savings	2340
Costs (£)	500
Payback Period (Years)	5.0

Table 6: Total savings, spending, and payback period for the school who received a consultation

4.2.2.5 Recreation Centre

The recreation centre we performed a consultation for was Ashtead Squash and Tennis Club, a local sports club in Leatherhead. Found in Appendix U, is the action plan for this building. The following table shows the totals for this facility.

Recreation Centre	
Money Savings (£)	409
CO_2 Savings (kg)	2,306
kWh Savings	4,232
Costs (£)	997
Payback Period (Years)	2.4

Table 7: Total savings, spending, and payback period for the recreation centre who received a consultation

4.2.2.6 Mixed Estate

The mixed estate we performed a consultation for was Denbies Wine Estate, the largest single estate winery in England. Denbies Wine Estate includes the winery, office space, restaurant, and a retail store. Denbies was a great location for this research project because it was made up of different kinds of businesses. Due to time constraints and scheduling conflicts, only a preliminary walk-through consultation was able to be performed. With this preliminary consultation, a generalized report was created, found in Appendix V, and great savings are expected from them.

4.2.3 Savings by Energy Conservation Measure

Similar to the previous section, the table below was derived by adding up the totals from Appendix K-U for each ECM. This table shows what ECMs were most applicable to the various types of businesses that received consultation. The reason hot water pipe and valve insulation only applied to one SME was not that it isn't a useful ECM; it is that all of the SMEs that received consultation already had this done. Thin Client computers, however were only applicable to one office building due to the low memory usage of the software they were running. All other SMEs had researched it and found that it would not be useful for their companies due to the intense memory usage of the software they were using.

Type of ECM	Envelope	Lighting	Lighting Control	Pipe and Valve Insulation	Thin Client Computers
SMEs who it applied to	9	8	4	1	1
Savings per Year (£)	804	4023	498	100	230
Savings per year (CO_2)	8051	20815	4334	430	170
Savings per year (kWh)	19447	38171	7952	2340	310
Costs	1530	18062	3220	500	1400
Payback Period	1.9	4.5	6.5	5.0	6.1

Table 8: Savings by ECM

This table only includes calculated savings and not the suggestions included in the "small notes" section in each of the audit reports. As mentioned in each report, the "small notes" suggestions had no tangible savings due to the large amount of variables needed to estimate their annual monetary, CO_2, and kWh savings.

4.2.4 Overall Totals for the Mole Valley district

When all of the calculated savings from each business is summed, the figures in the table below are found. This table includes calculated savings found in Table 8, it does not include behavioral changes and any of the changes present in the "Small Notes" section in each of the audit reports. These savings may seem insignificant when compared to the total carbon footprint of Mole Valley, 771,000 tonnes of CO_2 in 2008, but if all the businesses in the area take an initiative to reduce their carbon emissions, there can be significant savings for the district.

Overall Totals

Money Savings (£)	5655
CO_2 Savings (kg)	33800
kWh Savings	68220
Costs (£)	24712
Payback Period (Years)	4.4

Table 9: Total savings, spending, and payback period for all the businesses that received a consultation

The Mole Valley Revenues and Benefits Department has found that there are around 3,000 registered businesses. When averaging the CO_2 savings for each of the SMEs in this study, 3.38 annual savings of tonnes of CO_2 was found for each SME. Using these three numbers, it can be found that if each business in the Mole Valley takes similar sustainable action, the carbon footprint of Mole Valley may be reduced by 1.3%, based on numbers from our study and the total footprint from 2008.

4.3 Information and Tools to Be Given to Mole Valley District Council

Upon leaving the United Kingdom, we left the Mole Valley District Council with a set of informational materials and tools that they can use to further reduce carbon emissions and energy usage among SMEs in the district. These tools include the consultation room based checklists, boiler room and building fabric checklists, questionnaire, savings calculators, and a set of energy saving brochures.

4.3.1 Protocols

Throughout this project, we have developed and used a set of protocols for conducting energy consultations. These protocols included the use of an energy usage questionnaire and checklist, seen in Appendix D. The questionnaire and checklists are for the MVDC to use when performing future energy consultations. The MVDC will also be able to put these items on their sustainability website, so that SMEs, as well as the public, will be able to audit their own facility, if they wish to do so. The questionnaire is a set of questions, which determine the information that is necessary when conducting an energy consultation. The first checklist creates an inventory of all energy consuming equipment, as well as the radiators, windows, doors, and other potentially energy wasting areas. The second checklist is for use when inspecting the boiler room and takes into account the pipes, their insulation, and the type and age of the boiler, as well as other useful information. These tools are easy to follow and when implemented will provide a method for anyone interested in saving energy to assess their own energy usage.

4.3.2 Calculators

The team created savings calculators to quickly estimate the savings and payback period of installing certain ECMs, based on input data. These savings calculators use data ratings from typical equipment as well as some estimated numbers, such as hours of use. There were three calculators used to determine savings, one for lighting, one for building envelope, and one for window upgrades and thin film insulation.

4.3.2.1 Lighting Calculator

When an individual uses the light calculator, they will input the old light bulb wattage, the new light bulb wattage the cost of the light bulb, the number of light bulbs being replaced, the hours of operation for the year and the cost of electricity. With this information the user will receive information on the kWh, CO_2 emissions, and monetary savings per year, as well as the payback period. These results are found through the following equations.

$$kWh\ saved = \frac{(Old\ Lightbulb\ wattage - New\ Lightbulb\ wattage)}{1000\ \{W\ to\ kW\ conversion\}} * hours\ in\ a\ year$$

$$Kg\ of\ CO_2\ saved\ per\ year = \ kWh\ saved * .54522$$

$$money\ savings\ per\ year = \ kWh\ saved * electricity\ price\ (\text{p/kWh})$$

$$Total\ cost = number\ of\ light\ bulbs\ being\ replaced * cost\ of\ light\ bulb$$

$$Total\ cost\ with\ installation = number\ of\ light\ bulbs\ being\ replaced * (installation\ cost\ per\ light\ bulb + cost\ of\ light\ bulb)$$

$$Payback\ period = \frac{Total\ Cost}{Money\ savings\ per\ year}$$

$$Payback\ period\ with\ installation = \frac{Total\ Cost\ with\ installation}{Money\ savings\ per\ year}$$

All these results will vary depending on the accuracy of the hours of operation that the user inputs for how many hours the light bulbs are on during the year. The more accurate this value is the closer the calculated results will be to the actual results that a user will see. Other causes for inaccuracy are the results that include installation costs as the estimation of £4 per light bulb, received from a lighting specialist, may not be what the user actually pays that is why we always recommend getting a quotation if the lighting needs to be installed.

All other variables are constants that can be found on the packaging of the light bulbs, the Carbon Trust website (i.e. the .54522 constant for the CO_2 emissions calculations), or on an electricity bill. The only other way that the results could vary from actual results is if an individual uses our suggested 10 pence for electricity instead of their own. This calculation will not cause too much variation in the actual results as this is an average that had been derived from our experience doing the consultations. These results will be helpful in guiding the user in the right direction as it will give them an idea of what they should expect to see in savings and costs. Images of the calculator can be seen in Appendix J.

4.3.2.2 Building Envelope Calculator

When an individual uses the building envelope calculator, they will input the quantity of leaks, the type of seal that will fix the leak, the level of severity of the leak, the hours that the user heats their building, the type of heating they use and the price they pay on their energy bill. From this data the user will receive information on annual monetary savings, total investment, payback period and the annual CO_2 emission savings. These results are found through the following equations.

$$Annual\ savings = \frac{Leak\ Severity\ \{W\} * hours\ per\ year * energy\ price}{1000\ \{W\ to\ kW\ conversion\} * .8\{efficiency\ factor\}}$$

$$Total\ cost = cost\ of\ seal * number\ of leaks$$

$$Payback\ period = \frac{Total\ Cost}{Annual\ Savings}$$

$$Kg\ of\ CO_2\ saved\ per\ year = \frac{Annual\ Savings}{Energy\ Price} * (.54522\ or\ .18523)\{depeding\ on\ if\ it\ is\ electric\ or\ gas\ heating\}$$

All these results will vary depending on the accuracy of the hours of operation that the user inputs for how many hours they heat their building. The more accurate this value is the closer the calculated results will be to the actual results that a user will see. A cause for inaccuracy is that the cost of each type of seal is an estimated value for each sealing solution after looking as several different places for the cost of the items. Another reason for differing results is because the amount of energy lost from a leak has been estimated from our experience and actual energy loss from a leak will vary. The final reason for inaccuracy is the efficiency factor of .8. This efficiency factor is low to allow for variation in actual efficiency of the heating systems.

All other variables are constants that can be found on the Carbon Trust website (i.e. the .54522 constant for the CO_2 emissions calculations), or on an energy bill. The only other way that the results could vary from actual results is if an individual uses our suggested 10 pence for electricity or 3 pence for gas instead of their own. This calculation will not cause too much variation in the actual results as this is an average that had been derived from our experience doing the consultations. These results will be helpful in guiding the user in the right direction as it will give them an idea of what they should expect to see in savings and costs. Images of the calculator can be seen in Appendix I.

4.3.2.3 Window Heat Loss Calculator

When an individual uses the window heat loss calculator, they will input the type of window they have, their replacement windows, if they are using or will use thin film insulation, the average area per window, the number of windows, the average temperature difference, the hours per year they heat, installation costs, the type of heating, and the price of energy. With this information the user will receive information on current spending per year, new spending per year, savings per year, kWh saved per year, payback period, and the annual CO_2 emission savings. These results are found through the following equations,

$$Current\ spending\ per\ year = \frac{\left(\frac{1}{Uvalue_{window}} + \frac{1}{Uvalue_{thin\ film}}\right) N * A * \Delta T * t * energy\ price}{1000\ \{W\ to\ kW\ conversion\}}$$

$$New\ spending\ per\ year = \frac{\left(\frac{1}{Uvalue_{new\ window}} + \frac{1}{Uvalue_{thin\ film}}\right) N * A * \Delta T * t * energy\ price}{1000\ \{W\ to\ kW\ conversion\}}$$

where N is the number of windows, A is the average area per window, ΔT is the temperature difference between the outside and inside temperature, and t is the hours per year.

$$Savings\ per\ year = Current\ spending\ per\ year - New\ spending\ per\ year$$

$$kWh\ saved\ per\ year = \frac{Savings\ per\ year}{energy\ costs}$$

$$Payback\ period = \frac{Installation\ Costs}{Savings\ per\ year}$$

$$Kg\ of\ CO_2\ saved\ per\ year = kWh\ saved\ per\ year * (.54522\ or\ .18523)$$
$$\{depeding\ on\ if\ it\ is\ electric\ or\ gas\ heating\}$$

All these results will vary depending on the accuracy of the hours of operation that the user inputs for how many hours they heat their building. The more accurate this value is the closer the calculated results will be to the actual results that a user will see. A cause for inaccuracy is how precise the user's input of the average temperature difference is, as it will vary depending on local climate and can be hard to determine. Another reason for inaccuracy is from the determination of the u-values for windows and the thin film insulation. These numbers vary depending on the age of the window, how the windows are made, material and a number of other variables. There are average u-values for them that were acquired from a local window specialist. To allow for more accuracy if a user does know the u-value of their windows or the windows they will be using they are able to insert them in the calculator.

All other variables are constants that can be found on the Carbon Trust website (i.e. the .54522 constant for the CO_2 emissions calculations), on an energy bill, measured, or counted. The only other way that the results could vary from actual results is if an individual uses our suggested 10 pence for electricity or 3 pence for gas instead of their own prices. This calculation will not cause too much variation in the actual results, as this is an average that has been derived from our experience doing the consultations. These results will be helpful in guiding the user in the right direction, as it will give them an idea of what they should expect to see in savings and costs. Images of the calculator can be seen in Appendix K.

These calculators were left with the MVDC, so that they can quickly and easily calculate their savings or the savings of SMEs when considering future ECMs. These calculators will also be available on the Council's sustainability website, for use by SMEs and the general public. When used in conjunction with the questionnaire and checklists, they will have a guide for conducting their own energy consultation. The first calculator we are leaving calculates the savings from and payback period of replacing lights and other electrical equipment with higher efficiency models. The second calculator determines savings from and payback period of install thin film insulation on windows and doors in a building. Each of these calculators comes with by an explanation of how to use them and what information can be gained from them. Leaving a clear and detailed explanation of the calculators will facilitate the functionality of the calculators and make them much more useful to the general public.

4.3.3 Brochures

To promote carbon reduction efforts in the Mole Valley we left the Council with a set of informational brochures, promoting and advising in ways to save energy. These brochures, seen in Appendix E - 0, include titles such as 'Top 5 Ways to Save', 'Energy Efficient Lighting Information', 'How to Find the Right Utility Company', and 'Enhanced Capital Allowance Awareness'. These brochures will be made available, by the MVDC, to the general public as well as to SMEs in the Mole Valley through the Chamber of Commerce, and are designed to be easy to read for optimized use. The 'Top 5 Ways to Save' brochure lists and explains the top five easiest ways to save energy in a business or home. These five best energy saving techniques are to make behavioural changes, insulate windows and doors, insulate pipes and valves, use the higher efficiency lighting, and shop around for a utility company. The 'Energy Efficient Lighting Information' brochure explains in a way that is easy to understand what the best lighting options are, what needs to be considered before deciding to change your lighting, and the benefits of using higher efficiency lighting. The brochure on 'How to Find the Right Utility Company' suggests what you should look for in a utility company, and reminds that you should always have a contract with your energy provider and should submit to them regular meter readings, for accurate billing statements. The final brochure, titled 'Enhanced Capital Allowance', simplifies how the there are many ECMs which qualify the purchaser for a tax break, what the tax break is, how and where to find the lists of ECMs that qualify for an ECA, and how to apply for the ECA. These brochures will be handed out as well as made available online for anyone interested in using the provided information to their advantage. These will be a way for the MVDC to promote energy saving activities in the district, and further reduce their carbon footprint.

5.0 CONCLUSIONS & RECOMMENDATIONS

5.1 Recommendations

5.1.1 Recruiting SMEs

During the process of recruiting SMEs, the team came across many difficulties and learned from many experiences. After completing fieldwork, there are recommendations that can be made for the Mole Valley District Council, so that in the continuation of these consultations they are better prepared to recruit as many SMEs as possible. These recommendations include holding a mail campaign, creating an improved flier, having Merlin the Sustainability Mole hand out brochures, hosting energy awareness events, and having articles or advertisements in the local papers.

The mail campaign would involve sending brochures or fliers to every business in the district. We suggest this because it is a good way to spread the news of energy consultations, as well as promote energy efficiency knowledge among the SMEs of the area, even if they are not interested in having a consultation done for them. In order to optimize the usefulness of the mail campaign it is first necessary to create a flashier flier with brighter colors, to better catch the attention of those who will be receiving them. While the flier we created is aesthetically pleasing, it does not grab the attention of a passerby, it is more effective as an informational handout at events. The new flier should catch a business owner's attention, making it more likely that they will read the flier and be interested in receiving an energy consultation.

Another way to draw attention to the sustainability department of the MVDC and its efforts is to have Merlin the Sustainability Mole, the sustainability department's mascot, hand out the energy saving brochures to people on the High Streets of all the major Mole Valley towns. The brochures will gain the interest of the public and help to make them more informed and aware that energy savings are cheap and simple. If people start saving even a £50 or £100 pounds a year, this will snowball into a larger effort to save money in many more ways, because the simple ones will already be done. This will also be a good opportunity to publicize Merlin the Mole, letting people know who he is so when they see him, they think of sustainability.

Another method to raise sustainability awareness in the Mole Valley is to hold energy awareness events for the people in Mole Valley, as well as SME employees and owners located outside of the district. Events such as this will be greatly beneficial in recruiting SMEs, because those who attend will be interested in learning how to save energy, and therefore willing to participate in an energy consultation. This is important to create a sense of community within the sustainability crowd. A sense of community can create a support group, people to ask for advice, and a way to further increase WOMM.

The final and most useful suggestion is to have as many articles and advertisements published in the local papers as possible. Through our recruitment process, we found that this was the best way to find willing SMEs to participate. Newspaper articles reach everyone in the district, so this is the best way to reach the largest number of people and businesses with the least cost to the Council. It is important that the same article is not published each week in the *Dorking Advertiser*, the local newspaper in Dorking. There is a high probability that most people in Dorking will read this article because the *Advertiser* is a weekly publication, not daily like most other major newspapers in the UK, so it is important that articles are interesting and vary from week to week.

5.1.2 Conducting Consultations

During the energy consultations, the group discovered that there were many limitations to what they could do and what feedback they could give to the SMEs. A few recommendations can improve this for future energy consultations in the Mole Valley. These suggestions include attaining technology and using it, performing multiple consultations at different times of the day, and attaining regular meter readings for at least a month before consultation. Each of these will result in better, more efficient consultations.

During the consultations the team only had access to light meters, which are useful in determining if a room is over lit and the lights can be adjusted, replaced or completely taken out. Many other useful technologies would improve the quality and ease of the consultations. One example of useful technology is an electrical meter, which when placed on energy consuming equipment will display the amount of consumed energy. Another type of technology is a thermal camera to accurately measure how much heat is being lost through a window or gap in envelope. These are more effective when done over several occasions to average results and ensure accuracy.

The team was only able to visit each SME once, during their normal hours of operation. It would be beneficial to be able to visit a building at different times of the day, week and year such as on the weekends and at night during the week. Visiting a SME at different times provides the consultant with valuable information that they could not otherwise attain during a consultation during the day, such as the minimum consumption of the building and where major energy savings can occur. Such as unnecessary lights that remain on during the night.

After discovering that energy suppliers estimate businesses' usage and that a business did not take regular meter readings or have a smart meter, it was difficult to determine the amount of energy they were actually consuming. To avoid this situation ask an SME to take regular meter readings, if they are not already before the consultation, so that you can provide them with results that are more accurate.

5.1.3 Action Plan

After each consultation, the team created a unique action plan for the individual SME. The first action plans written consumed an excess amount of time, however as the project moved on, the return time of the reports decreased. The group learned many ways of creating these accurately and efficiently with the best possible data. These recommendations for the Mole Valley District Council will allow them to create action plans in the future with the most useful information and in the most efficient manner. The suggestions include creating a more standardized layout for the consultation reports, and finding and suggesting more funding opportunities.

Having a standardized format for the action plans will make creating them quick and easy. Each ECM in a consultation report should be explained in general terms and then continued with site-specific examples and relating pictures. If the explanations for common ECMs are already prepared then they can be inserted into an action plan as necessary, reducing the time it will take to write the report. It is also important to remember to suggest funding opportunities, especially for the more expensive ECMs. Carbon Trust loans and ECA are two available funding opportunities. A suggestion for future action plans is that the Council finds additional funding opportunities. Funding will increase the likelihood that the SME will implement more expensive, more energy saving ECMs.

5.2 Conclusions

Throughout this project the team has had many experiences and learned much about energy consultations and dealing with people and businesses. Six major themes that reflect what a good consultant should do or have were clearly present throughout every consultation performed. These characteristics should be applied throughout the consultation process; these are being proactive, persistent, flexible, and responsive. During an actual consultation, a good consultant should try to gather as much data as possible, in order to not miss any small detail. This goes along with having a consultant with a multitude of energy auditing experience to attain the most “creative” savings opportunities. These characteristics and lessons recurred throughout the consultation process, and taught us what a successful energy consultation program needs in order to thrive.

5.2.1 Characteristics

Mole Valley’s SMEs will not hear about a free consultation service without advertisement of a proactive service manager. Recruiting SMEs is not an easy job; the first task, to raise awareness of the actual service, is a hard one. A proactive manager will get involved in the community and generate creative marketing strategies to attract attention to the service. They will take advantage of the resources available to them and involve as many people in the district as possible to create a sense of communal energy reduction. This is because one SME’s sustainable actions do not contribute much to the district’s carbon emissions, but all of the SMEs together contribute to about 35% of the total carbon emissions in Mole Valley.

