Analysis of Energy Management in GMIT

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DECLARATION OF ORIGINALITY

SEPTEMBER, 2010

The substance of this thesis is the original work of the author and due reference and acknowledgement has been made, when necessary, to the work of others. No part of this thesis has been accepted for any degree and is not concurrently submitted for any other award. I declare that this thesis is my original work except where otherwise stated.

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_______17/9/2010____________

Date

Abstract

Energy Management is the process of monitoring, controlling and conserving energy in a building or organisation. The main reasons for this are for cost purposes and benefit to the environment. Through various techniques and solutions for lighting, heating, office equipment, the building fabric etc along with a change in people's attitudes there can be a substantial saving in the amount spent on energy. A good example of energy waste in GMIT is the lighting situation in the library. All the lights are switched on all day on even in places where that is adequate daylighting, which is a big waste of energy. Also the lights for book shelves are left on. Surely all these books won't be searched for all at the one time. It would make much more sense to have local switches that the users can control when they are searching for a particular book. Heating controls for the older parts of the college are badly needed. A room like 834 needs a TRV to prevent it from overheating as temperatures often reach the high twenties due to the heat from the radiators, computers, solar gains and heat from users of the room. Also in the old part of the college it is missing vital insulation, along with not being air tight due to the era when it was built. Pumped bonded bead insulation and sealant around services and gaps can greatly improve the thermal performance of the building and help achieve a higher BER cert. GMIT should also look at the possibility of installing a CHP plant to meet the base heating loads. It would meet the requirement of running 4500 hours a year and would receive some financial support from the Accelerated Capital Allowance. If people's attitudes are changed through energy awareness campaigns and a few changes made for more energy efficient equipment, substantial savings can be made in the energy expenditure.

Acknowledgement

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Chapter 1

1.1 Introduction

With the ever growing concern for the environment, the rising price of oil along with increasing consumption of both electricity and oil Energy Management is growing in popularity. Buildings use an extreme amount of energy through electricity and heating. Due to the modern age in the developed world electricity is needed to power computers, TVs, radios, printers, lights and many other essential item that help us go about our daily duties. An example of a developed country using too much energy is the USA where only 4% of the world's population uses 21% of the world's primary energy. With newly developing countries like China catching up in industrialisation and energy usage there could suddenly become a shortage and a fight for oil in the near future. If we were to run out of the fuels that run the majority of our power stations and that heat our buildings our livelihoods would come to a complete halt and end up in the dark ages, as we currently don't have enough renewable energy sources to fulfil our demands. So to help keep this from happening we need to reduce the amount of energy that we require to power our buildings. An example of energy conservation would be turning down the heating in your home. Energy management would be to use a more energy efficient lighting by switching to T5 lamps for example. Once our energy needs have been reduced it can then be possible to size the organisation for the use of renewable energies, which will save money by not having over specified renewable energy equipment and further help reduce the amount of CO_2 produced.

Chapter 2 talks about what Energy Management is, the reasons for doing so such as climate change, peak oil etc. Also discussed in the chapter are the drivers and barriers to its development.

Chapter 3 goes through the European Energy Management Standard EN 16001

Chapter 4 discusses energy saving and the 4 main categories they are grouped in, along with audit types

Chapter 5 is the biggest chapter and discusses energy conservation and management measure for heating, lighting, building fabric, office equipment and the BEMS

In chapter 6 the energy consumption of GMIT through the primary data used. Also a energy awareness campaign for the college is out lined.

Chapter 7 is the conclusions.

1.2 Aim

An academic institute such as GMIT is a perfect place to start as it uses vast amounts of electricity and fossil fuel to power the diverse range of equipment and lights along with the heating of the building. The aim is to try reduce the amount of energy used and to spot where wastage is occurring.

1.3 Research Methodology

The purpose of the research was to gain an in depth knowledge into Energy Management and what can be done to reduce consumption. The information provided was achieved through a variety of media that includes both primary and secondary data. This section describes the method of carrying out the research in order to produce the thesis. Most of the information sought was provided through the electronic resources from the GMIT library and from book with knowledge of the sector.

The primary data was provided by going through electricity, gas and oil bills provided by the Building and Estates Office as well as from the ESBIE website. Lighting data was obtained by manually counting light fittings in the various areas

Chapter 2

Energy Management

2.1 Energy Management

Energy Management is the process of monitoring, controlling and conserving energy in a building or organisation. Buildings are increasingly becoming the focus of energy-saving initiatives because not only are they a significant energy consuming sector but the technologies and products to make buildings substantially more energy-efficient have already been developed. Improving the energy-efficiency of buildings also means that they are more comfortable and cheaper to run for the owner and occupier. The most significant influence in energy efficiency is often the way the building is used by the management and occupants.

Figure 1 Earths Lights from Space source globalwarmingart.com

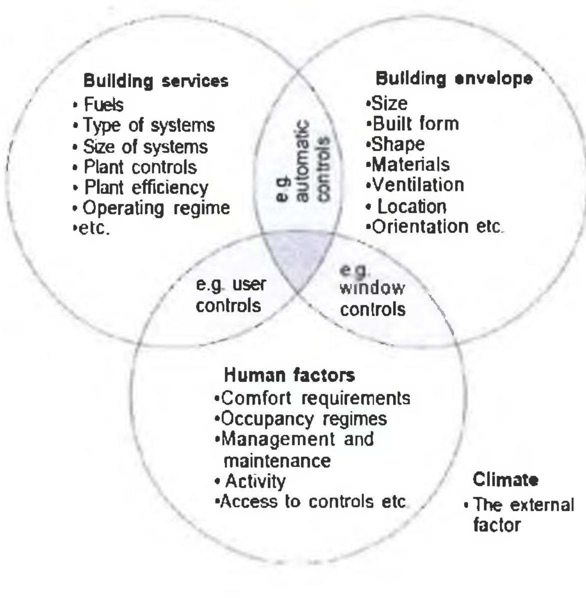

Figure 2 Key Factors That Influence Energy Consumption source CIBSE Guide F

2.2Benefits of Energy Management

Managing energy is simply good management of an organisation's resources. The main benefits of saving energy are:

2.2.1 Saves Money

Saving energy saves money. Cost reduction is important for private companies as this saving contributes directly to increased profit. A useful question for a company is to ask: "How much extra turnover would we require to produce profits equivalent to a saving of 20% of our energy bill" For public sector organisations a saving on energy means finances can be used more usefully elsewhere.

2.2.2 Saves Fossil Fuel

Fossil fuels are a finite commodity and will not last forever. The less fossil fuel we use in this generation, the more will be available for future generations. It also buys time to develop new renewable forms of energy so that we move to a low carbon economy.

2.2.3 Reduces Pollution

Saving energy, particularly electricity, reduces the amount of carbon dioxide (CO2) and other harmful gases we put into the atmosphere. Carbon dioxide is a greenhouse gas and is a major contributor to global warming and climate change.

2.2.4 Improved Working Environment

Buildings which are too hot or cold can have a negative impact on occupants' comfort, morale and productivity. Also poor control of energy can lead to damage of building fabric or equipment/goods within a building. There can also be implications for health, safety and risk management.

2.2.5 Legal Compliance

Buildings must comply with legislation e.g. Building Regulations and the EU Directive on Energy Performance of Buildings. Lack of compliance by poor energy management can lead to legal action, fines and poor publicity for an organisation.

2.2.6 Improved Environmental Performance

Organisations which are proactive in energy management have something positive to report to stakeholders. Greening an organisation can help to secure compliance to internationally recognised environmental standards, e.g. ISO 14000.This in turn can lead to more business opportunities because the organisation is proven to be acting responsibly.

2.2.7 Reduction in Replacement and Maintenance Costs

Plant and equipment within buildings usually have to be replaced or maintained more regularly if they are misused or left on unnecessarily. Saving energy can extend equipment life and reduce replacement and maintenance costs.

2.3 Reasons for Energy Management

2.3.1 Climate Change

The greenhouse effect is the heating of the surface of the planet due to the presence of an atmosphere containing gases that absorb and emit infrared radiation. Greenhouse gases trap heat within the surface-troposphere system. This mechanism is fundamentally different from that of an actual greenhouse which works by isolating warm air inside the structure so that heat is not lost by convection. The greenhouse effect was discovered by Joseph Fourier in 1824, first reliably experimented on by John Tyndall in 1858 and first reported quantitatively by Svante Arrhenius in 1896.

The black body temperature of the Earth is 5.5 °C. Since the Earth's surface reflects about 28% of incoming sunlight the planet's mean temperature would be far lower about -18 or -19 °C. Along with the added contribution of the greenhouse effect it is instead much higher roughly 14 °C.

Global warming a recent warming of the Earth's surface and lower atmosphere is believed to be the result of an "enhanced greenhouse effect" mostly due to human-produced increases in atmospheric greenhouse gases. This human induced part is referred to as anthropogenic global warming. This increase in radiative forcing from human activity is contributed to mostly by increased atmospheric carbon dioxide levels. Recent progress in climate modelling has generated a consensus among climate scientists that greenhouse gases emitted by human activities are likely (66-90% chance) to have caused most of the observed global temperature rise over the past 50 years (IPCC 4th Report)

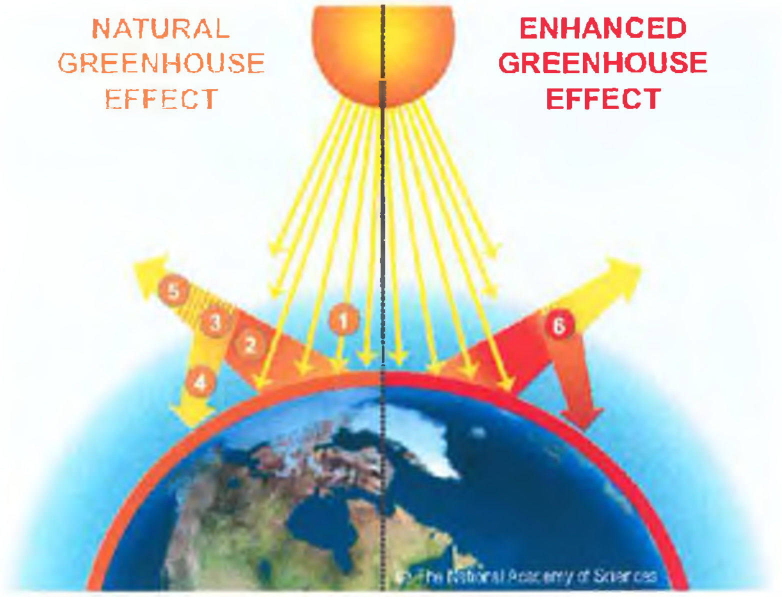

Figure 3 The Greenhouse Effect

2.3.2 Evidence for Climate Change

Evidence for climate change is shown in the IPCC Reports. IPCC's Fourth Report by Working Group 1 shows the following findings:

Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land-use change, while those of methane and nitrous oxide are primarily due to agriculture. The global net effect of human activity since 1750 has been of warming with a radiative forcing of + 1.6 W/m^2.

Warming of the climate system is unequivocal as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level.

Observed impacts include, but are not limited to:

- Eleven of the last twelve years rank amongst the twelve hottest on record
- The ocean has warmed to at least 3000m depth and is absorbing more than 80% of the heat added to the climate system
- Global sea rise gas accelerated

- Mountain glaciers and snow cover have declined on average in both the northern and southern hemispheres
- Average Arctic sea extent ice has shrunk by 20% at its summertime minimum since satellite observations began in 1978
- More intense and longer droughts have been observed over wider areas since the 1970s, particularly in the tropics and subtropics

Figure 4 Muir and Riggs Glacier Difference in Ice Levels source Globalwarmingart.com

Paleoclimate information supports the interpretation that the warmth of the last half century is unusual in at least the previous 1300 years. The last time the Polar Regions were significantly warmer than present for an extended period was about 125,000 years ago at which time reductions in polar ice volume led to 4-6m of sea level rise.

Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely (greater than 90% probability) due to the observed increase in anthropogenic greenhouse gas concentrations.

For the next two decades, warming of about 0.2°C per decade is projected for the range of emission scenarios considered. Even if the concentrations of all greenhouse gases and aerosols had been kept constant at year 2000 levels a further warming of about 0.1°C per decade would be expected.

Continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely (greater than 90% probability) be larger than those observed during the 20th century. There is now higher confidence in projected patterns of warming and other regional-scale features including changes in wind patterns, precipitation and some aspects of extremes and of ice.

Anthropogenic warming and sea level rise would continue for centuries due to the timescales associated with climate processes and feedbacks even if greenhouse gas concentrations were to be stabilized today.

Models indicate:

- It is very likely (greater than 90% probability) that hot extremes, heat waves and heavy precipitation events will become more frequent
- If global average temperatures were to exceed 1.9 to 4.6 degrees C (3.4 to 8.3 degrees F) compared to pre-industrial temperatures, the Greenland ice sheet would lose mass faster than it gains, producing a net contribution to sea level rise. If sustained for thousands of years, the loss of ice would eventually lead to complete elimination of the Greenland ice sheet and contribute an additional 23 feet to sea level rise
- It is very likely (greater than 90% probability) that hot extremes, heat waves and heavy precipitation events will continue to become more frequent

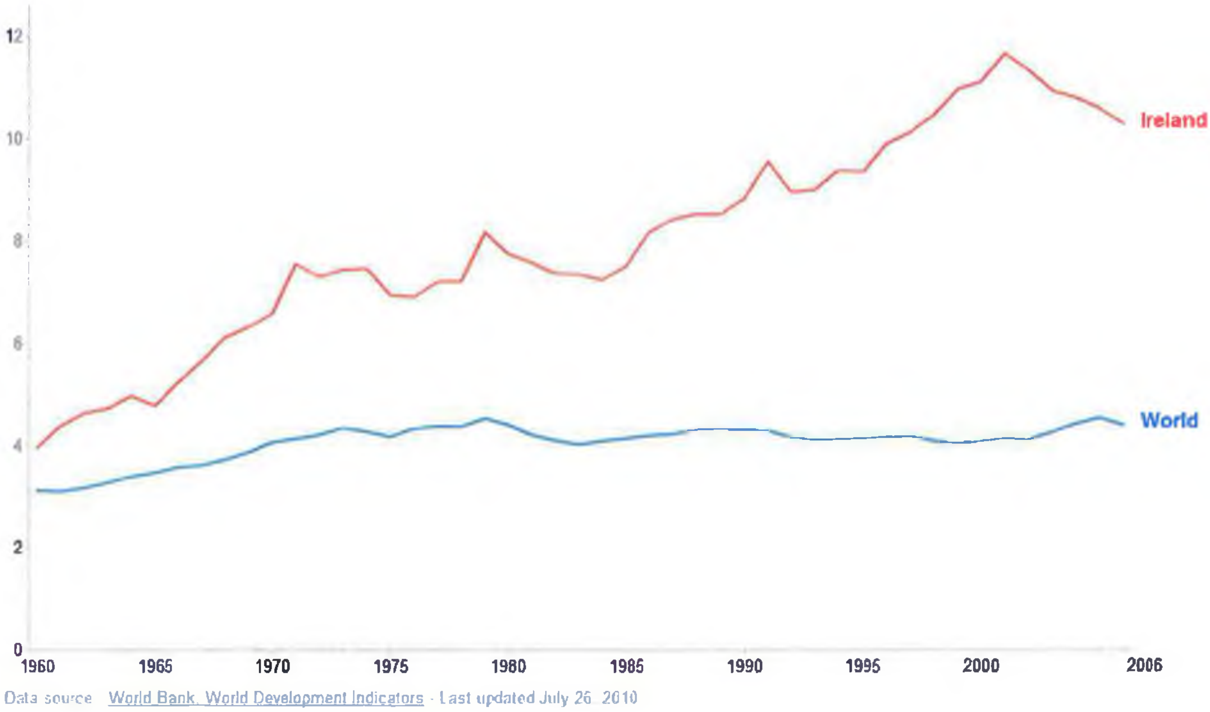

Figure 5 Ireland vs. World CO_2 Emissions in metric tons per capita source Google

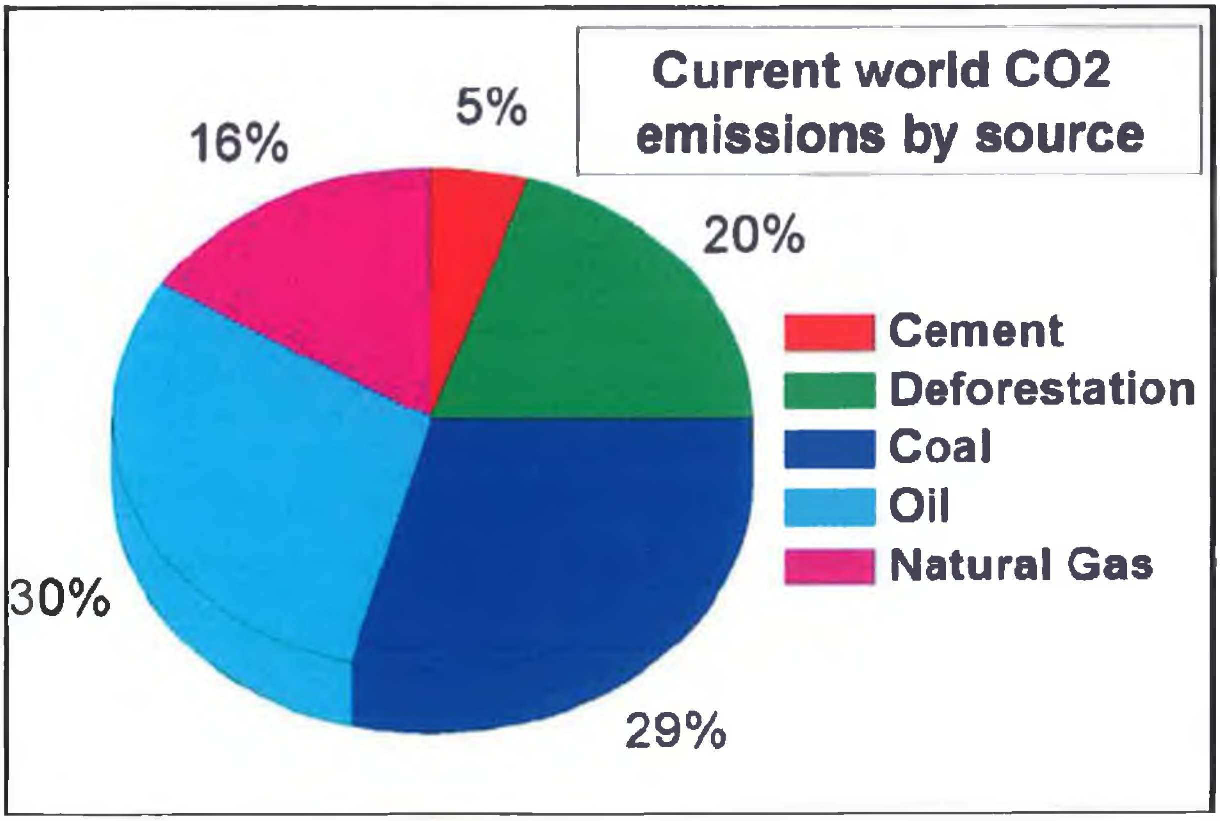

Figure 6 World CO_2 Emissions by Source, source Wikipedia.org

2.3.3 Kyoto Protocol and European Commitments

As a member of the EU we must limit the growth in our emissions to 13% above the 1990 levels in the 2008- 2012 period as stated in the Kyoto Protocol. The European Union has committed itself to reducing its greenhouse gas emissions to 20% below 1990 levels by 2020 which we must follow.

2.3.4 Energy Performance of Buildings Directive

Requires all member states to:

- set minimum energy requirements for new build construction
- develop a national methodology to calculate energy performance (BER)
- provide energy rating certificate for all buildings when sold or let (DEC)
- nearly zero energy buildings by 2020

2.3.5 Peak Oil

This is the point in time where the max rate of global oil extraction is reached and then heads into decline. This will send oil prices soaring. This concept is based on the observed production rates of individual oil wells and the combined production rate of a field of related oil wells. The aggregate production rate from an oil field over time usually grows exponentially until the rate peaks and then declines, sometimes rapidly, until the field is depleted. This is based on the Hubbert Curve. M. King Hubbert observed that in any large region unrestrained extraction of a finite resource rises along a bell shaped curve that peaks when about half the resource is gone. Hubbert fitted a bell curve to production statistics and projected that crude oil production in the lower 48 U.S. states would rise for 13 more years, then crest in 1969, give or take a year. He was right as production peaked in 1970 and has continued to follow Hubbert curves with only minor deviations (Scientific American, 1998).

2.3.5 Oil Dependence on Regions

In 1973 and 1979 a pair of sudden price increases rudely awakened the industrial world to its dependence on cheap crude oil. Prices first tripled in response to an Arab embargo and then nearly doubled again when Iran dethroned its Shah sending the major economies sputtering into recession. In 1973 the five Middle Eastern members of the Organization of Petroleum Exporting Countries (OPEC) were able to hike prices not because oil was growing scarce but because they had managed to corner 36% of the market (Scientific American, 1998). As can be seen from Figures 4 & 5 below the Middle East has the majority of the proven world oil reserves. Russia and the Middle East also have the majority of gas reserves. This could lead to problems in the future, e.g. if another oil embargo was to happen the country would come to a complete standstill and further into a recession as we are highly dependent on the use of fossil fuels for electricity generation, heating, transport etc.

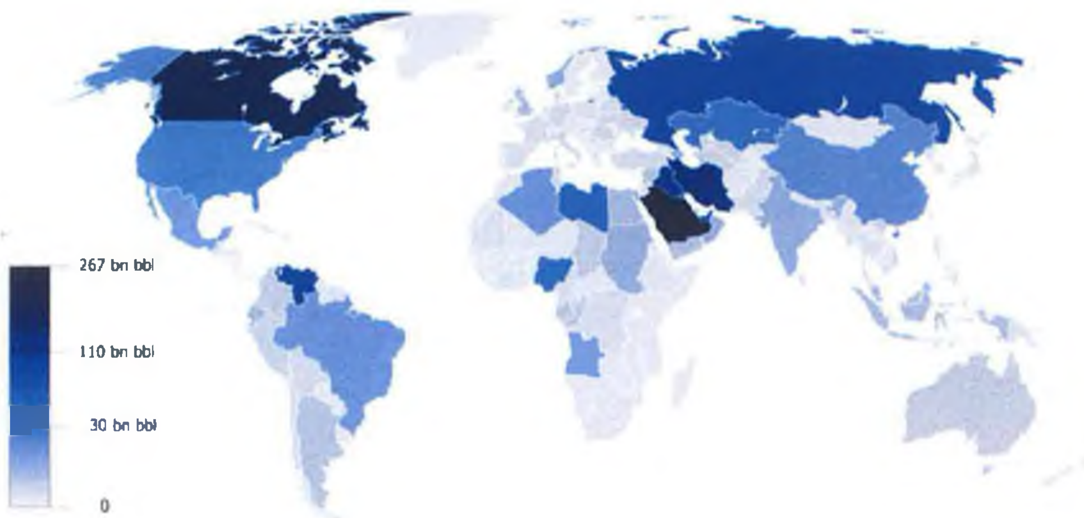

Figure 7 World Oil Reserves source Wikipedia.org

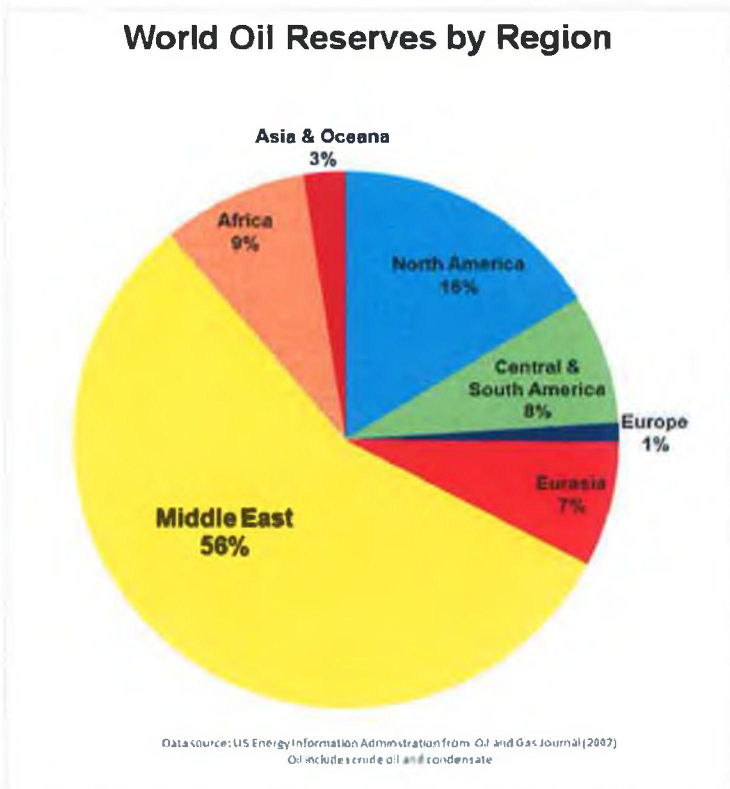

Figure 8 Oil Reserves by Region source Wikipedia.org

Country	Reserves [16]		Production [17]		Reserve life 1
	10^9 bbl	10^9 m^3	10^6 bbl/d	10^3 m^3/d	years
Saudi Arabia	267	42.4	10.2	1,620	72
Canada	179	28.5	3.3	520	149
Iran	138	21.9	4.0	640	95
Iraq	115	18.3	2.1	330	150
Kuwait	104	16.5	2.6	410	110
United Arab Emirates	98	15.6	2.9	460	93
Venezuela[2]	95	15.1	2.7	430	88
Russia	60	9.5	9.9	1,570	17
Libya	41	6.5	1.7	270	66
Nigeria	36	5.7	2.4	380	41
Kazakhstan	30	4.8	1.4	220	59
United States	21	3.3	7.5	1,190	8
China	16	2.5	3.9	620	11
Qatar	15	2.4	0.9	140	46
Algeria	12	1.9	2.2	350	15
Brazil	12	1.9	2.3	370	14
Mexico	12	1.9	3.5	560	9
Total of top seventeen reserves	1,243	197.6	63.5	10,100	54

Table 1 Summary of Reserve Data source Wikipedia.org

2.4 Drivers of Energy Management

2.4.1 Energy Map

Energy MAP is the Energy Management Action Plan from SEAI. It is an online tool which provides a step by step guide to creating a best practise action plan for business and industries. The 20 steps of Energy MAP are divided into of five pillars of excellent energy management:

- Commit
- Identify
- Plan
- Take Action
- Review

Commit

Step 1: Senior management commitment

Step 2: Appoint senior manager to Energy MAP

Step 3: Appoint Energy MAP coordinator

Step 4: Establish an Energy MAP team

Step 5: Establish an Energy MAP Policy

Identify

Step 6: Develop and overview total energy consumption

Step 7: Survey energy use & identify significant energy users

Step 8: Identify key factors that influence energy consumption & Energy Performance Indicators

Step 9: Identify energy saving opportunities

Plan

Step 10: Set objectives and targets

Step 11: Establish Programme Plan

Step 12: Formally allocate sufficient human, financial & systems resources

Take Action

Step 13: Implement the Programme Plan

Step 14: Promote energy efficiency awareness and practices amongst employees

Step 15: Train key personnel in energy efficient practices

Step 16: Operate, maintain, purchase & design significant energy users efficiently

Review

Step 17: Continuously measure & monitor energy performance & check against targets

Step 18: Identify & implement corrective and preventative actions

Step 19: Periodically review Energy MAP and identify improvements

Step 20: Management Review of Energy Map

This can be very beneficial GMIT as it would help with energy management without having to invest as much as one would need to be EN 16001 accredited.

