Reducing The Carbon Output Of A Modern Commercial Building

CSA Grade 5 Thesis

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Introduction

The burning of fossil fuels for energy production releases greenhouse gases such as CO_2 into the Earth's atmosphere. These greenhouse gases accumulate to form a barrier which prevents solar radiation from leaving the Earth's atmosphere. This process is known as the greenhouse effect.

The greenhouse effect plays a vital role in keeping this planet warm and without it the Earth would be uninhabitable. However, scientists believe that an excessive amount of greenhouse gases are entering the atmosphere as a result of human activity. This is causing an enhanced greenhouse effect and as a result global temperatures are increasing and climates are changing.

In order for mankind to counter act the detrimental effects that modern lifestyles are having on our planet, public awareness of the problem needs to be improved and everybody on this planet must do their bit to help tackle the problem. This will involve the reduction of energy consumption and the adoption of cleaner renewable energy which does not involve the release of greenhouse gases.

Reducing the Carbon Footprint of a Modern Commercial Building

The built environment is the single biggest contributor to energy consumption in the UK accounting for approximately 70% of the country's total primary energy consumption. Within this domestic housing is accountable for 42% of energy usage, industry 34% and services 23%.

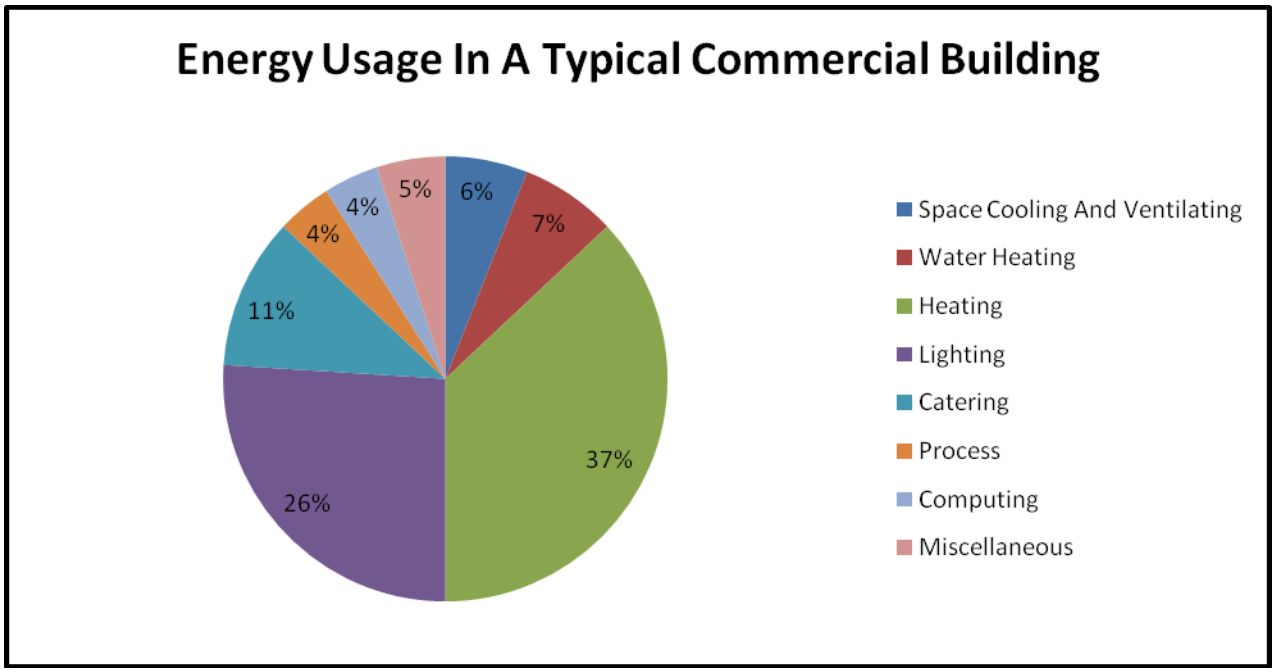
This thesis will concentrate on a modern air conditioned, commercial office building. To begin with, the energy usage profile of a typical building will be studied. From this, potential areas for energy savings will be identified and the arguments for and against the use of solar energy will be discussed.