Sometimes the owner of an SME is the one recruited. This person is often disconnected from the maintenance and management staff of the building. When the consultant contacts the building manager, they may or may not be interested in the consultation. Persistence is important in a situation such as this because, most often, a single request to set up energy consultation will not suffice. It will most likely require as many as three or four requests to finally set up an appointment. Persistence also appears as an important quality when directly contacting businesses for energy consultation. A good salesperson will not take “No.” for an answer and will return to the place of business at a later date to try once again. SMEs must take sustainable action eventually; due to strict national legislation, being persistent only reminds them of this.

Energy consultations require the extraction of information from the building manager. They are an important part of the consultation process because often they will explain either what the energy efficiency problems are or where to look for them. A proactive energy consultant will be able to conduct a good interview with the building manager. This entails a controlled conversation with the building manager to keep the flow of conversation going but also ensuring all of the important questions are answered. Always remembering to be proactive and persistent will result in a thorough completion of any energy consultation.

The next and most important characteristics of a good energy consultant are to be flexible and quickly responsive to all aspects of the consultation approach. During the recruiting process utilizing every opportunity to talk to an SME and promote the idea of having an energy consultation done. A street campaign is conceptually the easiest opportunity to recruit SMEs, but it may not be the most effective. The most unexpected, marketing opportunities result when a responsive consultant can quickly identify an opportunity to attain another SME for consultation. As previously mentioned, direct contact, or WOMM, was one of the most effective recruitment measures, due to the group being flexible and responsive when recruitment opportunities subtly presented themselves.

As previously stated, the consultant should research businesses that have made appointments for consultation, as this is good practice, but not everything that will happen during a consultation can be foreseen. No two consultations are the same, so it is important that the consultant be flexible. Even if two consultations are in an office building with similar practices, they will be using different software, lighting, toilets, desks, and heating systems. Each SME also has a different level of growth, gross income, taxable goods, and customer base. This means that each SME will have taken varying levels of sustainable actions, some more practical than others. A flexible consultant can bend to these changes and quickly respond in any situation. This is especially useful during consultations on SMEs that have mixed facilities such as a sports centre with a pub, like the Ashtead Squash and Tennis Club, and a large mixed estate with restaurant, retail store, and wine making facility, such as Denbies.

5.2.2 Collecting Data

Preparing for an energy consultation before going to the building is a substantial part of gathering as much data as possible. However, the rest of the data gathering entails taking note of every detail possible and recording the entire consultation experience with digital photography. The more information you gather while at the business, the more accurate and detailed your action plan will be able to be. Details that may seem insignificant at the time of consultation can sometimes later be useful to suggest energy savings. Taking pictures of every piece of energy consuming equipment and recording its model number is important, so that you may be able to research a new kind of technology for a possible ECM. Recording the experience in photography enables a less experienced consultant to respond on his/her own time when writing the action plan.

5.2.3 Experience

An experienced consultant should have a general knowledge of the most state-of-the-art green technologies and when these technologies are suitable for a SME. Sometimes a very efficient technology may be available but not practical for a specific SME. The Rug Centre would benefit from the use of green roofing technology; however, the building was not structurally sound enough to maintain the weight of the sod and plants that would be above it. The building lacked sufficient support beams that would allow such a system to be used, even though it would greatly benefit from it.

Experience is something every consultant must gain before performing audits individually and should shadow, performer audits, or consult with other auditors. Whether it is in a big building or the smallest SME, this experience is necessary especially since energy savings in small, historic buildings, like those in Dorking, are the toughest to help. Experience performing consultations and insight into the business usually reveals subtle

ECMs that can range from slight behavior adjustments to a state-of-the-art technology. An example of this type of thinking is suggesting that a company running servers in an air-conditioned room 24 hours a day switch to economy 7 billing in conjunction with automatic night storage heaters to save money on energy bills. This combines business function, behavior, and technology all into one ECM.

Even with the best attempts at recruiting SMEs, some are still not interested. This leaves us with this question: why aren't people interested in saving money and utilizing the many energy saving suggestions available to them? During our research, the team found that the biggest reason people don't take advantage of these efforts is a lack of knowledge. They may think it will be difficult or time consuming, and don't want to be inconvenienced. Energy conservation measures like those listed in the 'Top 5 Ways to Save' brochure are easily implemented, and of little time consumption. In order to gain the interest of the SMEs who need the most help, the public needs to be made aware of how easy it is to reduce their carbon footprint.

6.0 WORKS CITED

UNFCCC. (2011). Retrieved February 1, 2011, from United Nations Framework Convention on Climate Change: http://unfccc.int/2860.php

University of Oxford. (2007, January). *Do Your Bit*. Retrieved January 2011, from Low Carbon ICT: http://projects.oucs.ox.ac.uk/lowcarbonict/doyourbit/

United Kingdom. (2009). Retrieved February 13, 2011, from eia: http://www.eia.doe.gov/countries/country-data.cfm?fips=UK#data

Webster, B. (2010, February 3). *Government admits Britain will fail to meet 2010 carbon emission target*. Retrieved from The Times Online: http://www.timesonline.co.uk

(2010). Retrieved from The Carbon Trust: http://www.carbontrust.co.uk

Antares Group Incorporated. (2011). *Energy Efficiency.* Retrieved February 27, 2011, from Antares Group Incorporated: http://www.antaresgroupinc.com/projects_efficiency.html

Barnett, J. (2010 йил June). Imagined publics and engagement around renewable energy technologies in the UK. *Public Understanding of Science* .

Carbon Trust. (2011). *Building Controls*. Retrieved from Carbon Trust: http://www.carbontrust.co.uk/cut-carbon-reduce-costs/products-services/technology-advice/pages/building-controls.aspx

Carbon Trust. (2011). *Building Fabric: Air Infiltration*. From Carbon Trust: http://www.carbontrust.co.uk/cut-carbon-reduce-costs/products-services/technology-advice/Pages/building-fabric-air-infiltration.aspx

Carbon Trust. (2010). *Better Business Guide to Energy Saving.* London: Queen's Printer and Controller of HMSO.

Carbon Trust. (2011). *Boiler and heater distribution*. Retrieved from Carbon Trust: http://www.carbontrust.co.uk/cut-carbon-reduce-costs/products-services/technology-advice/Pages/boiler-heat-distribution-replace.aspx

Carbon Trust. (2010, January). *Carbon Trust*. Retrieved January 2011, from Metering: http://www.carbontrust.co.uk/emerging-technologies/technology-directory/pages/metering.aspx

Carbon Trust. (2011). *Eligibility.* Retrieved February 27, 2011, from Carbon Trust: http://www.carbontrust.co.uk/cut-carbon-reduce-costs/products-services/business-loans/pages/loans-eligibility.aspx

Carbon Trust. (2010). *Lighting.* London: Queen's Printer and Controller of HMSO.

Carbon Trust. (2006). *Low temperature Hot Water Boilers.* London: Queen's Printer and Controller of HMSO.

Climate Change - Health and Environmental Effects. (2010, July 16). Retrieved February 13, 2011, from U.S. Environmental Protection Agency: http://www.epa.gov/climatechange/effects/index.html

Climate Change Levy & Agreements. (2010). Retrieved from The Carbon Trust: http://www.carbontrust.co.uk

Condly, S. J. (2003). The Effects of Incentives on Workplace Performance: A Meta-analytic Review of Research Studies. *Performance Improvement Quarterly , 16* (3), 46-63.

EWC. (2011). *Efficient Windows Collabrative*. Retrieved April 18, 2011, from Window Technologies: http://www.efficientwindows.org/lowe.cfm

ECI. (2006, October). *Environmental Change Institute - Oxford University*. Retrieved January 2011, from http://www.eci.ox.ac.uk/research/energy/eusave-boilers.php

Energy Star. (2000, January). *Energy Star*. Retrieved January 2011, from Find Energy Star Products: http://www.energystar.gov/index.cfm?c=products.pr_find_es_products

DEFRA. (2009, December). *DEFRA.* Retrieved January 2011, from Saving Energy Through Better Products and Appliances: http://www.defra.gov.uk/environment/economy/documents/energy-products-1209.pdf

Finance Act 2000. (2001). Retrieved from legislation.uk.gov: http://www.legislation.gov.uk/ukpga/2000/17/contents

International Energy Outlook 2010. (2010). Retrieved January 30, 2011, from eia: http://www.eia.doe.gov/oiaf/ieo/pdf/0484%282010%29.pdf

International Energy Statistics. (2009). Retrieved February 13, 2011, from eia: http://www.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=90&pid=44&aid=8

Hewlett-Packard Development Company, L.P. (2011). *HP Small and Medium Business*. Retrieved April 18, 2011, from When to consider a thin client solution?: http://www.hp.com/sbso/solutions/pc_expertise/article/thinclients_consider.html

howstuffworks.com. (2011). *Is it better to turn my computer off when I am not using it or leave it on all the time?* Retrieved February 27, 2011, from howstuffworks: http://www.howstuffworks.com/question328.htm

Kyoto Protocol Reference Manual. (2008). Retrieved February 13, 2011, from UNFCCC: http://unfccc.int/resource/docs/publications/08_unfccc_kp_ref_manual.pdf

Kelly, W. T., & Levy, S. L. (1993). *Patent No. 5183204.* United States.

Krarti, M. (2000). *Energy Audit of Builing Systems - An Engineering Approach.* Boca Raton, Florida, USA: CRC Press LLC.

Landman, M. (2011, March 30). *Mother Earth News Blog*. Retrieved April 18, 2011, from Green Curricula and Learning Activities : http://www.motherearthnews.com/blogs/blog.aspx?blogid=1500&tag=energy

Legislation. (2010). Retrieved from Department of Energy and Climate Change: http://www.decc.gov.uk/

Lorenzoni, I., Nicholson-Cole, S., & Whitmarsh, L. (2007, January 7). Barriers perceived to engaging with climate change among the UK. (N. Adger, K. Brown, & D. Conway, Eds.) *Global Environmental Change* , 445-459.

Murphy, J. (2007). *Governing Technology for Sustainable Development.* London: Earthscan.

Thumann, A., & Younger, W. J. (2008). *Handbook of Energy Audits* (11th ed.). Linburn,, GA, USA: The Fairmont Press.

The Council's Contribution. (2011, 01 11). Retrieved from The Sustainability Zone: http://www.molevalley.gov.uk/greener

Thorn, P. (2009). *Carbon Survey - Dorking Sports Centre.* Efficiency Direct Ltd. Carbon Trust.

Trends in Atmospheric Carbon Dioxide. (2011). Retrieved February 13, 2011, from Earth System Research Laboratory: http://www.esrl.noaa.gov/gmd/ccgg/trends/

7.0 APPENDICES

Appendix A SME Recruiting Flier and Letter

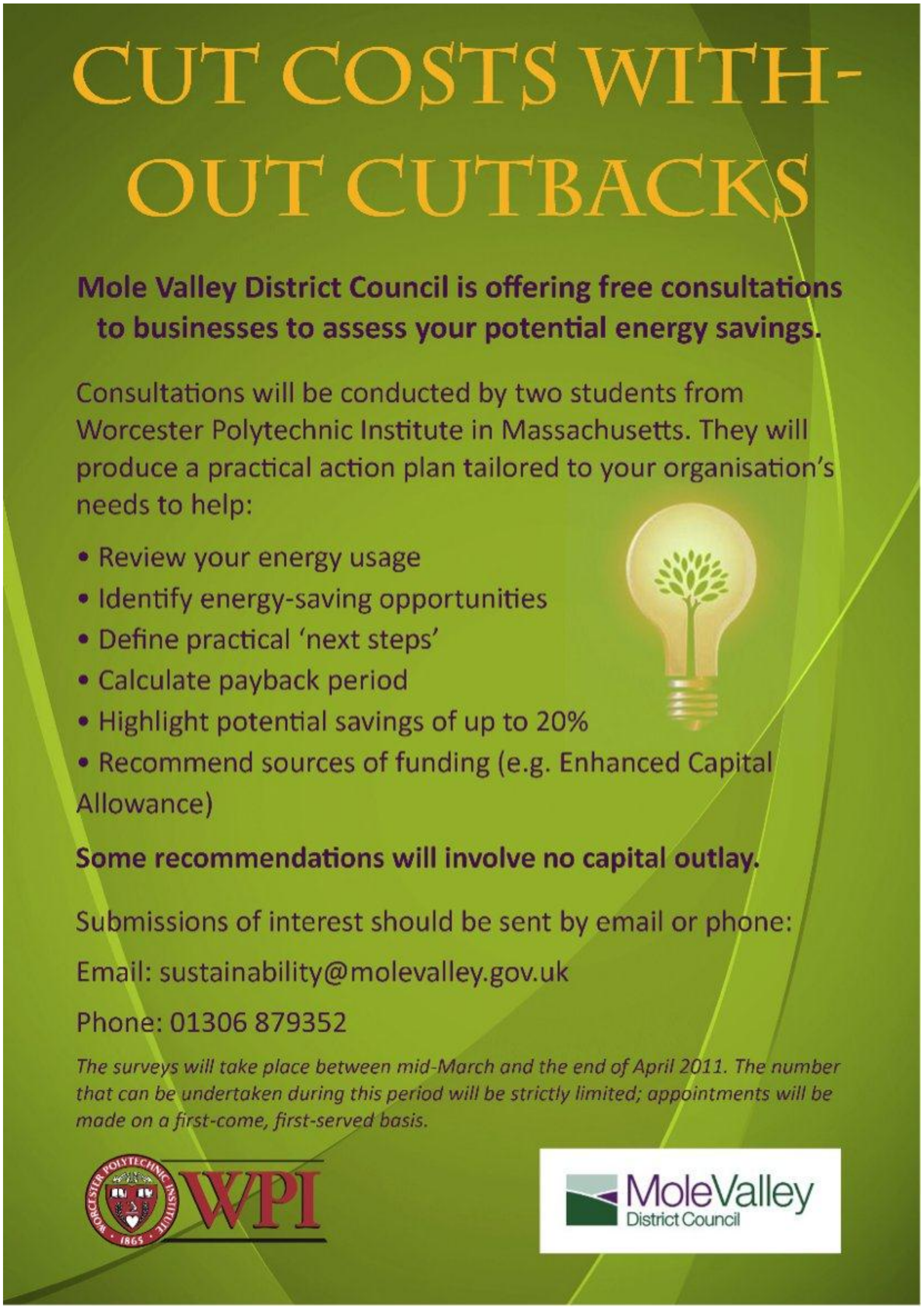

Figure 10: A5 Flier for SMEs

Philip Gauthier
Anthony Gianfrancesco
Jillian Morang
Zhongjie Wu
100 Institute Road
Worcester, MA, USA 01609
18 February 2011

[**Recipient Name**]
Chamber of Commerce President
[Town] Chamber of Commerce
[**Street Address**]
[**City, ST ZIP Code**]

Dear[**Recipient Name**]:

We are students at Worcester Polytechnic Institute, an engineering school that specializes in project-based learning. We are conducting research from 15 March 2011 to 15 April 2011, in partnership with the Mole Valley District Council, in order to help small businesses reduce their energy expenditures up to 20% and help cut equivalent carbon emissions.

At no charge to the business, we will perform a carbon survey that will cut costs on monthly energy bills. This will, in turn, provide additional income for the participating business. The survey would entail a walk-through of the facility and a few basic questions. A detailed report of the findings will be produced for the business containing suggestions for top energy savings.

If interested please contact Graeme Kane of the Mole Valley District Council

Graeme Kane
Sustainability Manager
Mole Valley District Council
Tel: 01306 870 622
Email: Graeme.kane@molevalley.gov.uk

Sincerely,
Philip Gauthier
Anthony Gianfrancesco
Jillian Morang
Zhongjie Wu
Mole Valley Carbon Survey Team

Figure 11: Letters to SMEs

Appendix B Press Releases by Mole Valley District Council

Press Release

22 March 2011

US Students Visit

During March and April, Mole Valley District Council (MVDC) has invited four students from the Worcester Polytechnic Institute (WPI) in Massachusetts, USA, to help assist local businesses to reduce their carbon emissions.

Each year, the WPI sends several groups of students to London to work with local authorities and museums to conduct a piece of research or project work which will be of value to the hosting organisation.

The students are all doing undergraduate degrees in engineering and sciences and are available to conduct free energy audit surveys for local businesses in Mole Valley.

Denbies Wine Estate in Dorking has already signed up for such an energy consultation to be completed by the students. The students will be surveying the facility in early April and will subsequently produce a detailed report providing advice and suggestions as to how Denbies can lower its carbon emissions and save on energy bills.

If you feel your business might benefit from such an audit, please contact Graeme Kane, Sustainability Manager, or email sustainability@molevalley.gov.uk by 8th April to avoid disappointment.

Graeme Kane, MVDC's Sustainability Manager said "This project benefits everyone involved: businesses get free energy advice to help save them money; the Council can continue to reduce the district's carbon footprint at no financial cost; and the students get the opportunity to develop their methodologies and complete a worthwhile and interesting project. I hope many local businesses will take up this opportunity and contact us."

Ends

Media contacts for further information:

Sally Horsburgh
Communications & Marketing Officer
Customer Services & Partnerships
Tel: 01306 879269
Email: sally.horsburgh@molevalley.gov.uk

Mole Valley District Council, Pippbrook, Dorking RH4 1SJ

Notes to editor

The project has been arranged by MVDC's Sustainability team Graeme Kane and Josh Lambe.

The students' names are:
Philip Gauthier
Anthony Gianfrancesco
Jillian Morang
Zhongjie Wu

The WPI sends approximately 40 students to the UK every term to conduct research projects which are technical in nature. The host organisation proposes the research topic based on their needs and priorities; the vast majority of the projects have nothing to do with reducing carbon emissions.

Press Release

22 March 2011 ** For publication before 25 March **

US Students Visit

During March and April, Mole Valley District Council (MVDC) has invited four students from the Worcester Polytechnic Institute (WPI) in Massachusetts, USA, to help assist local businesses to reduce their carbon emissions.

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If you feel your business might benefit from such an audit, please contact Graeme Kane, Sustainability Manager, or email sustainability@molevalley.gov.uk by 8th April to avoid disappointment.

Councillor Chris Reynolds, Portfolio Holder for Environment, said "Hosting four students from the WPI is a real coup for Mole Valley District Council and offers our small and medium businesses (SMEs) a wonderful opportunity of being advised how to reduce energy costs and carbon footprint. This is all part of the student's technology degree and comes at no cost to either the Council or those companies audited. This is a real win-win situation and I, for one, will look forward to seeing their final report"

Ends

Media contacts for further information:

Sally Horsburgh
Communications & Marketing Officer
Customer Services & Partnerships
Tel: 01306 879269
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Notes to editor

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Appendix C Useful Figures

Existing lamp type		Energy-efficient option		Energy saving benefits
	Standard (tungsten) light bulbs		Replace with energy saving compact fluorescent bulbs in the same fitting*	75% energy saving plus longer lamp life
	38mm (T12) fluorescent tubes in switch-start fittings		Replace with equivalent 26mm (T8) fluorescent tubes of lower wattage	8% energy saving plus longer lamp life
	High wattage filament lamps or tungsten halogen lamps as used in floodlights		Replace with high-pressure sodium or metal halide lighting	65-75% energy saving plus longer lamp life
	Mains voltage reflector lamps, filament spot and flood types		Replace with low-voltage tungsten halogen lighting or metal halide discharge lighting	30-80% energy saving for equivalent lighting performance
	Fluorescent fittings with the old 2ft 40W, and 8ft 125W fluorescent lamps		Replace with modern, efficient fittings using reflectors/louvres or efficient prismatic controllers with high-frequency electronic or low-loss control gear and triphosphor lamps	30-45% energy saving with much improved lighting quality. The use of high-frequency electronic control gear eliminates flicker, hum and stroboscopic effect
	Fluorescent fittings with opal diffusers or prismatic controllers which are permanently discoloured		Replace with new prismatic controllers or replace complete fittings as above	No reduction in energy consumption but increases the amount of light by between 30% and 60%

Figure 12: Light bulb replacement options

HEAT LOSS FROM UNINSULATED HOT PIPING AND SURFACES

Sources: 180 deg F and higher: ASHRAE Fundamentals 1993 © American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., www.ashrae.org.