2.4.2 Accelerated Capital Allowance

The ACA is a tax incentive for companies paying corporation tax and aims to encourage investment in energy efficient equipment. The ACA offers an attractive incentive whereby it allows companies to write off 100% of the purchase value of qualifying energy efficient equipment against their profit in the year of purchase. The ACA is based on the existing Capital Allowances tax structure for plant and machinery and is only applicable to eligible energy efficient equipment. Claiming the ACA is also carried out the same way as for the standard Capital Allowances (www.seai.ie)

Equipment Category	**Minimum expenditure***	**Technology& associated criteria**
Building Energy Management Systems (BEMS)	€5,000	Building Energy Management Systems (BEMS)
Lighting	€3,000	Lighting
		Lighting Controls
Motors and Drives	€1,000	Motors
		Variable Speed Drives (VSDs)
		Permanent Magnet Motors
Information and Communications Technology (ICT)	€1,000	Enterprise Servers

		Enterprise Storage Equipment
		Precise Cooling
		Heat Rejection
		Centralised Direct Current Power Distribution
		Power Management
		Uninterruptible Power Supply
		Blade Servers
		ICT Communications
		ICT Optimisation Solutions
Heating and Electricity Provision	€1,000	Co-generation
		Wind Turbines
		Hot water Generation
		Localised Steam Generators
		Stationary Fuel Cell Power Systems
		Photovoltaic Systems
		Boiler Controls
		Condensate Recovery Systems
		Steam Systems
		Biomass Boilers
Process and Heating, Ventilation and Air-conditioning (HVAC) Control Systems	€1,000	HVAC Zone Control
		HVAC Heat Recovery
		Pumps
		Hydraulic Power Recovery Turbine
		Blowers
		Fans
Electric and Alternative Fuel Vehicles	€1,000	Electric Vehicles and Associated Charging Equipment
		Alternative Energy Vehicle Conversions
Catering and Hospitality	€1,000	Commercial Dishwashers
		Commercial Laundry Dryer
		Commercial Combination Ovens
		Commercial Laundry Washer
		Water Boilers
Electromechanical Systems	€1,000	Electrical Actuators
		Extrusion Blow Moulding Machines
		Injection Blow Moulding Machines
		Injection Moulding Machines
		Process Energy Management Systems
		Voltage Stabilisation
Refigeration and Cooling	€1,000	Compressors and Condensing Units
		Condensers
		Refrigerated Display Cabinets
		Refrigeration System Controls and Monitoring

Table 2 ACA Equipment Categories

2.5 Barriers to Energy Conservation

2.5.1 Lack of Objective Consumer Information

Efficiency claims are often made by competing manufactures without an objective third party to evaluate the actual efficiency claims.

2.5.2 Failure of Consumers to Make Optimal Efficiency Decisions

Consumers often choose the least expensive appliance, rather than the appliance that will save them money over the long term. Sometimes consumers are confused about efficiency ratings and efficiency improvements.

2.5.2Replacements Based on Availability Rather Than Efficiency

Decisions about the replacement of worn out/broken equipment are made without energy efficiency as a high priority. Usually the main concern is restoring service as soon as possible, which means buying whatever equipment is most readily available.

2.5.3 Energy Prices Don't Take into Account Full Environmental/Social Costs

External costs associated with public health, energy production, global warming, acid rain, air pollution, energy security or reliability is usually ignored.

2.5.4 Competition for Capital to Make Energy Efficient Investments

Energy efficient investments in the commercial and industrial sectors often must compete with other business investments therefore efficiency investments with a payback of more than 3 years are avoided.

2.5.5 Separating Building Ownership from Utility Bill Responsibility

Renters will rarely make energy efficiency investments in buildings that they don't own, especially when the utilities are included in the rent.

2.5.6 Commercial Buildings and Retail Spaces are often built on Speculation with Low First Cost a Priority

The buildings long term operation cost which is usually paid by the tenant rather than the owner is not important to builder.

Important energy management tools for utilities and energy planners to achieve energy efficiency are Integrated Resource Planning (IRP) and Demand Side Management (DMS). IRP is the process of simultaneously examining side by side all energy savings and energy producing options to optimise the mixture of resources and minimise total costs. Considerations of environmental and health costs can be included. DMS is a broad term that encompasses the planning and implementation of utility sponsored programmes that influence the amount or timing of customers energy use.

Chapter 3

European Energy Standard

3.1 EN 16001

The overall aim of this European standard is to help organizations establish the systems and processes necessary to improve energy efficiency. This should lead to reductions in cost and greenhouse gas emissions through systematic management of energy. This standard specifies requirements for an energy management system (EMS) to enable an organization to develop and implement a policy and objectives which take into account legal requirements and information about significant energy aspects. It is intended to apply to all types and sizes of organizations irrespective of any geographical, cultural and social conditions. This standard applies to the activities under the control of an organization.

The standard is based on the methodology Plan Do Check Act.

- Plan: establish the objectives and processes necessary to deliver results in accordance with the organization's energy policy
- Do: implement the processes
- Check: monitor and measure processes against energy policy, objectives, targets, legal obligations and other requirements to which the organization subscribes, and report the results
- Act: take actions to continually improve performance of the energy management system

Figure 9 EN 16000 Methodologies from a Managerial and Technical Perspective source Ronan McDonagh notes

The management direction should be clear and concise. The policy forms the basis for the setting of energy targets and it should be sufficiently clear to be capable of being understood by internal and external parties, i.e. employees, customers, public authorities, investors, etc.
The energy policy should:

- commit the organization to address the products, processes and other activities which affect the significant energy consumption
- have the organisation to continually improve its energy efficiency and look for alternative forms of energy and renewable energy
- adhere to all energy management laws and regulations
- all people who work for the company should be informed on the policy and it should be freely available to the public

3.1.3 Planning

3.1.3.1 Identification and review of energy aspects

The purpose of identifying the energy aspects of the company is to realise the areas of significant energy consumption such as the equipment and processes. This helps to prioritise efforts to reduce energy consumption. A register for energy saving opportunities should be kept which can help to reduce costs and CO_2 emissions. The following should be identified as a minimum:

- the energy aspect
- its value in money and CO_2 terms
- action required
- actual or estimated cost
- date completed and actual outcome

If an organisation is to implement an energy management system it should first establish its current energy consumption through an initial review of energy aspects.
Each review of the energy aspect is to include:

- past and present energy consumption and energy factors based on measurement and other data
- identification of areas of significant energy consumption, in particular of significant changes of energy usage in the past period

- an estimate of the expected energy consumption during a period; the estimate may be based on
    - meter readings
    - hours run
    - name plate data
    - compiled utility bills
    - planned operational changes
- identify people in the organisation whose actions may lead to significant changes in the energy consumption
- opportunities for improving energy efficiency

There are great opportunities for energy saving from non cost housekeeping measures such as through telling people to turn off equipment when it's not in use and raising the awareness of energy performance in the personnel's work practices. It is recommended that the review be updated at pre defined intervals. There should be progressively more detailed analysis of all the areas of energy usage in each updated review. Changes of the energy aspect should be taken account for e.g. production expansion, plant modifications etc. This allows the organisation to assess the performance of the last period and identify possible initiatives for the next period.

3.1.3.2 Legal Obligations and Other Requirements

The applicable legal requirements need to be identified in relation to energy. These may include national, international and local government etc.

Other requirements which might influence the organisation are

- emissions trading requirements
- agreements with customers
- non-regulatory guidelines
- voluntary principles or codes of practice
- voluntary energy agreements
- requirements of trade associations
- agreements with community groups or non-governmental organizations
- public commitments of the organization or its parent organization
- corporate/company requirements

The organisation should identify who is responsible for reviewing all legal requirements. The organisation should describe how it:

- communicates the relevant information to people
- keeps up to date on new laws and regulations
- updates their register of applicable regulations at pre defined intervals

3.1.3.3 Energy Objectives, Targets and Programme

Objectives and targets should be reviewed and revised periodically. Setting energy targets ensures that the organisation has defined success criteria which measures progress towards improved energy efficiency. These targets should be:

- ambitious, commits the organisation to continual improvement
- realistic, targets can be met in the specified time limit
- specific and measureable

As a minimum targets should be established for each of the significant energy aspects identified by the review. Some targets may apply to equipment or facilities (e.g. a specific production line), while others may address the energy consumption of departments (e.g. transport and logistics department), training or energy awareness, additional measurement and monitoring

Energy targets should be expressed through energy performance indicators such as consumption per item, per kg, per m^2 or equivalent. This makes the energy target largely independent from variations in activity.

Best Available Technology should be considered when establishing an energy management programme, with the following identified and addressed:

- what are the priority activities and projects
- what is to be achieved in a certain time frame
- who is responsible and has the authority to ensure the plans are implemented
- how are the energy management programmes monitored and revised
- do the energy management programmes reflect the energy policy, objectives and targets together with legal and other requirements

3.1.4 Implementation and Operation

3.1.4.1 Resources, Roles, Responsibilities and Authority

For the energy management system to be successful commitment from all personnel within an organisation is needed. This commitment should begin at the highest level of management. Top management should the energy policy to ensure that the energy management system is implemented. A specific management representative should be designated with the responsibility and authority for implementing the energy management system. This representative would also be responsible for reporting top management on the performance and results of the system. The operation of the system should be the responsibility of experienced employees with the appropriate skills, resources and authority. It is also important that the key energy management system roles and responsibilities are well defined and communicated to all persons working for the organisation.

3.1.4.2 Awareness, Training and Competence

The organisation should identify the awareness, knowledge, understanding and skills needed by any person with the responsibility and authority to perform tasks. Contractors working for the organisation should be able to demonstrate that their employees have the required competence and/or appropriate training. Training programmes should be established and reviewed with training records maintained.

3.1.4.3 Communication

Communication is essential to ensure the successful implementation and operation of the energy management system. Regular information which is relevant to the energy management system helps motivate and commit employees to the company's energy policy and take an active part in achieving the energy objectives and targets. Internal communication should include:

- energy policy, objectives and targets
- how individuals can contribute
- info on current energy usage and trends
- legal obligations and other requirements
- opportunities for improvement both organisationally and individually
- financial and environmental benefits of energy management
- who to contact for further details

All level of personnel should be encouraged to make proposals for improvements on the energy management system. These proposals should be reviewed and responded to. Ways of communication are:

- organisation intranet sites
- emails and bulletins
- staff notice boards, magazines, energy displays
- tool box talks
- awareness days and campaigns

3.1.4.4 External Communication

The organisation is required to decide whether to communicate externally about its EMS and energy performance. If it intends to do so, you should develop, document and use a communication plan. The external communication plan should detail:

- who is responsible for communicating the info on the EMS and performance
- what info is communicated
- means of communication used
- where and how the records of communication are kept

The organisation may be required to communicate externally as part of a legal requirement (IPPC licensing) or through an external agreement (eg SEI)

3.1.5 Energy Management System Documentation

The level of detail within the system documentation should be sufficient to describe the energy management system and the interrelation between its processes, systems and activities. It should also tell you where to obtain more detailed information on the operation of the different elements. This documentation may be integrated with other management systems within the organisation. Examples of documentation:

- statements of policy, objectives and targets
- info on significant energy aspects
- work instructions
- process information
- organisational charts

- internal and external standards
- records
- technical documents such as equipment drawings, energy distribution drawings, maintenance plans, equipment manuals etc
- results of reviews
- action plans with follow up indicators

The decision to document procedures should be based on:

- the consequences of not doing so
- demonstrating legal and other requirements
- ensuring that the activity is undertaken consistently
- easier maintenance and revision
- requirements of this standard

3.1.5.1 Control of Documents

The primary focus should be on improved energy performance and implementing the EMS, not on a complex document control system. However documents under this standard should be subject to a procedure for ensuring:

- all EMS documents can be identified with respect to the originator, process, system/activity covered, contact persons etc; these documents should be reviewed regularly and revised where necessary
- current versions of documents available in work areas where the relevant activity is taking place
- documents no longer applicable marked clearly or removed

Documents may be in hard copy or electronic form depending on what is easier for the employees to use.

3.1.6Operational Control

Procedures for operation and maintenance should include:

- housekeeping procedures and checklists to avoid and minimise wastage

- operating and maintenance plans for machinery, equipment and facilities
- description of service intervals for the relevant equipment, including what is subject to servicing
- identification of departments and personnel responsible for operation and maintenance of the equipment
- schedules for inspection of the relevant equipment and description of how the inspection is to take place

Energy conscious design ensures that energy efficient alternatives are considered when designing any new or modified equipment, plant, facilities or buildings which have the potential to impact on the significant energy aspects. This design should ensure that:

- thorough analysis of the energy demands is performed at the very first design stage
- energy assessment is carried out at relevant design stages where appropriate
- the tasks of the people for energy conscious design are clearly identified

When undertaking energy efficiency assessments whether in the design or purchasing of equipment that will affect significant energy aspects the following should be established:

- criteria for when assessments are required
- those responsible for performing the assessment
- the resources (time and financial) available
- investigation into the economic and technical energy efficient alternatives
- those responsible for the review and approval for the assessment
- those responsible for making the final decision on the options available

There can be varying levels of assessment, depending on the criteria the organization establishes. The greater the energy consumption, the more reason to focus on the possibilities of reducing the consumption by designing and/or procuring the most energy efficient equipment on the market. By informing suppliers of the energy policy and procurement procedures the organization will encourage dialogue with the supplier regarding the possibility of improving energy efficiency.

3.1.7Checking

3.1.7.1 Monitoring and Measurement

Monitoring and measurement is the management of energy consumption by means of regular comparisons of actual and expected consumption. It should analyse energy consumption, variations over time, achievements of targets etc. It can be useful to monitor energy consumption through energy performance indicators (EPI) such as through kWh per unit production or kWh/m^2. Comparison between actual and expected consumption will highlight unexpected deviations and may allow hidden waste to be detected. Examples of monitoring and targeting include the following:

- ongoing monitoring and recording of the significant energy consumption and associated energy factors
- summarising the significant energy consumption in the form of key figures
- comparing actual and expected energy consumption
- action taken in case there is deviation for the expected energy consumption
- records of significant changes from the expected consumption, the causes and remedies

The organization should plan monitoring and measuring of all significant energy consumption and energy factors. These plans should include a description of the following:

- how significant energy consumption and energy factors are measured and monitored
- extent of monitoring, its frequency, calibration and maintenance of measuring equipment
- roles and responsibilities of relevant personnel
- how expected energy consumption is calculated in relation to energy factors

3.1.7.2 Evaluation of Compliance

The organization should establish, implement and maintain procedures for monitoring the compliance of the energy management system with legal obligations and other requirements relating to significant energy consumption. Records of the results should be maintained to allow compliance.

3.1.7.3 Nonconformity, Corrective Action and Preventive Action

Non-conformances should be investigated and the corrective action taken. Non-conformances exist when the organization's energy policy, objectives, targets, programmes or documented procedures are not complied with.

The organisation should:

- identify the cause of nonconformance
- take appropriate corrective action
- take action to prevent reoccurrence
- change the documented procedures where necessary to keep up to date with new initiatives or procedures
- keep all relevant documentation in accordance with legal and documented time frames

3.1.8 Control of Records

The purpose of recording is to ensure that the necessary documentation is provided to show the achievement of targets, action plans and other requirements of the energy management system.

The extent of the documentation may vary according to each organization's requirements. These records may include:

- information about relevant laws and regulations
- applicable training records
- relevant energy management communication material to all stakeholders such as press releases, awareness campaigns, presentations, websites, awards, etc
- significant energy consumption and energy performance indicators
- records of installation, inspection, maintenance and calibration of measuring equipment
- communication of energy policy to contractors, subcontractors and suppliers
- dates of inspection and servicing of energy using equipment
- procurement of energy efficiency equipment
- design activities which have considered energy efficiency
- results of audits
- management reviews

3.1.9 Internal Audit of Energy Management System

An internal audit of an EMS is an independent, systematic review of part or an organisation's entire EMS. The purpose of the audit is to determine if the plans, activities and procedures described in the system are being conducted in the manner which the management system requires, for example:

- effective and efficient implementation of energy management programmes, processes and systems
- opportunities for continual improvement
- capability of processes and systems
- effective and efficient use of statistical techniques
- use of I.T.

Internal audits may be performed by employees of the organization or by external parties appointed by the organisation. In both cases the people performing the audits must be qualified, experienced, impartial and independent of the area of the organization to be audited.

3.1.10 Review of EMS by Top Management

The purpose of the management review is to ensure continual improvement and adaptation of the system so that the system operates in line with company energy policy. The review implies that the individual elements and overall operation of the energy management system are evaluated in a critical manner in relation to the ability of the system to comply with the energy policy and achieve the energy targets. It should be the top management of the organization that reviews the system at specified intervals.

Top management can use the review as a powerful tool in identifying opportunities for energy efficiency and system performance improvement. The reviews should help provide data for the strategic planning of the organisation. Outputs should be communicated to people in the company on how the management review process has lead to new objectives that benefits the company.

It may be of benefit to produce a performance statement summarising how energy performance has continually improved and met its stated energy targets.

3.1.11Pitfalls to Avoid

- Making your system too complex
- Focusing on doing and not recording
- Focusing on the technical aspects and ignoring the system
- Maintaining two systems
- Not seeing the value in internal audits
- Restricting communication
- Not giving enough resources to the system

3.1.12 Recommendations

- Top management commitment is an important key to success
- Project manager cannot hold the responsibility
- Allocate resources required (time and financing)
- Staffing is crucial for success – key staff must be included
- Design an energy organisation that commits the management
- Include all employees in the process
- Define clear scope and objectives for the management system
- Follow up activities are important for anchoring the management system in the organisation
- Keep the system design simple

Chapter 4

Energy Savings & Audit Types

4.1 Energy Applications

- *Space Conditioning*: energy used directly for heating or cooling an area for comfort conditioning
- *Boiler Fuel:* this is subdivided into space conditioning and process energy, depending on how the steam or hot water from the boiler is used
- *Direct Process Heat:* energy used to heat the product being processed e.g. for kilns, reheat furnaces etc excluding energy used in boiler steam or hot water
- *Lighting*
- *Mechanical Drive:* motors used for ventilation systems, pumps, crushers, grinders, production lines etc process this mechanical drive

4.2 Energy Saving Methods

There are four general categories in which energy savings can be grouped are as follows:

4.2.1 Housekeeping Measures

Energy savings can result from better maintenance and operation. These measures include shutting off unused equipment, improving electricity demand management, reducing winter temperature settings, turning off lights, eliminating steam, compressed air and heat leaks. Proper lubrication of equipment, proper cleaning and replacement of filters in equipment and periodic cleaning and lamp replacement in lighting systems will result in optimal energy use in existing facilities (IEEE Bronze Book, 1995).

4.2.2 Equipment and Process Modifications

These can either be applied to existing equipment (retrofitting) or incorporated into the design of new equipment. Examples include the use of more durable or more efficient equipment, the implementation of more efficient design concepts or the replacement of an existing process with one using less energy (IEEE Bronze Book, 1995).

4.2.3 Better Utilisation of Equipment

This can be achieved by carefully examining the production processes, schedules and operating practices. Generally industrial plants are multiunit, multiproduct installations that evolved as a series of independent operations with minimum consideration for overall plant energy efficiency. Improvements in plant efficiency can be achieved through proper sequencing of process operations, rearranging schedules to utilise process equipment for continuous periods of operation to minimise losses associated with start up; scheduling process operations during off peak periods to level electrical energy demand and conserving the use of energy during peak demand periods. Commercial facilities will typically achieve energy saving by re lamping, installing variable speed drives in ventilation systems and considering solar effects (IEEE Bronze Book, 1995).

4.2.4 Reduction of Losses in the Buildings Shell

Reduction in heat losses is achieved by adding insulation, closing doors, reducing exhaust, utilising process heat etc (IEEE Bronze Book, 1995).

A study by the UN concluded that more efficient energy use is one of the main options for achieving global sustainable development for the 21st century. At a global level just 37% of primary energy is converted into useful energy meaning that nearly two thirds is lost (Kreith & Goswami, 2008) regaining part of the lost energy by improving energy efficiency is one of the main technological drivers for sustainable development worldwide.

Different types of potential as proposed by the International Energy Agency (IEA)

- ***Theoretical Potential:*** represents achievable energy savings under theoretical considerations of thermodynamics as estimated by the American Physical Institute
- ***Technical Potential:*** achievable energy savings that result from implementing the most energy efficient commercial and near commercial technologies available at a given time regardless of economic consideration
- ***Market Trend Potential:*** efficiency improvements that can be expected to be realised for a projected year and a given set of boundary conditions, such as energy prices, consumer preferences and energy policies
- ***Economic Potential:*** energy savings that would result if all replacements, retrofits and new investments in the energy sector were shifted o the most energy efficient technologies that are cost effective at a given energy market price. The economic potential implies a well functioning market with competition between investments in energy supply and demand
- ***Societal Potential:*** "cost effective" savings when all externalities are taken into account. These include cost from health impact, air pollution, global warming and other ecological impacts for society

Sector	Technological Area	Economic Potential		Price Level	Base Year
		2010	2020	Assumed	
Industry					
	Iron & steel, coke ovens	9-15%	13-20%	1994	1995
	Construction materials	5-10%	8-15%	1997	1997
	Glass production	10-15%	15-25%	1997	1997
	Refineries	5-10%	7-10%	1997	1997
	Organic chemicals	5-10%		1997	1996
	Pulp & paper		50%	1996	1997
	Investment & consumer	10-20%	15-25%	1994	1995
	Food	10-15%		1997	1997
	Cogeneration in Industry		10-20%	1997	1997
Residential					
Exist Bld	Boilers & burners	15-20%	20-25%	today's prices	1997
	Building envelopes	8-12%	10-20%	today's prices	1995
				today's prices	1995
	New buildings		20-30%	1997	1997
	Electric appliances	20-30%	35-45%		
Commercial,					
Public & Agri	Commercial buildings	10-20%	30%	8-13cts/kWh	1995
	Electricity	10-25%	20-37%	4-10cts/kWh	1997
	Heat		15-25%	today's prices	1998
	Public buildings		30-40%	7-15cts/kWh	1992
	Agri & forestry		15-20%	today's prices	
	Horticulture		20-30%	today's prices	
	Decentralised cogen		20-30%	today's prices	1995
	Office equipment		40-50%	1995	1995
Transport	Cars	15%		today's prices	1995
	Door to door integration	4%			1995
	Modal split of freight		3% *		1995
	Trains & railways		20%	today's prices	1999
	Aircraft, logistics	15-20%	25-30%	today's prices	1998

Table 3 Economic Energy Efficiency Potentials in Western Europe, 2010 & 2010 source Kreith & Goswami, 2008

* Refers to the final energy use of the entire sector

Globalisation of many industrial sectors creates enormous potential for improving energy efficiency on a global scale. Mexico implemented a large scale energy efficient lighting programme for the residential sector. It was funded by the Mexican Electricity Commission and other donors between 1995 and 1998. About 1 million compact fluorescent lamps were sold in the areas of the programme which avoided 66MW of peak capacity and resulted in monthly energy savings of 30 GWh (Rinstinen & Kraushaar, 2006)

4.3 Reducing Energy Techniques

- ***Peak clipping:*** reduction in the system peak loads
- ***Valley filling:*** building of off peak loads
- ***Load shifting:*** shifting of load from peak to off peak hours
- ***Strategic conservation:*** load shape change that results from utility stimulated programmes

4.4 Energy Audit Types

Energy audits are the first step to improve the energy efficiency of buildings and industrial facilities. Generally 4 types of audit can be distinguished:

- ***Walk Through Audit:*** sort on site visit of the facility to identify areas where simple and inexpensive actions (typically operational and maintenance measures) can provide immediate energy use and operating cost savings
- ***Utility Cost Analysis:*** careful evaluation of metered energy uses and operating costs of the facility. Typically the utility data over several years are evaluated to identify the patterns of energy use, peak demand, weather effects and potential for energy savings
- ***Standard Energy Audit:*** comprehensive energy analysis for the energy systems of the facility. In particular the audit includes the development of a baseline for the energy use of the facility, the evaluation of the energy savings and the cost effectiveness of the energy conservation measures
- ***Detailed Energy Audit:*** this is the most comprehensive but time consuming energy audit type. Specifically the audit includes the use of instruments to measure energy use for the whole building and for some systems within the building (e.g. by end uses such as lighting systems, office equipment, fans, chillers etc.). Also sophisticated computer simulation programmes are typically considered for detailed energy audits to evaluate and recommend energy retrofits to the facility.

Chapter 5

Energy Conservation Measures

5.1 HVAC Systems

The energy use by HVAC systems can represent up to 40 % of the total energy requirement for a typical commercial building. A number of measures can be considered to improve the energy performance of both primary and secondary HVAC systems. Some of these measures are listed below:

- ***Setting Up/Back Thermostat Temperatures:*** when appropriate setting back heating temperatures can be recommended during unoccupied periods. Also setup of cooling temperatures can also be considered.
- ***Thermal Comfort Sensors:*** sensors can be used to generate comfort indicators such as predicted mean vote (PMV) and/or predicted percent dissatisfied (PPD).
- ***Retrofit of Constant Air Volume Systems:*** for commercial buildings variable air volume (VAV) systems should be considered when the existing HVAC systems rely on constant volume fans to condition the building.
- ***Retrofit of Central Heating Plants:*** the efficiency of a boiler can be drastically improved by adjusting the fuel air ratio for proper combustion. Also the installation of new energy efficient boilers can be economically justified when old boilers are to be replaced. PART L of Building Regulations state condensing boilers mandatory
- ***Retrofit of Central Cooling Plants:*** currently there are several chillers that are energy efficient, easy to control and operate and are suitable for retrofit projects. In general it is cost effective to recommend energy efficient chillers such as those using scroll compressors for replacement of existing chillers.
- ***Installation of Heat Recovery Systems:*** heat can be recovered from some HVAC equipment. For instance heat exchangers can be installed to recover heat from air handling units (AHU's) exhaust air streams and from boiler stacks. Can recover 50-80% of the energy used to heat or cool ventilation air supplied to the building.
- ***Thermal energy storage (TES) systems:*** offer a means of using less expensive off peak power to produce cooling or heating to condition the building during on peak periods. Several optimal control strategies have been developed in recent years to maximise the cost savings of TMS systems

5.2 Condensing boiler

Condensing boilers are highly efficient. They use less fuel and have lower running costs than other boilers. Higher efficiency levels are made possible by extracting heat contained in the combustion gases, which would otherwise have been lost to the atmosphere.

This is because both oil and gas contain hydrogen locked within their chemical structure. When oil or gas is burned, the hydrogen links with oxygen in the air to form H_2O (water). This water (as vapour) can be seen from the exhausts of cars on cold days. The vapour (or steam) contains about 8% of the total fuel's energy and capturing it makes energy efficiency sense. This is exactly what condensing boilers do. They "condense" the vapour and capture the energy contained there, making modern boilers so much more efficient.