There are two ways in which the carbon footprint of a building can be reduced. These are;

1) Reduce the amount of energy that the building uses.
2) Find alternative low carbon renewable energy sources to satisfy the energy requirements of the building.

In order to assess the areas in which energy usage can be reduced, it is first necessary to analyse the main services that use energy within a building. From this it is possible to consider ways in which these

energy demands can be reduced. The following pie chart shows the areas in which energy is used within a modern air conditioned commercial office building.



Source = BRE report – Reducing Carbon Emissions From Commercial And Public Sector Buildings In The UK. **Chart produced in Microsoft Excel**

As can be seen from the above chart, the main use of energy in a commercial building is space conditioning with heating, cooling and ventilating contributing a combined total of 43% of a buildings energy demands. This is an obvious area that should be considered when striving to make a building more energy efficient.

Lighting, with 26% of a buildings overall energy usage, is another area that considerable energy savings may be made. The use of energy saving light bulbs is one way in which the amount of energy per lumen can be reduced.

Reducing Energy Consumption of Space Conditioning

In order to maintain comfortable working conditions in office buildings it is necessary to maintain suitable levels of fresh air whilst cooling or heating air within the building to comfortable temperature and humidity levels. This process of comfort conditioning is the most energy intensive service within a

building. There are many ways that energy usage for comfort conditioning can be reduced. These include;

1) **Building Envelope thermal improvement.**

Thermal efficiency of a building will greatly influence the amount of energy required to maintain comfort levels within it. The envelope of a building should be hermetically sealed to prevent infiltration of unconditioned air and the escape of conditioned air. A higher infiltration rate will lead to increased energy requirements to maintain comfort levels.

The use of insulating materials on the envelope of the building will reduce the amount of heat transfer into and out of the building. Materials with higher 'U' values have improved insulating properties. The use of such materials will reduce the amount of energy used to maintain comfort levels by reducing the amount of heat energy lost or gained through the external materials of the building.

2) **Lower Comfort Levels**

It is a common situation for air conditioning systems in buildings to control to temperature set points of 21 – 23 ^{o}C. This usually involves cooling the air within a space to maintain these temperatures. Cooling is one of the most energy intensive processes as it involves the use of refrigerant systems which incorporate compressors and pumps to remove heat energy from the air.

Cutting down cooling requirements would mean that energy would be saved by reduced demand on pumped chilled water systems cutting down both the required pump flow and the load required on the chillers.

Most people are comfortable in temperatures of 23 - 25 ^{o}C. In fact it is often found that people in offices at 21 ^{o}C complain that they are cold and it is a common occurrence to see people with portable electrical heaters on underneath their desks. This is a complete waste of energy as energy is being used both in the running of the heater and of course the air conditioning system is expending more energy as it works against the heater to maintain its set temperature. If space temperature set points were adjusted to around 25 ^{o}C, the energy saved would considerably reduce the amount of energy required for cooling.

The above scenario however is the reverse in the winter when the space may require heating. As the outside air temperature will be a lot lower and heat losses from the building will be greater, there will be a higher demand for heating. The increased internal temperature set point of 25 ^{o}C would therefore mean that heating demand would be increased from the original situation when the set point was 21 – 23 ^{o}C. However, the heating of a space is a lot less energy intensive than cooling. Also, heat gains will be

present from equipment and bodies providing a source of “free” heating. Careful control of the internal temperature setpoint could lead to reduced energy demand.

3) Tighter Controls And Efficient Sizing Of Plant

Another way of reducing the energy consumption of AC plant is to ensure that the control systems that are in place are effective. A poorly controlled system will lead to excessive energy consumption as spaces are overcooled or over heated. An example of this would be a poorly placed return air sensor that may be picking up heat directly from a light fitting or electrical appliance. This would lead to the system cooling the area when the temperature of the room may actually be quite acceptable.