140 deg F bare piping loss data: "Engineered Plumbing Design," American Society of Plumbing Engineers, 1982.

160 deg F bare piping loss interpolated

120 deg F bare piping loss extrapolated

	120 degF	140	160	180	280	380	480	580	1080	
Pipe (in)										
1	35	53	71	89	221	396	623	911	3742	Btuh per foot
2	61	91	121	152	378	681	1076	1581	6607	
3	86	129	172	216	539	973	1542	2271	9562	
4	109	163	217	272	689	1228	1949	2876	12,179	
6	156	233	310	387	969	1758	2797	4138	17,667	
8	229	299	396	493	1236	2246	3580	5305	22,758	
Flat, vertical				212	533	973	1559	2321	10,231	Btuh per SF
Flat, horiz-ontal, facing up				235	586	1061	1683	2485	10,606	
Flat, horiz-ontal, facing down				184	465	861	1400	2113	9754	

HEAT LOSS FROM INSULATED PIPING

Source: Engineering Toolbox Calculator

Assumes 0.1 mph wind for indoor piping, and insulation K=0.25

As a general rule of thumb, the heat loss for insulated vs. un-insulated pipe is a 10:1 reduction in heat loss. Units are Btuh per foot.

Pipe (in)	Insulation (in)	120	140	160	180	200 deg F
1	1	5	8	10	12	14
2	1	9	12	15	19	22
3	1	11	16	21	25	30
4	1	14	20	26	32	37
4	2	9	13	16	20	23
6	1	20	28	36	44	52
6	2	12	17	22	27	31
8	1	26	36	46	57	67
8	2	15	21	27	33	39

Figure 13: Heat loss from insulated hot piping (Doty, 2008)

Appendix D Energy Consultation Questionnaire and Checklist

Energy Consultation
Questionnaire

Location: Attendees:

Building: Note Taker:

Room: Date and Time:

General / Documentation

Q: Is there a copy of the floor plan or blueprints available? Tip: We would like to write on these, so a copy is preferable. This would help navigate the building as well as help identify any faults in envelope and design.	**Q: What is the length of lease on the building if not owned.**
Q: Are there any billing statements present? The more the better. If they don't save these, they should start. Also, do is there smart meter? Tip: A plot will be made with this information to try and find where and how much energy is going towards heating. Can help indicate simultaneous heating and cooling.	**Q: What year was the building built or last refurbished?** Tip: This is to check which building regulations have been applied to the building, try to bring it up to a more recent code.
Q: How many square meters is the building? Tip: This will help for benchmark data with EUI. (A US benchmark)	**Q: Do you have information of renovations and additions (date, what was done, etc.)** Tip: This will help identify areas that can be passed over. In the case of an addition, envelope may be bad in that area.
Q: What is the percentage of building occupied and what for? Are there areas closed off? Tip: This could indicate areas that don't need a lot of heat and light.	**Q: Are there any planned or recent ECM's that we should know about?** Tip: Once again, areas where we could skip or provide advice.
Q: What is the number of employees/staff? Tip: Could indicate an area where spot heating and cooling can be used.	**Q: Is there a 12-month budget that would allow for ECM's?** Tip: This is so we can identify what the business is willing to do/ how much of a loan they should apply for.

1

Q: What is the building's time of use?	
Tip: This will affect lighting, cooling and heating schedule. Please include store hours/maintenance hours.	

Building Envelope

Q: What are the levels of insulation for this building?

Q: Are doors to outside or different temperature rooms left open?

Q: Are staff comfortable with the temperature? Are there hot or cold spots?

HVAC

Q: Are windows and doors closed where AC/heating is on?	**Q: Do you have frost thermostats? How about their Settings?**
Q: Has the boiler been inspected in the last year? Tip: Dirty boilers can have a 10% efficiency loss.	**Q: Is a variable speed drive being used in the ventilation system?**
Q: Are boilers interlinked with thermostats?	***Q: Find the boiler, ask or check to find it's age, listen to it operate/surface level inspection of its condition** Tip: If a boiler is more than 5 years old, a more efficient model probably exists.
Q: When were the filters in the ventilation system last changed?	***Q: Is the correctly sized LTHW boiler being used?**
Q: Are filters off after operating hours?	***Q: Check for unauthorized heating equipment. Ask employees about comfort levels.** Electronic radiators, space heaters, fansÉ Could indicate envelope issues.
Q: Are extract fans off after hours?	***Q: Are there thermostatic radiator valves on radiators? What are their settings?** Tip: Should be on 3 (out of 5).

Q: Check thermostat settings for temperature and on/off time. If no electronic one, then get one. Benchmark is 19 C-24 C

Tip: There should be a dead band of at least 5 C. Also, the thermostat should be turned on/off an hour or so after/before opening/closing.

Electrical

Q: What type of light is being used?

Tip: Typically want to change to more efficient fluorescent T-8 and LED bulbs. Make sure bulb suites the lighting situation

Q: Is an area over lit?

Tip: Make sure that there are no redundant light sources in an area, check with lux meter, if available.

Q: Is external lighting on during unnecessary hours?

Tip: Make sure that lights are off during the day and after closing hours

Q: Does the machinery process have constant flow, or is it spotty? Can demand be spread out?

Tip: Do more at night when electricity costs less.

MoleValley District Council

Energy Consultation

Room Based Checklist

Location: Building: Attendees: Note Taker:

Room: Date and Time:

Doors

No	Interior/ Exterior	Draft (Y/N)	Seals	Skirt	Self-Closing	Material	Other Features	Quantity	Comment
1									
2									
3									

Lighting

No	Type	Power	Cleanness	Fixture Reflectivity	Auto Control	Quantity	Comment
1							
2							
3							
4							
5							
General Comments:							

Windows

No	Panes (1/2)	Draft (Y/N)	Age (1-5)	Quality (1-5)	Shades (Y/N)	Size	Direction	Coating	Quantity	Comment
1										
2										
3										
4										

Radiator

No	On/Off	Settings (1-5/MAX)	TRV(Y/N)	Obstructed(Y/N)	Quantity	Comment
1						
2						

Energy Consultation

Room Based Checklist

Location: Building: Attendees: Note Taker:

Room: Date and Time:

Doors

No	Interior/ Exterior	Draft (Y/N)	Seals	Skirt	Self-Closing	Material	Other Features	Quantity	Comment
1									
2									
3									

Lighting

No	Type	Power	Cleanness	Fixture Reflectivity	Auto Control	Quantity	Comment
1							
2							
3							
4							
5							
General Comments:							

Windows

No	Panes (1/2)	Draft (Y/N)	Age (1-5)	Quality (1-5)	Shades (Y/N)	Size	Direction	Coating	Quantity	Comment
1										
2										
3										
4										

Radiator

No	On/Off	Settings (1-5/MAX)	TRV(Y/N)	Obstructed(Y/N)	Quantity	Comment
1						
2						

MoleValley
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Energy Consultation

Boiler and Building Fabric Checklist

Location:

Building:

Room:

Attendees:

Note Taker:

Date and Time:

Boiler

No	Type	Power	Age	Control Technology	Setting	Calibration	Last Inspected	Last Cleaned	Quantity	Comment
1										
2										
3										
4										

General Comments:

Pipes

No	Insulation	Length	Diameter	Pipe/Valve	Comment
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

Roof / Ceiling / Wall

No	Item	Color	Insulation	Comment
1				
2				
3				
General Comments:				

Appendix E Brochure: Top 5 Ways to Save

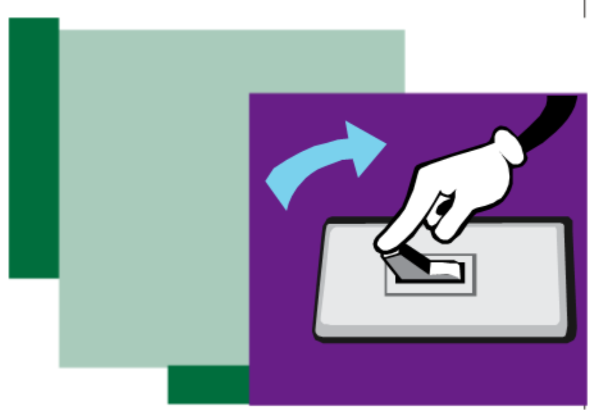
Top 5 Ways To Save!

Five easy ways to save on energy bills and reduce carbon emissions in your business

MoleValley District Council

Five Actions That Will Save Money and Reduce Carbon Emissions

1) Make Behavioural Changes
2) Insulate Windows and Doors
3) Insulate Pipes and Valves
4) Use the High Efficiency Lighting
5) Shop Around for a Utility Company



Alternative formats

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Save Money, Reduce Carbon!

Using less energy lowers the amount you spend on your utility bills, and help to reduce the amount of carbon dioxide being emitted into the atmosphere. This pamphlet is designed to give you five easy ways to start saving money and by doing so reduce carbon emissions.

1.) Make Behavioural Changes

Behavioural changes are the quickest, most cost-effective changes that can be made when reducing energy use. Three small changes can be made and will result in immediate savings.

The first of these changes is to remember to turn off lights and electrical equipment when they are not in use. This includes shutting down computers at night and always turning off the light when you leave a room, even if you plan to use the room again soon. These are not always done because they can be an inconvenience, but the amount saved on bills will show the importance of completing these tasks every time you leave a room.

Another change to be made is to make sure all of the building's radiators are unobstructed and set to the appropriate level. This means not placing chairs, boxes, or desks in front of radiators, as well as having them set to three or four out of five. If a radiator is blocked it will work harder, and will consume more energy, when heating a room. Sometimes, especially with small rooms, it is not possible to have a completely unobstructed radiator, but leaving it as clear as possible will help to reduce your utility spending. Having the radiator set to maximum will cause it to never turn off and may overheat the room. This consumes more energy and lowering the heat settings and moving obstructions can save a lot of energy

The final behavioural change is to record regular meter readings. This will show you when you are using more energy and make you aware of anything that may be causing you to use more energy than necessary. If you do not want to have to take your own weekly meter readings, looking into a Smart Meter or Automatic Meter would be beneficial to you. Smart meters automatically take and record readings every half hour, and will show you what times of day, and what days you use the most or least energy.

2.) Insulate Windows and Doors

If you have old, single paned or leaky windows, then energy is being wasted as the air escapes from your building. If replacing the windows is too expensive, or otherwise not a reasonable option, then applying Thin Film insulation to the windows will help seal and better protect from the outside air.

Low-E Coating film is another method that prevents the heat from the sun coming through the windows. This will improve the efficiency of your cooling system during the summer, if your building gets a lot of sun through the windows. While this is a good option, it should not be used on doors or large double paned windows that are larger than two square meters.

Doors that are not well sealed, or do not close, also result in wasted energy. To prevent this from occurring, install rubber seals and skirts on all of the exterior doors of your building.

Inaddition, window blinds will enhance the insulation. It preserve the heat in the winter and stop the sun radiation from the sun in the summer. When purchasing a curtain, choose ones with low u-value. Cloth curtains are typically better than metal blinds.

3.) Insulate Pipes and Valves

Hot water pipes are a main source of energy loss in many buildings. Insulating the heating pipes and their valves reduces heat loss, improves efficiency and relieves strain on the building's heating system resulting in savings on energy bills and for the environment.

4.) Use High Efficiency Lighting

Many types of lighting have become out-dated and consume much more energy than is necessary, such as incandescent lighting. Replacing light bulbs with LED equivalents will provide significant savings on your electricity bills.

LED lighting may not always be the best lighting option, since they are expensive and may provide a different quality of light than standard incandescent, halogen, or fluorescent bulbs. If LEDs do not suit your business's needs, then CFL bulbs and tubes should be used. If possible upgrade your fixtures for the T5 tubes. If you do not want to upgrade your fixtures because of the price, be sure you are using T8 tubes rather than T12 ones.

For more information, refer to the Enerngy Efficient Lighting Guide.

5.) Shop Around for a Utility Company

Knowing what your options are when choosing a utility company is very important. When searching for a company, call different providers so that you know you are getting the best deal available. You also want to be sure to have a contract with your electric company because without one you may not be on the most competitive price.

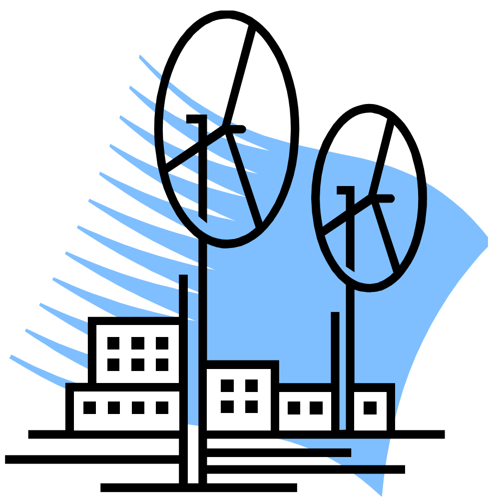
For the most accurate bills possible, and to ensure you are only paying for the energy you are using, take monthly meter readings and report them to your provider. If you do not want to take the readings yourself, consider having a smart meter installed.

For more information, refer to the Finding the Right Utility Company Guide.

Appendix F Brochure: Finding the Right Utility Company

The first step in saving money on your electric bill is making sure you have the best supplier for you.

This basic guide has been written in order to provide small businesses with a means to negotiate electricity prices.



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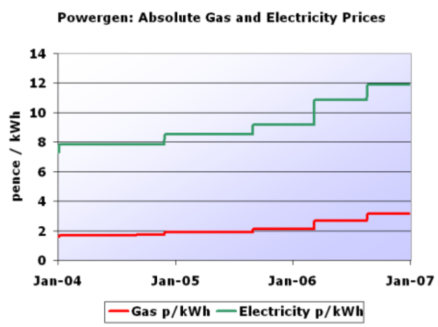
Finding the Right Utility Company

Save on energy bills by having the right supplier

MoleValley District Council

How to Shop Around for an Electricity Supplier

According to the figure below, gas prices and electricity prices are rising at an increasing rate. The figure shows average electricity prices from the company Powergen, one of the "Big 6" utility companies.



Though the plot only shows prices for Powergen, when one company increases their prices, the others usually follow in a relatively quick time period.

The worst way to pay for energy is through a non-contracted agreement, or tariff rate, with variable pricing for estimated units of electricity used. The best is a contract with a locked electricity rate for an agreed amount of time. Choosing the time period of the contract can be tricky because longer contracts will have a higher price per kilowatt hour (kWh) in an attempt to factor in the rising electricity prices. The most common advice is to go with the longer contract unless the price is significantly higher than the short-term rate.

There are two types of billing options for a contracted electricity agreement; these are debit and quarterly bills. Debit billing, usually the cheaper option, allows the energy user to pay a fixed rate every month, while quarterly billing allows the user to pay a variable bill, bill dependent upon energy use, every quarter.

These billing statements include two types of fees, the price per unit and the standing price. The standing price is a charge per day and can vary based on the electricity company, but should not be the major factor in making a decision. The price per unit is how much an electricity company charges for a kWh. Since not all energy companies raise their prices at the same time, shopping around is very important.

Energy companies will allow separate pricing for electricity used during the day and electricity used at night, known as Economy 7 or Economy 10, provided the correct meter is installed. Generally, Economy 7 is most beneficial when less than 75% of the total electricity used in total is during the day. The typical hour for which Economy 7 starts is 21.00-6.00, 0.00-7.00 or 1.00-8.00, this depends on service area and energy provider. Be sure to ask an energy consultant about both Economy 7 and Economy 10 and whether it is right for you or not. For more information on Economy 7 please visit: http://www.uswitch.com/gas-electricity/economy-7

The best type of meter for Economy 7 pricing is a smart meter, which takes half-hourly or hourly readings. By the year 2020, all businesses will be required to have smart meters. Usually these are not free but can be paid for incrementally through the standing charge portion of an electricity bill. Since smart meters cost around £100, an increased standing charge of 30p a day will accumulate to a smart meter after one year. This smart meter will be purchased by the building owner and will belong to them, not the electricity company. The purchased meter can be used if the electricity company is changed, provided the new electricity company supports smart metering. Most of the "Big 6" electric companies support smart metering, be sure to ask upon calling. Most of these major electricity companies also do a combined gas and electricity bill. Be sure to ask if this lowers the price at which energy is purchased.

A list of the biggest electric companies has been provided below to facilitate comparative pricing.

Company Name	Phone Number
E.ON	0800 051 5517
Powergen	0800 051 0760
British Gas	0800 480 0202
EDF Energy	0845 366 3664
Scottish and Southern Energy	0808 156 0056
npower	0845 270 0926
Scottish Power	0800 980 2476

A list of impartial websites for advice on finding a cheaper company or energy saving advice is also provided.

Consumer Focus: Energy Watch
http://www.energywatch.org.uk/
Surrey Business Link
http://www.businesslink.gov.uk/south_east.html
uSwitch (Comparing Website)
http://www.uswitch.com/electricity-gas/

After research on comparative prices has been done, a free energy consultant can be contacted. They will find the cheapest electricity available and use the prices you found to possibly find better deals.

Company Name	Phone Number
Business Advisory Service	0845 180 0700
Blue Mark Consultants	0800 987 5505
Quaestor Cost	0800 970 0432
uSwitch	0800 051 5492

Appendix G Brochure: Energy Efficient Lighting Information

Choosing Lighting with Higher Efficiency

Technology is advancing at such an alarming rate in so many different areas, that it is impossible to keep track of all of it. The best lighting technology, available today, is LED lighting, which takes advantage of a different kind of physics not normally known for application in lighting a room. As technology increases and better materials are found, the cost and efficiency of lighting will only improve. However, choosing more efficient lighting is not as simple as finding a light bulb or tube with a lower wattage, watts being the amount of power needed to illuminate the light bulb. A few additional lighting characteristics must be considered before choosing the lighting that is right for you.

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Energy Efficient Lighting Information

How to choose the best lighting for your business

Options

In general, there are three ways to illuminate a space in a building or a house. They are light bulbs called incandescent or halogen, fluorescent, and light emitting diode (LED). Each of these lighting options is available in both bulb and tube varieties.

By nature, the incandescent and halogen lighting are the least efficient lighting solutions. Incandescent and halogen bulbs work from heating up a coil of wire until it glows, emitting light. Fluorescents and LEDs work from moving electrons between different energy levels by exciting them. When an electron is excited, it moves to another energy level and emits a photon, more commonly known as a light wave.

The difference between an LED and a fluorescent is that the fluorescent needs a power consuming ballast to turn on. The ballast is required in each fluorescent fixture, in order to condition the current supplied to the tube. This ballast consumes power and the resulting "ballast loss" is not included in the rated watts of the bulb. LEDs have a lower wattage than fluorescents and do not have this ballast loss. These are both reasons LEDs are the most energy efficient.

Lighting Color

Light color is measured in Kelvin, and can be referred to as "temperature" due to these units of measurement. Lights come in different colors, usually fluorescent lighting has a whitish/blue color tone to it, this can be seen in the figure below, it is rated at around 3500 K whereas an incandescent is approximately 2700 K. LED light bulbs can range in color greatly. Normally they are rated at around 5000 K.

Though daylight is rated at around 6500 K and should be considered as a more natural choice for lighting, people have become accustomed to the dim, 2700 K glow radiated by the incandescent light bulb. Due to consumer complaints about the default ultraviolet color of LEDs, people are continuously developing new technologies to replicate fluorescent and incandescent lighting colors in LEDs.