5.3 Compressed Air

This has become widely needed for most manufacturing facilities. Its uses vary greatly from air powered hand tools and actuators to sophisticated pneumatic robotics. However there is a huge amount of compressed air wasted in a large number of facilities. It is estimated that only 20-25% of the input electrical energy is delivered as useful compressed air energy. Leaks are reported to account for 10-50% of the waste and misapplication accounts for 5-40% of loss in compressed air (Kreith & Goswani, 2008).

The compressor can be selected from several different types such as centrifugal, reciprocating or rotary screw with one or more stages. For small and medium sized units screw compressors are currently the most commonly used in industrial applications. Some energy conservation measures are listed below:

- Repair leaks in distribution lines. There are several methods to detect leaks ranging from using water and soap to the use of sophisticated equipment such as ultrasound leak detectors.
- Reduction of inlet air temperatures and the increase of inlet air pressure.
- Reduction of the compressed air usage and air pressure requirements by making modifications to the processes.
- Installation of heat recovery systems to use the compression heat within the facility for water heating or building space heating.
- Installation of automatic controls to optimize the operation of several compressors by reducing part load operations.

- Use of booster compressors to provide higher discharge pressures. Booster compressors can be more economical if the air with the highest pressure represents a small fraction of the total compressed air in the facility. Without booster compressors the primary compressor will have to compress the entire amount of the air to the maximum desired pressure.

5.4 Indoor Water Management

Water and energy savings can be achieved in buildings by using water saving fixtures instead of the conventional fixtures for toilets, faucets, showerheads, dishwashers and clothes washers. By eliminating leaks in fixtures and pipes savings will also be achieved.

5.4.1 Waterless Urinals

- A single Zero-Flush waterless urinal can save over 150,000 litres of water a year
- This enables savings of over €350 per annum to be made on water costs for each urinal fitted (Zeroflush.com)

5.4.2 Infrared Taps

- It has been found that infrared taps can reduce water consumption by up to 70% compared to conventional taps.
- This is because the taps shut off automatically after a set period. (autotaps.com)

5.4.3 Dual Flush Toilets

- Replacing a 9 litre flush toilet with a dual flush of 6/3 litre may save up to 50 per cent of water used for toilet flushing (DfES, 2002).

5.5 Technical Solutions

When a building has been surveyed the surveyor will analyse the data and give recommendations on solutions. These solutions generally fall into three categories:

- No Cost Measures (Good House Keeping)
- Low Cost Measures
- High Cost Measures

5.5.1 No Cost

Obviously this area is of great interest to many building users, particularly if control failures have been identified that are simple to correct and then have considerable energy savings. For example an optimised start control could fail in such a way as to cause a heating system to run continuously. However it needs to be considered that a significant amount of time might be needed to achieve no cost savings. Maintenance is vital here.

5.5.2 Low Cost

Low cost measures might include the buying of new controls such as for heating, cooling and lighting e.g. like the change of a 24 hour timer to a 7 day one in a building heating system. These measures are generally below €3000. (SEI Building Energy Managers Resource Guide)

5.5.3High Cost

This is a major investment such as replacing a complete lighting system. It might be more useful to consider the recommendations at the next refurbishment. These are typically above €3000. These investments are generally justified by the energy and cost savings they have in the future.

5.6 Building Fabric

For new buildings it is vital to include a high level of energy efficiency in the fabric at the design stage. It is always worth going beyond the minimum standards set in Building Regulations. For new builds there is a range of opportunities not available in existing buildings e.g. examining the best orientation of the building, designing in or out passive solar gain, positioning of internal use of space such as IT suites located on north side of buildings and varying the size of glazing to suit solar direction.

In retrofit situations it is hard to justify spending the money on major fabric elements as the savings are generally small in comparison to the capital cost. However the best opportunities for building fabric improvements occur during refurbishment.

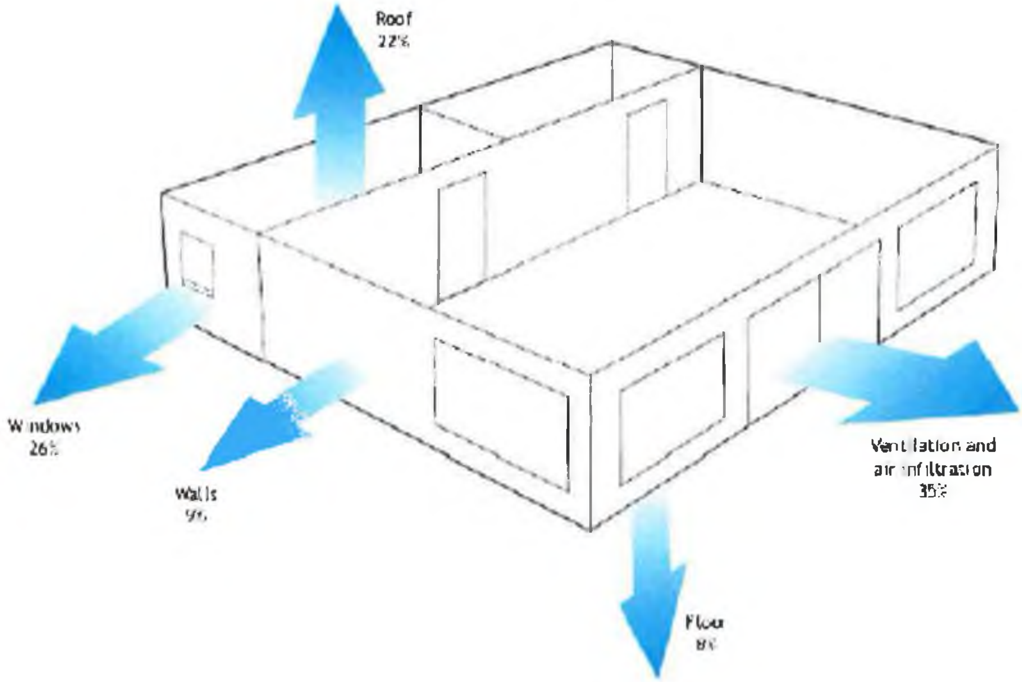

Figure 11 Typical Heat Loses source Carbon Trust CTV014

5.6.1 Roofs

It is important to check the thickness of insulation in the ceilings of pitched roofs. Some areas could have old ineffective insulation and in some cases it could be missing entirely. It is also possible to fit suspended ceiling beneath flat and pitched roofs. This saves energy by reducing the treated volume (SEI Energy Managers Resource Guide). An important factor in improving roof insulation is to consider additional ventilation, vapour barriers or other measures to prevent condensation in roof spaces. Insulation should not be allowed to obstruct ventilation particularly at the eaves. Any services above the insulated ceiling such as water tanks or pipe work needs to be insulated to protect against freezing.

5.6.2 Walls

Cavity wall insulation is cost effective with paybacks of between 3 and 5 years with minimum disruption to occupants (SEI Energy Managers Resource Guide). It is only applicable where there is a suitable cavity with no danger of interstitial condensation and no risk of damp penetration due to rain. A common retrofit insulation technique is to use bonded bead insulation. The insulation is pumped into the cavity through holes drilled into the outside wall. KOREfill and Certainfil are types of cavity wall insulation which utilise two basic components. These components are a specially manufactured grade of closed cell polystyrene FRA thermal bead, which is coated with an air drying adhesive during the injection process. This special bonding agent allows the beads to flow freely until the cavity wall is completely fitted. The adhesive then sets forming the beads into a bonded homogeneous heat saving mass which will not shrink, crack, settle or be unduly affected by the removal of any of the outer brickwork for alterations or window replacement (www.ecowiseinsulation.net).

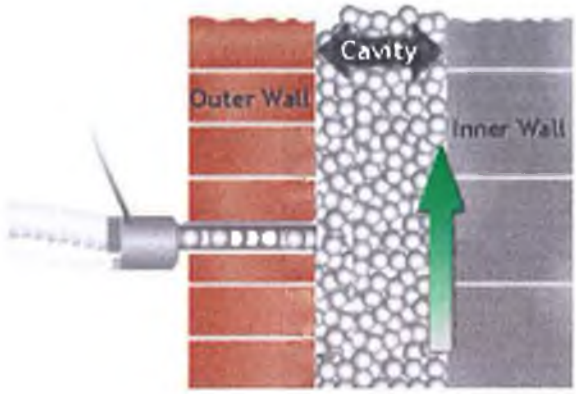

Figure 12 Bonded Bead Insulation being Installed source Ecowiseinsultaion.net

This cavity wall insulation has an affective thermal conductivity of 0.033W/mK and will satisfy the new building regulations i.e. 100mm cavity = 0.27u Value (W/m^2K)

Expected Results with KORE Fill Cavity Wall Insulation

Year House Build	Cavity Width	Expected Insulation Level in Cavity	U-value	KORE Fill Installed	New U-value
1997–2002	100mm	60mm SD EPS	0.45	40mm	0.29
1990–1997	100mm	50mm SD EPS	0.51	50mm	0.29
1980's	80mm	40mm SD EPS	0.59	40mm	0.35
1970's	40mm	None	1.65	40mm	0.55

* *Note: Insulation λ = 0.033W/mK*

Table 4 Expected Results from Korefill Cavity Wall Insulation source Ecowiseinsulation.net

Where there are no cavities it is possible to install external or internal wall insulation. Internal wall insulation is usually more expensive than external wall insulation. Internal wall insulation has the disadvantages of reducing room volume and can be disruptive to building occupants during installation. There is also the danger of thermal bridging. External wall insulation has low risk of thermal bridging, but it can be expensive to install in high rise buildings and in some instances can have a negative effect on building appearance.

GMIT could use the pumped bonded bead insulation for the older parts of the campus. Additional should also be placed in the roof spaces in both the old and newer parts and would play a great part in achieving a higher Building Energy Rating (BER).

5.6.3 Doors

Doors can be the source of the ingress of large volumes of unwanted air. Opportunities for savings include:

- Install draught stripping material
- Use of automatic door closers on external doors
- Maintaining doors in terms of proper closure, door handles working properly, automatic door closers working, loose hinges corrected and fixing of distorted frames
- Use of door lobbies, revolving doors or fast acting automatic doors for busy entrances
- Also consider the thermal properties of the doors

5.6.4 Floors

Floors are often forgotten/ignored but can provide opportunities for energy saving by looking for air infiltration through suspended floors. Heat lost through floors generally consists of two types:

- Heat loss through the floor perimeter, which is proportional to the length of perimeter and the temperature difference between inside and outside
- Heat loss through the ground which depends on the temperature difference between inside and outside and the overall floor area.

The greatest heat loss through an uninsulated floor is from the edges. Insulating the floor perimeter in a 1 meter band will not only provide good insulating results but will also prevent the risk of cold bridging at the junction of the floor and external wall.

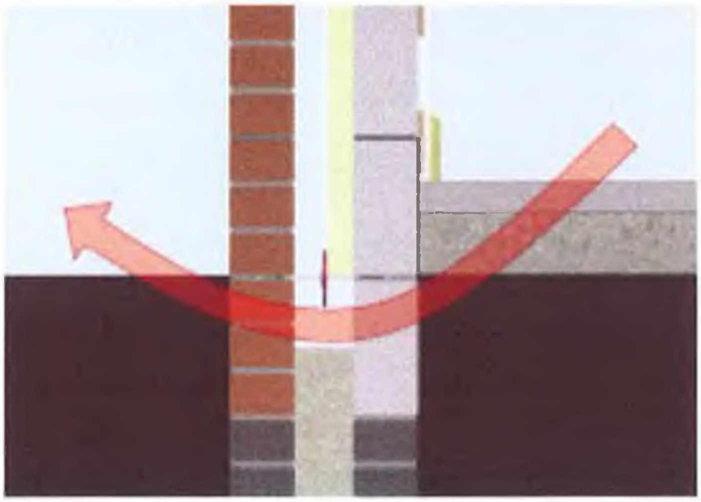

Figure 13 Heat Flow through Slab source uvalue.ie

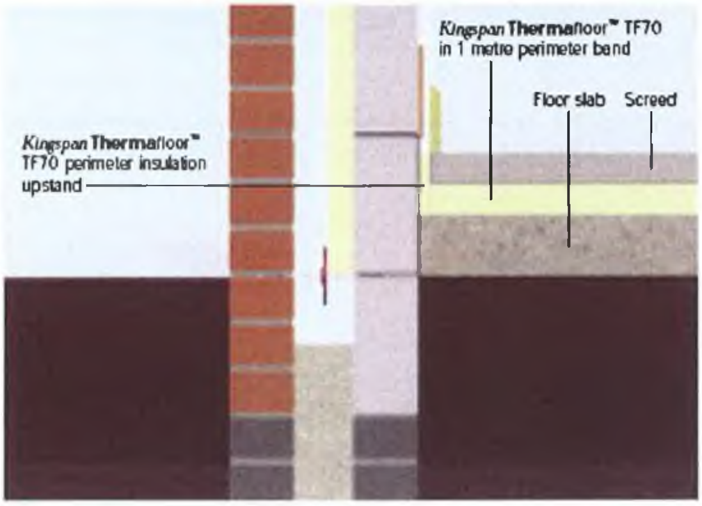

Figure 14 Perimeter Insulation source uvalue.ie

Under floor insulation is effective in suspended floors and above floor insulation beneath carpets and floor coverings is effective in both suspended and solid floors. However for suspended floors it is important to check the impact of restricted ventilation.

5.6.5 Windows

Where windows can be opened by occupants it is important to check for maintenance issues, e.g. catches/ handles in need of repair, broken draught stripping, broken or cracked panes of glass and distorted frames. When specifying new windows for a new design or refurbishment it is essential to specify double or triple glazing and consider using low emissivity glass. Other opportunities include:

- Fitting films to existing windows to minimise glare and solar gain thus reducing cooling loads and reduce radiative heat loss
- Fit daylight blinds which reflect direct sunlight but allows in daylight and lets occupants still see through the blinds
- Reduce excessive glazed areas, but only if it can be achieved without compromising daylighting levels
- Fit and maintain draught stripping
- Seal gaps between window frames and walls
- Make building occupants aware that windows do not need opening if the building is being heated or cooled
- Consider the choice of the inert gas used in double glazing
- Use lifecycle costing methods on the embedded energy in window materials e.g. PVC, hardwood and aluminium
- Consider the recycle potential of materials at the end of the life of the building

Solar control glass can be specified for any situation where excessive solar heat gain is likely to be an issue, e.g. large facades, glass walkways, atria and conservatories. This is especially important on the south facing aspect of the building.

Pilkington Activ Suncool glass provides solar control and low emissivity as well as being self cleaning. This would be perfect for a room like 834 and the library as they receive high amounts of solar glare. This can greatly reduce the need for cooling and artificial lighting within the building, while the insulation properties can reduce heat loss to 1.0 W/m2K in a standard Insulating Glass Unit (www.pilkington.com/resources/)

How the solar control works: glass controls solar heat radiation from the sun by reflectance, transmittance and absorptance.

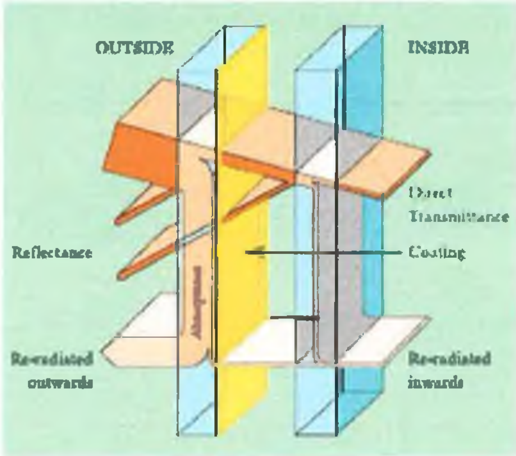

Figure 15 Insulating Glass Unit Incorporating Coated Solar Control Glass source Pilkington.com

How low emissivity works: low-emissivity glass will reflect energy back into a building to achieve much lower heat loss than ordinary float glass. Solar energy enters the building mainly as short wave radiation but once inside it is reflected back by objects towards the glass as long wave radiation. Low-emissivity glass has a coating that allows the transmission of the sun's short wave radiation at a much higher rate than long wave radiation

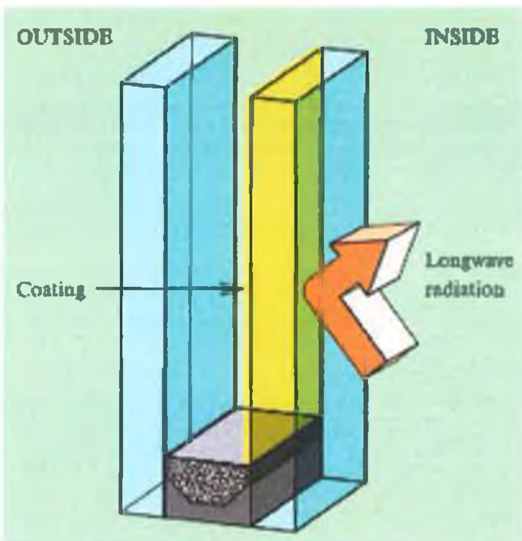

Figure 16 Insulating Glass Unit Incorporating Low E Glass source Pilkington.com

5.6.6 Air Tightness

Air leakage is the flow of air through gaps and cracks in the building fabric. Uncontrolled air leakage increases the amount of heat loss as warm air is displaced through the envelope by colder air from outside. Air leakage of warm damp air through the building structure can also lead to condensation within the fabric which reduces insulation performance and causes fabric deterioration. Building Regulations 2008 TGD-L indicates that reasonable provision for air tightness is to achieve a pressure test result of no worse than $10m^3/(h.m^2)$@50Pa. Current good practice for energy efficient buildings includes achieving air tightness of $7m^3/(h.m^2)$@50Pa and best practice is $3m^3/(h.m^2)$@50Pa. The air tightness appropriate for a particular building design will depend upon the Building Energy Rating the person is aiming to achieve.

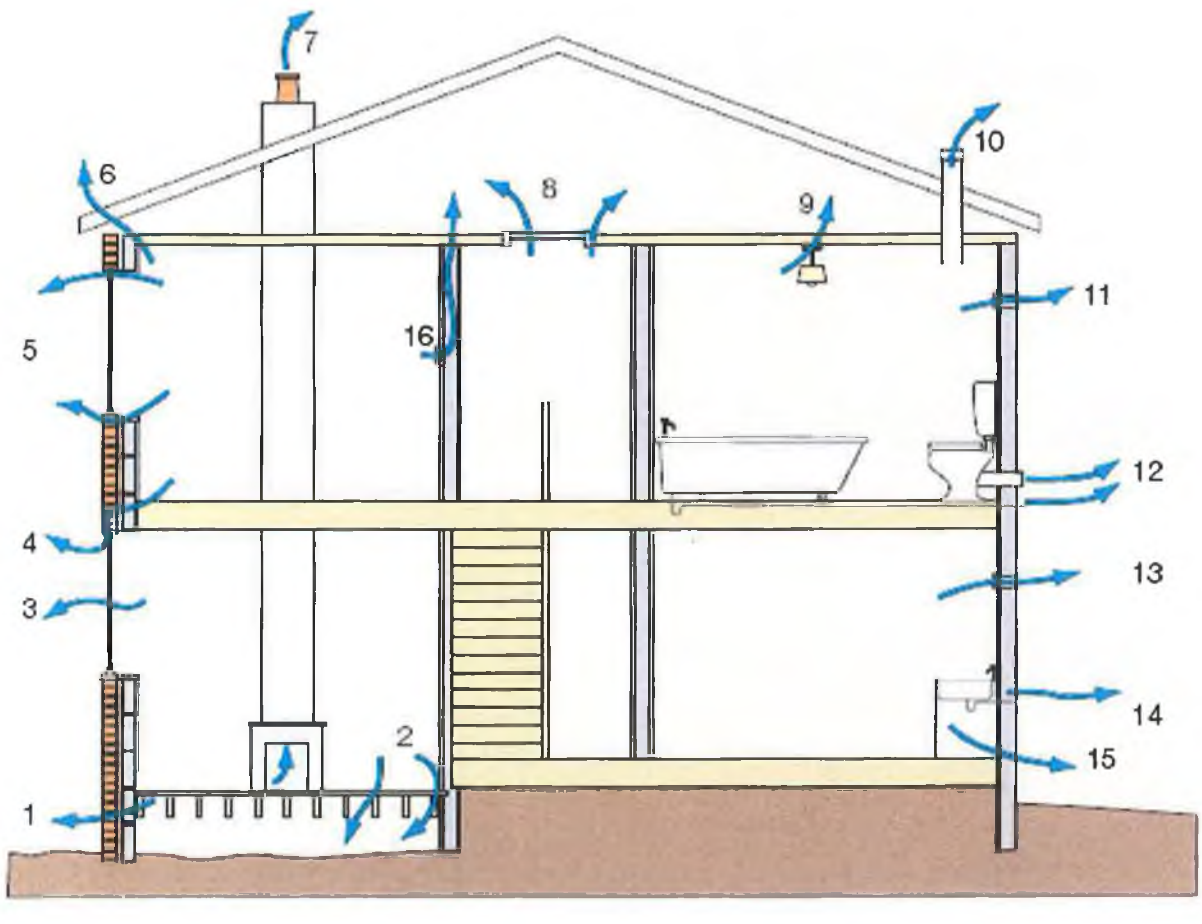

Figure 17 Common Sources of Air Leakage source Energy Saving Trust GPG224

Limiting building air leakage, infiltration or air permeability and maximizing building air tightness testing is essential in producing an energy efficient, comfortable and durable building. Reduced air-leakage should be in the interests of building's owners. Substantial savings in heating costs will result from reduced air tightness. Also the size (and therefore capital cost) of the heating system can also be saved with the reduction in heat demand of the building.

Use sealant materials to fill the gaps around windows and doors to prevent air leakage from the reveals and thresholds. Apply draught proofing to gaps around window opening casements, sashes and top-lights. Seal gaps around service pipes and the cables that pass through external walls, ceilings and ground floors. Ensure there is a good seal around boiler flue pipes where they pass through the external wall/ceiling. Check the performance of the sealing material to ensure it will not be affected by heat. Repair any damage to window frames and ensure the casements, sashes and top-lights close firmly. It may be necessary to replace closing mechanisms. The use of thermal imaging should be used to identify air leakage. New buildings should always be built to the motto "build tight, ventilate right" to achieve a high Building Energy Rating.

Figure 18 Sealant Placed Around Pipes to Achieve Good Air Tightness source google.ie

Due to the modular construction of the old part of the building many gaps are located around the joins of the components and also where services are running through the building. These are easily spotted by the eye in many cases and if needed thermal images could locate more gaps. Sealants should be placed around all pipes, windows and doors. Gaps between walls must be filled to achieve the required amount of air tightness.

5.7 Heating/Hot Water Controls

In the majority of buildings the largest amount of delivered energy is used for space heating and hot water. By controlling these elements substantial savings can be achieved in energy cost and CO_2.

For systems to be efficient it is important to address the following (Building Energy Managers Resource Guide):

- *Heating Sources*: The most efficient plant should be chosen for the application to generate the required amounts of heat and hot water.
- *Distribution*: Once generated the heat must be distributed efficiently and effectively using an appropriate heat transfer medium (usually air or water).
- *Controls*: These should ensure that heat and hot water are only delivered to the required areas at the correct time and temperature. The controls should also respond quickly to other factors such as solar gains, changes in the weather and internal heat gains from equipment and occupants.

5.7.1Heating Controls

5.7.1.1 Time Switches

Time switches are simple controls that switch services on and off in response to programmed time settings. The two most common types are 24h and 7 day controls.

5.7.1.2 Optimum Time Controls

An optimum start controller learns how quickly the building reaches the desired temperature and brings the heating on at just the right time to achieve the correct temperature as people arrive. Installing these controls typically results in heating switching on later on mild days, as shorter warm-up times are required.

5.7.1.3 Thermostats

These keep the temperature in a room to the required level. Modern electronic thermostats can control to within 0.5°C.

5.7.1.4 Thermostatic Radiator Valves (TRV)

A TRV is a simple control valve with an air temperature sensor used to control the heat output from a radiator by adjusting water flow.

5.7.1.5 Weather Compensation

Automatically varies the system temperature in relation to weather conditions. This provides useful energy savings in spring and autumn and avoids overheating a building.

5.7.1.6 Black Bulb Thermostats

These measure radiant heat instead of air temperature. These are used to control gas-fired radiant heaters.

5.7.1.7 Zone Controls

These are useful when some areas of a building require more or less heat than others such north facing areas with no solar gain would require more than south facing highly glazed areas.

5.8 Considerations for Heating Systems

5.8.1 Heat Pumps

Heat pumps operate as the reverse of the refrigeration cycle. Heat from a cooler source can be upgraded to a hotter source by use of refrigerants and work done by a compressor. Under the right conditions a heat pump can transfer more heat from a cooler source to a hotter output, than the energy required to run the compressor. The heat can be obtained from a variety of sources including rivers, lakes and the earth.

The ratio of the energy obtained from the condenser to the energy put in as work to the compressor is used as quantitative measure of performance. This ratio is called the Co-efficient of Performance (COP).The COP is the governing factor for all refrigeration vapour compression cycles and affects the economics of the system. The COP can be varied by the design of the system but can be as high as 10 for theoretical calculations but up to 4 or 5 for practical cycles (Energy Managers Resource Guide). If a heat pump has a COP of 4 then every one unit of energy put into the compressor results in four units of heat coming from the condenser.