The deployment of variable frequency drives on all motors and drives is a way of reducing energy consumption. Although the monetary cost of an inverter is high, the energy saving to be made by running a pump at say 45 Hz rather than 50 Hz is significant over the lifetime of the plant. The use of inverters or variable resistors to control motor speed means that a motor will pull less current and use less energy.

Plant and duct/ pipe systems should be effectively sized to ensure that excessive resistance is not applied to the system requiring higher levels of pumping power which in turn requires larger motors.

Effective commissioning of HVAC systems is extremely important to ensure that energy wastage is kept to a minimum. A poorly commissioned system will not function within its design parameters leading to detrimental effects on comfort levels and consequently on energy consumption.

A new installation should be designed with commissioning in mind. All necessary VCD’s, metering stations, valves e.t.c should be installed in the correct locations to allow effective commissioning of the system.

4) Use Of Passive Conditioning Systems

It is sometimes possible to use passive heating, cooling or ventilating systems that do not require electrical energy to condition the office space. Strategies such as night cooling can be used to remove heat that has accumulated throughout the working day. Cold night air is allowed to pass through the building which lowers the temperature of the building fabric. The following day, the cooled materials can absorb more heat energy leading to lower internal temperatures.

Natural ventilation can also be used to reduce the energy needed to provide fresh air to the building occupants.

Microgeneration technologies

The methods discussed so far concentrate on ways to reduce the amount of energy a building uses. To further reduce the carbon footprint of a building, it is possible to adopt 'cleaner' renewable energy supplies that do not produce carbon dioxide.

The Department of Trade and Industry DTI is striving to ensure that more electricity supplied from the national grid is produced from zero or low carbon technologies; however, it is often possible to generate power on a local scale and reduce the demands that a building will have on the national energy grid. The technologies employed in local renewable energy production are referred to as micro generation technologies.

There are several micro generation technologies that can be incorporated into a commercial building. These include;

Photovoltaic (PV) – Solar power

Wind Power

The use of wind power is a very limited option due to the limitations of wind direction and velocity in certain areas. Wind plant needs to be large to produce significant amounts of power and is not aesthetically pleasing.

This thesis will evaluate the use of photovoltaic energy generation and will assess the suitability of the technology for commercial buildings.

Photovoltaic Energy Generation

PV cells consist of several layers of doped semi conductor material such as silicon. The term doping refers to the deliberate addition of impurities to manipulate the charge of the material.

A PV cell consists of positive (P type) and negative (N type) semi conductor materials arranged in layers. The cell operates by converting photons from the solar radiation striking the P-N junction into an electrical current. The electrical current is DC and can be used to charge batteries or passed through an inverter to convert it into AC for use to power electrical appliances.

PV cells have been used within small electronic devices for some time and have been used a source of energy for satellites since the launch of the Vanguard 1 satellite in 1958. The technology has been adapted for use in buildings as a form of renewable energy. An example of a building that makes use of

PV technology is the International Solar Office in Sunderland. The building houses a 73kW PV installation that supplies a third of the buildings total electricity needs.

There are several types of PV installation to consider.

Pure PV systems refer to the installation of an array of PV cells onto an existing roof which do not form part of the fabric of the building.

Building integrated PV systems whereby the array of PV cells is incorporated as part of the buildings fabric. This thesis will evaluate the feasibility of this type of system.

Feasibility Of PV Systems

There are arguments for and against a landlord specifying building integrated photovoltaic systems (BIPV) into the design of a commercial building. These arguments are considered in bullet point form below;

Arguments For BIPV

- Provides a source of clean energy without continued release of carbon into the atmosphere.
- Equipment is quiet, clean and relatively unobtrusive.
- PV panels are low maintenance and only require occasional cleaning.
- Systems can be integrated into the buildings fabric and may be used architecturally to be visually unobtrusive or to highlight the green nature of the building.
- The systems are modular in nature and installations of varying capacities can be easily applied.
- The PV panels contain a low embodied energy. This means that the energy expended in their manufacture is relatively low thus making them even more environmentally friendly.
- Onsite energy generation means less wasted energy through transmission losses of supply.
- The green image of the building may be attractive to prospective tenants that may be striving to reduce their carbon footprint. This gives the building an edge over buildings that do not use renewable sources.