Choosing what lighting color is appropriate for an SME involves these options. Some retail stores choose to paint the walls and organize things in a certain manner in order to create an ambiance that makes customers feel comfortable. For example, a restaurant may want to create a romantic atmosphere. This means that they would choose dim lighting with a color close to candle, that is to say, 1850 K. To achieve this, they should choose a light with a low color temperature and applying a similar opaque color to the walls to reflect the light.

Searching for new lighting with equivalent color to that of an incandescent is very important for retail stores that fall into the category previously described above. Other retail stores that would apply for this yellowish light would be stores with a lot of wood, either wood display units or stores with actual wood products. Stores that may want a bright white, 5000 K bulb would be those similar to a jewelry shop where it is advantageous to have a brilliant display.

Figure 1: Different colours of lighting.
http://www.myledlightingguide.com/Blog/Images/color.png
!

Lumens

Another characteristic of lighting that must be examined closely is the amount of light that is seen in the room; this is measured in lumens. Usually, the box the bulb or tube is packaged in will clearly display how many lumens the bulb has in a typical setting. If not, a simple search on any Internet search engine describing the fitting type and wattage will usually reveal how many lumens the bulb has. LEDs that are rated as equivalent are usually less bright than the bulb they are supposed to equate to. Over time, fluorescent tubes and bulbs will lose brightness until they eventually fade to black. LEDs on the other hand lose less of their luminosity over time; this means that selecting a LED tube with around 10-15% less lumen should be acceptable.

Labour Cost

When considering replacing fluorescent tubes with LED tubes, there is a small amount of labor that must be included in the cost of the new tubes. There is certain wiring that is connected to the fitting's ballast that must be reconfigured so that they bypass the ballast; it is recommended that an electrician or trained person conduct this type of job. This will of course add to the initial cost of using the energy saving lighting. Most offices and residences have a room height of around three meters, and scaffolding is not required for labor conducted on this type of room. As soon as the height exceeds three meters, the electrician must introduce scaffolding to the job, which then increases the labor costs and disturbance to employees significantly. For light bulbs, like halogen spotlights, retrofitting an LED equivalent is literally as easy as changing a light bulb, which means there is no additional initial cost to the bulb.

Appendix H Brochure: Enhanced Capital Allowance (ECA)

Brief List of ECA Equipment Categories

- Boiler Equipment
- Combined Heat and Power
- Compact Heat Exchangers
- Compressed Air Equipment
- Heat Pumps
- Heating, Ventilation and Air Conditioning (HVAC) Equipment
- Lighting
- Motors & Drives
- Radiant & Warm Air Heaters
- Refrigeration Equipment
- Thermal Screens
- Uninterruptible Power

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April 2011

Enhanced Capital Allowance

How Going Green will save you money!

*Most materials were adapted from the official ECA website

MoleValley District Council

What Is an ECA?

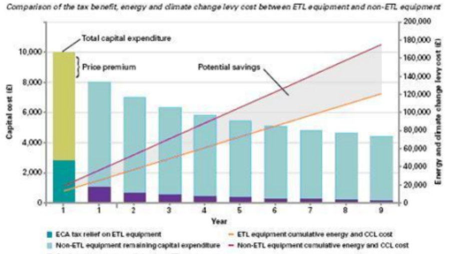
The ECA is an abbreviation for Enhanced Capital Allowance. It was introduced in 2001 by the government to encourage businesses to invest in low-carbon, energy-saving equipment. If you invest in a new piece of eligible equipment, your investment, including purchase and transportation costs along with other arisen costs of the product count against your taxable profit.

For detailed description, please refer to http://www.eca.gov.uk/etl/about/

What are the Benefits?

According to the ECA website, "The Enhanced Capital Allowance (ECA) scheme can bring significant financial savings, in the short and long-term, as well as improving a company's energy-efficiency and its impact on the environment." You can apply for 100% tax relief based on the equipment, which brings an instant cash flow. In addition, the energy efficient device will lower your energy bills and Climate Change Levy, as long-term benefit.

Comparison of the tax benefit, energy and climate change levy cost between ETL equipment and non-ETL equipment



What Is the Structure of the ECA scheme?

The ECA scheme consists of two parts:

The Energy Technology Criteria List (ETCL) is a list of the criteria, reviewed annually, that devices need to meet to qualify for an ECA.

The Energy Technology Product List (ETPL), updated each month on the website, lists the products and technologies that are eligible for an ECA.

What are the Limitations?

1. There are limits on the claim value of most equipment.
2. The equipment you plan to claim must be new and unused, so second-hand equipment is not eligible.
3. The equipment must meet the energy-saving criteria, published in Energy Technology Criteria List, or ETCL.
4. Direct costs arising from the investment, including transportation, installment, professional fees, can be included in the claim. However, indirect cost, such as time staff spent to search for eligible equipment, does not qualify.

How to claim an ECA?

According to the ECA website, "ECA claims should be submitted as part of your normal corporate or income tax return. It's important to retain all documents relating to your ECA claim, including invoices, dated screen prints from the ECA website and anything from the company that installs the equipment. HMRC may investigate any aspect of a tax return and you should have all necessary evidence to hand to support your claim."

How to determine if the purchase is eligible?

There are three ways to determine if your equipment meets the criteria.

Some of the equipment that is eligible has a symbol, shown below, on them. The symbol can be on the equipment itself or on marketing material. If you are not sure if the equipment has the symbol, you can also contact the manufacturer / supplier to ask them if it is eligible.This is the easiest and fastest way to check if the equipment is eligible.

Qualified for Energy Technology List www.eca.gov.uk TM
Authorised User No. 00000

If you do not want to contact the manufacturer / supplier, you can lookup online to see if your equipment is already in the database. However, there are four non-listed technologies. This is because some technologies have a variety of products the on market. The website does not list these products under these categories. Typically, the equipment needs to be compliant with ETL criteria to be eligible for ECA. Under these situations, business owners can consult product manufacturer or suppliers who will be able to give professional advice on the ECA eligibility of their products. The confirmation issued by a manufacturer or supplier can be used to support ECA claim. The four non-listed technologies are:

- Component based automatic monitoring and targeting equipment (AMT)
- Combined heat and power (CHP)
- Lighting
- Pipework insulation

For the full list of categories, you can check: http://www.eca.gov.uk/etl/find/ you can also use the list to look up technologies and equipment that you may want to purchase if you do not have any specific idea of what equipment you should be looking for.

FAQ

If you have other questions, you can refer to: http://www.eca.gov.uk/etl/faqs.htm

Screenshot: Building Envelope Calculator

This calculator has been designed to allow individuals to be able to get a better understanding of the savings people can see if they take some small steps to improve the envelope of their building. The calculator on the following tab gives you feedback on the money, kilowatt-hours and CO_2 saved when the required data is inputted. This information can be used to understand the effect that you have on the environment and how you can save money on your energy bill. By using this calculator individuals will be able to take steps towards bettering the environment. Results are estimated and professional audits should be acquired when necessary. Results will also vary dependent upon actual spending, leak severity, and local climate.

Step 1: Item
The item cell is for you to input what type of leak you have. It has no actual bearing on the results but is for your convenience so that you can keep track of what leaks you are repairing and sealing.

Step 2: Quantity
This cell is for the number of leaks of the specific type that you are trying to seal.

Step 3: Type of Seal
This is a drop down list that provides some basic options on the various types of seals and fixes that can be applied to a leak.

Step 4: Cost of each
This cell will be populated with a price based on the type of seal that is chosen. This price is estimated and actual price of fix may vary. If you know the actual price please select the blank option and input your own price.

Step 5: Level of Severity of Leak
This is a drop down list with choices from 1-4; 1 being the least severe to 4 being the most sever. The scale is provided below the calculator along with examples of what that level of leak may look like.

Step 6: Hours per week and Weeks per year
These two cells are to input how many hours a week and how many weeks in the year you heat your building.

Step 7: Gas or Electric Heating
This is a drop down list for you to put whether your heating is gas or electric heating.

Step 8: Electricity/Gas Cost
This cell is for you to input the price you pay per unit of electricity or gas. If you do not know the price of your electricity or gas use .1 and .03 as estimations for the respective prices.

With all this information filled in the Results section will be automatically updated and all the information that you may want will be complete. If anywhere along the way you would like to change information simply update the appropriate cell with the correct information and the Results will automatically update.

Calculator

Intputs

Item	Quantity	Type of Seal	Cost of Each (£)	Level of Severity of Leak*	Hours per Week	Weeks per Year	Gas or Electric Heating	Electricity/Gas Cost (£ / kWh)

Outputs

Annual Saving (£)	Total Investment (£)	Payback Period (years)	CO_2 saved (kg)

*Examples of the level of severity of the leak are provided below to aid in determining which type of leak you have.

**All prices and calculations are estimates and professional quotes should be acquired when necessary

1
Okay/Typical
Small gap under interior Door

2
Medium
Large amount of light from unheated hallway

3
Bad
Crack in window allowing air in

4
Really Bad
Square meter hole in wall leading to outside

Appendix J Screenshot: Lighting Calculator

This calculator has been designed to allow individuals to be able to get a better understanding of the savings people can see if they take some small steps to improve the type of lighting they use. This can be done through making sure that you have the most efficient lighting. The calculator on the following tab gives you feedback on the money, kilowatt-hours and CO_2 saved when the required data is inputted. This information can be used to understand the effect that you have on the environment, how you can save money on your energy bill and make the appropriate decision for you situation. By using this calculator individuals will be able to take steps towards bettering the environment. Results for labour costs are estimated so professional quotes should be acquired.

Step 1: Power
These cells are to input the watts of your current lightbulbs.

Step 2: Type
These cells are for you convience to be able to keep track the various types of lighting solutions you may put in.

Step 3: Power
These cells are to input the watts of the new lighting solutions.

Step 4: Price
These cells are for the unit price of the new lightbulbs.

Step 5: Amount
These cells are for the number of lightbulbs that are being replaced

Step 5: Hours per week and Weeks per year
These cells are to input the number of lights that you are going to change.

Step 6: Price of Electricity
These cells are for you to input the price you pay per unit of electricity. If you do not know the price of your electricity £0.1 .

With all this information filled in the Results section will be automatically updated and all the information that you may want will be complete. If anywhere along the way you would like to change information simply update the appropriate cell with the correct information and the Results will automatically update.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1		Old Bulbs	New Bulbs				Average Usage		Total Cost		Savings per Year			Payback Period	
2		Power	Type	Power	Price	Amount	Hours per Week	Weeks per Year	Bulb Only	Bulb + Labour**	Energy Bills	Energy	CO_2	Bulb Only	Bulb + Labour**
3		W		W	£		hr				£	kWh	kg		year
4	Example	50	LED	4	43	1	40	48	43.00	47.00	8.83	88.32	48.15	4.87	5.32
5	1								0.00	0.00	0.00	0.00	0.00	N/A	N/A
6	2								0.00	0.00	0.00	0.00	0.00	N/A	N/A
7	3								0.00	0.00	0.00	0.00	0.00	N/A	N/A
8	Total								0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Price of Electricity*		0.10	£/kWh											
10	*If you do not know the average price of your electricity use £ 0.10/kWh														
11	**This calculation is base off an insulation cost estimate of £ 4 per light bulb. A professional quotation should be acquired.														

Appendix K Screenshot: Heat Loss Calculator

This calculator has been designed to allow individuals to be able to get a better understanding of the savings people can see if they take some small steps to improve the insulation of their windows. This can be done through changing the windows to newer models, putting thin film insulation on the existing windows or by doing both. The calculator on the following tab gives you feedback on the money, kilowatt-hours and CO_2 saved when the required data is inputted. This information can be used to understand the effect that you have on the environment, how you can save money on your energy bill and make the appropriate decision for you situation. By using this calculator individuals will be able to take steps towards bettering the environment. Results are estimated based off averages of u-values and professional audits should be acquired when necessary. Results will also vary dependent upon actual spending, actual u-values, and local climate.

The calculator on the next page is fairly easy to follow detailed directions are supplied below in case of any confusion.

Step 1: Old Window, New Window and Thin Film
These cells are for you to input what type of window you currently have, what type of window you may replace it with and if they have or will have thin film insulation. If you know the u-value for the windows please feel free to put them in as well.

Step 2: Area per window
This cell is for the average size of the windows in meters that you will be replacing or putting thin film insulation on.

Step 3: Number of windows
This cell is to put in the total number of windows you will be making a change to.

Step 4: Temperature Difference
This is the temperature difference between the inside temperature and the outside temperature.

Step 5: Hours per week and Weeks per year
These two cells are to input how many hours a week and how many weeks in the year you heat your building.

Step 6: Installation Costs
This is to put an estimated cost in or an actual quotation price in.

Step 7: Gas or Electric Heating
This is a drop down list for you to put whether your heating is gas or electric heating.

Step 8: Electricity/Gas Cost
This cell is for you to input the price you pay per unit of electricity or gas. If you do not know the price of your electricity or gas use .1 and .03 as estimations for the respective prices.

With all this information filled in the Results section will be automatically updated and all the information that you may want will be complete. If anywhere along the way you would like to change information simply update the appropriate cell with the correct information and the Results will automatically update.

Heat Loss Through Windows Calculator

Inputs

Old window*	thin film	New window*	thin film	Area per window (m^2)	number of windows	Temperature Difference (°C)	hours per week	weeks per year	Installation Costs	Gas or Electric Heating	Price of Gas/Electricity (£)**

Results

Current Spending per Year (£)	New Spending per year (£)	Savings per year (£)	kWh Saved per Year (kWh)	Payback Period (years)	CO_2 Savings per Year (kg CO_2)

*If you know the U-Value of your window please feel free to input your own values

**If you do not know the gas or electric price use .03 and .1 respectively

***Keep in mind that professional quotes should be acquired as all calculations are estimations based off average U-values.

Appendix L Consultation Report: Park House

Park House Energy Consultation

Prepared For:

Graeme Kane and Andy Carter

Prepared By:

Philip Gauthier, Anthony Gianfrancesco, Jillian Morang, Zhongjie Wu

21/03/11

1. Introduction

The purpose of this energy consultation was to discover potential areas of energy reduction and savings within the Park House building. This consultation was conducted using a questionnaire and check list during a walk-through, with supplementary data on past gas and electric usage. The Park House building is home to 24 hour Telecare Service call centre. Due to its 24 hour use, certain savings are limited there are still many ways to save electricity in this building.

The energy consultation, analysis, and report were completed by four American university students, for a project requirement for Worcester Polytechnic Institute. These students are working with the Mole Valley District Council to help reduce the carbon emissions of small and medium enterprises in the Mole Valley.

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2. Action Plan

The recommendations listed below are prioritized by payback period and estimated costs. Further explanations of each recommendation are provided.

Priority	Recommendations	Estimated Annual Savings			Estimated Costs (£)	Payback Periods (years)
		(£)	CO_2 (Kg)	(kWh)		
1	Behavioural Changes	-	-	-	Minimal	Immediate
2	LED Lighting	800	4180	7670	2400	3.0
3	Envelope and Door Insulation	40	1360	2500	200	5.2
4	Thin Client Computers	230	170	310	1400	6.2
Total		1070	5710	10480	4000	3.7

3. Current Use and Potential Savings

This is a breakdown of your current costs and what your expected cost may be with these recommendations.

Utility	Energy Consumption		Costs		CO_2 Emissions	
	kWh/year	%	£/year	%	CO_2 (Kg)	%
Electricity	52,276	59	5,769	82	28,502	81
Gas	35,897	41	1,252	18	6,649	19
Total	88,173	100	7,021	100	35,151	100
	Projected Energy Consumption	% Savings	Projected Savings(£/year)	% Savings	Projected CO_2 Emissions (Kg)	% Savings
	77,693	12	5,951	15	29,441	16

4. Energy Savings

a. Priority 1: Behavioral Changes, No Cost Solutions

Make sure that all radiators are unobstructed and kept on appropriate settings. Obstructed radiators are forced to work harder to heat a room resulting in higher energy usage. Also, a radiator that is left on its maximum setting will not turn off and over heat a room. Keeping radiators unobstructed and at a setting of 3 to 4 you will save energy and money.

Site Specific Examples:

- In last upstairs office the desk is located in front of the heater. This room should be rearranged to leave the heater as unobstructed as possible.
- In the staff room the chairs were placed in front of the heater. Pull the chairs away from the heater and put up the attached sign to remind employees that they shouldn't block the heater.
- Some heaters were set much higher than necessary. Check them to be sure they are not set above four.

Turn off lighting and electrical equipment when it is unnecessary. Lights and equipment that are left on when they are not in use consume unnecessary energy. Putting signs up reminding people to turn lights and equipment off when leaving a room will help to save energy. See attached examples on signs to turn off lights.

Site Specific Examples:

- Be sure that the lights in unoccupied rooms are always switched off.
- Try to use more natural light, whenever possible. Open the shades in office areas (specifically second office upstairs) and turn off the lights during the day.
- Create maintenance schedule for cleaning skylights, to maximize their use.
- Turn off switches on electrical outlets or unplug all items when they are not being used, to avoid using power for items that are not on.
- The upstairs offices may be over lit and taking out one of the two T8 fluorescent tubes per fixture in these areas should be considered, though a light test should be conducted at night to determine this.

b. Priority 2: LED Lighting

Replace existing lights in the facility with newer lights. Many old lighting elements have become inefficient over the years. Replacing the existing elements with LED equivalents allows you to save significant amounts of money on your energy bill.

Site Specific Examples:

- All fluorescent lights should be replaced with lower wattage LED light tubes.

Old Light Bulb Wattage (W)	New Bulb Type	New Light Bulb Wattage (W)*	Hours Worked Per Year	Number of Bulbs Replacing	Price of Electricity (£)**	Total Bulb Costs*	Total Costs Including Labour**	Savings per Year (£)	kWh Saved per Year (kWh)	Payback Period (years)	Payback Period Including Labour Costs (years)**	CO_2 Savings per Year (Kg of CO_2)
58	LED	22	1,920	20	0.10	1,118	1,198	144	1,382	7.8	8.3	754
58	LED	22	61,320	20	0.10	1,118	1,198	656	6,290	1.7	1.8	3,429
			Totals	40	---	2,236	2,396	800	7,672	2.8	3.0	4,183

*All calculations are based off of pricing and wattage from NET LED

**Based off an estimated £4 instillation cost per bulb. Professional quotation should be acquired.

c. Priority 3: Envelope and Insulation

Doors that protect rooms from different temperature air should have rubber seals and skirts. Doors that are not insulated will cause drafts in a building resulting in the heating and cooling to work harder to maintain the buildings temperature.

Site Specific Examples:

- The cleaning room door already has a skirt, but the rubber seals need to be replaced.
- Main entrance to building is extremely leaky and requires a skirt and rubber seal around all edges of the door and its extended opening.
- All other exterior doors should be insulated with a rubber seal, to protect against the loss of heat in the building.
- The door to the air conditioned server room, the interior door between the meeting room and main corridor, and the door to the electrical room should have skirts as well as the rubber seal installed.
- The storage closet door, between the two toilets, has a vent which large amounts of cold air can escape through into the heated corridor. This room originally housed showers, but was converted to a storage closet and the vent was never removed, though it is no longer necessary.
- The door to access the LTHW boiler, in the kitchen, does not close properly. This door should be fixed, so that it closes tightly to better insulate and improve the efficiency of the boiler.
- We were not able to enter all of the rooms (meeting room) and doors to these areas should be inspected and insulated as appropriate.

Heated pipes that are in colder areas and are not insulated lose heat. Insulating these will save money on heating bills, as the system will not have to work as hard to maintain the temperature as it moves through the piping.