The term ground-source heat pump (GSHP) is applied to a variety of systems that use the ground, groundwater, or surface water as a heat source and sink. The general terms include ground coupled (GCHP), groundwater (GWHP), and surface water (SWHP) heat pumps. The GCHP is a subset of the GSHP and is often called a closed loop heat pump. The most widely used unit is a water-to-air heat pump, which circulates water or a water/antifreeze solution through a liquid-to-refrigerant heat exchanger and a buried thermoplastic piping network. The GCHP is further subdivided according to ground heat exchanger design: vertical and horizontal (ASHRAE, 2007)

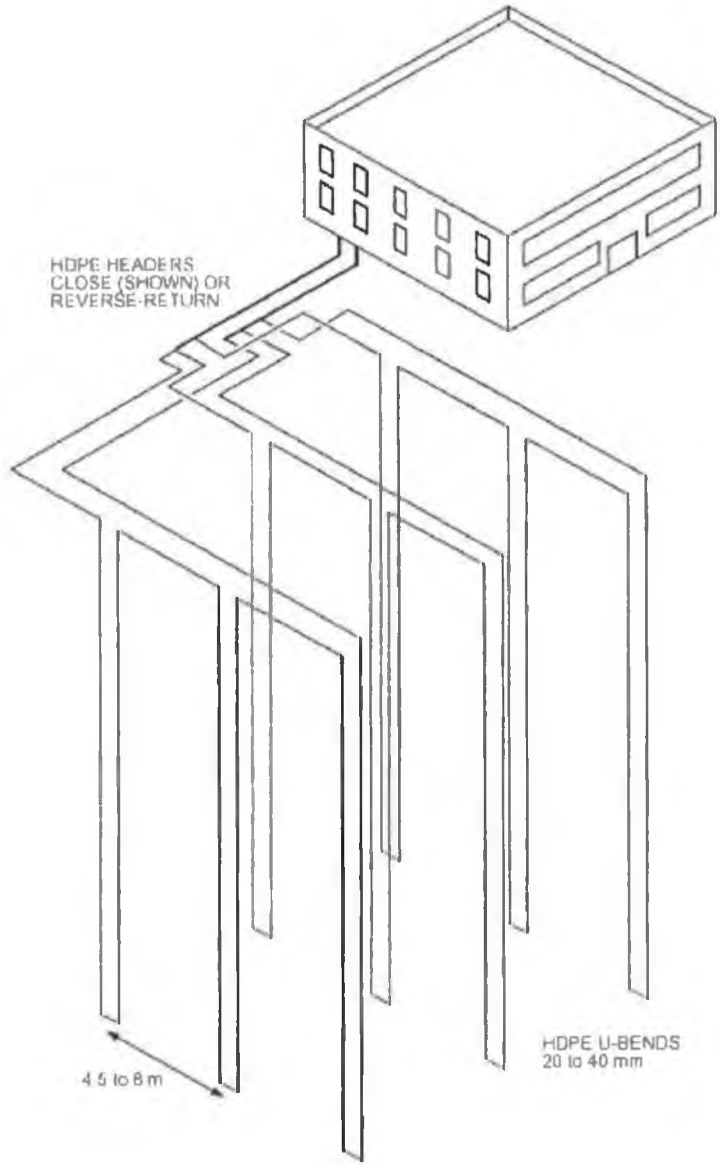

Figure 19 Vertical Ground Coupled Heat Pump source ASHRAE Handbook 2007

Advantages of the vertical GCHP are:

- it requires relatively small plots of ground
- is in contact with soil that varies very little in temperature and thermal properties
- requires the smallest amount of pipe and pumping energy
- can yield the most efficient GCHP system performance

Disadvantages are

- typically higher cost because of expensive equipment needed to drill the borehole
- the limited availability of contractors to perform such work

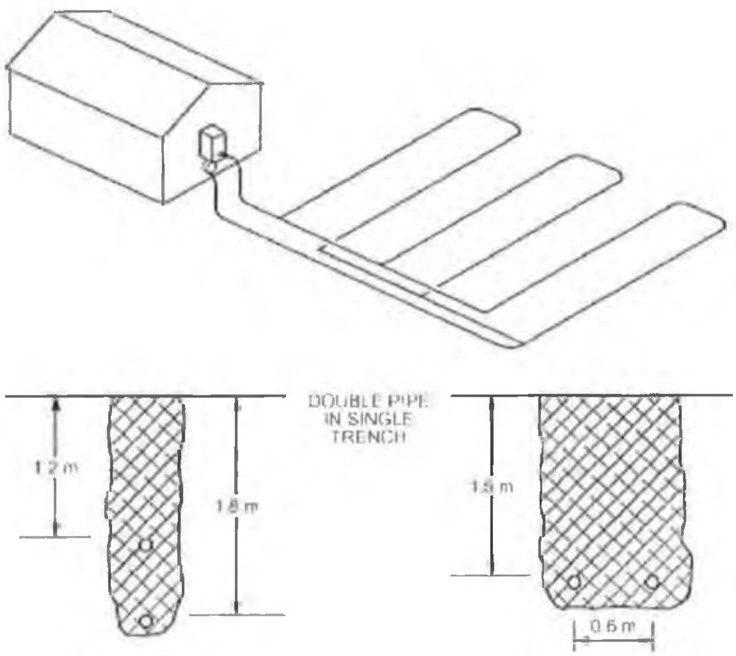

Figure 20 Horizontal Ground Coupled Heat Pump source ASHRAE Handbook 2007

Advantages of horizontal GCHPs are:

- they are typically less expensive than vertical GCHPs because relatively low-cost installation equipment is widely available
- many residential applications have adequate ground area
- trained equipment operators are more widely available

Disadvantages include:

- larger ground area requirement
- greater adverse variations in performance because
- ground temperatures and thermal properties fluctuate with season, rainfall and burial depth
- slightly higher pumping-energy requirements
- lower system efficiencies

5.8.2 Active Solar Heating

This is used to describe systems which collect the sun's radiation and uses solar collectors to transfer it in the form of heat to air, water or some other fluid. As the technology does not require direct sunlight for it to be effective, there are opportunities in all parts of Ireland to exploit solar radiation for this purpose. Solar water heating is the most commonly used application of active solar thermal in Europe (www.estif.org)

Applications of active solar technology include:

- hot water supply
- swimming pool systems
- space heating

5.8.3 Heat Recovery

Heat recovery systems can form a fully integrated part of a design, resulting in lower running costs and possibly reduced plant capacities as they use heat energy that would otherwise be rejected as waste. These systems most commonly recover heat from ventilation systems, using devices such as heat wheels, plate heat exchangers or run-around coils to recover energy from exhaust air then use it to pre-heat or pre-cool supply air. There must be sufficient energy being rejected at times when it can be used to justify the added complications and running costs of installing heat recovery devices. Check that any additional electrical energy input required, e.g. fan power to overcome resistance of heat exchangers or coils, does not waste the energy saved, bearing in mind that it uses electricity rather than the fossil fuel energy (CIBSE Guide F).

5.8.3.1 Run Around Coil

When two recuperative heat exchangers are linked together by a third fluid which transports heat between them, this is known as a run around coil (Beggs, 2009). These comprise finned-tube copper coils located in supply and exhaust air streams connected by pipe work through which water or antifreeze solution is pumped. Typical thermal effectiveness is 45-65% depending on the number and spacing of coil rows and the temperatures prevailing. Run around coils have the advantage that they can be used in applications where the two fluid streams are physically too far apart to use a recuperative heat exchanger. The additional air resistance and pumping energy should be taken into account.

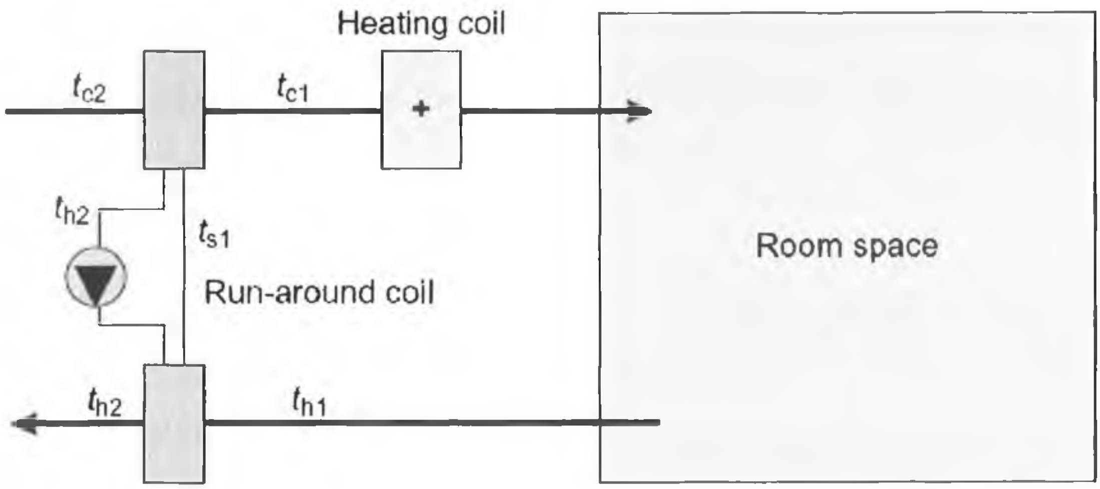

Figure 21 Run Around Coil System source Beggs, 2009

5.8.3.2 Plate Heat Exchanger

Plate heat exchangers are made up of a large number of thin metal plates that are clamped tightly together and sealed with gaskets. The thin plates are profiled so that flow ways are created between the plates when they are packed together and a very large surface area is created across which heat transfer can take place. Ports located at the corners of the individual plate separate the hot and cold flow of fluid and direct them to alternate passages so that no intermixing of the fluid happens. The whole exchanger experiences a counter flow pattern. The maximum operating temperature is usually about 130 ° C if rubber sealing gaskets are fitted, but this can be extended to 200 ° C if compressed asbestos fibre seals are used (Beggs, 2009). Plate heat exchangers are popular because they are extremely compact and can be easily expanded or made smaller to accommodate future alterations. Effectiveness can be in the range 30-70%, depending on the spacing of the plates, but is typically less than 50% (CIBSE Guide F).

Figure 22 Plate Heat Exchanger source Google.ie

5.8.3.3 Shell and Tube Heat Exchanger

These consist of a bundle of tubes inside a cylindrical shell through which two fluids flow, one through the tubes and the other through the shell. Heat is exchanged by conduction through the tube walls. Baffles are often used to direct fluid around the heat exchanger and also to provide structural support for the tubes (Beggs, 2009).

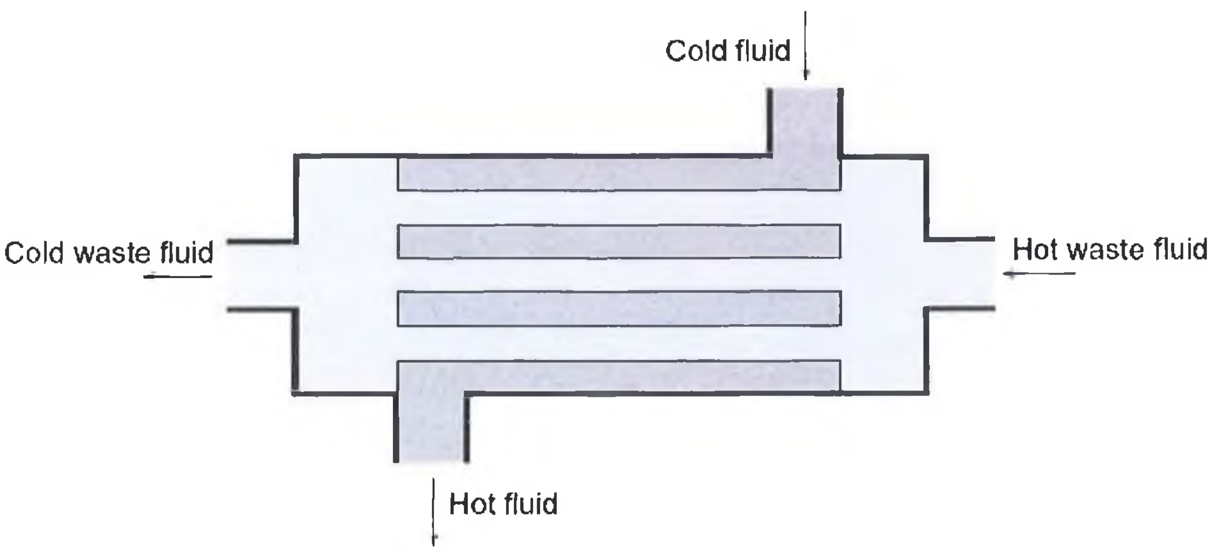

Figure 23 Shell and Tube Heat Exchanger source Beggs, 2009

5.8.3.4 Flat Plate Exchanger

These are made up of a series of metal plates separating hot and cold air/gas flow in a box like structure. The plates are sealed to prevent the intermixing of the two flows. These are often used in ducted air conditioning systems to reclaim heat from the exhaust air stream without any cross contamination occurring.

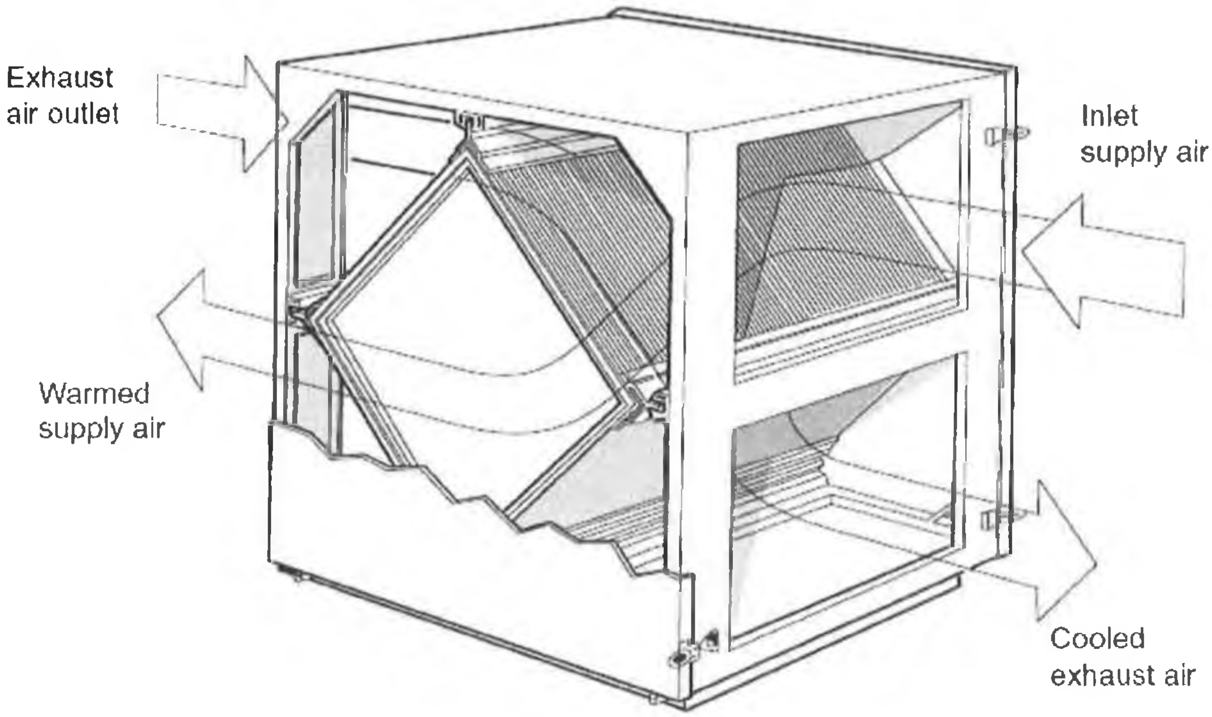

Figure 24 Flat Plate Heat Exchanger source Beggs, 2009

5.8.3.5 Thermal Wheels

Thermal wheels are made up of a matrix of material mounted on a wheel which spins at approx 10 RPM through hot and cold fluid streams. The material matrix is generally an open structured metal like knotted stainless steel, aluminium wire or corrugated sheet aluminium or steel (Beggs, 2009). For higher temperatures honey comb ceramic materials are used. The major advantage of thermal wheels is that there is a large surface to area volume ratio resulting in a relatively low cost per unit surface area. Usually thermal wheels are used solely to recover sensible heat, but it is also possible to recover latent heat by coating a non metallic matrix with a hygroscopic or desiccant material. Typical effectiveness is 60-85% depending on the media construction in the thermal wheel. A sensible heat exchanger may recover up to about 65% sensible heat while the hygroscopic exchanger can recover around 80% total heat (CIBSE Guide F). Cross contamination can be minimised by using a purge section.

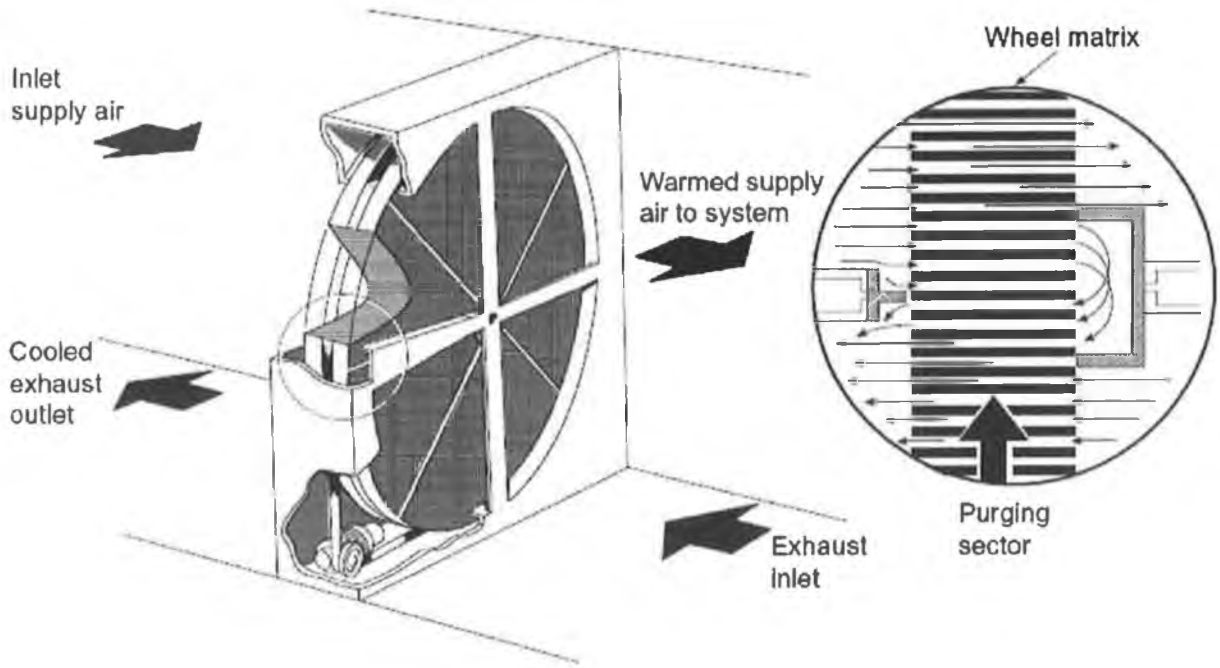

Figure 25 Thermal Wheel source Beggs, 2009

5.8.4 Heat Recovery in GMIT

GMIT use heat recovery in a couple of different forms. A run around coil is used in the lecture halls and theatres in the newer section of the building. It works in the same way as described above taking heat from the exhaust air and heating up the supply air if needed which saves on heating costs. More heating controls however need to be used in the older parts of the building. A perfect example of where TRVs would be of huge benefit is room 834. This room is often in the high twenty degrees due to solar gains along with the boiler sending hot water to it three times a day. If TRVs were fitted to the radiators here it would be a much more comfortable environment.

Also there are two types of ground source heat pumps used. Both horizontal and vertical ground coupled heat pumps are used to heat the water around the college again saving on the oil needed to run the boilers.

5.8.5 Combined Heat and Power (CHP)

Combined Heat and Power (CHP) plants are power plants that make use of both electrical and heat outputs resulting in a more efficient use of fuel. In conventional power stations most or even all of the heat produced is wasted giving typical overall efficiencies of 40%, while newer combined cycle gas turbine stations only achieve efficiencies of around 47% (Beggs, 2009). This means that over 50% of the primary energy in the generation process is wasted and not converted into delivered electricity. This wasted energy is converted to heat which is rejected to the environment. Some of this waste can be overcome by generating power locally at the point of use and putting the heat produced to good use. In typical CHP systems heat exchangers are used to reclaim waste heat from exhaust gases during the electricity generation which helps achieve efficiencies of 85% or greater (Greeno & Hall, 2009). CHP fuelled with natural gas is a low carbon rather than a zero carbon option but using biomass as a fuel allows the possibility of renewable CHP. The best sites for CHP are those where there is an all year round heat demand. Examples include industrial processes, airports, hospitals, leisure centres with swimming pools, hotels, universities and multi-accommodation sites. Simple paybacks of 4 to 5 years can be achieved if the CHP unit operates for about 4500 hours per year or about 12-14 hours per day (CIBSE Guide F). It is better to undersize a CHP unit than oversize it as this will ensure that the unit is always running when in operation with any shortfall being made up by backup boilers and bought in electricity. This makes it common to use the CHP unit to satisfy base heat load requirements (CIBSE Guide F).

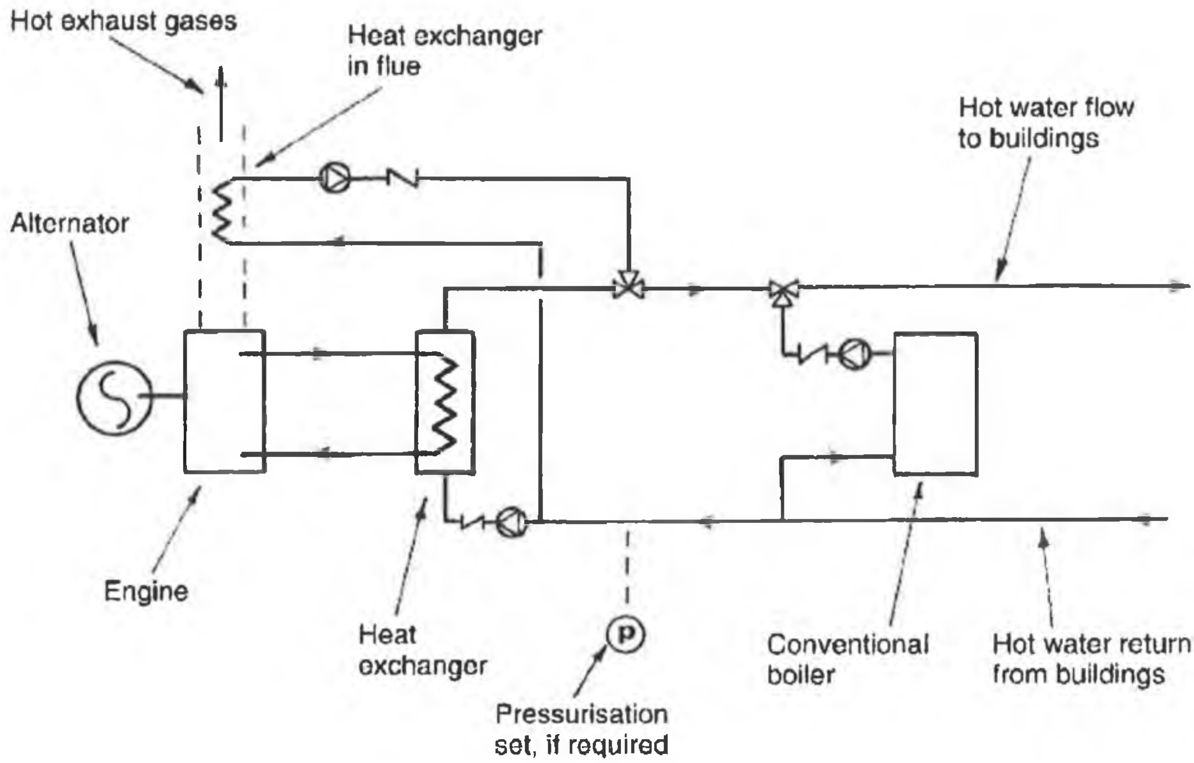

Figure 26 Principles of CHP source Greeno & Hall, 2009

The three main categories of CHP are:

5.8.5.1 Large Scale CHP

This category is usually of output greater than 1MWe (1MW electrical output) and typically might be a gas turbine or a spark ignition gas engine with heat recovery systems fitted to generate steam or hot water. Large scale CHP is often used in industrial processes where there is a large demand for heat e.g. paper mills, breweries and food processing. It is also used in large institutions such as hospitals and universities.

5.8.5.2 Small Scale CHP

This category is mainly in the range from 50 kWe up to 1 MWe and is usually a packaged unit with generator, gas reciprocating engine and heat recovery. They are often used in leisure centres, hospitals, hotels and multi-residential dwellings.

5.8.5.3 Micro CHP

Micro-CHP are small units designed for domestic dwellings or small businesses. The sizes vary in electrical output up to about 10kWe.

Greenhouse Gas Emission	Estimated net reduction in emissions per kWh of electricity produced by CHP (g/kWh)
CO_2	1,000
SO_2	17
NOx	4.6
CO	(3)
CH_4	3.9

Figure 27 CHP Emissions source Building Energy Managers Resource Guide

The heat from a CHP unit can be used to drive a cooling system such as an absorption refrigerator. Plants producing electricity, heat and cooling are often referred to as CCHP (Combined Cooling Heat and Power), tri-generation or poly-generation plants.

It would be worth considering a small scale CHP system for GMIT due to the high heating and electrical requirement. As GMIT is open from 8 in the morning and doesn't close until around 10 at night it would meet the requirements of running 4500 hours a year. This could even be specified for the new school of engineering. GMIT would also be able to recover some of the cost for installing this from the Accelerated Capital Allowance

5.9 Lighting

Lighting in buildings accounts for about 20% of national electricity use (Building Energy Managers Resource Guide). In the UK the Carbon Trust say that 73% of this is used in commercial and industrial applications with the balance made up by domestic applications. This figure should be similar to what is used in Ireland.

Office Category	Typical energy consumed in lighting kWh/m²/annum	Lighting expressed as % of overall power consumption
1. Naturally ventilated cellular	23	43%
2. Naturally ventilated open-plan	38	45%
3. Air-conditioned standard	54	24%
4. Air-conditioned prestige	60	17%

Figure 28 Electricity Consumption of Lighting in Offices source Building Energy Managers Resource Guide

Energy efficient lighting should do the following:

- Maximise natural daylight
- Avoid unnecessary high illuminance
- Incorporate the most efficient luminaries, control gear and lamps
- Include effective lighting controls

Lighting is often the single biggest electrical consumption and cost in non air conditioned buildings as shown in the table above it can use up to 43% of the overall power consumption.

All lighting systems no matter how complex are made up of three basic components:

- **Lamp:** the source of the light, for example, the bulb
- **Luminaire:** a light fitting that holds the lamp and includes the optics, drivers, heat sink and control gear
- **Controls:** manual or automatic switching equipment, that operates the lighting system, including daylight sensoring, occupant sensing and zoning

The benefits of energy efficient lighting are:

- Saves energy and running costs
- Reduces loads on air conditioning systems
- Improves productivity

- Reduces errors
- Reduces maintenance costs
- Improves security and safety
- Enhances visual environment
- Provides end users with local control

5.9.1Lamp Types

5.9.1.1 Tungsten Filament

These lamps provide excellent colour rendering, are easily dimmable and no ballast is required but are particularly inefficient and for this reason should be avoided where possible. They have efficacies of around 8-15 lm/W with most of the electrical energy being converted to heat which can cause space overheating problems (Rinstinen & Kraushaar, 2006). Their life is short with most only lasting only 1000 hours.

5.9.1.2 Compact Fluorescent Lamps (CFL)

A wide range of CFLs are available which give significant savings (up to 75%) over tungsten equivalents. They are produced in a variety of forms and can be installed as direct replacement for most types of tungsten lamps. CFLs have a lower power rating than tungsten an 18W CFL compares with a 100W tungsten and this not only saves energy but reduces heat gains and maintenance costs as CFLs last between 8 and 12 times longer. These lamps can be divided into two distinct categories: ones with integral control gear and those that require separate control gear. Generally the life of the control gear lasts longer than the lamp so it is better to install lamps with separate control gear as it can be more cost effective. Dimmable ballasts are now available. The higher initial cost of the lamps is offset by greatly reduced maintenance and running costs.

5.9.1.3 Fluorescent Tubes

These are very common in the majority of commercial buildings and have efficacies of between 80-100 lm/W. By replacing the older T12 (38mm) with T8 (26mm) an average saving of 8% can be achieved. It is possible to extract air for heat recovery through the luminaries.