Arguments Against BIPV

- The initial setup costs of a BIPV system are relatively high. Although these costs are somewhat offset by the savings made through other building fabric materials, a PV system is still expensive to install and commission.
- The high cost of install and the low cost of electricity from energy suppliers means that the payback period of the system is very long. This makes the system less economically attractive.
- Lack of incentive from government to employ PV systems. A business is currently not offered any monetary incentive to adopt renewable energy sources. Although interest free grants are available, business rate cuts could be made to those adopting renewable energy based on the amount of energy obtained from low carbon sources.
- Amount of energy generated would vary depending on cloud cover and could not be taken for granted.

Weighing Up The Costs

The relatively high costs involved in the commissioning of a PV installation is the factor that discourages many developers from incorporating it into a design. Research carried out from various sources has enabled the cost of a 30kW BIPV system to be calculated. This, along with the amount of energy the installation should be expected to produce and a theoretical cost of a unit of electricity from an energy supplier has allowed the payback period of the installation to be calculated. The payback period refers to the amount of time it would take for the money saved from the purchase of electricity from the supplier to equal the cost of the setup.

Note – no interest or discounting has been applied to the calculation and the unit cost of £ 0.09 per kW/h unit is based upon my home electricity cost with several pence knocked off for a high user tariff. This calculation is not completely accurate and is used to illustrate the high costs of the system.

According to a report by Cambridge Consultants published by DTI in 2001 a BIPV system that uses panels to replace building fabric costs £1.74 per Watt after the offset of the construction material savings is factored in.

So for a 30kW installation the cost would be approximately £ 52,200.

Each kW p generates approximately 750 kW h per year. So a 30kW system would generate around 22,500 kW h per year.

Based on the hypothetical cost per kW h of energy from a supplier of £0.09, the cost of 22,500 units would be £ 2025.

Based on the above figures, it would take 25.78 years to pay for itself since;

£52,200 ÷ £2,025 = 25.78

Upon visiting www.electricity4business.co.uk it can be seen that costs per kW h can be as low as 6.4 pence which would make the payback period even longer.

Summary and Conclusion

There are many ways in which the carbon output of a modern commercial building can be reduced. There is no single right or wrong answer when considering the possibilities as every building is an individual case.

Developers need to adopt a mixture of the carbon saving strategies discussed in order to find a balance between energy saving and profitability.

Renewable energy sources are certainly the way forward but in order for them to be financially viable, the cost of such systems must be significantly reduced. As it stands, the prospect of a BIPV system is not attractive to profit making organisations due to the high setup cost and low prices of energy from suppliers.

However, the cost of PV systems has already fallen dramatically over the past decade and it is forecasted that further reductions of as much as 50% can be expected by 2010 due to the increased use of the technology and savings through economies of scale. Coupled with the inevitable hike in UK energy prices, the prospect of renewable will become more inviting.

More could be done by Government to encourage businesses to adopt micro generation technologies such as reduced taxes for users e.t.c which would improve the attitude of profit making organisations towards renewable energy.

Although the monetary cost to business may be relatively high, the cost to humanity of excessive carbon output is far greater. Mankind needs to act now to try to prevent irreversible damage to our planet regardless of whatever the short term costs may be.

Word Count = 2732 including titles e.t.c

Reference Sources

www.foresight.gov.uk = Government website in place to increase awareness of climate change and steps being taken by the UK to tackle the problem. Information on UK energy usage and schemes to reduce carbon outputs.

www.bre.co.uk = BRE report – Reducing carbon emissions from commercial and public sector buildings in the UK.

Open University Course T173 Block 5 = The course materials in block 5 contain information on the operation of PV systems. This was studied to obtain an understanding of the operation of PV systems.

www.electricity4business.co.uk = Information on approximate cost of electricity for businesses.

DTI Publication By Cambridge Consultants Ltd. Ref ETSU S/P2/00320/REP DTI/Pub URN01/759 Report entitled “Potential cost reduction in PV systems”. = Information on costs of PV installations used to carry out cost evaluation.

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