Site Specific Examples:

- There are heated pipes in the air conditioned server room which are not insulated and should be. This causes the air conditioning in the room as well as the heating for the building to work harder.

d. Priority 4: Thin Client Computers

The office's desk top computers should be switched to newer, more efficient IGEL Thin Clients. IGEL Thin Clients use at least 50% less energy than a standard desktop computer. Replacing them in appropriate situations can result in high savings.

Site Specific Examples:

- The office already has and uses the Thin Client server, installing the Thin Client unit would cause minimal disruption.
- Computers in reception and offices do not use any technical programs that would require more than the IGEL offers. There are seven computers of this type.

- Twenty-four hour service computers will not be changed. There are six computers of this type.
- IGEL Thin Client computers consume much less energy than the currently used desktop computers.

e. Small Notes

The following changes will help with energy savings but may not save as much as the above suggestions. Some of the suggestions may be more likely to be considered when other renovations occur in the building.

Site Specific Examples:

- When the building's carpeting is replaced consider buying brighter colors, to optimize incoming natural light and inside lighting.
- Consider putting in a smaller hot water tank. The current tank is larger than it needs to be, as there used to be a shower in the Park House building.

5. Brief Summary

In summary it can be seen that there are a number of ways to save energy for this building. Many of these savings are from behavioral changes such as making sure people turn lights off, having radiators not be obstructed, and having radiators on appropriate settings. Other changes require some capital but can result in great savings such as the LED lighting, which can save £800/year. Taking these steps and more will help to reduce your energy bill and save you money.

Appendix M Consultation Report: Biwater

Biwater Energy Consultation

Prepared For:

Simon Strudwick and Trevor Nash

Prepared By:

Philip Gauthier, Anthony Gianfrancesco, Jillian Morang, Zhongjie Wu

06/04/11

1. Introduction

The purpose of this energy consultation was to discover potential areas of energy reduction and savings within the Biwater office building in Dorking. This consultation was conducted using a questionnaire and check list during a walk-through, with supplementary data on past gas and electric usage. Biwater is an international company, whose Dorking office building is attached to the Dorking train station, and houses an additional tenant company. The Biwater staff is very energy conscious and already making many efforts towards carbon reduction.

The energy consultation, analysis, and report were completed by four American university students, for a project requirement for Worcester Polytechnic Institute. These students are working with the Mole Valley District Council to help reduce the carbon emissions of small and medium enterprises in the Mole Valley.

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2. Action Plan

The recommendations listed below are prioritized by payback period and estimated costs. Further explanations of each recommendation are provided.

Priority	Recommendations	Estimated Annual Savings			Estimated Costs (£)	Payback Periods (years)
		(£)	CO_2 (Kg)	(kWh)		
1	Lighting Control	375	3,656	6,699	---	---
2	Additions to Building Management System	---	---	---	---	---
3	LED Lighting	520	2,940	5,390	2,494	4.8
4	Envelope and Door Insulation	3	16	30	---	---
Total		898	6,612	12,119	2,494	4.8

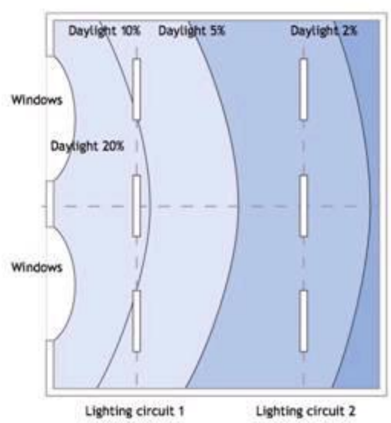
3. Energy Savings

a. Priority 1: Lighting Control

Lights that are on when they are not needed consume extra energy. There are different situations which can result in lights being on, though they not needed. Timed lights, lights in often though not continuously used areas, or incorrectly zoned lights are some examples of why more lights may be in use than are needed.

Site Specific Examples:

- The lights outside of the main entrance to the building are set on a timer to be turned on throughout the day, when the office is open. Installing a light sensor for these lights that would turn them off when it is a sunny day would save energy, since they are currently turned on all day, no matter how bright it is outside.
- The lights in the open office areas of the building are zoned in square sections. These lights should be zoned such that the line of lights closest to the windows are one zone with subsequent zones moving further from the windows. If they are zoned in this manner, the lights closest to the windows can be turned off when the sun provides sufficient lighting, therefore saving energy. This means, with sufficient sunlight, approximately one eight to one quarter of a large room's energy consumption can be cut, and one half of a small office can be cut.



Total Number of Bulbs in Zoning Area	Total Current kWh per Year	New kWh if 1/4-1/8 of Lights are Turned Off	Money Saved per Year (£)	CO_2 Savings (kg of CO_2)
298	21,890	19,150-20,520	270-130	1,500-750

*This is if the lights are off for half a day on average throughout the year

- Toilettes are frequently used areas, where the lights are left on when no one is in the room. All the toilettes in the building should have motion sensors installed on the lights. This will save energy by turning off the lights when the room is not being used, while adding the convenience of having the lights turn on when someone enters the area. For added employee convenience with motion sensors, check to see if it has a timer.

Location	Total Number of Bulbs in Zoning Area	Watt of Bulb	Total Current kWh per Year	New Consumption with Technology	Money Saved per Year (£)	CO2 Savings (kg of CO2)	Cost of Appropriate Sensor (£)	Payback Period (Years)
Outside	14	26	786	393	38	214	50	1.3
Toilette	14	50	1,512	378	37	618	50	1.4
Toilette	74	26	4,156	1,039	100	1699	50	0.5

b. Priority 2: Additions to Building Management System

Adding controls or sensors to a BMS will allow it to work less and, therefore save energy. Controlling the air flow and temperature in a building, especially a larger one, can be stressful and time-consuming for the facilities staff. The BMS is an automatic control that handles most of the managing load with timers and electronic thermostat settings. When the BMS has more information, it can work in a more efficient manner and help cut costs. Some devices can be added to the BMS to help it work in a smarter manner.

Site Specific Examples:

- Oxygen sensors measure the amount of oxygen extracted from a room, with these linked to a BMS, it could make way for a closed loop ventilation system. When the system senses a low-level of oxygen in the air, the outside air vent will open allowing for fresh air to mix in. When the vent is closed, old air is reused to make the system work less hard.

c. Priority 3: LED Lighting

Replace existing lights in the facility with newer lights. Many old lighting elements have become inefficient over the years. Replacing the existing elements with LED equivalents allows you to save significant amounts of money on your energy bill. If LED bulbs are not a viable option at the current time then CFL and fluorescent tubes can be used but make sure that the most efficient ones are in use i.e. T8 or T5's for fluorescent tubes and bulbs with high energy ratings of A or B should be used. The table below breaks down the recommended areas where lighting should be replaced with all the correlating information about payback periods and costs.

Site Specific Examples:

- All halogen spotlights can be replaced with lower wattage LED lighting where possible.

Old Light Bulb Wattage (W)	New Bulb Type	New Light Bulb Wattage (W)*	Price per New Bulb (£)*	Number of Bulbs Replacing	Price of Electricity (£)**	Total Bulb Costs	Savings per Year (£)	kWh Saved per Year (kWh)	Payback Period (years)	CO_2 Savings per Year (kg CO_2)
50	LED	7	43	58	0.09669	2,494	520	5,390	4.80	2,940

*All calculations are based off pricing and wattage from Halers Lighting 2011 Catalogue
**This is based off your current rates

d. Priority 4: Building Envelope

Instead of purchasing new windows, make the old ones work in a more efficient manner.

Site Specific Examples:

- The windows that surround the building can be more efficient with the aid of window insulation film. Specifically convection control film which cuts down the amount of heat lost from the inside of the building. It can also prevent window condensation, another reason for heat lost.
- Consider using platinum polystyrene beads to fill in the cavities in the window frame. The thermal conductivity of this substance is 0.033 w/m^2. This may or may not increase window insulation, a free quote and estimate can be obtained from various companies, ask for energy saving qualities.

Estimated Values

Number of Windows	kWh Saved per Window per Year	Total kWh Saved per year	Total Savings (£)
306	0.1	30.6	3

4. Additional Considerations

These are items that should be considered to help increase energy savings.

Site Specific Examples:

- The tube lights in the lift may be able to be replaced with LEDs. The lights in the lift are on all of the time, unless power to the lift is shut off. The large T-12 and T-8s in the lift can be replaced by 22-W LED lights. This would result in approximately a 1.5 year payback period, not factoring in the labor of such an exchange. Consult the elevator company about this.
- Consider changing the 28 Watt butterfly compact fluorescent one to the smaller 14 Watt bulb to consume half as much electricity. However, exchanging power consumption also means exchanging brightness; ensure that this does not violate any safety regulations.

5. Brief Summary

In summary it can be seen that while this building is already doing very well in energy efficiency, there are still areas which can be improved to help reduce energy usage. Many of these steps are of a higher cost or more difficulty, but will be worth the change due to the amount saved on energy bills.

Appendix N Consultation Report: Brodie Plant Goddard

Brodie Plant Goddard
Energy Consultation

Prepared For:

Robin L Goddard and Chris Bula

Prepared By:

Philip Gauthier, Anthony Gianfrancesco, Jillian Morang, Zhongjie Wu

23/04/11

1. Introduction

The purpose of this energy consultation was to discover potential areas of energy reduction and savings within Brodie Plant Goddard building in Dorking. This consultation was conducted using a questionnaire and check list during a walk-through, with supplementary data on past gas and electric usage. BPG is an architecture firm, whose Dorking office building is part of a bigger building with separate electrical and gas billing. BPG has recently updated their heating system in an attempt to make the temperature uniform throughout the office in order to increase employee comfort.

The energy consultation, analysis, and report were completed by four American university students, for a project requirement for Worcester Polytechnic Institute. These students are working with the Mole Valley District Council to help reduce the carbon emissions of small and medium enterprises in the Mole Valley.

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2. Action Plan

The recommendations listed below are prioritized by payback period and estimated costs. Further explanations of each recommendation are provided.

Priority	Recommendations	Estimated Annual Savings			Estimated Costs (£)	Payback Periods (years)
		(£)	CO_2 (Kg)	(kWh)		
1	Behavioral Changes	---	---	---	---	---
2	Envelope and Door Insulation	140	1,485	5,690	460	2.9
3	Lighting Control	69	373	690	600*	8.7
4	LED Lighting	709	3,868	7,093	6,233	8.8
Total		918	5,726	13,473	7,293	7.9

* I guess that it would take an electrician about five days at £100 a day to zone the lights, this is while he is rewiring the fixtures for LEDs. It will be around £500 a day if he were to do it on its own.

3. Energy Savings

a. Priority 1: Behavioral Changes, No Cost Solutions

Make sure that all radiators are unobstructed and kept on appropriate settings. Obstructed radiators are forced to work harder to heat a room resulting in higher energy usage. Also a radiator that is left on its maximum setting will never turn off and over heat a room. Keeping radiators unobstructed and at a setting of 3 to 4 you will save energy and money.

Site Specific Examples:

- Many of the radiators in the building were obstructed by furniture or other items and should be moved accordingly if at all possible. See Figure 1 and Figure 2 below for some examples.

Figure 1: Desk in front of a radiator

Figure 2: Desk in front of a radiator

- Ensure that the TRV's are at a level of 3-4 unless otherwise needed.
  - If the radiator is in a place where it is blocked, ensure that it is turned off.
  - There is a frequently vacated office with the TRV set on high. When the office is not in use, make sure the TRV is on a frost setting.
  - The main lobby has one radiator installed to heat a whole room with many leaky windows. Consider either turning the radiator off completely because the staircase is

blocking the heat, which makes it never actually reach the upstairs portion of the office. This renders the heater obsolete.

- Most employees turn radiators down when heat during the winter becomes too hot, however some employees claim to open windows during the winter when heating gets too intense. Try to stress temporarily turning on a fan and turning down the radiator valve. However this is not possible for employees near the edges of the building with floor radiators.
- Desks located near the edge of the building are not properly positioned as to take advantage of use. When talking to the two employees on the right side of the office, the side where the main conference room is located, they said that they didn't think the floor heating system worked at all and complained of being very cold in the winter. However, the employees on the side of the office with the printing room said they were very hot and had to open windows during the winter.

  The first set of employees had their desks positioned in such a way that the cubicle wall was consuming all of the heat being distributed by the floor unit. Consider rotating the desks on that side of the office by 180 degrees so that the person sitting at the desk has their back facing the heater.

  Make sure that the employees on the other side of the building have their cubicles either facing the heater or move them to a more centralized position in the office so that they do not consume heat. If reorganizing desks created a large disturbance, consider creating an office model in CAD and freely postulate repositioning employee desks without bothering anyone.

Turn off lighting and electrical equipment when it is unnecessary. Ensure that computers and lights are turned off when office is closed and when rooms are not in use.

Site Specific Examples:

- The kitchen light was left on all day when we went through the building. Consider imposing "light off hours" outside of lunch hours. Possibly, turn off lights after use during the hours of 11.00-14.00 to ensure that the fluorescent bulb life is not drastically reduced and excess energy is not being used.

b. Priority 2: Building Envelope

Instead of purchasing new windows, make the old ones work in a more efficient manner. Also ensure that doors are sealed to prevent cold air from infiltrating the inside of the building.

Site Specific Examples:

- The windows that surround the building can be more efficient with the aid of window insulation film. Specifically convection control film which cuts down the amount of heat lost from the inside of the building. It can also prevent window condensation, another reason for heat lost.

Installation Costs	Savings Per Year	kWh Saved per year	kg CO2 saved per year	Payback Period (years)
400	99	4320	800	4

- Some of the rubber seals on the windows were getting disconnected from the window pane. These require regular maintencance to ensure that cold air from the outside does not infiltrate.

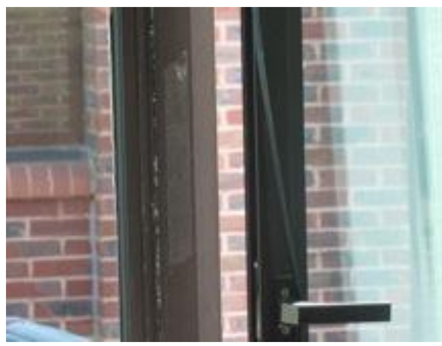


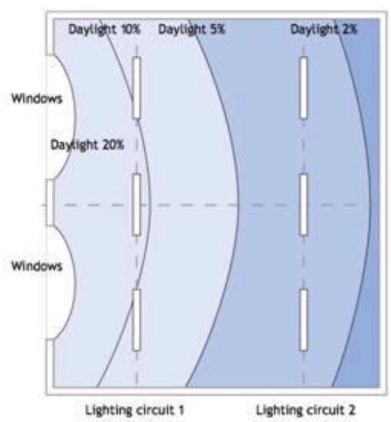
Figure 3: A window that had a seal falling off it. This is possibly an area for improvement.

c. Priority 3: Lighting Control

Lights that are on when they are not needed consume extra energy. There are different situations which can result in lights being on, though they not needed. Timed lights, lights in often though not continuously used areas, or incorrectly zoned lights are some examples of why more lights may be in use than are needed.

Site Specific Examples:

- The lights in the open office areas of the building are zoned in square sections. These lights should be zoned such that the line of lights closest to the windows are one zone with subsequent zones moving further from the windows. Lights in offices should also have separate switches so that they can be turned off when not in use. If they are zoned in this manner, the lights closest to the windows can be turned off when the sun provides sufficient lighting, therefore saving energy. This means, with sufficient sunlight, approximately one eight to one quarter of a large room's energy consumption can be cut, and one half of a small office can be cut.



Total Number of Bulbs in Zoning Area	Total Current kWh per Year	kWh saved if 1/8-1/4 of Lights are Turned Off	Money Saved per Year (£)	CO_2 Savings (kg of CO_2)
50	4104	513-1,026	51-102	277-554

*This is if the lights are off for half a day on average throughout the year

- Toilettes are frequently used areas, where the lights are left on when no one is in the room. All the toilettes in the building should have motion sensors installed on the lights. This will save energy by turning off the lights when the room is not being used, while adding the convenience of having the lights turn on when someone enters the area. For added employee convenience with motion sensors, check to see if it has a timer.

Location	Total Number of Bulbs in Zoning Area	Watt of Bulb	Total Current kWh per Year	New Consumption with Technology	Money Saved per Year (£)	CO2 Savings (kg of CO2)	Cost of Appropriate Sensor (£) (£50 ea.)	Payback Period (Years)
Toilet	8	14	242	61	18	98	100	5.6

d. Priority 4: LED Lighting

Replace existing lights in the facility with newer lights. Many old lighting elements have become inefficient over the years. Replacing the existing elements with LED equivalents allows you to save significant amounts of money on your energy bill. If LED bulbs are not a viable option at the current time then CFL and fluorescent tubes can be used but make sure that the most efficient ones are in use i.e. T8 or T5's for fluorescent tubes and bulbs with high energy ratings of A or B should be used. The table below breaks down the recommended areas where lighting should be replaced with all the correlating information about payback periods and costs.

Site Specific Examples:

- All halogen spotlights can be replaced with lower wattage LED lighting where possible.
- When installing LED lighting, labor must be performed to bypass the ballast. A price of £4 per bulb has been added to the total costs to factor this in.

New Bulb	New Wattage*	Total Costs*	Savings per year	Kwh saved per year	kg CO_2 saved per year	Payback (years)
1200mm LED	15.00	5,345.00	596.00	5,961.00	3,250.00	8.17
590mm LED	8.00	832.00	76.00	760.00	415.00	9.26
GU-10 LED	7.00	56.00	37.00	372.00	203.00	1.08
		6,233.00	709.00	7,093.00	3,868.00	8.79

*All calculations are based off pricing and wattage from Halers Lighting 2011 Catalogue

**This is based off an electricity rate of 10p per kWh

4. Additional Considerations

These are items that should be considered to help increase energy savings.

Site Specific Examples:

- It is possible that the extract fans are on after hours, it was not clear whether or not the building management system controls this.
- The LTHW boiler seemed to be oversized. It may have used to heat water for the two showers on the ground floor, however those showers have inline water heaters in them. The boiler is only heating water for four WC faucets and two kitchen faucets. These kitchen faucets do not need an excessive amount of hot water because only small plastic containers, plates, and cups are being washed and at most one at a time. Reducing the size of this boiler will help the heating system use less energy.
- The heating scenario in the lobby is difficult. Experiment with turning the heater completely off and see if employees walking to the WC and kitchen notice. If they do notice the heater off then consider adding thin film insulation to the two-story set of windows in the lobby area.
- Consider adding zoning to the lighting fixtures when the rewiring needs to be done for the LED additions. This way labor costs will be reduced and payback period for these suggestions will be lessened.

5. Brief Summary

In summary it can be seen that while this building is already doing very well in energy efficiency, there are still areas which can be improved to help reduce energy usage. Many of these steps are of a higher cost or more difficulty, but will be worth the change due to the amount saved on energy bills. Some savings opportunities in this report have not been quantified due to the large amount of variables present in the calculation. Carefully read over the report and take advantage of the most useful suggestions first. We recommend that you seek the opinion of another expert to check our numbers and suggestions. Good luck and happy savings!

Appendix O Consultation Report: Petris

Petris Technology, Inc.
Energy Consultation

Prepared For:

The Dorking Location of Petris Technology, Inc.

Prepared By:

Philip Gauthier, Anthony Gianfrancesco, Jillian Morang, Zhongjie Wu

24/04/11

1. Introduction

The purpose of this energy consultation was to discover potential areas of energy reduction and savings within Petris Technology, Inc building in Dorking. This consultation was conducted using a questionnaire and check list during a walk-through, with supplementary data on past gas and electric usage. BPG is an information management company with worldwide offices. Petris in Dorking shares a building with another company however; they have a separate electrical meter and do not use natural gas energy for anything.