5.9.1.4 Triphosphor Fluorescent Lamps T5 and T8

These provide approximately 10% more lumens and are therefore more efficient than the older halophosphate coatings and also give excellent colour rendering. Savings can be made in the running costs because lumen depreciation is less with triphosphor, which means the number of luminaries can be reduced to get the same illuminance. T5 lamps (16mm) are shorter in length than T8 units and can be used in smaller luminaries. These have been around for a number of years and are more efficient because of their smaller size, but this increases light intensity and glare might become a problem.

5.9.1.5 Metal Halide and High Pressure Sodium Discharge Lamps

These are high wattage lamps with high light outputs with applications for large spaces such as factories, industrial buildings and larger retail premises. They are also useful for exterior lighting, car parks and flood lighting. High pressure sodium (SON) and metal halide (MBI) lamps offer greater efficacies than high pressure mercury lamps (MBF). MBI lamps are available in a wide range of power ratings 70-2000W and give efficacies of 70-100 lm/W depending on the power rating while SON lamps have efficacies of 70-120 lm/W and power ratings from 50-1000W (Beggs, 2009).

5.9.1.6 LED

LEDs are solid-state devices (semi-conductors) which are small, solid, extremely energy-efficient and with no moving parts. They also offer the prospect of longer lifetimes when compared to all existing technologies. LEDs emit light when a current passes through a diode. The LED is usually small in area (less than 1 mm^2). This technology is growing all the time and new applications such as downlighters, display lighting and floodlighting are available. In some cases LED lamps can be used to replace CFL bulbs (www.philips.ie)

Within the overall design requirement lamps with the highest efficacy and circuits with the lowest losses should be selected to minimise installed load and running costs.

5.9.2 Control Gear

All discharge lamps such as fluorescent lamps require control gear to start and control the lamp. Matching the control gear to the lamp achieves the optimum lamp performance and circuit efficacy. Until recently ballasts consisted of a copper wire wrapped around a metal core with losses representing 10-20% of the total load (CIBSE Guide F).

High frequency ballasts have now been developed and these run at frequencies of between 20-40 kHz. These can reduce losses by 50% compared to the wire wound chokes. Advantages include virtually instantaneous starting, the possibility of dimming, flicker-free lighting and softer starting conditions that increase lamp life.

Type	Luminous Efficacy (Lumens/Watt)	Colour Appearance (Kelvin)	Colour Rendering (Ra)	Life (hours)
Tungsten	12	2600	100	1000
Tungsten (long life)	8.75	2500	100	6000
Tungsten (extra long life)	5.25	2500	100	16000
Tungsten Halogen	18	3000	100	2000 – 8000
Compact Fluorescent	70	2700-4000	85	8000+
38mm T12 White F/Tube	67	3500	59	7000+
25mm T8 White F/Tube (S/G*)	77	3500	58	8000+
25mm T8 White F/Tube (HF**)	88	3500	58	8000+
25mm T8 Full Spectrum Multiphosphor	64	5000	95	17500
25mm T8 H/F Triphosphor	100	2700-6000	80+	12000 – 18000
25mm T8 H/F Triphosphor	65	2700-6000	90+	12000+
16mm T5 H/F Triphosphor	90-106	2700-6500	80+	16000+
7mm H/F Triphosphor	55	3500-6000	85	8000-12000
Metal Halide	60-80	3000-6000	65-85	8000 – 12000
Mercury	45	3900-4300	40-49	12000+
Mercury D/Luxe	50	3300	60	12000+
Mercury Plug-in	45	3300-3600	50-70	8000 – 10000
Low Pressure Sodium/E	138	1800	0	6000
High Pressure Sodium	108	2000	25	12000 – 30000
High Pressure Sodium D/L	82	2200	60	12000
HPS Plug-in	85	2000	23	12000+
White Sodium	40	2500	80	8000+
Induction	70	3/4000	85	10000 – 60000
Light Emitting Diodes (LEDs)	50/100	Saturated/6000		50/100000

Table 5 Lamp Characteristics source Building Energy Managers Resource Guide

5.9.3 Lighting Controls

By using the proper lighting controls to ensure the correct level of lighting is provided at the right time and in the right place substantial savings can be made. These savings come from the better use of daylighting and switching off lights when the area is not being used. Localised controls can increase user satisfaction by allowing occupants to have more control over their working environment. The main types of lighting systems are:

5.9.3.1 Time Control Systems

These turn off lights according to a specific schedule programmed into the building management system, with occupants being able to switch lights on if needed with an override system. In open plan spaces energy savings of 20-30% are possible (CIBSE Guide F)

5.9.3.2 Occupancy Linked Control Systems

Control is achieved by using infrared, ultrasonic, acoustic or microwave sensors which detect either movement or noise in the room. These turn the lights on when occupancy is detected and off when no occupancy is detected for a pre set time. They are designed to override manual switches and to prevent a scenario where the lighting is left on in unused spaces.

5.9.3.3 Daylight Linked Control

This can be used with both timed and occupancy controls as an override depending on the amount of natural light available. This type of control is based on photocell controls and can also be used to switch on and off or dim lights when daylight is adequate. A time delay should be incorporated to prevent the continuous switching on/off by e.g. fast moving clouds. Dimming daylight linked controls can provide constant illumination level at the working plane by sensing the total amount of daylight and electric lighting. The dimming control can allow 0-100% of electric light depending on conditions.

5.9.3.4 Localised Switching

This is of particular benefit to large open spaces. These give individuals control over their visual environment. The switches should be placed in obvious and easily accessible places. Switching arrangements should permit individual rows of luminaires parallel to window walls to be controlled separately to maximise natural light. Controls can take the following forms:

- A pull cord switch
- Portable infra-red controllers on desks or mounted on a wall
- Ringing a code to the BMS

5.9.4 Maintenance

Over time luminaires and room surfaces get dirty and lamp output decreases. If a typical fluorescent installation is not cleaned over a three year period the illumination will drop to less than 50% of the original level (Building Energy Managers Resource Guide). Bulk replacement of lamps should be planned so that they are replaced at the end of their useful life before the output deteriorates to unacceptable levels. Relamping cycles will vary but usually an economic relamping cycle for fluorescents is when 10% of the lamps have failed. Replacement costs in a typical commercial environment are around €1.50 per lamp if they are all replaced at the same time. If replaced on an ad hoc basis the cost could range from €15 to €30 per lamp primarily due to the additional labour costs (Building Energy Manager Resource Guide).

5.9.5 Light Pipe Technologies

Although the use of daylighting is straight forward for perimeter zone that are near windows, it is not usually feasible for interior spaces, particularly those without any skylights. Recent but still emerging technologies allow the "piping" of light from roof or wall mounted collectors to interior spaces that are not close to windows or skylights.

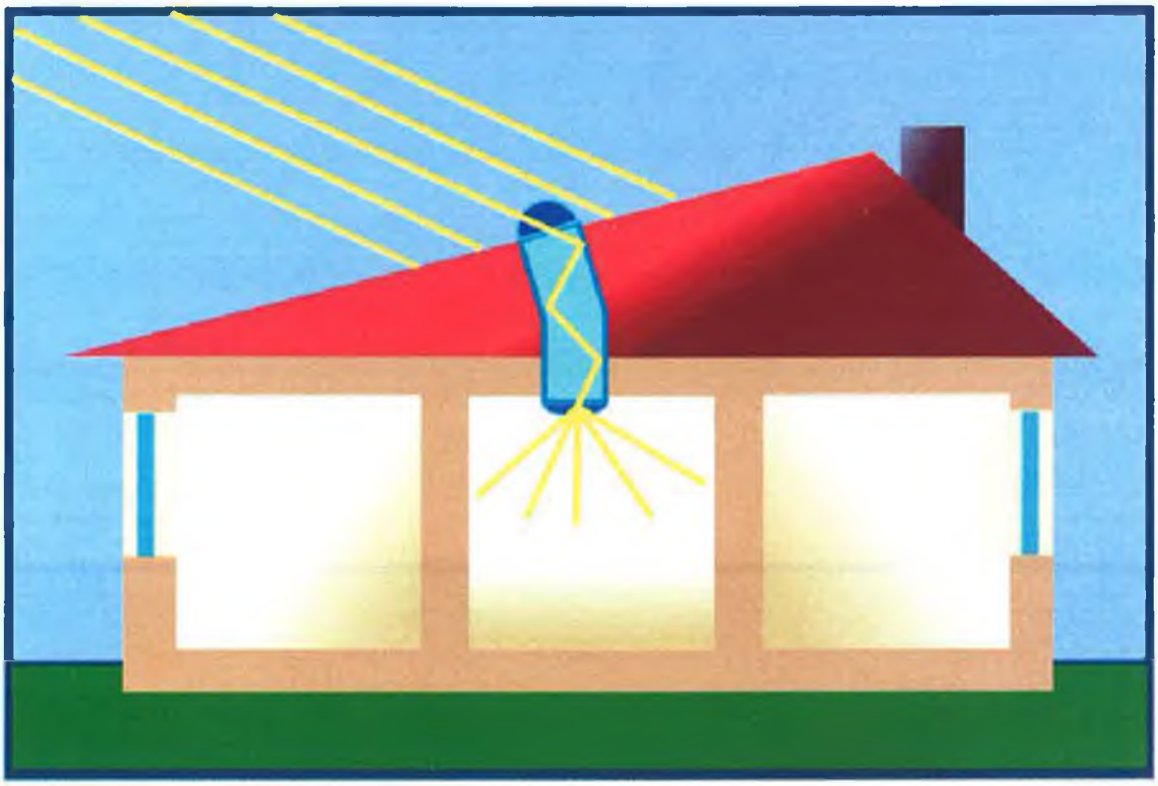

Figure 29 House with a Light Pipe source Google

5.9.6 GMIT Lighting

A lighting survey was carried out of the library, theatre 1000 and the lecture rooms in the new building of the college. From the survey it can be seen that various different types of lighting are used throughout these rooms and spaces. The lamps found used were T8's, T5's, CFL and Halogen lights. However due to difficulties in being able to obtain data about the light fittings and their output the author made assumptions on their wattage outputs. It is assume that the T8 lights are of 36W output for the reflective ceiling luminaries, with 18W being used for the up lighters on the walls. It must also be noted that it was not possible to see the up lighters or the concealed lamps due to their height above ground, so low wattage 18W T8 lamps are assumed used. The T5 lights are assumed to be 25W lamps, the CFL bulbs 18W and the halogen spot lights 50W. If all these lights in the survey were left on for 8 hours a day 526.336 kWh/day is used in these areas.

From this survey it was noted that a lot of energy is wasted by leaving lights on when areas are not in use and even when there is adequate light. On 10/9/2010 it was noted in Theatre 1000 that there are 62 x 2 18W CFL lamps and 14 concealed 18W T8 lamps in the room. On a quick observation the room was not in use at the time and yet 19 of the 62 (31%) CFL lights were left on along with **all** the concealed lights. It might have been possible that there was a lecture about to take place or was just after finishing. But this still does not explain why these lights were on for no reason. The other lecture rooms on the day of the survey fared much better as all the lights were off in the rooms. But is this due to the college not being back yet and the rooms hadn't been used in some time.

Another area where there seems to be a great waste of energy from lighting is the library. There are 484 36W T8 lamps used here along with 636 25W T5's, 33 18W CFL's, 33 18W T8's, 13 100W Halogen, 8 50W Halogen spots and 284 25W T5's task lights for desks. It was observed that lights were switched on even where there are places with adequate daylight and in areas where nobody is using. Another problem found is that on the book shelves. 636 25W T5 lamps light these areas and these lights are left on all the time during the course of the day. Below are a few pictures of lights left on when there seems to be adequate daylight.

To change these trends staff need to be made aware of how much energy they are wasting. This can be done through energy awareness campaigns and with appropriate posters. What would appear to be one of the biggest wastes of energy is leaving on the lights all day and night over bookshelves. Could it be possible to let individuals switch on the lights when they are looking for a particular book and have a notice to say switch off lights when finished. Surely this would see a dramatic reduction in the amount of lights left on in the library which would reduce cost as well as the amount of CO_2 produced. On www.philips.ie they have a tool to estimate the savings possible by switching to energy efficient lighting such as T5 lamps. Switching the 936 T8 lamps running 8hrs a day 250 days/yr at a cost of €0.12/kWh would save €7388.40 a year and have a reduction 2660 kg of CO_2 emissions. Also the addition of daylighting controls integrated into the BEMS would defiantly reduce the consumption of energy in the library. In places where there is over illuminance delamping should take place to reduce the energy requirements.

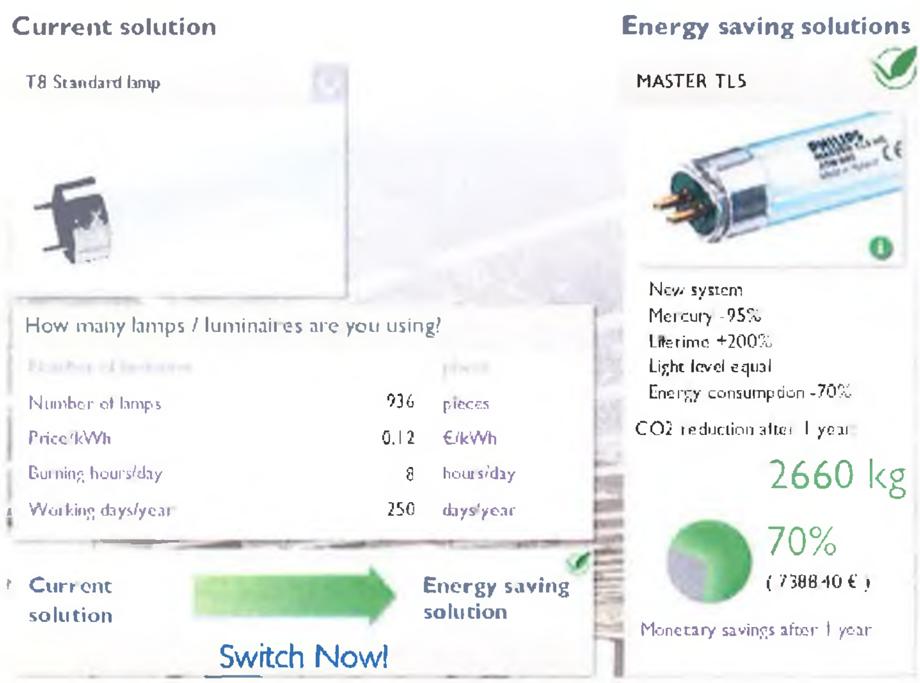

Figure 30 Savings by Switching T8 to T5 lamps source Philips.ie

Lighting	**T8 36W**	**T5 25W**	**CFL 18W**	**Spots 50W**	**T8 18 W**	**Halogen 100W**	**T5 25W**
Room		**Book Shelves**			**Up Lighters**		**Task Light**
Lib Gr	164	310	30	8	12	13	148
Lib 1st	320	326	3		11		136
941	30		28	4			
942	20		14	4			
943	20		14	4			
944	16		8	4			
994	30		28	4			
995	20		14	4			
996	20		14	4			
997	16		8	4			
1031	28						
1032	28						
1033	28						
1034	28						
1035	28						
1036	28						
1039	56						
1041	56						
1000			124		14		
	936	**636**	**285**	**40**	**37**	**13**	**284**
Wattage	33696	15900	5130	2000	666	1300	7100
Tot Watts	**65792**						
	x8hrs						
	526336						
	526.336	**kWh/day**					

Table 6 Type & Number of Lamps in Each Room

Figure 31 Lights on Outside the Library in Daytime

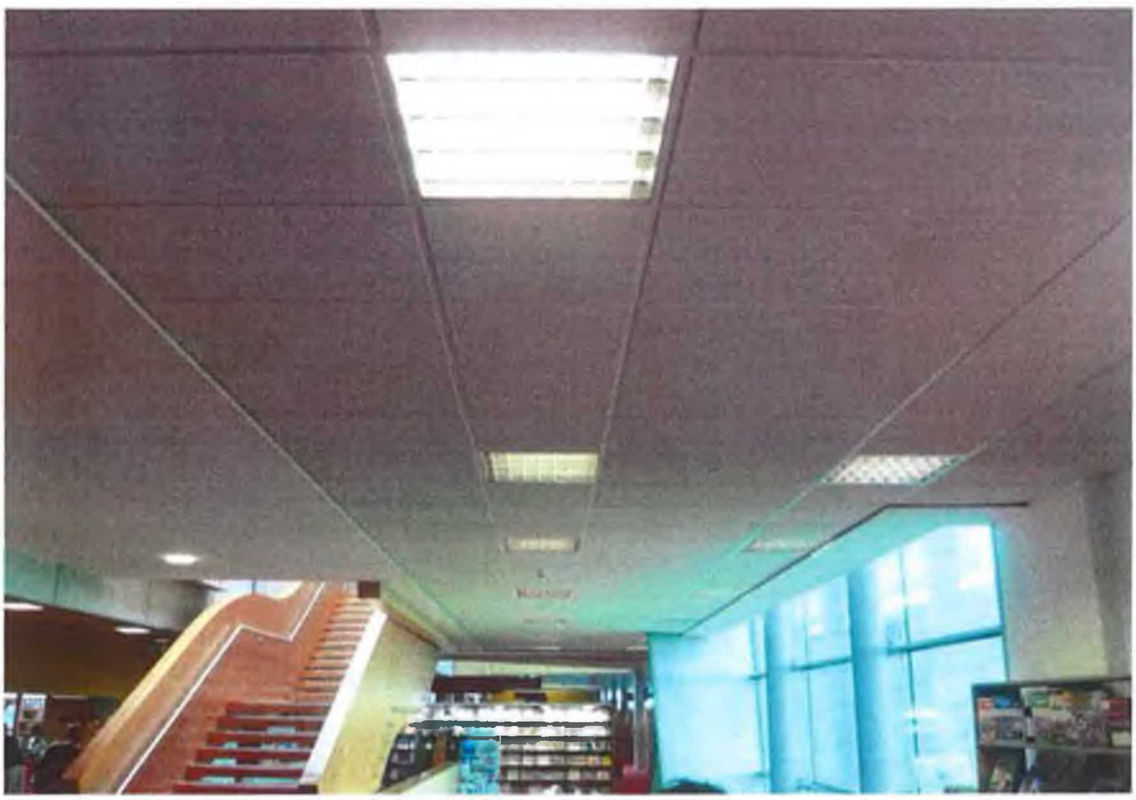

Figure 32 Lights on Even Though Enough Light From Window

Figure 33 Bookshelf Lights Constantly Switched On

Figure 34 No Need for Bookshelf Lights on Here

5.10 Office Equipment

Office equipment is a major electricity user in most office environments. This equipment includes computers, printers, photocopiers, fax machines, desk fans, vending machines and kettles etc. Office equipment is the fastest growing energy user in the business world, consuming 15% of the total electricity used in offices. This is expected to rise to 30% by 2020 (The Carbon Trust CTV005).

Users of office equipment should be encouraged to switch off equipment when it's not being used. All equipment should be switched off at night and at weekends unless there is a specific reason not to.

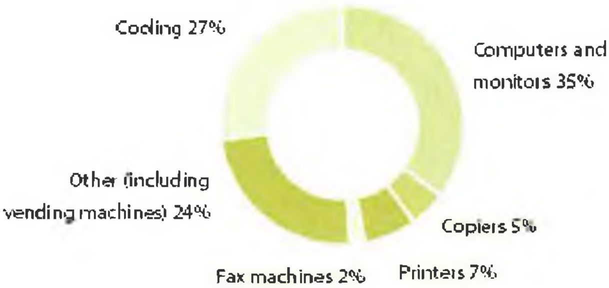

Figure 35 Typical Office Equipment Consumption source Building Energy Manager Resource Guide

Most modern computers and some equipment have energy saving software built into them. A government survey of PCs in the UK discovered that of all PCs with energy saving devices built-in only 25% were actually activated (Building Energy Managers Resource Guide). Most of the energy saving features apply to the monitors as they use more energy than the processors. If no activity has taken place for a preset period of time the computer powers down the screen until it reaches full sleep mode. Energy use typically falls from 80W to less than 10W per monitor. It needs to be noted that screensavers are not a low power mode. Some may reduce energy consumption by 10W at best but often it makes no difference at all. A typical processor with monitor left on for 24 hours each day can use €90 or more of electricity each year. Turning these off at night and weekends will reduce the bill to €20 a year. This amount can be reduced by a further €14 or more by adopting simple energy management techniques (The Carbon Trust CTV005).

Laser printers are often the highest energy users both in active and standby modes. A high specification inkjet printer should be considered. Although they are slower, inkjet printers use less energy in standby and print modes and the print quality is usually just as good. These could be used for non urgent documents. Labelling them 'low energy printers' on the network could encourage staff to select these for day-to-day use

The use of Thin Film Technology (TFT) monitors is replacing cathode ray tube monitors. These typically use 50-70% less energy, give off zero electromagnetic radiation and take up less space (Energystar.org)

To make sure you are getting energy efficient equipment make sure you use appliances with the Energy Star label.

Due to the high level of office equipment on the GMIT campus it is vital that the most energy efficient equipment is used and specified when ordering new equipment. Also as there are a high number of printers throughout the college it should be made sure that these are only switched on when needed and then switched off or put on standby. The IT technicians should ensure that the energy saving mode for computers is activated and set so that monitors and computers go to "sleep" mode. 7 day timers should be used to ensure that equipment isn't left on out of hours. Sophisticated time switches permit different settings for each day and control switching times to the nearest 10 minutes. It might also be possible for administration staff to use laptops instead of PCs as these use less energy. Energy efficient equipment will also reduce the heat gains in rooms. This would be very useful for a room like 834 in GMIT which is often uncomfortably hot. Also in future if there was to be more refurbishment or new buildings built e.g. the new engineering building it would be wise to put computer labs on the north side of the building because of the heat gains from computers, printers, photocopiers etc.

Item	Average power consumption (Watts)	Stand-by energy consumption obtainable (Watts)	Target recovery times (seconds)
PCs	40	20-30	Almost immediate
Monitors	80	10-15	Almost immediate
Laser printers	90-130	20-30	30
Photocopiers	120-1000	30-150	30
Fax machines	30-40	10	Almost immediate
Vending machines	350-700	300	Can be almost immediate

Table 7 Average Power Loads & Energy Saving Available source Building Energy Manager Resource Guide

✔	Action	Savings
	Switch off all non-essential equipment out of business hours	Approximately 60% of office equipment running costs
	Enable standby features on all equipment	Around 30% of costs associated with PC and monitor use
	Turn off unnecessary equipment during the day to reduce heat build-up	Improved comfort and reduced electricity use
	Fit seven-day time controls to equipment that is shared (e.g. printers and photocopiers)	Around 50% of costs associated with printers and copiers
	Set defaults on printers that are mainly used for internal documents to duplex and reduce print quality	Save on energy, toner and paper costs
	Raise awareness amongst staff of the benefits	Responsible staff achieve maximum savings
	Monitor out-of-hours electricity use by taking regular meter readings	Approximately 60% of costs associated with office equipment
	Use the right equipment for the job	Inkjet printers in sleep mode use 50% less energy than a laser printer
	Conduct regular walk-rounds to discover changes in user behaviour	Attitudes and behaviour change over time Timely action will maximise savings
	Purchase equipment with low energy options that match your requirements	This could save around 10% of your printing costs alone

Table 8 Energy Saving Actions for Office Equipment source The Carbon Trust CVT005

5.11 Building Energy Management System (BEMS)

BEMS are computer-based systems which automatically monitor and control a range of building services including heating, ventilation, air conditioning and lighting. Other facilities can be integrated into systems including ID security, fire alarms, CCTV, maintenance schedules and monitoring and targeting. According to the Carbon Trust CVT032 you can save 25% of the energy costs and have a payback period of 5 years.

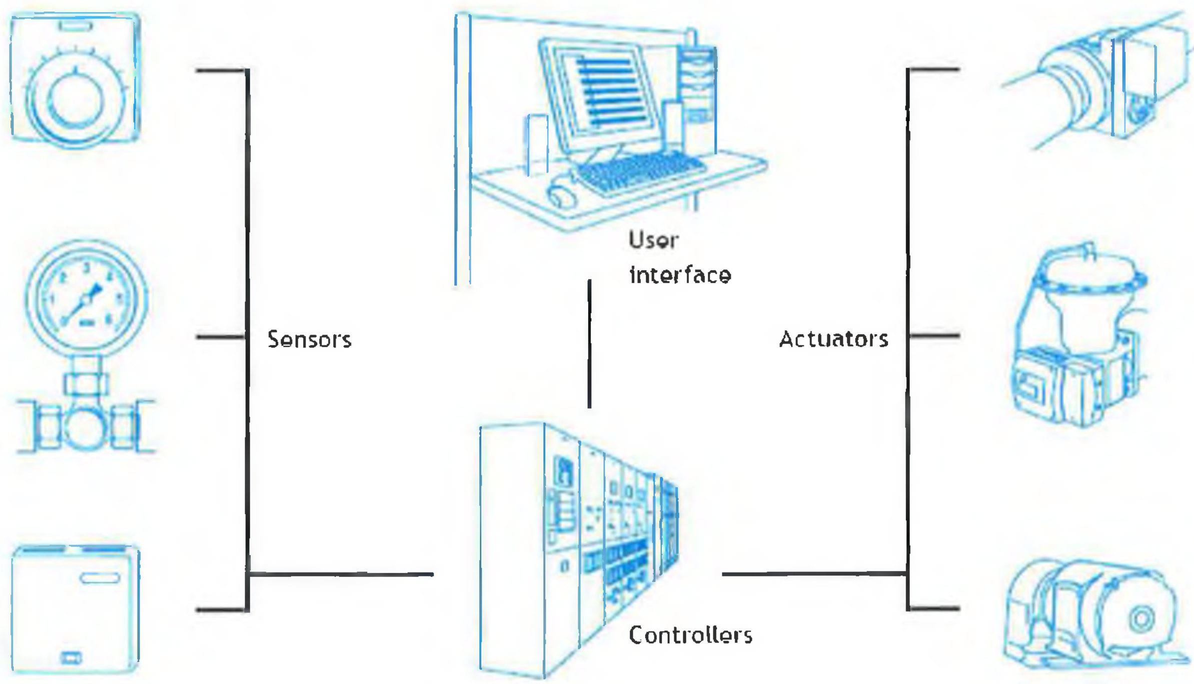

Figure 36 Basic Components of a BEMS source Carbon Trust CVT032

5.11.1 The Main Components of the BEMS

- Hardware: outstations, valves, controllers, sensors etc
- Software: tells the BEMS what to do
- Network: allows the hardware and software to communicate with each other
- Interface: allows users to adjust systems and link with other systems such as fire
- alarms, CCTV, security etc

5.11.1.1 Sensors

These provide information to the BEMS on their surroundings. There are three principal types:

5.11.1.2 Digital Inputs

Show for example whether a boiler is on or off or if a pump is running or stopped. These can monitor the condition of any device which has two possible states.

5.11.1.3 Analogue Inputs

Provides info on variables such as temperature, humidity, light levels etc. which have values associated with them.

5.11.1.4 Pulse Inputs

Act as counters usually providing information on consumption through interfaces with meters and other devices.