The energy consultation, analysis, and report were completed by four American university students, for a project requirement for Worcester Polytechnic Institute. These students are working with the Mole Valley District Council to help reduce the carbon emissions of small and medium enterprises in the Mole Valley.

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2. Action Plan

The recommendations listed below are prioritized by payback period and estimated costs. Further explanations of each recommendation are provided.

Priority	Recommendations	Estimated Annual Savings			Estimated Costs (£)	Payback Periods (years)
		(£)	CO_2 (Kg)	(kWh)		
1	Behavioral Changes	---	---	---	---	---
2	Envelope and Door Insulation	72	388	719	160	2.2
3	Lighting Control	26	140	260	600	23.1
4	LED Lighting	336	1832	3360	3252	9.7
Total		434	2,360	4,339	4,013	9.2

* I guess that it would take an electrician about five days at £100 a day to zone the lights, this is while he is rewiring the fixtures for LEDs. It will be around £500 a day if he were to do it on its own.

3. Energy Savings

a. Priority 1: Behavioral Changes, No Cost Solutions

Make sure that all radiators are unobstructed and kept on appropriate settings. Obstructed radiators are forced to work harder to heat a room resulting in higher energy usage.

Site Specific Examples:

- Some of the radiators in the building were obstructed by furniture or other items and should be moved accordingly if at all possible. See Figure 1 for an example. Desks in the office area were positioned in such a way that the backs of chairs were very close to the heater and absorbing all of the heat, consider arranging the office in a more radiator conscious floor plan.

Figure 1: Printer in front of a radiator

Turn off lighting and electrical equipment when it is unnecessary. Ensure that computers and lights are turned off when office is closed and when rooms are not in use.

Site Specific Examples:

- The kitchen light was left on all day when we went through the building. Consider imposing "light off hours" outside of lunch hours. Possibly, turn off lights after use during the hours of 11.00-14.00 to ensure that the fluorescent bulb life is not drastically reduced and excess energy is not being used.

b. Priority 2: Building Envelope

Instead of purchasing new windows, make the old ones work in a more efficient manner. Also ensure that doors are sealed to prevent cold air from infiltrating the inside of the building.

Site Specific Examples:

- The windows that surround the building can be more efficient with the aid of window insulation film. Specifically convection control film, which cuts down the amount of heat transmitted through the glass of the building. It can also prevent window condensation, another reason for heat loss. The windows in the conference room were not included in this due to it's spotty use. It should also be included in the thin film additions but it is not a first priority. This does include the windows in the server room however.

Energy Measure	Cost	Savings per year	kWh saved	C02 saved (kg)	Payback Period (years)
Add thin film insulation	£80	£17.42	174	94	4.6

- The emergency exit door leading to the storage room/loading dock has large gap between the double doors. Consider filling in the gap with a door skirt or resizing the door. Also, the front door of the vestibule and the door leading to the office should also sealed to prevent cold air from the lobby infiltrating the office.
- A skirt on the door to the server room can help keep cold air inside that room and prevent potential leaks of air conditioned air. Though the daily heat loss may be minimal, the AC unit is running all day, every day to ensure that the computers and servers are kept cold. The savings here add up to a substantial amount.

Door	Energy Saving kWh	Annual Saving £	Total Investment £	Payback Period year	C02 saved kg
Office to Docking Area	308	30.82	30	1	166
Server Room	175	17.52	15	0.9	95
Inner Vestibule Door	62	6.16	30	4.9	33
Total	545	54.5	80	1.5	294

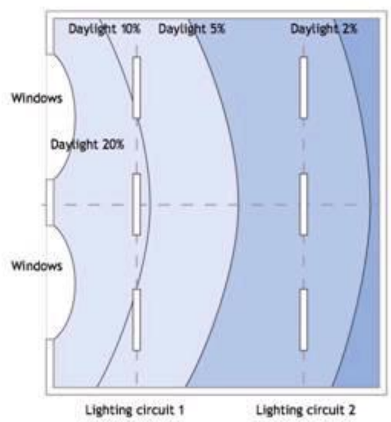
- Some of the rubber seals on the windows may be getting disconnected from the window pane. These require regular maintencance to ensure that cold air from the outside does not infiltrate the building's interior.

c. Priority 3: Lighting Control

Lights that are on when they are not needed consume extra energy. There are different situations which can result in lights being on, though they not needed. Timed lights, lights in often though not continuously used areas, or incorrectly zoned lights are some examples of why more lights may be in use than are needed.

Site Specific Examples:

- The lights in the open office areas of the building are zoned in square sections. These lights should be zoned such that the line of lights closest to the windows are one zone with subsequent zones moving further from the windows. If they are zoned in this manner, the lights closest to the windows can be turned off when the sun provides sufficient lighting, therefore saving energy. This means, with sufficient sunlight, approximately one eight to one quarter of a large room's energy consumption can be cut, and one half of a small office can be cut.



Total Number of Bulbs in Zoning Area	Total Current kWh per Year	kWh saved if 1/8-1/4 of Lights are Turned Off	Money Saved per Year (£)	CO_2 Savings (kg of CO_2)
16	608	76-152	7.6-15.2	41-82

*This is if the lights are off for half a day on average throughout the year

- Toilettes are frequently used areas, where the lights are left on when no one is in the room. All the toilettes in the building should have motion sensors installed on the lights. This will save energy by turning off the lights when the room is not being used, while adding the convenience of having the lights turn on when someone enters the area. For added employee convenience with motion sensors, check to see if it has a timer.

Location	**Total Number of Bulbs in Zoning Area**	**Watt of Bulb**	**Total Current kWh per Year**	**New Consumption with Technology**	**Money Saved per Year (£)**	**CO2 Savings (kg of CO2)**	**Cost of Appropriate Sensor (£) (£50 ea.)**	**Payback Period (Years)**
Toilet	8	14	242	61	18	98	100	5.6

d. Priority 4: LED Lighting

Replace existing lights in the facility with newer lights. Many old lighting elements have become inefficient over the years. Replacing the existing elements with LED equivalents allows you to save significant amounts of money on your energy bill. If LED bulbs are not a viable option at the current time then CFL and fluorescent tubes can be used but make sure that the most efficient ones are in use i.e. T8 or T5's for fluorescent tubes and bulbs with high energy ratings of A or B should be used. The table below breaks down the recommended areas where lighting should be replaced with all the correlating information about payback periods and costs.

Site Specific Examples:

- When installing LED lighting, labor must be performed to bypass the ballast. A price of £4 per bulb has been added to the costs to factor this in.

New Bulb Type	New Watt* of bulb	Total Costs*	Savings per year**	Kwh saved per year	kg CO2 saved per year	Payback (years)
1200mm LED	15 W	2,820.00	298	2,980.00	1,625.00	9.5
590mm LED	8 W	432	38	380	207	11.4
		3,252.00	336	3,360.00	1,832.00	9.6

*All calculations are based off pricing and wattage from Halers Lighting 2011 Catalogue

**This is based off an electricity rate of 10p per kWh

4. Additional Considerations

These are items that should be considered to help increase energy savings.

Site Specific Examples:

- Consider adding zoning to the lighting fixtures when the rewiring needs to be done for the LED additions. This way labor costs will be reduced and payback period for these suggestions will be lessened.
- It was brought to our attention that the heating system is sometimes left on overnight. This is a large amount of energy wasted since electric heaters are being used. There are two options to reduce energy bills. The first of which is to install timer switches on the wires that power the heater. The other option is to go for night storage heaters.
- The reason night storage heaters have been suggested is because night storage heaters consume most of their energy at night. In conjunction with your AC unit and server room, it may help lower electricity bills if you switch to economy 7 readings. I'm not sure how it will work due to the current linkage with BPG upstairs though. Talk to an energy consultant from one of the companies listed in Appendix B to cover your options.

5. Brief Summary

In summary it can be seen that while this building is already doing very well in energy efficiency, there are still areas which can be improved to help reduce energy usage. Many of these steps are of a higher cost or more difficulty, but will be worth the change due to the amount saved on energy bills. Some savings opportunities in this report have not been quantified due to the large amount of variables present in the calculation. Carefully read over the report and take advantage of the most useful suggestions first. We recommend that you seek the opinion of another expert to check our numbers and suggestions. Good luck and happy savings!

Appendix P Consultation Report: Rug Centre Ltd

Rug Centre Ltd. Energy Consultation

Prepared For:

Sheena Bamforth

Prepared By:

Philip Gauthier, Anthony Gianfrancesco, Jillian Morang, Zhongjie Wu

04/04/11

1. Introduction

The purpose of this energy consultation was to discover potential areas of energy reduction and savings within the Rug Centre Ltd.. This consultation was conducted using a questionnaire and check list during a walk-through, with supplementary data on past gas and electric usage. The Rug Centre Ltd. occupies part of the lower floor of an older building and is home to an area rug sales floor. Due to its age there are many opportunities to save electricity in this building.

The energy consultation, analysis, and report were completed by four American university students, for a project requirement for Worcester Polytechnic Institute. These students are working with the Mole Valley District Council to help reduce the carbon emissions of small and medium enterprises in the Mole Valley.

Notice: While there has been an effort made to ensure that the information contained in this report is accurate, it should be taken into consideration that some of the information may be incomplete, inaccurate, or become out of date. Therefore, Mole Valley District Council, Worcester Polytechnic Institute, and all associated persons do not provide any guarantees on the information provided in the following report.

2. Action Plan

The recommendations listed below are prioritized by payback period and estimated costs. Further explanations of each recommendation are provided.

Priority	Recommendations	Estimated Annual Savings			Estimated Costs (£)	Payback Periods (years)
		(£)	CO_2 (tonnes)	(kWh)		
1	Behavioural Changes	-	-	-	Minimal	Immediate
2	Change Electric Supplier	217	-	-	Minimal	Immediate
3	Repair Heater	142.2	77.58	142.3	190	1.34
4	LED Lighting	477.0	2364.15	4336.3	990.0	2.08
5	Door Insulation	11	54.52	100	40	3.64
Total		847.20	2496.25	4578.6	1220	1.44

3. Current Use and Potential Savings

This is a breakdown of your current costs and what your expected cost may be with these recommendations.

Category	Energy Consumption		Costs		CO_2 Emissions	
	kWh/year	%	£/year	%	CO_2 (tonnes)	%
Heating	6,473.80	50.17%	647.38	50.17%	3,529.65	50.17%
Lighting	5,148.87	39.90%	514.89	39.90%	2,807.27	39.90%
Other	1,282.32	9.94%	128.23	9.94%	699.15	9.94%
Total	12,904.99	100	1,290.50	100	7,036.06	100

4. Energy Savings

a. Priority 1: Taking Regular Meter Readings

Action

The business manager should consider taking meter readings twice a month and documenting them. These meter readings should be submitted to your electric supplier, however if you have a smart meter installed, the readings no longer need to be recorded.

Explanation

Energy companies may overestimate electrical usage because the readings can be estimated. Documenting the building's usage on a regular basis will help monitor energy consumption and identify any inconsistent charges. As well as showing the company's energy consumption patterns, submitting monthly readings to your electric company will ensure that the amount charged is accurate. Readings can be submitted by phone or online. For EDF energy, the link is here: https://edfenergy.com/meter-reading/edf-energy/start-2.do

b. Priority 2: Change Electric Supplier

Action

Consider contacting different electric companies and trying to sign a contract, using an economy7 tariff, with the company that is best for your enterprise. For further information on how to choose a better electric company, see 0.

Explanation

EDF energy charges your enterprise 11p/kWh, while contracted prices tend to be up to 15% lower than this. With a contract, energy companies can provide an economy 7 tariff, meaning lower prices for energy that is used during the night. Economy7 in the UK is usually 0130-0830 during daylight saving times and 0030-0730 during normal times. Since storage heating systems that consume electricity at night are being used, having differing night and day rates will be beneficial. The economy7 tariff plan will lower energy bills if daytime energy consumption is below 77.8% of the total consumption. Calculations show that only about 70% of your electricity is spent during the day, due to your use of storage heaters. Using low-power lighting and more storage heaters instead of portable heaters will make an economy 7 tariff more beneficial.

When contacting electric companies, we also suggest that you ask about having a smart meter installed. With a smart meter you do not have to take down the meter readings since they will be automatically recorded. These readings will still need to be submitted to the electric company for billing, though it is a more accurate and convenient method of obtaining regular meter readings. With a smart meter, you can retrieve your energy consumption records easily without reading the meter itself. A smart meter is typically installed by your electric supplier and costs £100.

c. Priority 3: Envelope and Door Insulation

Action

Add rubber seals and skirts to the front door of the enterprise. Consider covering the vent hole on the back wall with better materials. Also, look into window insulation film to improve window insultation.

Explanation

Doors that protect rooms from different temperature air should close properly and have rubber seals and skirts. Doors that are not insulated or do not close will cause drafts in a building, resulting in the heating and cooling systems to work harder to maintain the building's temperature.

The front door is the only insulation between the outside air and the warm inner air, in the front of the store. This door has gaps along the edges, which should be sealed. The top and outside edges should have rubber seals installed. The bottom and middle should have appropriate skirts added. These will prevent the infiltration of outside air.

Holes in the envelope of a building result in drafts causing the heating system to overwork. Sealing holes in the envelope of the building will reduce energy bills, because the heating and ventilation systems won't have to work as hard to maintain the temperature of the building. Even though you have some insulation during winter, adding better insulation will reduce the amount the room needs to be heated.

Figure 1 Hole in the back wall

d. Priority 4: Repair and Use Storage Heater and time switch

Action

Consider having the large storage heater at the back of your shop repaired and the time settings all of the storage heaters checked. Use the portable heaters as little as possible, especially if economy 7 rates are being applied.

Explanation

The portable heaters (convector heater) are responsible for nearly half your heating related energy consumption. If the use of these can be limited, or even stopped entirely, the enterprise's energy consumption, due to heating, will drop. This will also move much of the electricity consumed by heating during the day to nighttime, further reducing energy bills. Mended the large storage heater, through Dimplex, will cost £190, while the estimated annual energy savings will be approximately £142. The customer service and model number of the large storage heater are in the table below, for reference when contacting Dimplex.

Vendor	Dimplex
Customer Service Number	0845 600 5111
Equipment Model	XT-24

If the running time of your heaters can be adjusted, the "input control" knob should be turned to 5 and the time switch should be adjusted, to determine how long the heater runs at night. Turn on the heater as late as possible and turn off just before the low energy rate period ends.

If you CANNOT adjust the running time of your heaters, you should adjust the "input control" knob to control the amount of heat stored in the heater.

In both situations, always keep the "boost control" at minimum when you leave. During business hours, turn up the boost control to allow the heater to release heat. The boost control is how fast the stored heat is released. The input control directly affects your bills, while boost control indirectly affects your bills since you might require a higher input. Also consider turning off the heat an hour before leaving the store, in order to further conserve heat.

e. Priority 5: LED Lighting

Action

Consider changing all of the halogen spotlights to LED spotlights. Consider rearranging your shop front for better display of stock, since sunlight restricts potential customer's view into the store.

Explanation

Many old lighting elements have become inefficient over the years. Replacing the existing elements with LED equivalents allows you to save significant amounts of money on your energy bill. Currently, lighting takes up 40% of your total energy consumption. Changing all of the halogen spotlights to LEDs, will save £477 annually based on 37-hour weekly operation. Refer to second chart of Appendix A for suggestions and calculations. The pay back period for changing all halogen spotlights to LED spotlights is about two years, if each bulb costs £10 and each additional fixture costs £30.

Rearranging the front setting so that it displays more of your product, instead of using more indoor lighting to compete with the sun's glare, will attract customers without spending more energy. Since it is difficult to see inside the store during morning and early afternoon hours, putting additional rugs in the display window will allow more of the product to be seen. This may also allow for there to be fewer lights on inside the store, possibly saving on energy bills. However you mentioned that direct sunshine may fade the colors of rugs, so it is up to you to decide whether or not to rearrange your storefront.

5. Brief Summary

In summary it can be seen that there are a number of ways to save energy for this building. Many of these savings are from behavioral changes such as taking regular energy meter readings, and having radiators on appropriate settings. Other changes require some capital but can result in great savings such as the LED lighting, which can save £477/year. Taking these steps and more will help to reduce your energy bill and save you money.

Appendix A Detailed Energy Use Breakdown

This is a detailed break down of your current and proposed energy consumption. All numbers are estimated based on assumptions, meter readings and device ratings and may differ from reality. Assumptions are mostly indicated in the note column.

Below is a calculated annual energy consumption break down for current situation.

	Power	Day Hours each week	Night Hours each week	Weeks	Day Energy	Night Energy	Total	Note on Power Rating	Assumptions on Operating Hours
	kW	h	h		kWh	kWh	kWh		
Storage Heating(winter)	4250	0	30	17	0	2167.5	2167.5	1.7kW and 2.55kW	Nov 1 - Feb 28, 6 hours at night, 5 days a week
Portable Heater(winter)	4700	37	0	17	2956.3	0	2956.3	2.2kW and 2.5kW	Nov 1 - Feb 28, during business hours
Storage Heating(spring)	3000	0	30	9	0	810	810	1.7kW and 2.55kW	Mar 1 - Apr 30, 6 hours at night, 5 days a week
Storage Heating(fall)	3000	0	30	6	0	540	540	1.7kW and 2.55kW	Sep 15 - Dec 30, 6 hours at night, 5 days a week
Strip Lights	160	37	0	51	301.92	0	301.92	two 60W tubes, two 40W tubes	during business hours
Spot Lights (East Wing)	650	37	0	51	1226.55	0	1226.55	13 bulbs, 50W each	during business hours
Spot Lights (Centre)	850	37	0	51	1603.95	0	1603.95	17 bulbs, 50W each	during business hours
Spot Lights (West Wing)	1050	37	0	51	1981.35	0	1981.35	21 bulbs, 50W each	during business hours
Extorior Light	100	6.75	0	52	35.1	0	35.1	2 bulbs, 50W each	6:45-9:30, 17:00-20:00. 405 min per day
Fridge	70	119	49	52	433.16	178.36	611.52		always on
Bug Light	45	119	49	52	278.46	114.66	393.12		always on
Vacuum Machine	1200	0.25	0	52	15.6	0	15.6		15 minues / week
Other Appliances	30	119	49	52	185.64	76.44	262.08	fax and security	always on
Total					9018.03	3886.96	12904.99		

Below is a proposal annual energy consumption break down if you follow all the actions on the action plan. There will be a slight drop in heating and significant drop in lighting related energy consumption.

	Power	Day Hours each week	Night Hours each week	Weeks	Day Energy	Night Energy	Total	Note on Actions

	kW	h	h		kWh	kWh	kWh	
Storage Heating(winter)	7650	0	30	17	0	3901.5	3901.5	Repair large heater; adjust the timer; use heaters correctly
Portable Heater(winter)	4700	0	0	17	0	0	0	stop using
Storage Heating(spring)	5400	0	30	9	0	1458	1458	
Storage Heating(fall)	5400	0	30	6	0	972	972	
Strip Lights	160	37	0	51	301.92	0	301.92	
Spot Lights (East Wing)	64	37	0	51	120.768	0	120.768	use 16 LEDs instead of 13 bulbs
Spot Lights (Centre)	84	37	0	51	158.508	0	158.508	use 21 LEDs instead of 17 bulbs
Spot Lights (West Wing)	104	37	0	51	196.248	0	196.248	use 26 LEDs instead of 21 bulbs
Extorior Light	100	6.75	0	52	35.1	0	35.1	
Fridge	70	119	49	52	433.16	178.36	611.52	
Bug Light	45	119	49	52	278.46	114.66	393.12	
Vacuum Machine	1200	0.25	0	52	15.6	0	15.6	
Other Appliances	30	119	49	52	185.64	76.44	262.08	
Total					1725.404	6700.96	8426.364	

Appendix Q Consultation Report: Vineyard

The Vineyard Energy Consultation

Prepared For:

John Hodges

Prepared By:

Philip Gauthier, Anthony Gianfrancesco, Jillian Morang, Zhongjie Wu

07/04/11

1. Introduction

The purpose of this energy consultation was to discover potential areas of energy reduction and savings within The Vineyard's building. This consultation was conducted using a questionnaire and check list during a walk-through, with supplementary data on past gas and electric usage. The Vineyard is an independent wine merchant, which occupies the lower floor of a recently renovated historic building.

The energy consultation, analysis, and report were completed by four American university students, for a project requirement for Worcester Polytechnic Institute. These students are working with the Mole Valley District Council to help reduce the carbon emissions of small and medium enterprises in the Mole Valley.

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2. Action Plan

The recommendations listed below are prioritized by payback period and estimated costs. Further explanations of each recommendation are provided.

Priority	Recommendations	Estimated Annual Savings			Estimated Costs (£)	Payback Periods (years)
		(£)	CO_2 (tonnes)	(kWh)		
1	Behavioural Changes	-	-	-	Minimal	Immediate
2	Seal holes on the wall	6	21	38	10	1.7
3	Replace cabinet bulbs	186	676	1239	189	1.0
4	Replace ceiling bulbs	534	2081	3817	876	1.6
Total		726	2778	5094	1075	1.5

3. Current Use and Potential Savings

This is a breakdown of your current costs and what your expected cost may be with these recommendations.

Category	Energy Consumption		Costs		CO_2 Emissions	
	kWh/year	%	£/year	%	CO_2 (tonnes)	%
Electricity	13,194	56%	1,979	56%	7,194	79%
Natural Gas	10,372	44.%	1,556	44%	1,921	21%
Total	23,566	100%	3,535	100%	9,115	100%
Projections	23,566		3,535		9,115	

4. Energy Savings

a. Priority 1: Behavioral Changes, No Cost Solutions

Make sure that all radiators are unobstructed and kept on appropriate settings. Obstructed radiators are forced to work harder to heat a room resulting in higher energy usage. Also a radiator that is left on its maximum setting will never turn off and over heat a room. Keeping radiators unobstructed and at a setting of 3 to 4 you will save energy and money.

Site Specific Examples:

- The radiator near Mr. Hodges' desk had boxes piled in front of it. If possible boxes should be kept away from the radiators.

b. Priority 2: LED Lighting

Replace existing lights in the facility with newer lights. Many old lighting elements have become inefficient over the years. Replacing the existing elements with LED equivalents allows you to save significant amounts of money on your energy bill. When purchasing light bulbs, be sure to compare the color temperature and luminosity. In order to attain the appropriate amount of lighting having additional fixtures installed may be necessary. The new light bulbs may qualify for an ECA, see Appendix A to see if it applies.

Site Specific Examples:

- All fluorescent lights should be replaced with lower wattage LED light tubes.

Old Light Bulb Wattage (W)	New Bulb Type	New Light Bulb Wattage (W)*	Price per New Bulb (£)*	Number of Bulbs Replacing	Total Bulb Costs	Total Costs Including Labour***	Savings per Year (£)	kWh Saved per Year (kWh)	Payback Period (years)	Payback Period Including Labour Costs (years)***	CO2 Savings per Year (kg CO2)
50	LED	7	7	30	210	330	592	3,947	0.4	0.6	2,152
20	LED	5	7	27	189	297	186	1,239	1.0	1.6	676

50	LED + Fixture	7	37	18	666	738	355	2,368	1.9	2.1	1,291
---	---	---	Totals	75	1,065	1,365	1,133	7,555	0.9	1.2	4,119

*All calculations are based off pricing and wattage from NET LED

**If you do not know the average price of your electricity use .1 £

***This calculation is base off an insulation cost estimate of £ 4 per light bulb. A professional quotation should be acquired.

c. Priority 3: Envelope and Insulation

Holes in the envelope of a building result in drafts causing the heating system to overwork. Sealing holes in the envelope of the building will reduce energy bills, because the heating and ventilation systems won't have to work as hard to maintain the temperature of the building. Even though you have some insulation during winter, adding better insulation will reduce the amount the room needs to be heated.

Site Specific Examples:

- There is an old ventilation duct, outside of the water closet, which is not sufficiently insulated. Consider adding insulation to the gap between the metal plates.

Figure 1: Ventilation duct needing to be insulated

d. Priority 4: Replace Refrigerators

Using a larger number of smaller refrigerators can consume excess amounts of power. Having more refrigerators also occupies extra floor space, due to their stout construction. Replacing multiple refrigerators with one larger unit would take up less floor space because the one unit will be taller, versus wider.

Site Specific Examples:

- The refrigerator, freezer, and combination unit can be reduced to a single unit. To replace the current configuration, with a similar one, would cost around £200 for each new unit. These replacements would total 350 liters in storage capacity and have an average annual consumption of about 550 kWh per year. When replacing the three current units, look for a single combination unit with similar or larger capacity and less annual consumption.

e. Energy Saving in Future Plans

The following are suggestions for the future. When making an addition or change to the building, have energy consumption in mind.

Site Specific Examples:

- Refer to Appendix B for a document explaining how to shop around for energy companies.
- The room near the water closet may be transformed into a small office in the far future. This will require additional heating to be installed in the area. An energy conscious, but initially expensive, decision would be to use a steam radiator instead of an electrical heating unit.
- After discussion with the planning personnel at the MVDC Pippbrook offices, we were advised that a canopy in front of your business would be a violation of the historical legislation you must comply with.
- Look into getting window insulation film to help improve your building's window insulation.

5. Brief Summary

In summary it can be seen that there are a number of ways to save energy for this building. Many of these savings are from behavioral changes such as making sure people turn lights off, having radiators not be obstructed, and having radiators on appropriate settings. Other changes require some capital but can result in great savings such as the LED lighting, which can save £800/year. Taking these steps and more will help to reduce your energy bill and save you money.

Day Centre Energy Consultation

Prepared For:

Graeme Kane and Andy Carter

Prepared By:

Philip Gauthier, Anthony Gianfrancesco, Jillian Morang, Zhongjie Wu

21/03/11

1. Introduction

The purpose of this energy consultation was to discover potential areas of energy reduction and savings within the Day Centre in Leatherhead. This consultation was conducted using a questionnaire and check list during a walk-through, with supplementary data on past gas and electric usage. The Day Centre is an older building home to a small staff and daily events held for elderly visitors above the age of sixty. Due to its age there are many areas where energy savings can be found.

The energy consultation, analysis, and report were completed by four American university students, for a project requirement for Worcester Polytechnic Institute. These students are working with the Mole Valley District Council to help reduce the carbon emissions of small and medium enterprises in the Mole Valley.

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2. Action Plan

The recommendations listed below are prioritized by payback period and estimated costs. Further explanations of each recommendation are provided.

Priority	Recommendations	Estimated Annual Savings			Estimated Costs (£)	Payback Periods (years)
		(£)	CO_2 (Kg)	(kWh)		
1	Behavioral Changes	-	-	-	Minimal	Immediate
2	LED Lighting	200	1390	2,540	2,860	14.5
3	Envelope and Door Insulation	310	3190	5850	390	1.3
Total		510	4580	8390	3250	6.4

3. Current Use and Potential Savings

This is a breakdown of your current costs and what your expected cost may be with these recommendations.

Utility	Energy Consumption		Costs		CO_2 Emissions	
	kWh/year	**%**	**£/year**	**%**	**CO_2 (Kg)**	**%**
Electricity	31,655.00	23.43	4,263.34	55.87	17,258.94	47.39
Gas	103,430.00	76.57	3,366.85	44.13	19,158.34	52.61
Total	135,085.00	100	7,630.19	100	36,417.28	100
	Projected Energy Consumption	**% Savings**	**Projected Savings(£/year)**	**% Savings**	**Projected CO_2 Emissions (Kg)**	**% Savings**
	126,695	6	7,120	7	31,838	13

4. Energy Savings

a. Priority 1: Behavioral Changes, No Cost Solutions

Make sure that all radiators are unobstructed and kept on appropriate settings. Obstructed radiators are forced to work harder to heat a room resulting in higher energy usage. Also a radiator that is left on its maximum setting will never turn off and over heat a room. Keeping radiators unobstructed and at a setting of 3 to 4 you will save energy and money.

Site Specific Examples:

- Many of the radiators in the building were obstructed by furniture or other items and should be moved accordingly if at all possible. See Figure 1 and Figure 2 below for some examples.

Figure 1: Desk in front of a radiator

Figure 2: Chair in front of a radiator

- When TRV's are put in maintain them at a level of 3-4 unless otherwise needed.
  - In the unused office put the TRV on the lowest setting so that it remains off.
  - In the corridor towards the kitchen the radiators should be on the lowest setting as the kitchen staff will most likely not need the area to be heated.

- In the hair dressers the settings can be kept lower (1-3) as the hair dryers and other equipment will likely supply extra heat.

Turn off lighting and electrical equipment when it is unnecessary. Lights and equipment that are left on when they are not in use consume unnecessary energy. Putting signs up reminding people to turn lights and equipment off when leaving a room will help to save energy. See attached examples on signs to turn off lights.

Site Specific Examples:

- Be sure that the lights in unoccupied rooms are always switched off.
- Try to use more natural light, whenever possible
- Create maintenance schedule for cleaning skylights, to maximize their use.
- Turn off switches on electrical outlets or unplug all items when they are not being used, to avoid using power for items that are not on.
- Motion sensors should be installed in toilets that don't already have them, and the kitchen 'store' room. The lights in the store room are left on all day for the convenience of the kitchen staff, since the switch is located behind the door when it is opened, and they are often in the room for short periods of time.
- Higher traffic rooms, in which the lights are often left on when no one is occupying them, should have motion sensors installed to help decrease energy usage.

b. Priority 2: Envelope and Door Insulation

Doors that protect rooms from different temperature air should close properly and have rubber seals and skirts. Doors that are not insulated or do not close will cause drafts in a building, resulting in the heating and cooling systems to work harder to maintain the buildings temperature.

Site Specific Examples:

- All exterior doors should be insulated with a new rubber seal and skirt, to protect against the loss of heat in the building.
- The inner door of the main entrance vestibule is an automatic door that does not work correctly. The door is stuck open all day, allowing for cold air to enter the building continuously, and should be fixed.
- The exterior door in the dining room does not close properly. The door should be fixed so that the door properly latches when closed.
- The exterior door in the tea room also does not latch closed, leaving much space for cold outside air to enter the building.
- Insulate doors from main corridor to kitchen corridor and check to be sure they stay closed when exterior door of kitchen corridor is opened, to keep heat in main area of the building.

Holes in the envelope of a building result in drafts causing the heating system to overwork. Sealing holes in the envelope of the building will reduce energy bills, because the heating and ventilation systems won't have to work as hard to maintain the temperature of the building.

Site Specific Examples:

- The ceiling vents in the building tend to be forced open by the wind, resulting in cold air flowing into the building. This causes the need for the extract fans to be turned on. The heating also has to work harder when this occurs. Finding a way of keeping the vents closed during the winter will increase the efficiency of the buildings heating system.
    - A recommendation to fix this problem is to install removable covers over the vents.
- Some windows were found to be drafty and in some cases warped to the point that they were partially open on one side. See Figure 3 below.

Figure 3: Warped window

c. Priority 4: LED Lighting

Replace existing lights in the facility with newer lights. Many old lighting elements have become inefficient over the years. Replacing the existing elements with LED equivalents allows you to save significant amounts of money on your energy bill. If LED bulbs are not a viable option at the current time then CFL and fluorescent tubes can be used but make sure that the most efficient ones are in use i.e. T8 or T5's for fluorescent tubes and bulbs with high energy ratings of A or B should be used. The table below breaks down the recommended areas where lighting should be replaced with all the correlating information about payback periods and costs.

Site Specific Examples:

- All fluorescent and incandescent lights should be replaced with lower wattage LED light tubes.

Old Light Bulb Wattage (W)	New Bulb Type	New Light Bulb Wattage (W)*	Hours worked per year	Additional Hours per Week	Number of Bulbs Replacing	Price of Electricity (£)	Total Bulb Costs	Total Costs Including Labour**	Savings per Year (£)	kWh Saved per Year (kWh)	Payback Period (years)	Payback Period Including Labour Costs (years)**	CO2 Savings per Year (Kg of CO2)
65	LED Tube	30	1920	8	10	0.07748	746	786	62	806	12	12.6	440
58	LED Tube	30	1920	8	25	0.07748	1866	1966	125	1613	15	15.7	879
60	LED Bulb	5	1920		1	0.07748	12	16	8	106	1.5	2	58
60	LED Bulb	5	60		6	0.07748	72	96	2	20	46.9	62.5	11
				Totals	42	---	2696	2864	197	2545	13.7	14.5	1388

*All calculations are based off of pricing and wattage from NET LED

**Based off an estimated £4 instillation cost per bulb. Professional quotation should be acquired.

5. Additional Considerations

These are items that should be considered to help increase energy savings. These changes are difficult to quantify due to their vague and varying nature.

Site Specific Examples:

- There should be a maintenance plan set in place for the sky lights to be cleaned so that they are more effective.
- The insulation in the roof is falling out and should be fixed and maintained so that they can keep the building insulated. This will result in savings on the gas bill as the heating will not have to go on as much as possible. The Figure 4 below shows the falling insulation.

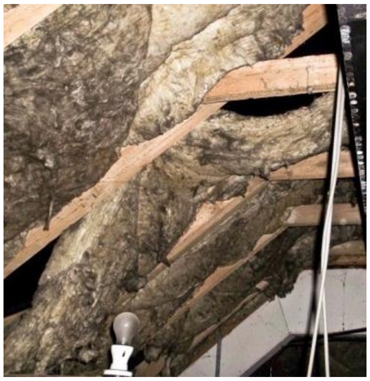

Figure 4: Insulation falling off the roof

6. Brief Summary

In summary it can be seen that there are a number of ways to save energy for this building. Many of these savings will come from the general maintenance of the building, such as ensuring that doors close and are sealed properly, as well as covering vents which bring cold air into the building. Other changes may require more capital outlay, but can result in great savings such as the LED lighting, which can save £200/year. Taking these steps and more will help to reduce your energy bill and save you money.

Appendix S Consultation Report: Falkland Arms

Falkland Arms Energy Consultation

Prepared For:

Christine Broom

Prepared By:

Philip Gauthier, Anthony Gianfrancesco, Jillian Morang, Zhongjie Wu

06/04/11

1. Introduction

The purpose of this energy consultation was to discover potential areas of energy reduction and savings within the Falkland Arms Pub in Dorking. This consultation was conducted using a questionnaire and check list during a walk-through, with supplementary data on past gas and electric usage. The Falkland Arms is a pub in Dorking located in a historic building with two chimneystacks and an outdoor drinking facility. The enterprise has already taken preliminary steps to reducing energy bills such as using thin film insulation on windows and compact fluorescent lighting.

The energy consultation, analysis, and report were completed by four American university students, for a project requirement for Worcester Polytechnic Institute. These students are working with the Mole Valley District Council to help reduce the carbon emissions of small and medium enterprises in the Mole Valley.

<u>Notice:</u> While there has been an effort made to ensure that the information contained in this report is accurate, it should be taken into consideration that some of the information may be incomplete, inaccurate, or become out of date. Therefore, Mole Valley District Council, Worcester Polytechnic Institute, and all associated persons do not provide any guarantees on the information provided in the following report.

2. Action Plan

The recommendations listed below are prioritized by payback period and estimated costs. Further explanations of each recommendation are provided.

Priority	Recommendations	Estimated Annual Savings			Estimated Costs (£)	Payback Periods (years)
		(£)	CO_2 (Kg)	(kWh)		
1	Building Envelope	219	1444	4350	220	1.0
2	Lighting Control in Toilets	28	165	303	120	4.2
3	LED Lighting	168	978	1794	473	2.8
Total		415	2597	6447	813	2.0

* This factors in putting thin film insulation on kitchen windows, not replacing them with double pane. This is because this option is more feasible due to initial investment cost.

3. Energy Savings

a. Priority 1: Building Envelope

Inefficient building envelope or fabric can result in a loss of heating energy. The goal of upgrading building fabric is to separate outside air from infiltrating the building envelope. Large amounts of windows, holes or gaps in the building's exterior and poor quality windows can all contribute to compromising the effectiveness of the overall building insulation.

Site Specific Examples:

- The single-pane windows and backdoor in the kitchen can be enhanced for better insulation. There are two sensible options present here: Use thin film insulation over the windows or upgrade to double pane windows.

Old Window	New Window	Installation Cost	Price of Gas	Money Saved per Annum	kWh saved per Annum	kg CO_2 Saved per Annum	Payback Period (years)
Single Pane w/o Thin Film	Single Pane /w Thin Film	100	0.034	97	2850	528	1
Single Pane w/o Thin Film	Double Pane /w thin film	2100	0.034	152	4468	828	13.8

- The chimneys to the fireplaces are a contributor to cold air infiltrating the building envelope. Consider attaining a chimney flue to stop cold air from entering the building. Also, look into a more elaborate scheme to block the fireplace entrance when it is not being used. Cardboard is a fairly good insulator however the current insulating scheme does not seem to fit the fireplace hole very well.
- Exterior doors and the door to the W.C. should all be checked to ensure that rubber seals are in place and are stopping cold air penetration to the bar/lounge area.

- The old ventilation fans should be removed/filled. These holes are approximately one square meter and are located near the ceiling, so any hot air collected is leaked out through these old holes.

Item and where its located	Quantity	Est. Cost of Each Item	Marginal Energy Saving/item	Electricity/ Gas Cost	Annual Saving	Total Investment	Payback Period	kWh saved	Carbon Emission Reduction
Units =>	ea.	£	W	£ / kWh	£	£	year	kWh	kg
Ventilation hole	2	20	500	0.03	81	40	0.5	1080	589
Exterior Doors	2	30	200	0.03	36	60	1.7	480	262
W.C. Doors	1	20	50	0.03	5	20	4.0	120	65
				Totals	122	120	1.0	1680	916

b. Priority 2: Lighting Control in Toilets

Lights that are on when they are not needed consume extra energy. There are different situations which can result in lights being on, though they not needed. Timed lights, lights in often though not continuously used areas, or incorrectly zoned lights are some examples of why more lights may be in use than are needed.

Site Specific Examples:

- Toilettes are frequently used areas, where the lights are left on when no one is in the room. All the toilettes in the building should have motion sensors installed on the lights. This will save energy by turning off the lights when the room is not being used, while adding the convenience of having the lights turn on when someone enters the area. For added employee convenience with motion sensors, check to see if it has a timer.

Light Bulb Wattage (W)	Sensor*	Number of Bulbs	Sensor price	Number of Sensors	Price of Electricity (£)	Total Cost	Current Spending	New Spending**	Savings per Year (£)	kWh Saved per Year (kWh)	Payback Period (years)	CO_2 Savings per Year (kg CO_2)
12	Motion Sensor	10	60	2	0.1	120	43	14	28	303	4.2	165

*Motion sensor price was estimated from prices on lightinguniverse.com/sensors_3146.html

**The new spending is based off the estimation that the lights will remain on for only a third of the time they are currently on

c. Priority 3: LED Lighting

Replace existing lights in the facility with newer lights. Many old lighting elements have become inefficient over the years. Replacing the existing elements with LED equivalents allows you to save significant amounts of money on your energy bill. If LED bulbs are not a viable option at the current time then CFL and fluorescent tubes can be used but make sure that the most efficient ones are in use i.e. T8 or T5's for fluorescent tubes and bulbs with high energy ratings of A or B should be used. The table below breaks down the recommended areas where lighting should be replaced with all the correlating information about payback periods and costs.

Site Specific Examples:

- All halogen spotlights and CFL bulbs can be replaced with lower wattage LED lighting where possible.