5.11.1.5 Actuators

These are the action element of the system and fall into two categories:

5.11.1.6 Digital Outputs

Switch equipment on or off

5.11.1.7 Analogue Outputs

Adjust devices to a specific position e.g. dimmers for lights

5.11.2 Controls

These are the basic parts of the BEMS. The capacity of the BEMS can be increased by adding more controllers to the network. These include:

- Internal clock and microprocessors which contain the network and control software. These devices can act as sand alone devices.
- Interfaces to sensors and actuators

5.11.3 What a BEMS Does

5.11.3.1 Automatic Switching Plant On and Off

This is done on the basis of time, type of day or environmental conditions. For example, the BEMS can control lighting to avoid unnecessary consumption outside normal working hours or when daylight levels are adequate.

5.11.3.2 Optimisation of Plant Operation

A typical application is the optimum start/stop routine for space heating where the start and stop times can be automatically adjusted by the system to compensate for external temperature changes and the thermal inertia of the building. Other examples include the control of fuel/air ratios on boilers and to maximise free cooling in air conditioned buildings.

5.11.3.3 Monitoring of Plant Status and Conditions

A building manager can be alerted to alarm conditions in time to take action. Energy management systems can therefore improve standards of operation and maintenance.

5.11.3.4 Provision of Energy Management Information

Data on energy flows, consumption, trends and overall building performance are easily accessible. Managers can make quick assessments of energy efficiency improvement measures and also use the information for forward planning and costing.

5.11.3.5 Remote Monitoring and Control Capabilities for Plant and Services

In large buildings it gives better use of man power. This is more obvious when plant and services are addressed over the telephone networks allowing geographically remote buildings to be remotely monitored and controlled.

5.11.3.6 Building Management

BEMS can be incorporated with other systems such as fire and security with alarms and indicators.

5.11.3.7 Planned Preventative Maintenance

Can have software for managing routine maintenance of plant within the building, irrespective of whether the plant is controlled by the BEMS. This will reduce labour costs, improve reliability and reduce energy costs.

5.11.4 BEMS Save Energy By:

- Optimising the efficiency of plant
- Minimising unnecessary energy use
- Improving maintenance
- Ease of plant operation
- Data logging for monitoring and targeting

- Providing data on building energy performance to help identify potential energy saving measures

Beneficiary	Benefit
Building owner	Higher rental value Flexibility on change of building use Individual tenant billing for services
Building tenant	Reduced energy consumption Effective monitoring and targeting of energy consumption Good control of internal comfort conditions Increased staff productivity Improved plant reliability and life
Occupants	Better comfort and lighting Possibility of individual room control Effective response to HVAC-related complaints
Facilities manager	Control from central supervisor Remote monitoring possible Rapid alarm indication and fault diagnosis Computerised maintenance scheduling Good plant schematics and documentation
Controls contractor	Bus systems simplify installation Supervisor aids setting up and commissioning Interoperability enlarges supplier choice

Table 9 Benefits of a BEMS source CIBSE Guide H

5.11.5 Operator Training

There should be a minimum of two operators who are fully trained to use the BEMS. According to the SEI's Building Energy Managers Resource Guide training should be in two parts: a general course on the principles of BEMS and site specific training on the system they will use. The success of the BEMS is a combination of the user and the system. The user must able to interpret data and be able to make sensible judgements on adjustments.

5.11.6 GMIT BEMS

Currently the BEMS in GMIT only serves the newest section of the campus. The system used is a Cylon Unitron BMS. This system mainly deals with the heating and cooling of the building. An example of how it works can be seen from the library. The fresh outside air enters at a low level under the sails on the south side of the building. This air then passes over temperature controlled finned-tube heaters which can preheat the air when necessary. Exhaust air leaves the library through dampers located at roof level. Space heating in the library is provided by radiator circuits. During winter the ventilation is controlled by a combination of temperature and CO_2 concentration to ensure that only minimum fresh air is introduced. The temperature set point is 20°C while the CO_2 set point is 600ppm. When the CO_2 set is reached more fresh air must be brought in. In summer a min set point of 18°C and a max of 24°C are set. Once 24°C has been reached dampers in the roof are open and more air is brought in to cool the area. These dampers are also controlled by wind speed according to the weather station on the roof. In summer the minimum damper influence is 6mph and the max is 12 mph. These figures influence how open the dampers are and help to prevent a breeze flowing through the library, which creates noise and discomfort. In the future GMIT might try to expand the BEMS control to lighting as well. This could greatly reduce the lighting consumption by accounting for daylighting and occupancy level if sensors such as passive infra red with daylight detection are installed. It can be even be integrated with the CCTV and fire alarm. This would allow it to switch off heating or cooling and shutting dampers if fire or smoke is detected and would stop the spread of fire through the vents.

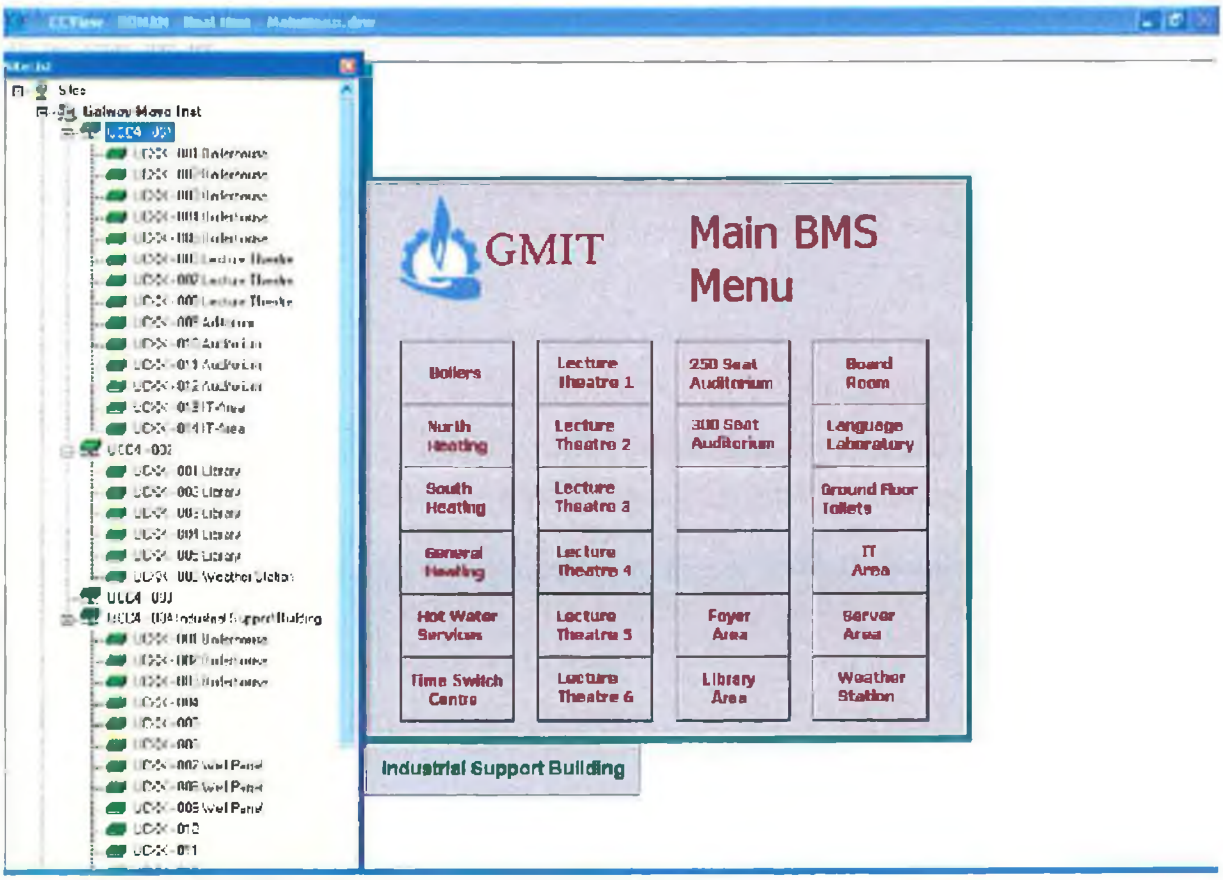

Figure 37 Snapshot of GMITs BMS Interface

Chapter 6

GMIT Energy Consumption

6.1 GMIT Energy Consumption

This chapter gives a description of the energy consumption in GMIT in terms of gas, oil and electricity. Also documented are the findings of the consumption amounts of gas, oil and electricity over a number of years. A simplistic approach to finding the buildings KPIs is also mentioned.

Both oil and gas are used widely in GMIT with oil fulfilling the main heating requirements as stated on its Display Energy Cert. The entire college received a Building Energy Rating of C3, 363kWh/m^2/yr. This is in fact quite good for a building of this type as a typical rating for this type of building is D2. The non electrical output of the campus is 80kWh/m^2/yr while the electrical output is 283kWh/m^2/yr. The typical values for a building of this type are 286kWh/m^2/yr and 253kWh/m^2/yr for electrical output.

From figures that have been gathered for 2009 by the author the following KPIs are found. These however are different to what was found on the Display Energy Cert (DEC).

Electrical:

Jan	347,084
Feb	334,852
Mar	356,274
Apr	281,572
May	286,207
Jun	207,988
Jul	206,051
Aug	220,294
Sep	260,770
Oct	333,978
Nov	351,839
Dec	294,874
	3,481,783

Divide this final figure by the floor area 33505m^2 taken from the DEC and the figure obtained is **103.9kWh/m^2/yr**

Non Electrical:

	Gas kWh	Oil kWh	
Jan	318010.6	567058.5	
Feb	208290	180458.5	
Mar	319749	222145.1	
Apr	81620	292250	
May	226850.6	175350	
Jun	55692.4	17593.45	
Jul	23330.6	0	
Aug	11893.2	0	
Sep	0	0	
Oct	81376.2	116900	
Nov	87863.4	541024.9	
Dec	331652.8	303565.9	
	1746329	**2416346**	**4162675**

Again divide the total by the floor area and the figure obtained is **124.2kWh/m^2/yr**.

These added together give a total **KPI 228.1 kWh/m^2/yr**

CIBSE TM46 set the energy benchmarks for a university campus as 80kWh/m^2/yr for electrical and 240kWh/m^2/yr for fossil fuels.

	Good practice		Typical practice		
	Fossil fuels	Electricity	Fossil fuels	Electricity	
Catering:[a]					
— fast food restaurants	480	820	670	890	Gross floor area
— public houses	1.5	0.8	3.5	1.8	(kW.h m^2 per £ 1000 turnover)
— restaurants (with bar)	1100	650	1250	730	Gross floor area
— restaurants (in public houses)	2700	1300	3500	1500	(kW.h cover[d])
Entertainment:					
— theatres	420	180	630	270	Gross floor area [b]
— cinemas	515	135	620	160	Gross floor area [b]
— social clubs	140	60	250	110	Gross floor area [b]
— bingo clubs	440	190	540	230	Gross floor area [b]
Education (further and higher) [a][c]					
— catering, bar restaurant	182	137	257	149	Gross floor area
— catering, fast food	438	200	618	218	Gross floor area
— lecture room, arts	100	67	120	76	Gross floor area
— lecture room, science	110	113	132	129	Gross floor area
— library, air conditioned	173	292	245	404	Gross floor area
— library, naturally ventilated	115	46	161	64	Gross floor area
— residential, halls of residence	240	85	290	100	Gross floor area
— residential, self catering flats	200	45	240	54	Gross floor area
— science laboratory	110	155	132	175	Gross floor area
Education (schools)[a][c]					
— primary	113	22	164	32	Gross floor area
— secondary	108	25	144	33	Gross floor area
— secondary (with swimming pool)	142	29	187	36	Gross floor area

Table 10 Energy Benchmarks source CIBSE Guide F

Space type	% of average higher education campus	Electrical target (kWh/year)	Fossil target (kWh/year)
Teaching	25	22	151
Research	20	105	150
Lecture hall	5	108	412
Office	30	36	95
Library	10	50	150
Catering	2.5	650	1100
Recreational	7.5	150	360
Total academic	100 of academic (75% of total)	75	185
Residential	100 of residential (25% of total)	85	240

Table 11 Target Consumption Figures source Energy Consumption Guide

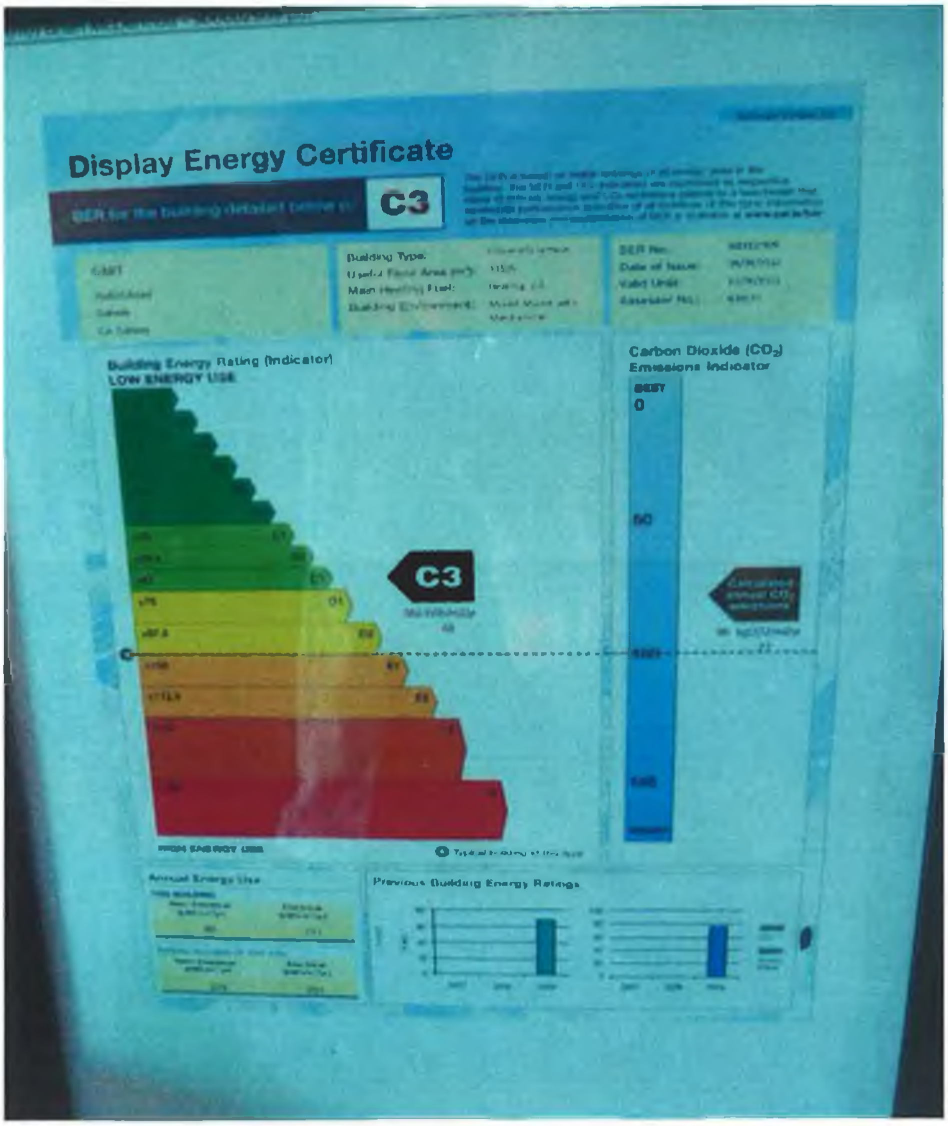

Figure 38 GMIT Display Energy Cert

6.2 GMIT Gas Consumption

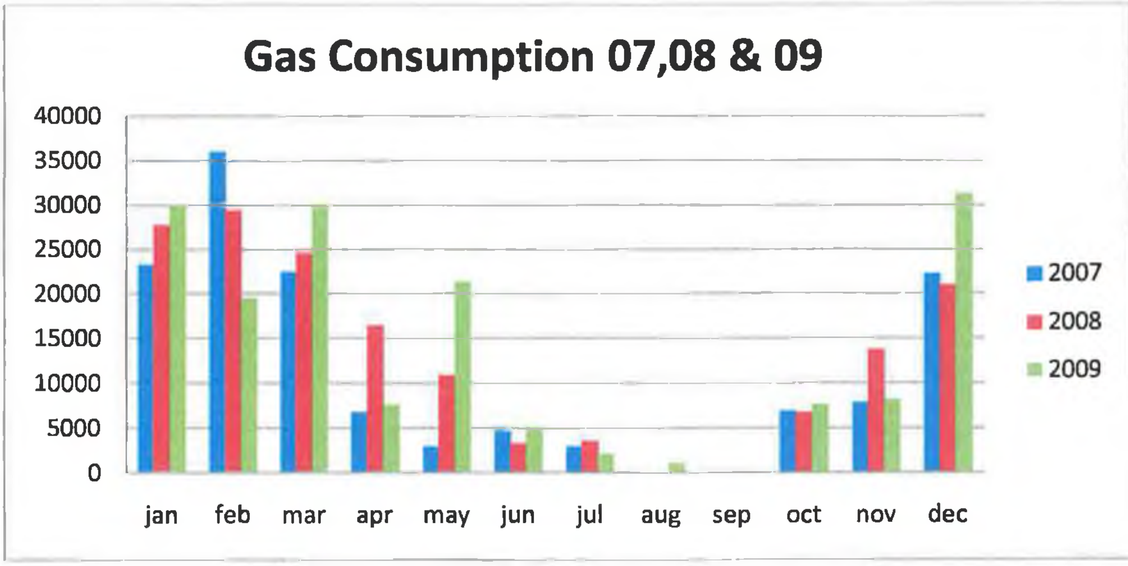

Figure 39 GMIT Gas Consumption

These gas figures were obtained by going through invoices that the Building and Estates office had on file. 2009 was the biggest user of gas with December having a particular high level of consumption. This could be put down to the fact that the winter of 2009 was unusually cold, which would increase the heating requirements. May 2009 also uses a large amount of gas but this can be attributed to the fact that very little gas was ordered in April.

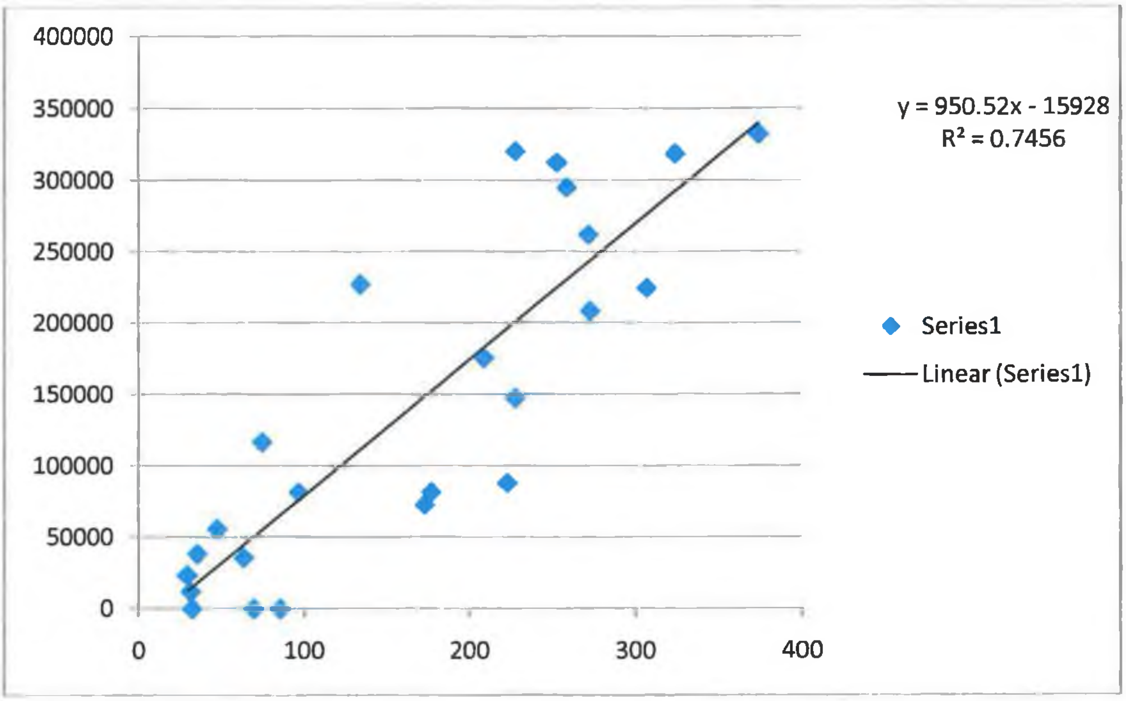

Figure 40 Gas Consumption with Degree Days

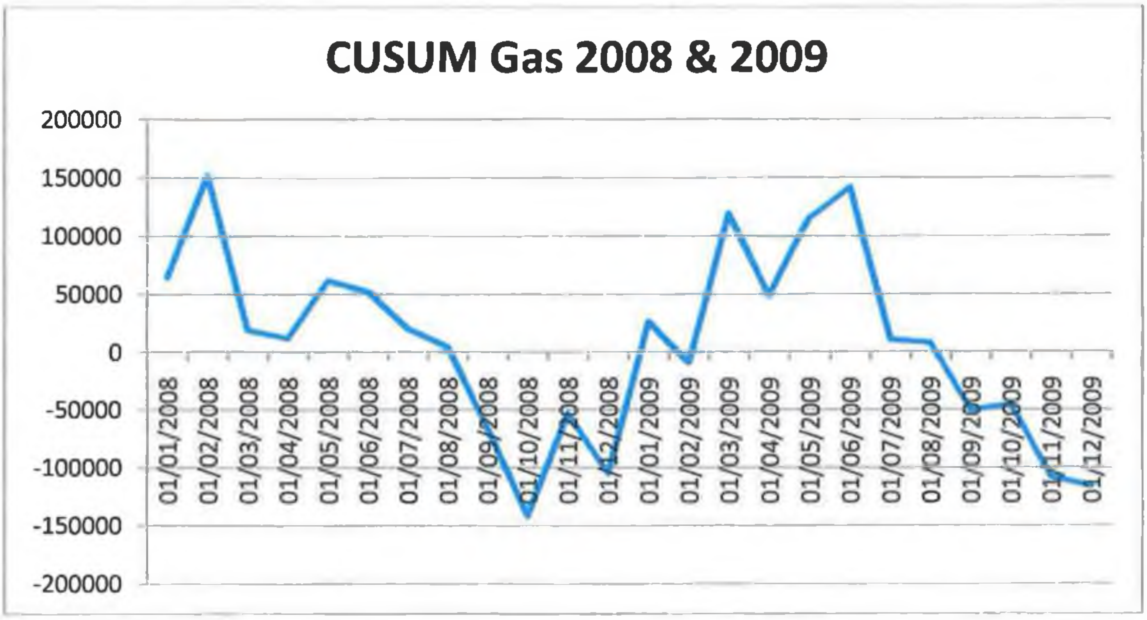

Figure 41 CUSUM Gas

By using the degree day's method and converting the gas into kWh a form of CUSUM graph for 2008 & 2009 was generated. It should be noted that some figures for the gas consumption were zero due which may have possibly altered the results. This can be seen where the line performs exceptionally well during the end of the summer and the start of the college year.

6.3 GMIT Oil Consumption

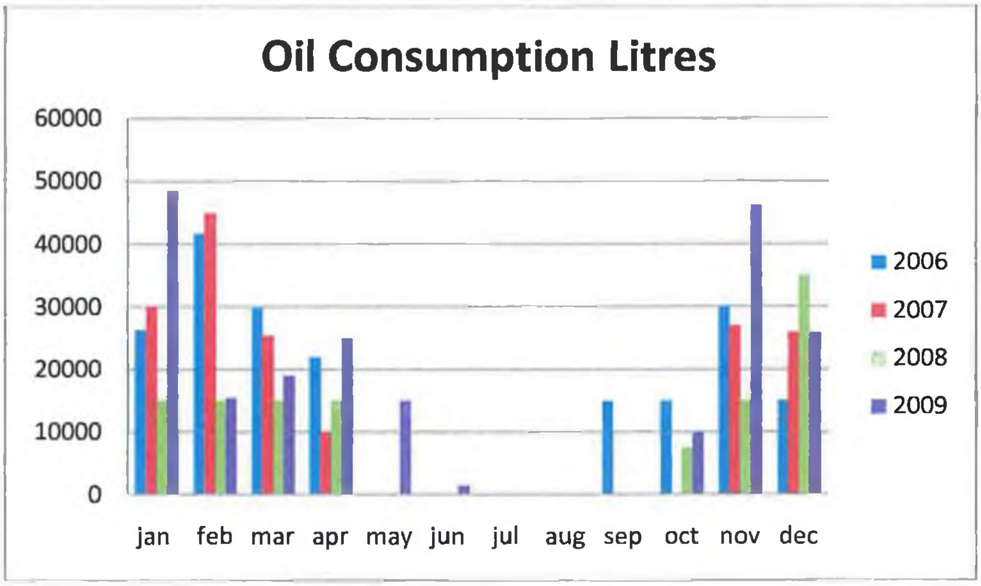

Figure 42 GMIT Oil Consumption

These figures were once again taken from the records kept by the Building and Estates office. Caution should be taken when reading these graphs as many months of dockets were missing for various years. 2009 appears to be the most data complete year and is most likely the truest reflection on oil consumption in the college. 2006 also seems to have a complete list of the heating requirements with only missing information for the summer months which is most likely that no heating was required for these periods. 2008 appears to use very little oil but this is due to the fact that there is a lot of missing information on whether heating was used and the documents lost or if there was no heating required for this period.

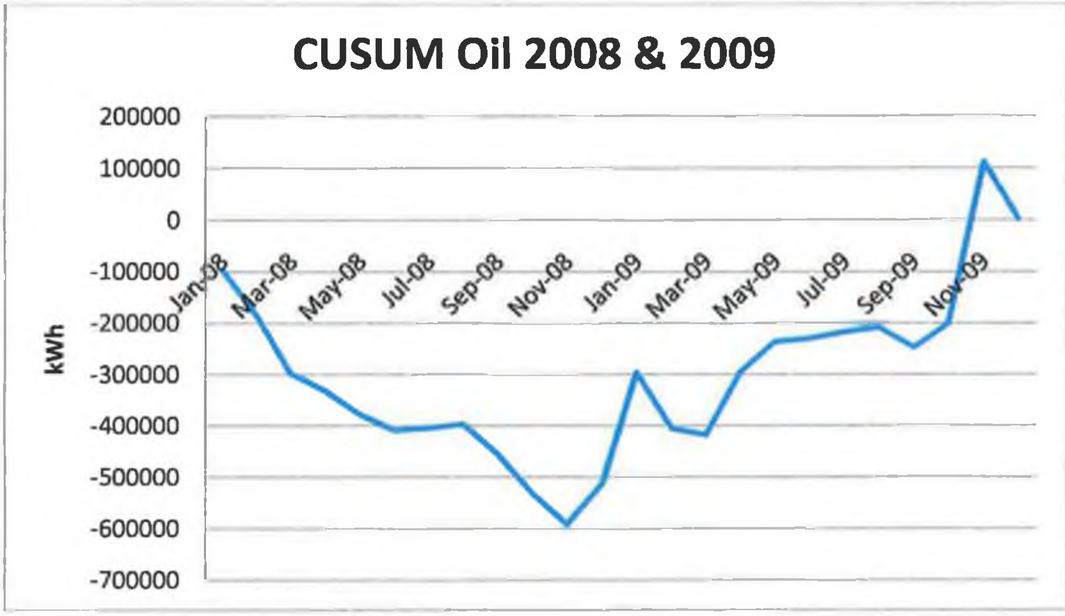

Figure 43 CUSUM Oil

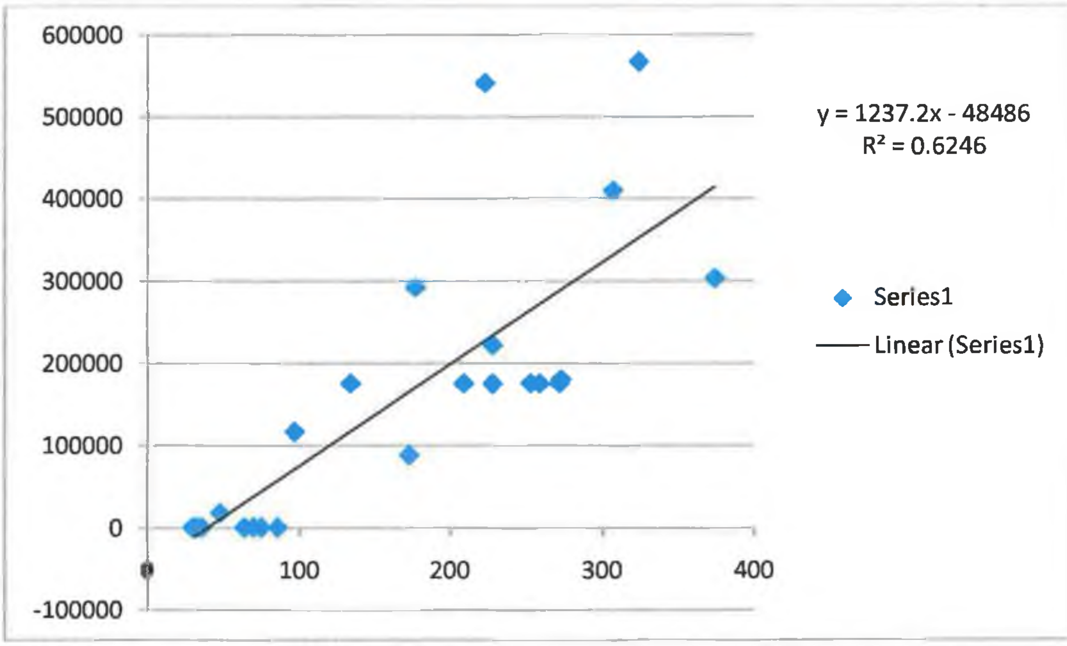

Figure 44 Oil Consumption with Degree Days

The CUSUM data with degree days is taken for the years 2008 & 2009. It was not possible to use any other years due to the degree day information only going back 36 months. As there are pockets of missing data the results have been affected. Because of this 2008 appears to perform exceptionally well. The best comparison would have been between 2006 & 2009 to get an accurate result on the oil consumption characteristics.

6.4 GMIT Electricity

GMIT sources its electricity from ESB Independent Energy. This is a relatively new deal with the college making the switch from ESB in September 2009 due to more competitive prices.

ESB INDEPENDENT ENERGY ALL ISLAND SEM FUEL MIX

JANUARY 2008 TO DECEMBER 2008

Electricity supplied has been sourced from the following fuels	Percentage of total	
	Electricity supplied by ESB Independent Energy	**Average for All Island Market (for comparison)**
Coal	18.6%	17.4%
Oil	3.7%	3.5%
Gas	64.6%	60.6%
Peat	6.9%	6.5%
Renewable	5.7%	11.2%
Other	0.5%	0.8%
Total	**100%**	**100%**
ENVIRONMENTAL IMPACT		
CO2 Emissions	568g/kWh	533g/kWh
Radioactive Waste	0	0

Table 12 ESBIE Fuel Mix source ESBIE.ie

The majority of ESBIEs energy comes from its Combined Cycle Gas Turbine in Dublin. This is shown by 64.6% of gas used in their fuel mix compared to the national average of 60.6%. Figures that stand out from this table are the renewable energy proportion used and the amount of CO_2 emissions/kWh. The renewable energy figure is roughly half the national average at 5.7% compared to 11.2% and they produce 35g/kWh of CO_2 more 6.6% than the national average. Unless these figures have changed in the mean time GMIT cannot say that they switched to ESBIE for their green credentials.

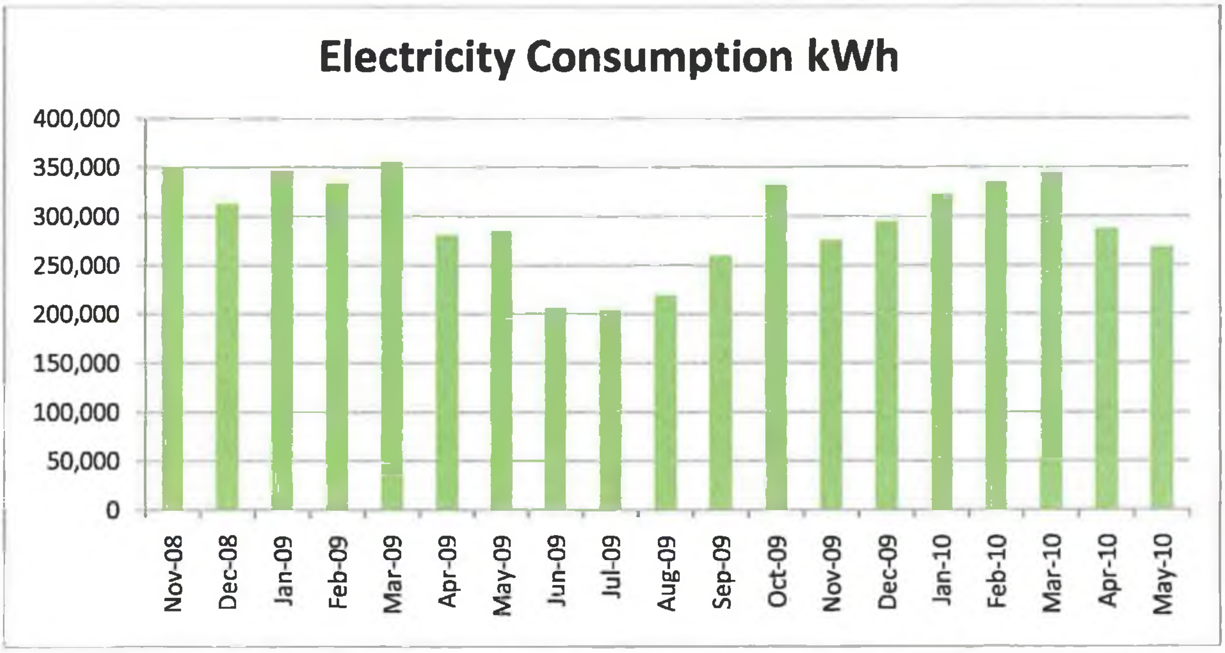

Figure 45 Electricity Consumption November 2008 to May 2010

From electricity bills for the period November 2008 to May 2010 the chart above was generated. From this trend and comparisons can be seen. In each year March seems to be the biggest consumer of electricity. This seems strange as one would expect one of the winter months such as November to have a higher consumption. This could be possibly down to the fact that both heating and cooling is needed for this month, which requires the work of fans and motors etc. It can also be seen how the electricity reduces for the summer and gradually increases for the winter with the exception of October. October 2009 seems very high compared to September, which could be down to that college doesn't start until the first or second week in September so the college is not up and running fully. Also as with March there might be heating and cooling requirements for October.

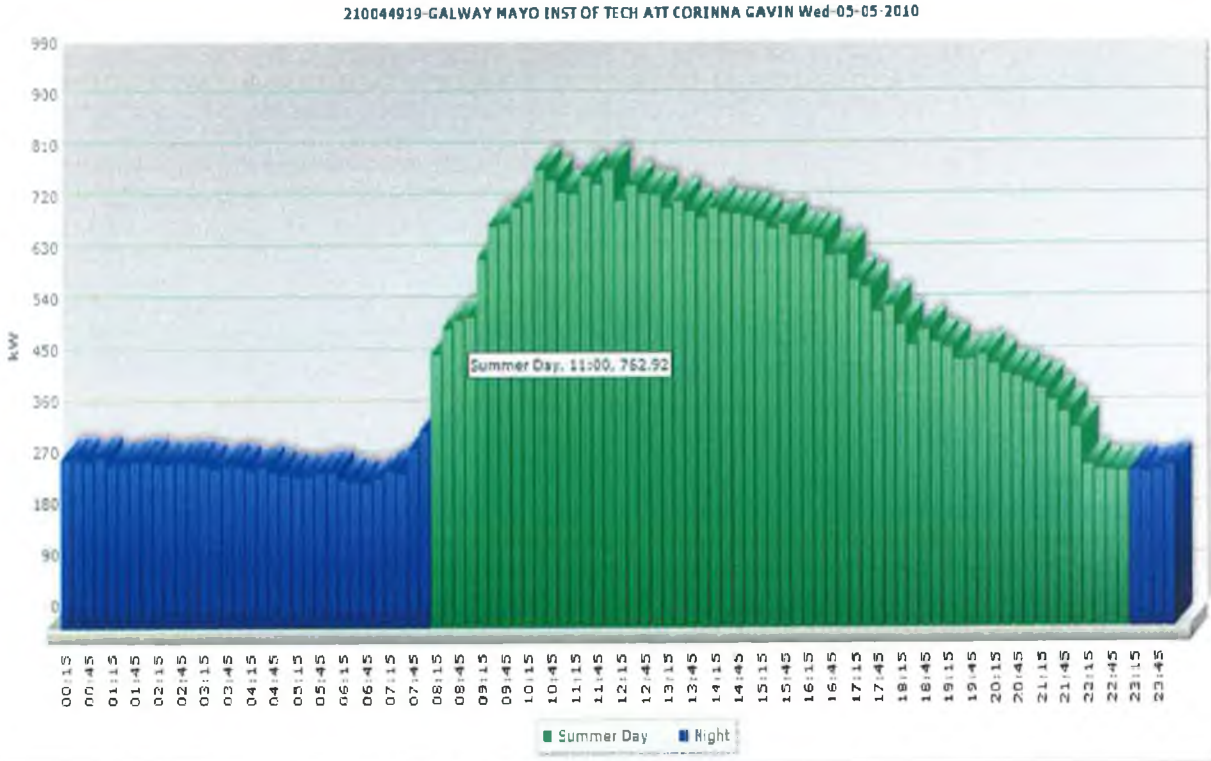

Figure 46 Power Consumption Summer

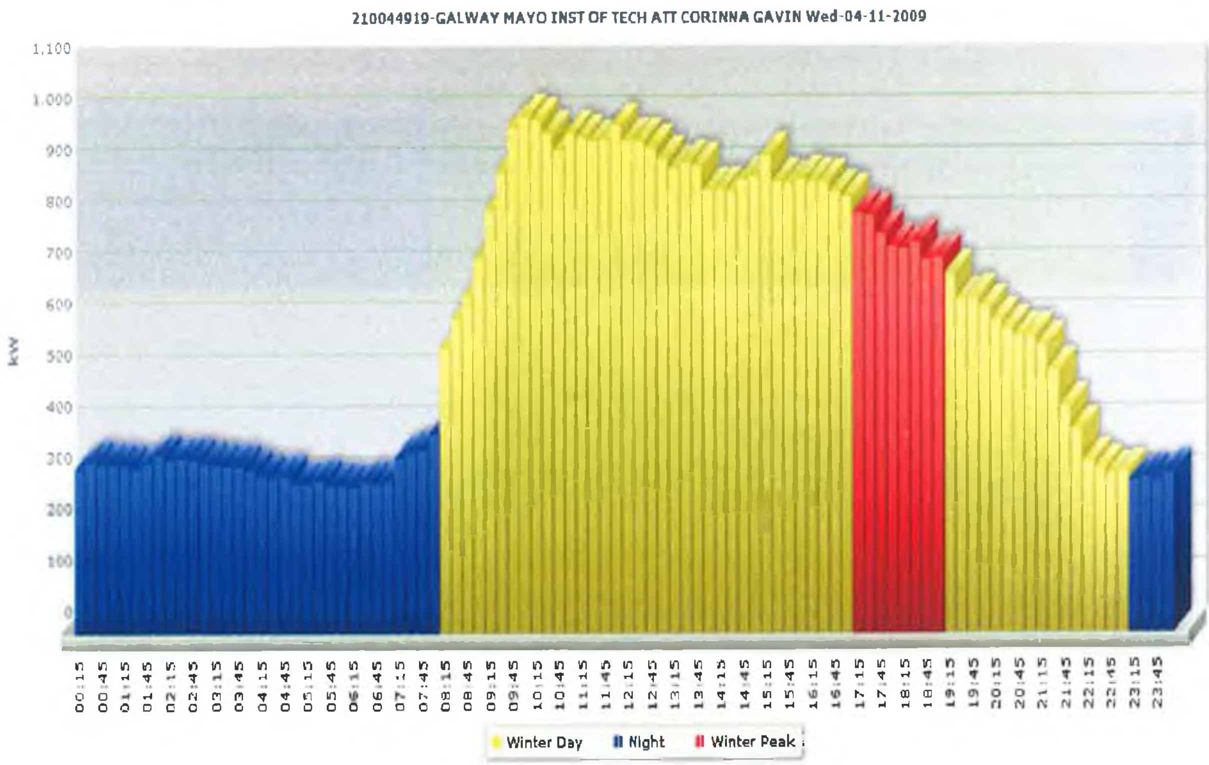

Figure 47 Power Consumption Winter

Figure 46 is the typical energy consumption for the college during the summer. We can see from the base load is roughly 300 kW. Activity starts to take place in the college at around 8 am as can be seen from the sudden surge in power usage. Peak power usage roughly 810 kW seems to happen around 12 pm and after that there is a slow decline in the usage until 5 pm where the next significant drop in power occurs. This is most likely due to the fact that the majority of people have finished lectures and classes. This then slowly declines until 10 pm where the college is closed for the night and the base load is once again met. We can see clearly the reduction in power as less people are in the building and using the facilities.

Figure 47 give an example of electricity consumption for a typical day during the winter. The sudden surge in power at 8am then same as the summer shows that this is when the college opens. Peak power happens slightly earlier in winter at about 9:45 am but then it follows the same trend as the summer day with a gradual decline in the amount of electricity used throughout the day as students and staff leave the college with a sudden final drop at 10pm when the college is closed and the college is running at the base load.

The author however thinks that it might be possible to reduce the shoulder periods of power between 5 and 9 pm by having maintenance or a dedicated team to go around and switch off all lights in rooms not in use and by having 7 day timers switch off equipment. It might be even possible to close sections of the library such as upstairs during the quieter times of the year when no examinations are taking place.

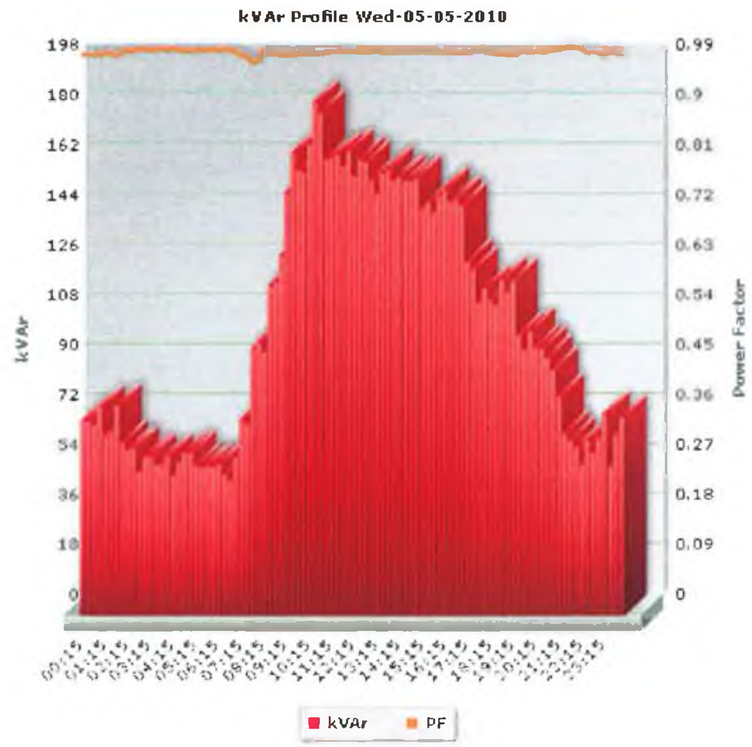

Figure 48 Summer Power Factor

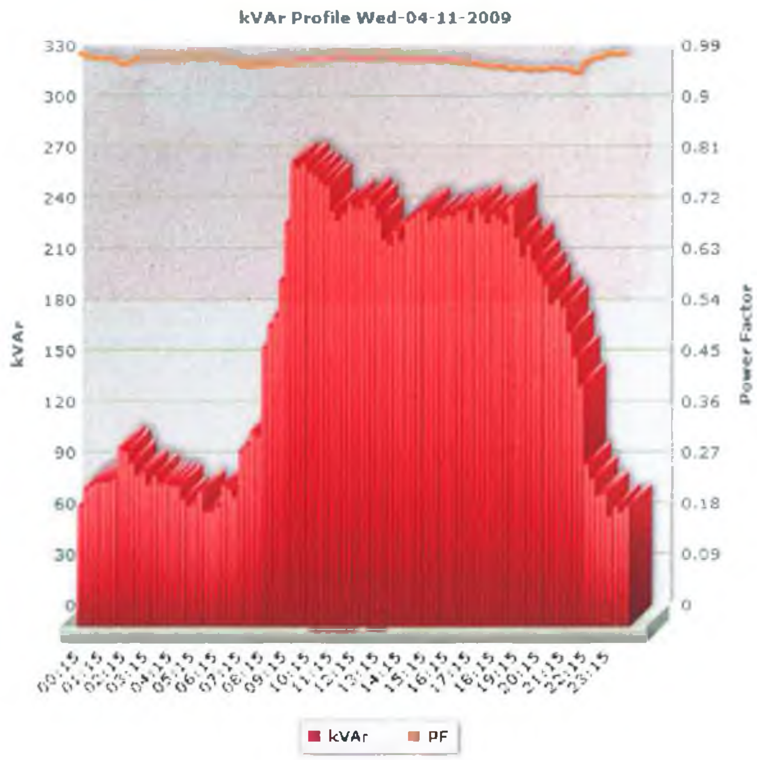

Figure 49 Winter Power Factor

Here we can see that there is a good power factor load in relation to the consumed energy. If this was to fall below 0.9 there would be a need to be investigated. There is some wattless energy being used most likely due to inductive loads such as the large numbers of fluorescent lights in the building and electric motors. The winter power factor is slightly less than the summer power factor due to these lights being on for longer periods of time. If the apparent power/wattless units was to be 1/3 or the real power then the college would be fined/charged heavily at a fixed rate by the utility company. Luckily this is not the case here as the correct power factor correction equipment is installed in the college. But an area that seems to stick out from Figures 48 and 49 above are that when the college is empty during the night at sudden little spikes in the apparent power happen. This could be due to motors for fridges and other equipment left running.

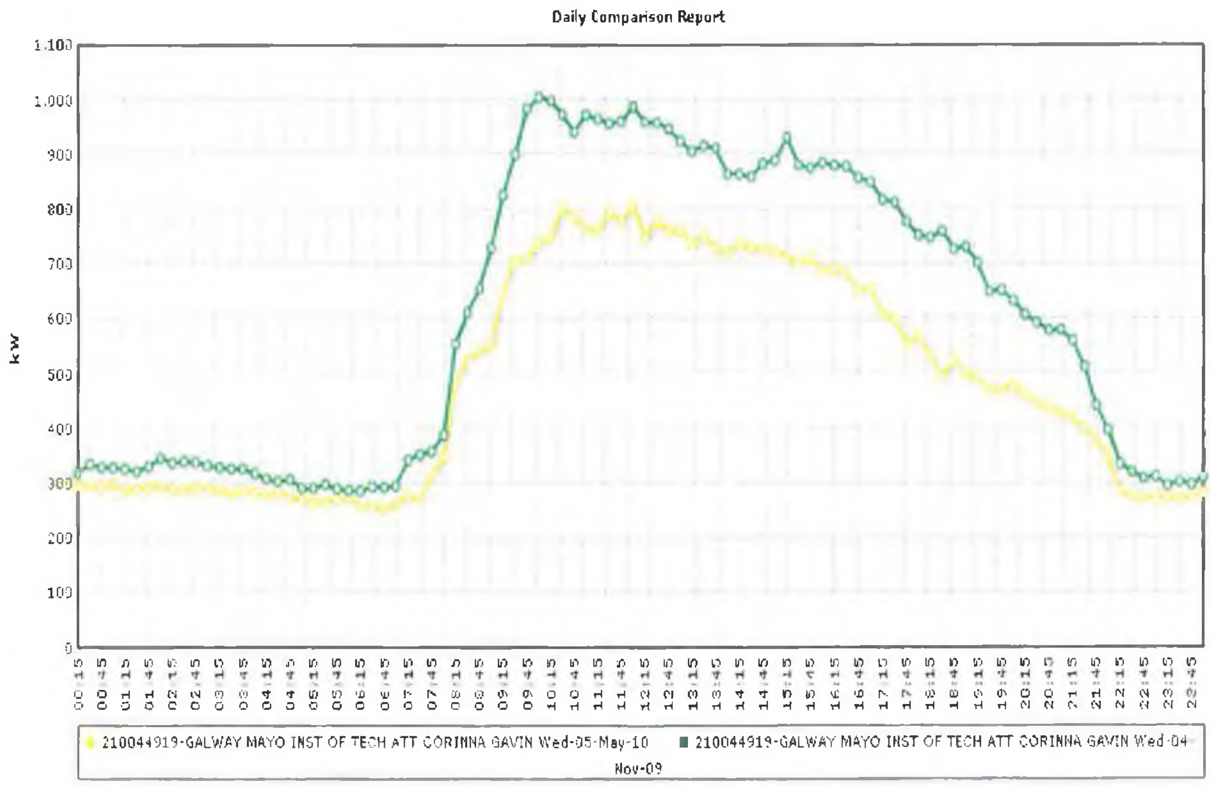

Figure 50 Comparison Of November & May

Figure 50 above is the electricity usage comparison of a day during the summer, May and during winter, November. It gives a good indication of the base load for the college, around 300kW. The two months follow very similar trends in their energy use throughout the day. The most likely reason for the difference in the two months is the energy used to light the building. The similar trend gives the impression that all the same equipment is used in the college with the added need for light due to the dark winter months.

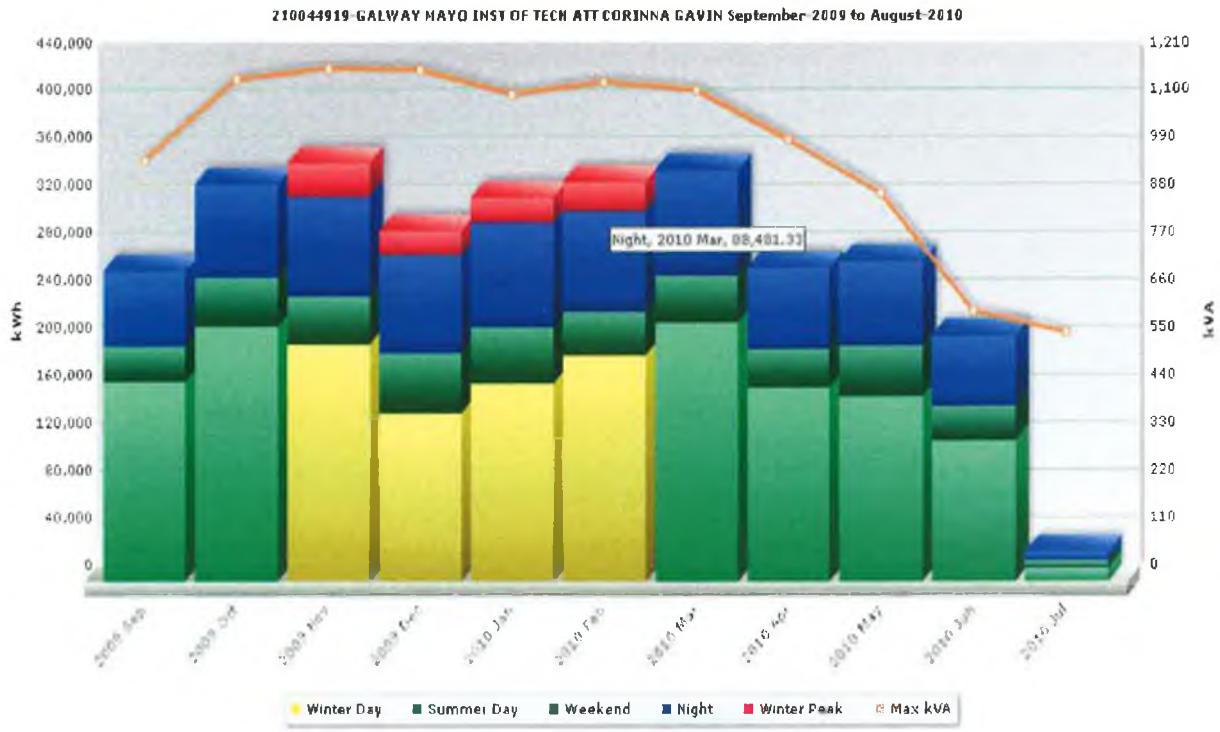

Figure 51 Electricity Consumption September 2009 to June 2010

Above shows the electricity consumption from September 2009 to June 2010 with only a part reading for July. This was taken from the ESBIE website. It can be seen that November 2009 used the most electricity in this time period. This is most likely due to the fact that the college is attended for the full month and its winter, which would lead to less daylight and more hours of lighting used especially during the peak periods. December and January readings are lower due to the college closing for the Christmas holidays. March 2010 was also a big user of electricity which is slightly harder to explain as the weather was improving and the days were getting longer so less electricity for lighting should be used. Another anomaly that can be seen throughout the chart is that the weekend and night time electricity use are not all the same. This shows that not all equipment is being switched off during out of hours, 7 day timers can help solve this problem. More energy awareness through campaigns can change this problem. Reduction of electricity from May to June reflects the longer daylight hours and the students leaving for the summer.