Old Light Bulb Wattage (W)	New Bulb Type	New Light Bulb Wattage (W)*	Price per New Bulb (£)*	Number of Bulbs Replacing	Price of Electricity (£)	Total Bulb Costs	Savings per Year (£)	kWh Saved per Year (kWh)	Payback Period (years)	CO2 Savings per Year (kg CO2)
50	LED	7	43	11	0.093	473	168	1794	2.8	978

*All calculations are based off pricing and wattage from Halers Lighting 2011 Catalogue

**This calculation is base off an insulation cost estimate of £ 4 per light bulb. A professional quotation should be acquired.

4. Additional Considerations

These are items that should be considered to help increase energy savings.

Site Specific Examples:

- From brief conversation with Planning employees in the Pippbrook building, it seems as though the doors and windows located in the back of the building are not considered historic because they are located in the back of the building where they are not seen by the public. The staff offers free advice upon email containing a short description of the project including pictures of its location relative to the storefront.
- Fireplace heating is a very aesthetic and cozy option for heating, however much of the heat produced by the actual flame is leaked through the chimney. Another option would be to completely block up the chimney to stop cold air from infiltrating the building, however no fire will be present, and the pub may lose the cozy ambiance. The best option for fireplace heating is a wood pellet stove. This will keep the aesthetic of a fireplace however; will lose the sounds and actual feel of a raw fire. Not only will the sounds of a raw fire will be lost, you will also lose the cold draft present from the chimney, which would help increase the building envelope the same way the previous option would.

  There are two options with the wood pellet stove; one option is a standalone unit another is a unit that can be put in the chimney. The chimney insert is good as it will prevent drafts leaking out the chimney but you lose the use of the fireplace and will be a little more expensive than the standalone unit. The standalone unit will give you back the use of the fireplace but will require finding a location to put the unit in the room. Both options will hopefully help to supplement your current heating and enable you to lower your heating system and lower your heating bill.
- Some LED holiday lights are being used out in the garden. There are some that are not LEDs, consider replacing these with LED lights.
- Flush controllers for urinals in the Gentlemen toilets to sense motion or times used. A piece of technology you may wish to purchase that takes advantage of the ECA can be found here: http://goo.gl/yXELm. There is also another product from the same company with a few small changes that also applies, this can be found here: http://goo.gl/k9ADE.

Cost*	Number of units	Percent Savings**	Current Costs per year	Savings per year	Estimated payback
£350.00	2	30%	£500.00	£150.00	4.7
*Cost was estimated					
**Percent savings information from cistermiser.co.uk/IRC-Valve.aspx					

5. Brief Summary

In summary it can be seen that while this building is already doing very well in energy efficiency, there are still areas which can be improved to help reduce energy usage. Many of these steps are of a higher cost or more difficulty, but will be worth the change due to the amount saved on energy bills.

Appendix T Consultation Report: Polesden Lacey Infant School

Polesden Lacey Infant School
Energy Consultation

Prepared For:

Rowena Bruce: Finance Officer

Prepared By:

Philip Gauthier, Anthony Gianfrancesco, Jillian Morang, Zhongjie Wu

21/03/11

1. Introduction

The purpose of this energy consultation was to discover potential areas of energy reduction and savings within the Polesden Lacey Infant School building. This consultation was conducted using a questionnaire and check list during a walk-through, with supplementary data on past gas and electric usage. Polesden Lacey Infant School is an Eco school and won Sustainable School of the Year 2010 during the Teaching Awards at the London and South East Finals. Due to its current efforts towards carbon efficiency we are only able to provide a few minor suggestions.

The energy consultation, analysis, and report were completed by four American university students, for a project requirement for Worcester Polytechnic Institute. These students are working with the Mole Valley District Council to help reduce the carbon emissions of small and medium enterprises in the Mole Valley.

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2. Action Plan

The recommendations listed below are prioritized by payback period and estimated costs. Further explanations of each recommendation are provided.

Priority	Recommendations	Estimated Annual Savings			Estimated Costs (£)	Payback Periods (years)
		(£)	CO_2 (Kg)	(kWh)		
1	Radiator Efficiency	-	-	-	Minimal	Immediate
2	Boiler Valve Insulation	100	430	2340	500	5
Total		100	430	2340	500	5

3. Current Use and Potential Savings

This is a breakdown of your current costs and what your expected cost may be with these recommendations.

Utility	Energy Consumption		Costs*		CO_2 Emissions	
	kWh/year	%	£/year	%	CO_2 (Kg)	%
Electricity	23,696	18	237	5	12,920	81
Gas	107,971.50	82	4,319	95	20,000	19
Total	131,668	100	4,556	100	32,919	100
	Projected Energy Consumption	% Savings	Projected Savings(£/year)	% Savings	Projected CO_2 Emissions (Kg)	% Savings
	131,238	0.33	4,456	2.2	32,489	1.3

***This is assuming rates of 4p for gas and 10p for electricity. More accurate estimations can be determined with accurate prices.**

4. Energy Savings

a. Priority 1: Radiator Efficiency

Make sure that all radiators are unobstructed and kept on appropriate settings. Obstructed radiators are forced to work harder to heat a room resulting in higher energy usage. Also, a radiator that is left on its maximum setting will not turn off, and will over heat a room. Keeping radiators unobstructed and at a setting of 3 to 4 you will save energy and money.

Site Specific Examples:

- In the front entrance the radiator is blocked by chairs and a table. Consider rearranging this area to allow the heating system to work more efficiently.

Figure 1: Chairs and table blocking radiator

- Several radiators throughout the building were set to max. This can cause over heating because the radiator won't shut off when the room is warm. All radiators should be checked and set between three and four at most, to provide the most effective use of the system.

b. Priority 2: Boiler Valve Insulation

The valves on heated pipes can lose heat and cause the system to work harder than necessary. Insulating these valves will increase the efficiency of the heating system and decrease carbon emissions.

Site Specific Examples:

- Consider insulating the valves on all heated pipes in the boiler room. You can do this on your own, buying the insulation, or have a company come in and give you a free quote to have the insulation done professionally. You may also be able to apply for Enhanced Capital Allowance (ECA), which will help pay for some of the insulation through tax breaks. For more information on ECA go to: www.eca.gov.uk/

5. Brief Summary

This building and its occupants are already making great efforts to reduce their energy usage and carbon emissions. The few given suggestions will help to further reduce energy bills. The Polesden Lacey Infant School sets an example in eco awareness which others should follow.

Appendix U Consultation Report: Ashtead Squash and Tennis Club

Ashtead Squash and Tennis Club Energy Consultation

Prepared For:

Tony Cooper and George Gregory

Prepared By:

Philip Gauthier, Anthony Gianfrancesco, Jillian Morang, Zhongjie Wu

20/04/11

1. Introduction

The purpose of this energy consultation was to discover potential areas of energy reduction and savings within the Ashtead Squash and Tennis Club building in Ashtead. This consultation was conducted using a questionnaire and check list during a walk-through, with supplementary data on past gas and electric usage. The Club has three courts for playing squash inside its perimeter. There is also a fully functioning area for catering events, which includes a kitchen and pub.

The energy consultation, analysis, and report were completed by four American university students, for a project requirement for Worcester Polytechnic Institute. These students are working with the Mole Valley District Council to help reduce the carbon emissions of small and medium enterprises in the Mole Valley.

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2. Action Plan

The recommendations listed below are prioritized by payback period and estimated costs. Further explanations of each recommendation are provided.

Priority	Recommendations	Estimated Annual Savings			Estimated Costs (£)	Payback Periods (years)
		(£)	CO_2 (Kg)	(kWh)		
1	Behavioural Changes	---	---	---	---	---
2	New Lighting	403	2,198	4,032	947	2.35
3	Envelope	6	108	200	50	8
Total		409	2,306	4,232	997	2.43

3. Energy Savings

a. Priority 1: Behavioral Changes, No Cost Solutions

Make sure that all radiators are unobstructed and kept on appropriate settings. Obstructed radiators are forced to work harder to heat a room resulting in higher energy usage. Also a radiator that is left on its maximum setting will never turn off and over heat a room. Keeping radiators unobstructed and at a setting of 3 to 4 you will save energy and money.

Site Specific Examples:

- The radiator in the vestibule has a rubbish bin resting against it. Consider placing the basket in another area to allow for maximum heat flow.

b. Priority 2: Energy Efficient Lighting

Replace existing lights in the facility with newer lights. Many old lighting elements have become inefficient over the years. Replacing the existing elements with LED equivalents allows you to save significant amounts of money on your energy bill. If LED bulbs are not a viable option at the current time then CFL and fluorescent tubes can be used but make sure that the most efficient ones are in use i.e. T8 or T5's for fluorescent tubes and bulbs with high energy ratings of A or B should be used. The table below breaks down the recommended areas where lighting should be replaced with all the correlating information about payback periods and costs.

Site Specific Examples:

- All halogen spotlights can be replaced with lower wattage lighting where possible. LED lights are also dimmable, so they will work with the current fittings. The calculations below do not include the 50 Watt halogen GU-10 spotlight fittings.

Old Light Bulb Wattage (W)	New Bulb Type	New Light Bulb Wattage (W)*	Price per New Bulb (£)*	Number of Bulbs Replacing	Total Bulb Costs	Savings per Year (£)	kWh Saved per Year (kWh)	Payback Period (years)	CO2 Savings per Year (Kg of CO2)
60.00	LED R63	5.00	36.00	24.00	864.00	355.00	3,548	2.43	1,935
40.00	LED R50 E14	4.00	17.00	5.00	85.00	49.00	484	1.75	264
			Totals	29.00	949.00	404.00	4,032	2.35	2,199

*All calculations are based off of pricing and wattage from NET LED

**If you do not know the average price of your electricity use .1 £

***Based off an estimated £4 instillation cost per bulb. Professional quotation should be acquired.

c. Priority 3: Building Envelope

Increasing the building envelope keeps inside air separate from outside air and therefore save energy. Exterior doors and windows can be improved with very low monetary investment. Instead of purchasing new windows, make the old ones work in a more efficient manner.

Site Specific Examples:

- The windows that surround the building can be more efficient with the aid of window insulation film. Specifically convection control film which cuts down the amount of heat lost from the inside of the building. It can also prevent window condensation, another reason for heat loss.

Estimated Values

Number of Windows (Approx)	kWh Saved per Window per Year	Total kWh Saved per year	Total CO_2 saved per year (kg)	Total Savings (£)
50	4	200	108	6

- The squash courts, specifically Court 1 with its three exterior walls, should be isolated from the first and second floor lounge area. This can be done by adding rubber seals to the upper and side thresholds of the door and a rubber skirt to the bottom. These seals will stop cold air from infiltrating the heated space.
- The front doors to the building and the lobby doors should have door skirts similar to the interior doors. The difference with the lobby doors is that there is a gap between the two doors in the middle. Side skirts can be added to ensure that cold air does not infiltrate the rest of the building.

- The exterior door in the beer storage room has a large gap under between the bottom of the door and the concrete threshold. Cold air can escape through this and cause wasted electrical energy. Consider sealing this door even more rigorously than the others due to the large amount of energy used in this room.

Item and where its located	Quantity	Est. Cost of Each Item	Est. Total Installation Cost	Marginal Energy Saving per item	Usage per Day	Days per Year	Unit Heat from Unit Electricity	Electricity or Gas Cost	Annual Saving	Cost of Product	Payback Period	kWh saved	Carbon Emission Reduction
Units =>	ea.	£	£	W	h	days	efficiency	£ / kWh	£	£	year	kWh	kg
Doors looking over Squash Courts	2	12	0	200	4	137	0.8	0.03	8.22	24	2.9	109.6	60
Exterior Doors	3	25	0	200	12	137	0.8	0.03	36.99	75	2.0	328.8	179
Interior doors	5	12	0	75	4	137	0.8	0.03	7.71	60	7.8	41.1	22
Thin film in kitchen	10	5	0	500	4	137	0.8	0.03	102.75	50	0.5	274	149
								Total	155.67	209	1.3	753.5	411

4. Additional Considerations

These are items that should be considered to help increase energy savings.

Site Specific Examples:

- When considering the use of motion sensors, first read the attached document, in Appendix A, which explains how purchasing energy efficient equipment can result in tax refunds.
- Contact the Lucozade vendors to see if a more energy efficient vending machine can be installed instead of the older model currently in place. Energy Star vending machines consume up to 15% less energy than the non-Energy Star model.

5. Brief Summary

In summary it can be seen that while this building is already doing very well in energy efficiency, there are still areas which can be improved to help reduce energy usage. Many of these steps are of a higher cost or more difficulty, but will be worth the change due to the amount saved on energy bills.

Appendix V Consultation Report: Denbies Wine Estate

Denbies Energy Consultation

Prepared For:

Victor Maguire

Prepared By:

Philip Gauthier, Anthony Gianfrancesco, Jillian Morang, and Zhongjie Wu

24/04/11

1. Introduction

The purpose of this energy consultation was to discover potential areas of energy reduction and savings within the Denbies Wine Estate. This consultation was conducted using a questionnaire and checklist during a walk-through, with supplementary data on past gas and electric usage. Denbies is a large facility with many different things inside of it. There is a electrically powered train, a retail store, an office building, conference rooms, vehicles to provide tours of the estate, and many other things.

The energy consultation, analysis, and report were completed by four American university students, for a project requirement for Worcester Polytechnic Institute. These students are working with the Mole Valley District Council to help reduce the carbon emissions of small and medium enterprises in the Mole Valley. This report will lack in specific examples due to the short amount of time we spent in each room. This report consists of observations we picked up on while we were walking through the facility.

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2. Energy Savings

a. Behavioral Changes

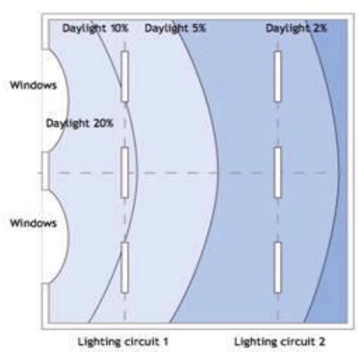
Behavior changes may seem small at the time of implementation, but they can add up to make a large difference in the long run. Make sure that all radiators are unobstructed and kept on appropriate settings. Obstructed radiators are forced to work harder to heat a room resulting in higher energy usage. Also a radiator that is left on its maximum setting will never turn off and over heat a room. Keeping radiators unobstructed and at a setting of 3 to 4 you will save energy and money. Turning off unnecessary lighting or choosing to work in the dark are more type of behavioral changes that can occur.

b. Lighting Control

Lights that are on when they are not needed consume extra energy. There are different situations that can result in lights being on, though they are not needed. Timed lights, lights in not continuously used areas, or incorrectly zoned lights are some examples of why more lights may be in use than are needed.

Site Specific Examples:

- Toilettes are frequently used areas, where the lights are left on when no one is in the room. All the toilettes in the building should have motion sensors installed on the lights. This will save energy by turning off the lights when the room is not being used, while adding the convenience of having the lights turn on when someone enters the area. For added employee convenience with motion sensors, check to see if it has a timer.
- The lights in the open office areas of the building are zoned in square sections. These lights should be zoned such that the line of lights closest to the windows are one zone with subsequent zones moving further from the windows. If they are zoned in this manner, the lights closest to the windows can be turned off when the sun provides sufficient lighting, therefore saving energy. This means, with sufficient sunlight, approximately one eight to one quarter of a large room's energy consumption can be cut, and one half of a small office can be cut.



c. Energy Efficient Lighting

Replace existing lights in the facility with newer, more efficient lights. Many old lighting elements have become inefficient over the years. Replacing the existing elements with LED equivalents allows you to save significant amounts of money on your energy bill. If LED bulbs are not a viable option at the current time then CFL and fluorescent tubes can be used but make sure that the most efficient ones are in use i.e. T8 or T5's for fluorescent tubes and bulbs with high energy ratings of A or B should be used. All fitting types except for large warehouse high-pressure sodium bulbs should have LED equivalents.

d. Building Envelope

Inefficient building envelope or fabric can result in a loss of heating energy. The goal of upgrading building fabric is to separate outside air from infiltrating the building envelope. Large amounts of windows, holes or gaps in the building's exterior and poor quality windows can all contribute to compromising the effectiveness of the overall building insulation.

Site Specific Examples:

- The double-pane windows and glass doors can be enhanced for better insulation. There are two options present here: Use thin film insulation over the windows, use low e-coating, or upgrade to windows that contain low-e coating within them. The low e-coating is specifically for the windows in the restaurant area because you had advised us that it becomes terribly hot there in the summer.
- Exterior doors and the door to the W.C. should all be checked to ensure that rubber seals and gaskets are in place so that they can stop cold air penetration to the inside of the building.

e. Additions to Building Management System

Adding controls or sensors to a BMS will allow it to work less and, therefore save energy. Controlling the air flow and temperature in a building, especially a larger one, can be stressful and time-consuming for the facilities staff. The BMS is an automatic control that handles most of the managing load with timers and electronic thermostat settings. When the BMS has more information, it can work in a more efficient manner and help cut costs. Some devices can be added to the BMS to help it work in a smarter manner.

Site Specific Examples:

- Oxygen sensors measure the amount of oxygen extracted from a room, with these linked to a BMS, it could make way for a closed loop ventilation system. When the system senses a low-level of oxygen in the air, the outside air vent will open allowing for fresh air to mix in. When the vent is closed, old air is reused to make the system work less hard.

f. Downsize/Condense Energy Using Products

Using any number of smaller refrigerators instead of an equivalent sized unit consumes excess amounts of power. Having more refrigerators also occupies extra floor space, due to their geometry. Replacing multiple refrigerators with one larger unit would take up less floor space because the one unit will be taller instead of three wide small units. This can be extended to any energy using product that can be compacted, such as lighting if an area is over lit take light bulbs out or put a lower wattage one in.

3. Additional Considerations

These are items that should be considered to help increase energy savings, though they may not seem practical at the time. New technology is being developed every day and the costs of consumable energy are rising. These are also put in place to start you thinking about more ways to save on energy consumption too.

Site Specific Examples:

- Flush controllers for urinals in the Gentlemen toilets to sense motion or times used. A piece of technology you may wish to purchase that takes advantage of the ECA can be found here: http://goo.gl/yXELm. There is also another product from the same company with a few small changes that also applies, this can be found here: http://goo.gl/k9ADE.
- Consider hybrid vehicles for the outdoor tours to cut down on fuel costs and emissions. Since tours are most likely conducted at a slow and constant speed, a hybrid would be a good fit for this kind of scenario.
- Also, the diesel vehicles that tour the Denbies facilities can be run on used vegetable oil. A simple kit can be bought so that the trucks can be converted to a completely non-diesel machine. Also consider this to reduce fuel prices.
- Consider the purchase of a Power Perfector or voltage optimizer. This makes equipment run on a lower voltage. Energy using products such as refrigerators and lighting are known to work on a lower voltage. There may be problems with other kinds of equipment however. Projectors are notorious for not being compatible at a lower voltage. Other things such as the train tours are performed on and kitchen equipment may not work. Consult an electrician about such a product as you may be able to save a large amount of money.
- Obtain monitoring equipment similar to what Biwater, above the National Rail Dorking train station. They have equipment which monitors water usage, electrical usage, and gas usage for the whole building on a half-hourly basis and displays it in their lobby for patrons to see. This helps energy savings because it allows you watch your consumption in real time and turns saving energy into a game.

4. Brief Summary

In summary, it can be seen that while this building is already doing very well in energy efficiency, there are still areas which can be improved to help reduce energy usage. Many of these steps are of a higher cost or more difficulty, but will be worth the change due to the amount saved on energy bills. Savings opportunities in this report have not been quantified due to the large amount of variables present in the calculation that could not be observed during the quick walk-through performed. We suggest that you take advantage of the most useful suggestions first with the quickest payback period. We recommend that you seek the opinion of another expert to check our numbers and suggestions. Good luck and happy savings!