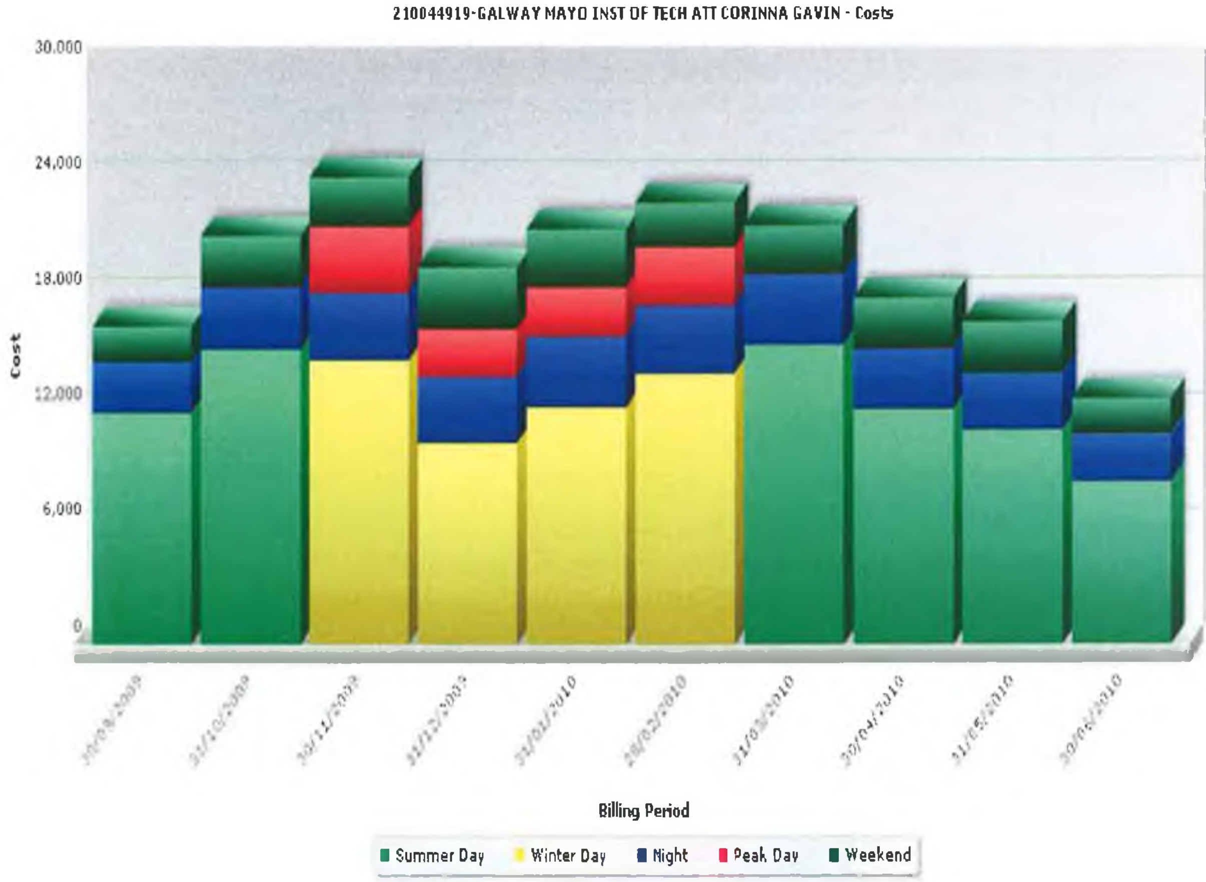

Figure 52 Raw Electricity Cost

The raw electricity cost follows the in the same way as the consumption of electricity with November being the most expensive month. Even though March used more electricity than February the cost of electricity is Cheaper for March due to the fact that February has a peak day charge, which is more expensive than other hours of the day. All the other months follow the same trend as their electrical consumption.

To deal with peak power charges, if it is possible to power down non essential equipment at these time it could save a substantial portion of money. This could be done by incorporating different interfaces with the BEMS.

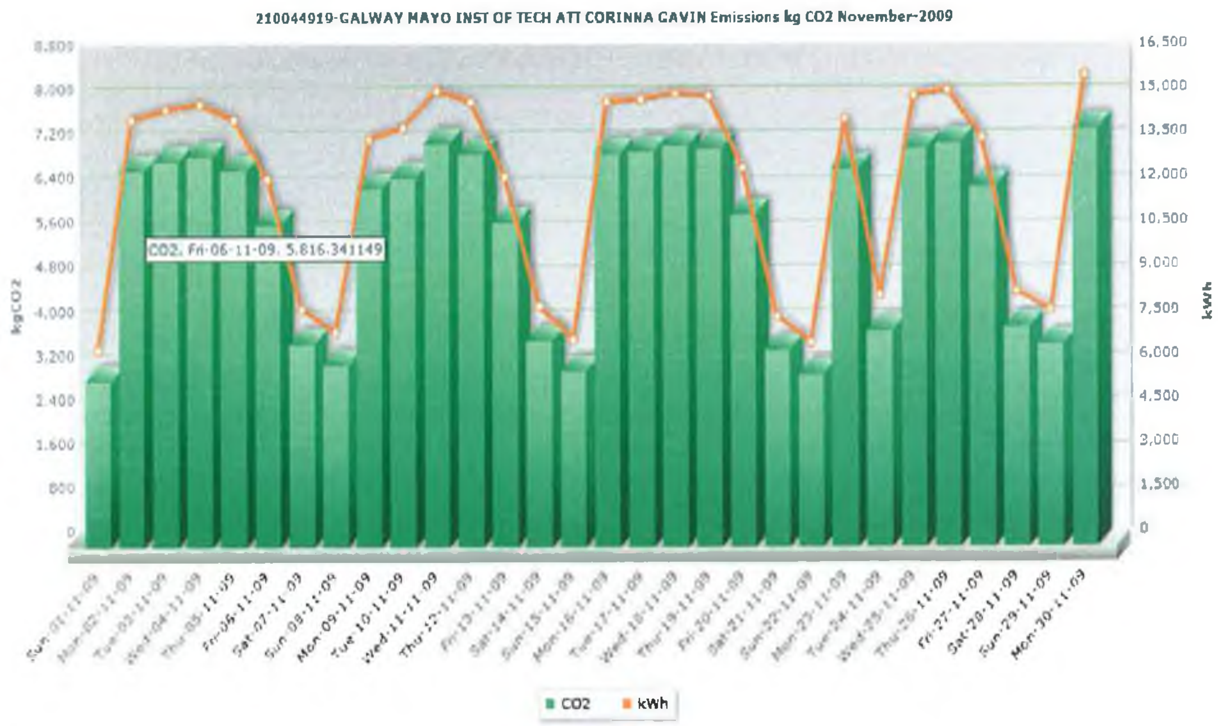

Figure 53 CO_2 Output for November 2009

Figure 53 Shows the CO_2 output for the month of November. The values of CO_2 correspond to the base values and peak values of electricity consumption as one would expect. Days during the week with low values such as the 24th are most likely due to a holiday.

6.5 Energy Awareness Campaign for GMIT

6.5.1 Steps to achieving a successful Energy Awareness Campaign

6.5.1.1 Management Commitment

Senior and middle management need to give their support to the campaign. Middle managers need to be convinced after senior management have made the commitment. In GMITs case this means that the president needs to buy into the project and have the heads of schools committed also. This can be done by appointing a campaign team made up by various people from different departments.

6.5.1.2 Funding

The main reasons energy campaigns fail is due to the lack of funding. To run a successful campaign an investment of between 1% and 2% of the total energy budget needs to happen. The Building Energy Managers Resource Guide says that for an investment of 1% to 2% of the annual utility expenditure can often result in savings of between 5% and 15% in 12 months.

6.5.1.3 Campaign Team

There needs to be a dedicated campaign team driving on the campaign. This can be made up by the heads of departments or heads of the different schools. These campaign teams need to be made up of people with enough authority to be taken seriously.

6.5.1.4 Strategy

This will see where the campaign is going, what needs to be done to motivate people to save energy and what the current awareness is.

6.5.1.5 Response Mechanisms

It is vital to respond to student and staff ideas. If they feel they are not being responded to they might feel their ideas are not being viewed and lose interest in the campaign.

6.5.1.6 Monitoring

This is the "how are we doing part" of the campaign. To answer this it is important to have an adequate energy monitoring system in place. This system needs to be able to look back historically at past energy use trends and take account of changes. The ESBIE data graphs can help this for GMIT.

6.5.1.7Timing

Don't start campaigns when staff and students are bogged down with work or other protocols such as health and safety issues or when students are coming up to exams.

6.5.1.8 Investment and Maintenance

Investing in energy efficient plant and equipment needs to happen for a successful campaign. These then have to be looked after and maintained properly e.g. energy efficient lights (T5s) and the luminaire need to be clean regularly.

6.5.1.9 Motivation

Clear messages need to be given to students and staff as why it is important to save energy e.g. environmental impact etc.

6.5.2 Methods

6.5.2.1 Personal

Presentations and workshops can be used. For example on induction days for both new staff and students energy management practices can be thought to them.

6.5.2.2 Literature

This can be incorporated into the college newsletter or even have specially dedicated newsletters produced once a month outlining procedures and the success of the campaign.

6.5.2.3 Energy Posters

These can be got free from the SEI website. Or another idea would be to hold an art competition for students and staff children in which the top 12 posters are made into a calendar. Also the same can be done for stickers for above equipment switches throughout the college.

6.5.2.4 Participation Challenges

Energy based competitions and quizzes could be held throughout the college with prizes for the winners. Rewards could be given to the best department or school which would give a healthy friendly competition and recognition give to the winning energy campaign team. Possibly there could be a name and shame policy for the worst performing department.

6.5.2.5 External Initiatives

It might be possible to have a partnership with a DIY store where students and staff can get discounts on energy efficient equipment for a limited throughout the campaign

Figure 54 Energy Awareness Campaign Poster source Powerofoneatwork.ie

Another way of raising energy awareness to the students and staff of GMIT is the introduction of the “Street Project”. This will provide data about energy usage for various parts of the college on monitor’s located along the corridors or the college. It is expected that this will have a similar interface to that of the Queens University Ontario Live Building. This offers real time models on lighting, ventilation and power usage.

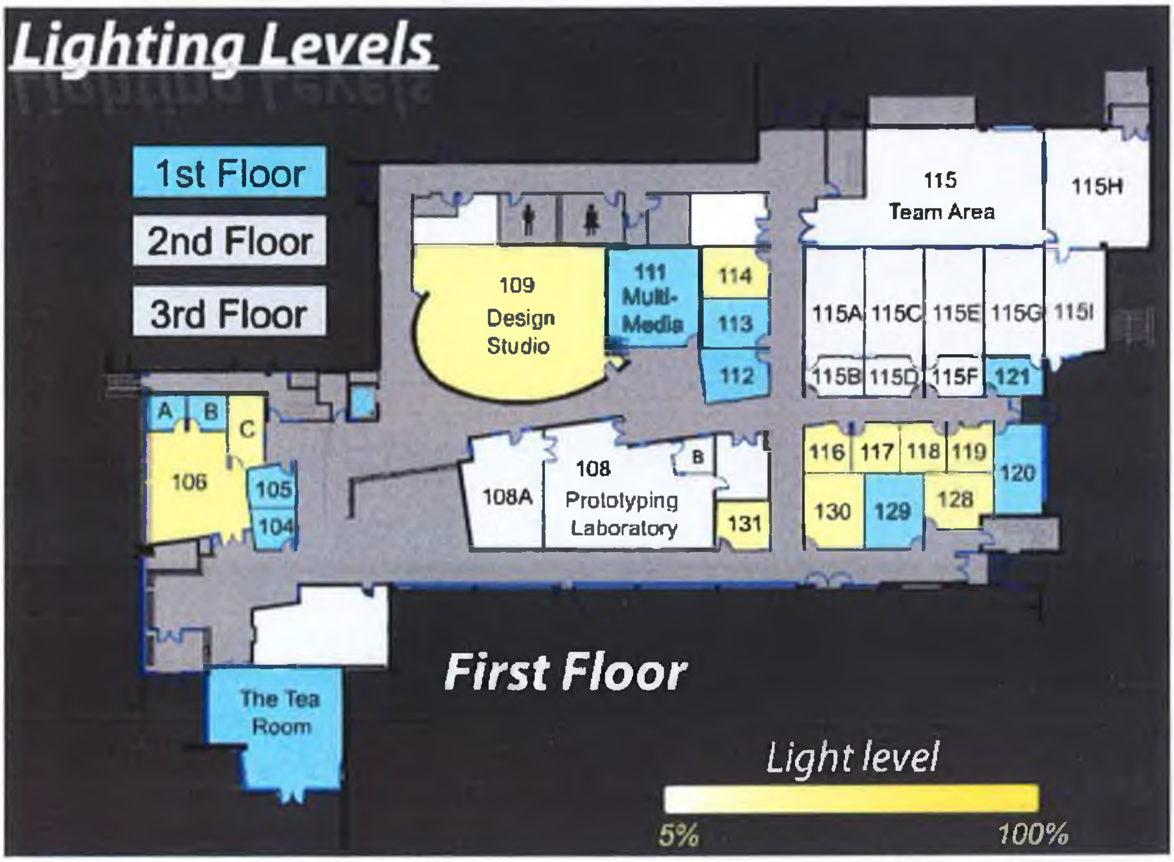

Figure 55 Queens Live Building Lighting source livebuilding.queensu.ca

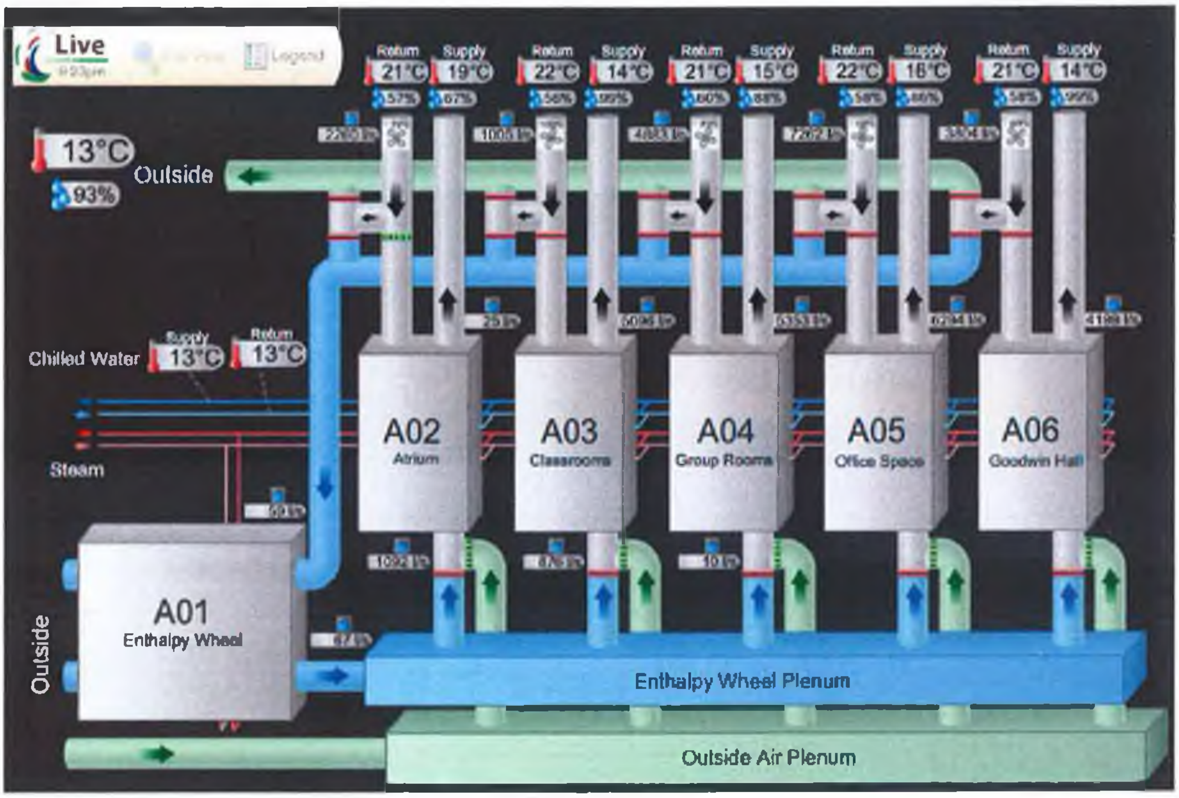

Figure 56 Queens Live Building HVAC source livebuiding.queensu.ca

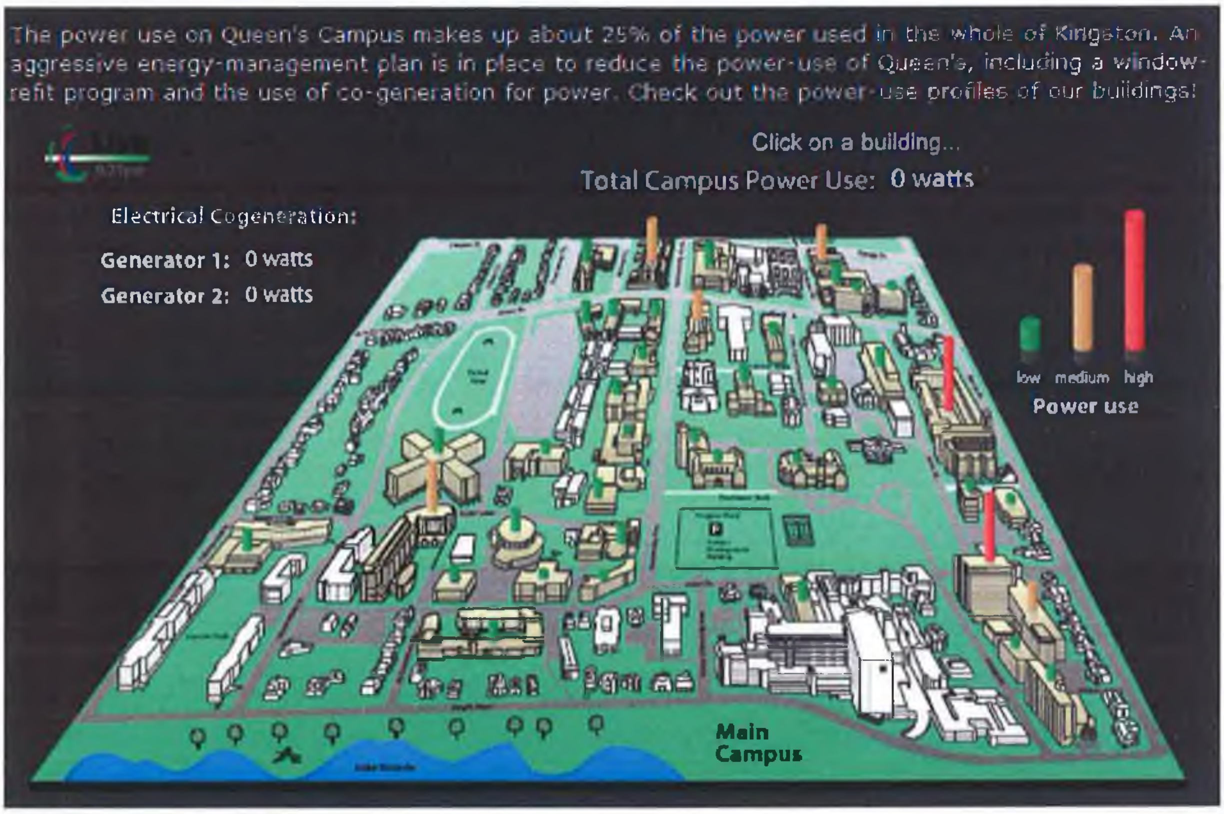

Figure 57 Live Building Campus Power Output source livebuilding.queensu.ca

Chapter 7

Conclusion

Because of the growing need to reduce costs and our consumption of fossil fuels energy management of building is playing an important role in today's society. Added to these facts are that there is legislation in place like the Kyoto Protocol which requires the limitation of green house gases to just 13% above 1990 levels. Another reason to reduce our fossil fuel consumption is because of the majority of oil and gas is in the control of one region, the Middle East. As experienced in the 1970's if another oil embargo happens that would bring modern society to a standstill and even put the world further into a recession. To avoid this we must reduce our reliance on fossil fuel for heating and electricity and after this has been done we can look at using renewable energy.

It was found that GMIT is a considerable user of electricity, gas and oil. The college has obtained a C3 BER rating while the average for a building of its type is D2. This seems to be faring better than it should but there are still plenty of areas where it can improve its energy management. Lighting is one area especially where it can greatly improve. A survey of the lighting in the library rooms was carried out. It was discovered that all lights are switched on in the library even though there was adequate daylighting and lights on in areas unoccupied by people. Also there are 636 T5 book shelves lights are switched on all the time, even if they are energy efficient it is still a waste. It is recommended to fit local switches that people have control over and can switch on when needed and off again. It was also recommended to close areas of the library during times of low occupancy, which would also save energy on lighting and computers. On the survey of Theatre 1000 it was found that 30% of the CFL lights were left on while all the concealed lights were on when the room was unoccupied. By using a calculation tool on the Philips website it was calculated that if the 936 T8 lamps of the survey were replaced with energy efficient T5 lamps a saving of €7388.40 and 2660 kgCO_2 would be made. This would be covered by The Accelerated Capital Allowance as long as minimum amount required for the programme is spent.

Heating controls would also be significantly important in the old section of the college. In room 834 with its high temperature due to solar gains, radiators, equipment and people would greatly benefit from TRVs as they monitor the room temperature and adjust the water flow in the radiators accordingly.

The use of bonded bead pumped insulation was also recommended in the text for use in the old section of the college. This in addition to making the building as airtight as possible by sealing up gaps and joints in the wall, around windows and for services would greatly improve the thermal efficiency of this part of the college and lead to a higher BER rating.

7 day timers should be installed on all office equipment to ensure that they are not left on at night or over the weekend. By replacing the old cathode ray tube monitors with new LCD monitors a saving of between 50-70% can be achieved. It should be made sure by the IT technicians that the energy efficiency mode is enable on monitors as a UK study found that on all PCs they surveyed only 25% of these were enabled.

The BMS unit in GMIT only covers the new building. This controls the heating and ventilation for the library and lecture halls. A great help in the energy management to the college would be to incorporate this with daylighting controls to control the lighting in lecture halls and the library. This could help eliminate the waste of energy of lighting unoccupied spaces and areas where there is enough light as currently happening in the library.

The new building uses heat recovery in the form of run around coils and for the supply and extract air. Under the building there are two types of ground source heat pumps, vertical and horizontal. It should also be considered, the possibility of installing a CHP system for the college to meet the min base heating load, the other boilers would act as backup, as it meets the criteria of operating for more than 4500hrs a year to have sufficient payback and operating efficiency.

By using the Energy Awareness Campaign idea outlined in the text and if the “Street” project comes online peoples mindsets can be altered to do things more efficiently by switching off equipment and lights when they are not needed significant energy savings can be achieved which would reduce the cost of energy of the college but also the CO_2 emissions too which will greatly help the environment.

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Appendix

	Gas kWh	Degree Days	Predicted	Difference	CUSUM
01/01/2008	294309	259	230256.7	64052.32	64052.32
01/02/2008	311852	253	224553.6	87298.44	151350.8
01/03/2008	261544.4	272	242613.4	18930.96	18930.96
01/04/2008	175461.8	209	182730.7	-7268.88	11662.08
01/05/2008	116642.4	75	55361	61281.4	61281.4
01/06/2008	35616	64	44905.28	-9289.28	51992.12
01/07/2008	38160	36	18290.72	19869.28	19869.28
01/08/2008	0	33	15439.16	-15439.16	4430.12
01/09/2008	0	86	65816.72	-65816.72	-65816.7
01/10/2008	72747.8	173	148512	-75764.16	-141581
01/11/2008	147573.2	228	200790.6	-53217.36	-53217.4
01/12/2008	224317.2	307	275881.6	-51564.44	-104782
01/01/2009	318010.6	324	292040.5	25970.12	25970.12
01/02/2009	208290	273	243564	-35273.96	-9303.84
01/03/2009	319749	228	200790.6	118958.44	118958.4
01/04/2009	81620	177	152314	-70694.04	48264.4
01/05/2009	226850.6	134	111441.7	115408.92	115408.9
01/06/2009	55692.4	48	29696.96	25995.44	141404.4
01/07/2009	23330.6	30	12587.6	10743	10743
01/08/2009	11893.2	32	14488.64	-2595.44	8147.56
01/09/2009	0	70	50608.4	-50608.4	-50608.4
01/10/2009	81376.2	97	76272.44	5103.76	-45504.6
01/11/2009	87863.4	223	196038	-108174.6	-108175
01/12/2009	331652.8	374	339566.5	-7913.68	-116088
	Oil kWh				
Jan-08	175350	259	271897	-96547	-96547
Feb-08	175712.4	253	264475	-88762.61	-185310
Mar-08	175350	272	287978	-112628	-297938
Apr-08	175350	209	210047	-34697	-332635
May-08	0	75	44289	-44289	-376924
Jun-08	0	64	30682	-30682	-407606
Jul-08	0	36	-3954	3954	-403652
Aug-08	0	33	-7665	7665	-395987
Sep-08	0	86	57896	-57896	-453883
Oct-08	87675	173	165515	-77840	-531723
Nov-08	175198	228	233550	-58351.97	-590075
Dec-08	410354.1	307	331273	79081.07	-510994
Jan-09	567058.5	324	352302	214756.52	-296237
Feb-09	180458.5	273	289215	-108756.5	-404993
Mar-09	222145.1	228	233550	-11404.93	-416398
Apr-09	292250	177	170463	121787	-294611
May-09	175350	134	117272	58078	-236533
Jun-09	17593.45	48	10890	6703.45	-229830
Jul-09	0	30	-11376	11376	-218454
Aug-09	0	32	-8902	8902	-209552
Sep-09	0	70	38104	-38104	-247656
Oct-09	116900	97	71503	45397	-202259
Nov-09	541024.9	223	227365	313659.89	111401
Dec-09	303565.9	374	414152	-110586.1	814.87

Date	Oil Litres	Gas Litres	Elec kWh
Jan-06	26354	33683	323990
Feb-06	41719	14043	311902
Mar-06	29780	37372	349834
Apr-06	22000	13742	270131
May-06	0	13010	282039
Jun-06	0	0	197931
Jul-06	0	6604	212898
Aug-06	0	0	no data
Sep-06	14997	15437	no data
Oct-06	15000	10445	326831
Nov-06	30000	10681	341498
Dec-06	15000	18325	277465
Jan-07	30000	23344	328643
Feb-07	45000	35996	321884
Mar-07	25450	22570	337347
Apr-07	9942	6859	263147
May-07	0	2986	274066
Jun-07	0	4677	205337
Jul-07	0	3000	206237
Aug-07	0	0	197658
Sep-07	0	0	255027
Oct-07	0	7000	335869
Nov-07	27,030	7879	bad data
Dec-07	25,995	22342	bad data
Jan-08	15000	27765	bad data
Feb-08	15031	29420	bad data
Mar-08	15000	24674	bad data
Apr-08	15000	16553	bad data
May-08	0	11004	bad data
Jun-08	0	3360	bad data
Jul-08	0	3600	bad data
Aug-08	0	0	bad data
Sep-08	0	0	271,213
Oct-08	7500	6863	351,092
Nov-08	14987	13922	351,260
Dec-08	35103	21162	313,314
Jan-09	48508	30001	347,084
Feb-09	15437	19650	334,852
Mar-09	19003	30165	356,274
Apr-09	25000	7700	281,572
May-09	15000	21401	286,207
Jun-09	1505	5254	207,988
Jul-09	0	2201	206,051
Aug-09	0	1122	220,294
Sep-09	0	0	260,770
Oct-09	10000	7677	333,978
Nov-09	46281	8289	351,839
Dec-09	25968	31288	294,874
Jan-10	46281	8289	322,998
Feb-10	25698	31288	336,235
Mar-10	19,106	11839	345,991

Apr-10	14,101		288,024
May-10			268,908
Jun-10			206,821